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Magnetic Planet



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International Association of Geomagnetism and Aeronomy

ABSTRACT VOLUME

This volume is organized in the order of the sessions, with the oral presentations first followed by the poster presentations.

An author index at the end simplifies searching for a specific author.

There are a few abstracts that are incomplete, as listed below. The authors of these abstracts are invited to send us the missing data to the following email: jsilvac@geociencias.unam.mx

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Abstract volume



SESSION J1

DIV. I/V RESULTS FROM SWARM AND PRECEDING MAGNETIC SATELLITE MISSIONS

J1-1 THE ESA DATA ACCESS AND DATA QUALITY STRATEGY FOR SWARM

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ESA/ESRIN; SERCO SPA; ESA/ESTEC

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Swarm is a three-satellite ESA Earth Explorer mission with the key objectives of mapping the geomagnetic field with unprecedented accuracy and studying the electrodynamics of the Earth's ionosphere. The mission will enter its Exploitation phase following the three-month commissioning period after launch. This presentation describes : the data access and distribution set-up; the calibration strategies during the Exploitation phase; and the set up for the product quality assurance strategy including the Expert Support Laboratories and Quality Working Groups, the Swarm Validation Teams, the ESA tools and procedures for data quality control.

J1-2 SWARM: UPDATE ON THE MISSION STATUS, PRE-LAUNCH INSTRUMENT PERFORMANCE TESTS AND ANALYSIS

Floberghagen, Rune; Haagmans, Roger; Menard, Yvon; Bock, Ralf; Mecozzi, Riccardo; Bouridah, Abderrazak; Ottavianelli, Giuseppe; Plank, Gernot; Piñeiro, Juan; Bergaglio, Bruno

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Swarm is the next Earth Explorer mission in ESA's Living Planet Programme scheduled for launch in the last quarter of 2013. This presentation will focus on the Mission status and the activities related to the preparation for launch. The objective of the Swarm mission is to provide the best ever survey of the geomagnetic field and its temporal evolution. The mission shall deliver data that aim to provide new insights into the Earth system by improving our understanding of the Earth's interior and near-Earth electro-magnetic environment including space weather. Swarm consists of a constellation of three identical satellites. Initially all satellites are released from a single launcher and satellite manoeuvring during the commissioning phase of the mission results in the specified constellation at the beginning of the operational phase. This consists of a side-by-side flying pair of satellites at an initial altitude of about 460 km and thereafter slowly decaying. These are complemented by a third satellite that starts in an orbit at 530 km altitude that drifts away from the lower pair over time. High-precision and high-resolution measurements of the strength, direction and variation of the magnetic field, complemented by precise navigation, accelerometer and electric field measurements, will provide the observations that are required to separate and model various sources of the geomagnetic field (core, mantle, lithosphere) and near-Earth current systems (ionosphere, magnetosphere). In the last year, the commissioning activities have been further consolidated and a number of tests and performance analysis has been carried out on the Swarm payloads. Some examples are the support bracket holding the Absolute Scalar Magnetometer instrument and the Electric Field Instrument Langmuir Probes. This paper presents the current status of these further preparation to launch and results from the platform and payload tests and any impact on the product performance.

J1-3 THE SWARM ELECTRIC FIELD INSTRUMENTS

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Swarm will combine precision electric and magnetic field measurements on multiple, three-axis-stabilized platforms in polar orbits. Electric fields will be derived from detailed images of thermal ion distribution functions recorded by CCD-based Thermal Ion Imager sensors, aided by Langmuir probe measurements of spacecraft potential and electron density and temperature. The combination of these measurements will provide an unprecedented view of energy exchange between the magnetosphere and ionosphere through Poynting flux, with a resolution approaching 1 microWatt per square meter. Swarm will also provide a new view of processes that include ion upflow and outflow, non-equilibrium and non-Maxwellian plasma distributions, temperature anisotropies, regional and global plasma convection, and plasma instabilities and irregularities at all latitudes. Combined with ground-based camera and radar arrays, Swarm is

especially well-suited to studies of ionospheric and auroral electrodynamics. This talk will review the capabilities and scientific potential of Swarm's Electric Field Instruments in the context of the state of the art.

- J1-4 SWARM'S ABSOLUTE SCALAR MAGNETOMETER CAN DO MORE**
Hulot, Gauthier; Leger, Jean-Michel; Fratter, Isabelle; Bertrand, François; Chulliat, Arnaud;
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Each of the three ESA Swarm satellites, hopefully to be launched by the end of the year, carries a vector field magnetometer (VFM) and an absolute scalar magnetometer (ASM), positioned on a boom away from the body of the satellite to minimize undesired magnetic perturbations, and distant enough from each other to avoid crosstalk between instruments. The VFM further shares an optical bench with a star imager (STR), to which it is thus rigidly attached. The rationale behind this set-up is that the ASM will provide very accurate absolute field intensity measurements, while the combination of the VFM with the STR will provide vector field measurements oriented in the terrestrial frame of reference. The ASM will also provide the values needed to calibrate and improve the accuracy of the three components of the field measured by the VFM. It is the output of this procedure (using the implemented baseline Swarm level 1b algorithms, also correcting for known satellite perturbations) that will provide the very accurate level 1b data the Swarm mission is aiming at. The above procedure is entirely based on the baseline 1 Hz scalar ASM outputs. But the ASM instruments can do more. Following an agreement between ESA and CNES, each instrument will also be able to provide two additional, non-nominal, types of data: 250 Hz measurements provided by a "burst mode" to be operated during the commissioning phase, and 1 Hz absolute vector field measurements produced as a by-product by the ASM and synchronized with the nominal 1 Hz scalar measurements. The burst mode will be used to explore the spectral content of the field encountered by each satellite. It will also be used to identify the frequency bands within which three modulations must be operated to produce the experimental absolute vector field ASM data, which would then provide a second set of vector field measurements (in addition to that provided by the VFM) on board each satellite. In this talk, we will discuss the possibility offered by these two additional ASM modes, for both validation and science purposes.

- J1-5 PERSPECTIVES ON THERMOSPHERE SCIENCE USING SWARM: THE GOCE-CHAMP-GRACE-DMSP MINI-CONSTELLATION**
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The space weather of the ionosphere-thermosphere (IT) system (ca. 100-1000 km) affects satellite orbital predictions and operation of various navigation and communications systems, issues of increasing importance to our 21st-century society. The Swarm mission will provide key measurements that define energy inputs into the system, as well as the response of the system to these and other energy inputs. In this paper we provide examples of how measurements from 4 satellites (GOCE, CHAMP, GRACE and DMSP) in different orbital planes and at different altitudes can be synergistically used to address contemporary problems in thermosphere science: geomagnetic storm response including traveling atmospheric disturbances, ionosphere-thermosphere coupling, wave coupling with the lower atmosphere. Ground-based observations are also key, and can be viewed collectively as the "fourth satellite" of Swarm. We demonstrate here how ground-based observations can be used to validate satellite measurements, and provide data that greatly enrich the science. We also discuss how first-principles global thermosphere-ionosphere-electrodynamics models serve as the "glue" that places diverse satellite measurements into the global system context, especially when the data are assimilated into the models to guide their solutions.

- J1-6 REAL-TIME SPECIFICATION OF THE EQUATORIAL IONOSPHERIC ZONAL ELECTRIC FIELD.**
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The equatorial zonal electric field is the primary driver of two important features of the equatorial ionosphere: (1) The Equatorial Ionization Anomaly (EIA), and (2) plasma density irregularities, also known as spread-F. During propagation through the ionosphere, communication and navigation radio signals are attenuated, delayed and scattered by these ionospheric features. Prediction of the zonal electric field is therefore a key to the real-time specification of the ionosphere. We divide the zonal electric field into a climatological contribution plus the prompt-penetration contribution caused by the solar wind effects. We predict the prompt-penetration effects using a transfer-function model (derived from Jicamarca radar and CHAMP measurements) driven in real-time by the interplanetary electric field from the Advanced Composition Explorer (ACE) satellite. The zonal electric field is predicted about one hour in advance, covering all local times and longitudes. The benefit of this application to space weather forecasting is

twofold: As the driver of the equatorial plasma fountain, the predicted zonal electric field is a leading indicator by 2-3 hours of the EIA and the Total Electron Content (TEC) of the equatorial ionosphere. Secondly, rapid uplift of the ionosphere by strong eastward electric fields is known to induce spread-F. The current challenge is to validate the model in near real-time as continuous ground-based measurements of the zonal electric field are sparse along the dip-equator. We plan to use the day-side equatorial electric field (a Level-2 product) from the upcoming SWARM mission to validate and improve our prediction service. The real-time prediction is available as a Google cloud application at <http://www.geomag.us/models/PPEFM/RealtimeEF.html>

J1-7 GLOBAL 3-D MAPPING OF MANTLE ELECTRICAL CONDUCTIVITY FROM SPACE. RECENT DEVELOPMENTS

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We present our recent progress in the development of inversion schemes that aim to map the three-dimensional (3-D) mantle conductivity distribution using satellite magnetic data. Two approaches are discussed. One is based on an inversion of time spectra of spherical harmonic (SH) coefficients describing the induced part of the magnetic potential. This approach has been elaborated during the development phase of the Swarm satellite mission. The second approach deals with an inversion of the responses (Q-matrices) that connect inducing and induced SH coefficients. Pros and cons of the proposed 3-D inverse solutions, along with outlook, are discussed.

J1-8 ACCOUNTING FOR EXTERNAL AND INTERNAL FIELD COVARIANCES IN 3-D INVERSIONS OF SWARM DATA IN TERMS OF MANTLE CONDUCTIVITY

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One of the primary missions of the Swarm multisatellite mission is to determine the 3-D distribution of electrical conductivity in the Earth's mantle. This contribution presents recent developments of an inversion method based on direct integration of magnetic fields in the time domain, and using the adjoint solution for fast evaluation of data sensitivities to model perturbations. In particular, the modified approach takes into account the covariance matrix of external and internal magnetic field coefficients recovered from (so far simulated) Swarm data. External field model is no longer fixed, but it is adjusted together with the recovery of the conductivity structure.

J1-9 BRIDGING THE GAP BETWEEN CHAMP AND SWARM USING OERSTED AND GROUND OBSERVATORY DATA

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The gap between the end of the CHAMP satellite mission in 2010 and the start of the upcoming Swarm mission, anticipated to be later this year, presents a challenge in the construction of global models of the Earth's magnetic field. Here we shall describe how Oersted scalar data between 2010 and 2013, with its intermittent global coverage, together with vector field data from the network of ground magnetic observatories, can be combined with the satellite vector data from the preceding decade in order to produce a reliable model geomagnetic field spanning 1997 to mid-2013.

We shall present the details of the latest update of the CHAOS-4 geomagnetic field model that extends to 2013.5. CHAOS-4 aims to describe the Earth's magnetic field with high spatial resolution (terms up to spherical degree $n = 85$ for the crustal field) and high temporal resolution (allowing for investigations of sub-annual core field changes). The latest update uses 14 years of data from the Oersted, CHAMP and SAC-C satellites, augmented with ground observatory monthly mean values. The maximum spherical harmonic degree of the static (crustal) field is $n = 100$. The core field time changes are expressed by spherical harmonic expansion coefficients up to $n = 20$, described by order 6 splines (with 6-month knot spacing) spanning the time interval from 1997.0 to 2013.5. The third time derivative of the squared magnetic field intensity is regularized at the core-mantle boundary. No spatial regularization is applied for the core field, but the high-degree crustal field is regularized for $n > 85$. We co-estimate a model of the large-scale magnetospheric field (with expansions in the GSM and SM coordinate system up to degree $n = 2$ and parameterization of the time dependence using the decomposition of Dst-index into external (Est) and induced (Ist) parts) and perform an in-flight alignment of the vector data (co-estimation of the Euler describing the rotation between the coordinate systems of the vector magnetometer and of the star sensor providing attitude information). The high-degree part of the crustal field model is solely determined from low-altitude CHAMP satellite observations after 2009.

We shall also discuss future prospects with regard to the Swarm mission, focusing on the expected benefits compared to the currently available data, as well as the scientific opportunities.

J1-10 GEOMAGNETIC FIELD MODELING WITH DMSP**Alken, Patrick; Redmon, Rob; Rich, Frederick; Maus, Stefan**

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The Defense Meteorological Satellite Program (DMSP) launches and maintains a network of satellites to monitor the meteorological, oceanographic, and solar-terrestrial physics environments. In the past decade, geomagnetic field modelers have focused much attention on magnetic measurements from missions such as CHAMP, Oersted and SAC-C. With the completion of the CHAMP mission in 2010, there have been limited satellite-based vector and scalar magnetic field measurements available for main field modeling. In this study, we investigate the feasibility of using the Special Sensor Magnetometer (SSM) instrument onboard DMSP for main field modeling. These vector field measurements are re-calibrated to remove large sources of error, including satellite-generated fields and systematic signals from onboard instrumentation. Euler angles are then computed to determine the orientation of the vector magnetometer with respect to a local coordinate system. Initial comparisons of the processed DMSP data with main field models from CHAMP give root mean square residuals of the order of 20 nT for both the total field and the vertical component. While these residuals are significantly larger than for CHAMP and Oersted measurements, the DMSP data may make a significant contribution toward filling the gap to the upcoming Swarm mission.

J1-11 MAGNETIC REMOTE SENSING OF OCEAN FLOW VARIABILITY**Tyler, Robert**

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It is known that ocean flow generates weak magnetic fields that are detected by land and satellite magnetic observatories, and that this presents a potentially important opportunity to develop a new method of remote sensing of ocean/climate variability. It could even be argued that at least in principle such a method could become a method of choice to measure large-scale flow and heat transports which are difficult to obtain using other methods. There are, however, fundamental challenges because the oceanic magnetic signals are weak and typically share space and time scales with other unresolved components. This is demonstrated by the fact that the most clear extractions of ocean-flow signals have so far involved cases where the expected ocean signal has a highly distinguishing statistical aspect (the highly stationary tidal and highly non-stationary tsunami signals that have been identified in magnetic observations are the strongest examples.) Here a brief review of the status of this opportunity and challenge will be given, including the new opportunities opening with Swarm. Then some preliminary results from new work will be presented. In the new work, inferences for the interdecadal to secular variability in ocean tidal parameters are drawn from the modulations of tidal signals statistically extracted from global magnetic observatory data. These modulations of tidal parameters is of special interest in ocean/climate studies because it is expected that these modulations may reflect changes occurring in the internal structure and baroclinic dynamics within the ocean. These internal tidal processes are thought to play a key role in mixing and thereby the meridional overturning that transports heat poleward. While the work reported here is underway, preliminary results demonstrate statistically significant extractions of these modulations which appear in some cases to match similar modulations obtained independently from oceanographic data.

J1-12 MODELING AND INTERPRETING THE LITHOSPHERIC MAGNETIC FIELD ON REGIONAL SCALES**Thebault, Erwan**

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The last decade of geopotential field research has led to vast improvements in our understanding and description of the Earth's magnetic field. It prompted international collaborations towards compiling, processing, modeling, and interpreting the wealth of high-quality satellite measurements. This success will continue with the forthcoming Swarm satellite mission of the European Space Agency. In parallel to this satellite adventure, huge efforts have been done by the scientific community to produce and publish high spatial resolution compilation of magnetic anomaly data depicting the crustal field on regional scales. This permitted the publication of the first global picture of the magnetic crustal field in the framework of the World Digital Magnetic Anomaly Map project. The available datasets and grids cover different ranges of altitudes. They sometimes have high horizontal densities depending on the considered geographical area and do not have the same spectral content. They can be represented globally in spherical harmonics but high spatial resolution requires a homogeneous data distribution at the Earth's scale and involves the estimation of an enormous number of parameters. Regional modeling techniques have been proposed to address these drawbacks and to take advantage of the availability of high resolution regional datasets over a portion of the Earth.

I will first briefly review the available datasets, from ground, sea, aeromagnetic and satellite levels, which can be used to construct high-resolution models of the crustal field. This will allow me to discuss the incompleteness of these measurements, illustrate the so-called magnetic spectral gap, and show how Swarm is expected to bridge the gap between the near-surface and the satellite data. I will then present some regional modeling methods developed in the spherical coordinates and will emphasize their pros and cons depending on their field of application. I will focus

on the Revised Spherical Harmonic Analysis (R-SCHA) technique and will present its latest developments. These developments were fostered by the preparation to Swarm mission. The R-SCHA technique can now ingest vector, scalar, and gradient magnetic data. Its relationship to the spherical harmonics was clarified. This allowed the definition of a regional spatial power spectrum comparable to global power spectra expressed in spherical harmonics. I will illustrate with an example the advantages of these relationships for modeling and interpreting quantitatively the regional magnetic crustal field models derived in R-SCHA. Finally, I will discuss some general ideas that could be developed for directly relating the R-SCHA parameters to some properties of the magnetic sources.

J1-13 CAN WE UNVEIL THE LARGE WAVELENGTHS OF THE EARTH'S MAGNETIC CRUSTAL THICKNESS ?

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The Earth's lithosphere is considered to be magnetic only down to the Curie isotherm. Therefore, the Curie isotherm can, in principle, be estimated by conducting spectral analyses on the available magnetic data given an a priori magnetization distribution. Here, we define a spatial power spectrum using the Revised Spherical Cap Harmonic Analysis (R-SCHA) regional modeling technique. We briefly discuss its properties and its relationship with the Spherical Harmonic spatial power spectrum. This relationship allows us to adapt any theoretical expression of the lithospheric field power spectrum expressed in Spherical Harmonic degrees to the regional formulation. We compared previously published forms to the recent lithospheric field models derived from the CHAMP and airborne measurements. We finally developed a theoretical form for the power spectrum of the Earth's magnetic lithosphere that we think provides more consistent results. This expression depends on the mean magnetization, the mean crustal thickness and a power law value that describes the amount of spatial correlation of the sources. In this presentation, we make a combine use of the R-SCHA surface power spectrum and this theoretical form. We conduct a series of regional spectral analyses for the entire Earth. For each region, we estimate the R-SCHA surface power spectrum of the NGDC-720 Spherical Harmonic model (Maus, 2010). We then fit each of these observational spectra to the theoretical expression of the power spectrum of the Earth's lithosphere. By doing so, we estimate the large wavelengths of the magnetic crustal thickness on a global scale that are not accessible directly from the magnetic measurements due to the masking core field. We then discuss these results and compare them to global maps for the crustal thickness derived with other techniques and geophysical data.

J1-14 SWARM AND ICEBASE: MAPPING GEOTHERMAL HEAT FLUX UNDER AN ICE SHEET

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NASA will solicit suborbital missions as part of its Earth Venture program element this fall. These missions are designed as complete PI-led investigations to conduct innovative hypothesis or scientific question-driven approaches to pressing questions in Earth System science. We propose to carry out a suborbital magnetic survey of Greenland using NASA's Global Hawk unmanned aerial vehicle to produce the first-ever map of the geothermal heat flux under an ice sheet. Better constraints on geothermal heat flux will reduce the uncertainty in future sea level rise, in turn allowing a more informed assessment of its impact on society. The geothermal heat flux depends on conditions such as mantle heat flux, and the tectonic history and heat production of the crust, all of which vary spatially. Underneath ice sheets, the geothermal heat flux influences the basal ice. Therefore heat flux is an important boundary condition in ice sheet modeling. Using magnetic data to constrain heat flux is possible because the magnetic properties of rocks are temperature dependent until they reach the Curie temperature. The technique has applications to understanding the response of Greenland ice sheet to climate forcing because the basal heat flux provides one of the boundary conditions. The technique also helps to locate the oldest ice. The oldest ice in Greenland should be found in areas of very low heat flux, and the identification of those areas is provided by this technique. Ice cores from the areas of oldest ice help to decipher past temperatures and CO₂ contents. Our latest model of the geothermal heat flux under the Greenland ice sheet (http://websrv.cs.umd.edu/isis/index.php/Greenland_Basal_Heat_Flux) is based on low-resolution satellite observations collected by the CHAMP satellite between 2000 and 2010. Those observations will be enhanced by the upcoming Swarm gradient satellite mission, but the resolution will improve by less than a factor of two, from 400 km resolution to approximately 250 km resolution. A high altitude, suborbital magnetic survey of Greenland would provide a heat flux model with resolution comparable to the crustal thickness, and would provide details of the high heat flux region associated with the Iceland mantle plume in E/SE Greenland, and the low heat flux region in NW Greenland, adjacent to the Canadian Shield. Magnetic field measurements from 20 km altitude are strongly preferred over lower altitude observations because of their ability to sample the longest wavelengths, provide uniform calibration with sufficient sensitivity, and suppress local remanent magnetic field signatures. We validate our heat flux estimates by assessing the possible contributions from remanent magnetism and variable susceptibility, and from other lithospheric processes such as structure, volcanism and impact, from unmodeled external magnetic fields, and from the assumptions utilized in the heat flux model.

J1-15 LONG DURATION STRATOSPHERIC BALLOON GRADIENT GEOMAGNETIC BALLOON MISSIONS

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We promote the idea to support forthcoming Swarm multi-satellite geomagnetic mission with the long duration balloon flights that will aim at simultaneous measurement of geomagnetic field at stratospheric altitudes (20-30 km). We have proposed the method allowing experimental recovery of lithospheric field along balloon flight. The main idea of this method - use the balloon gradient magnetic surveys to find the areas where the magnetic anomalies are absent. Then it is possible to compare the balloon's (in situ) and model's data. The difference will be the amendment for model data (correcting number). But corrections are available only for places close to along balloon route. Daily mean spherical harmonious model (DMSHAM) derived from CHAMP data is used to demonstrate the proposed method. In addition, there are a few reasons to develop such balloon missions:

- Balloon missions could provide more detailed information about lithospheric field compared with the satellite measurements;

- Balloon mission's data can be used not only for the validation of satellite models, but also for including these data for constructing of the field models;

- Measurements of geomagnetic field vertical gradients during balloon flights allows more accurate separation of lithospheric signal and signals from the external sources.

IZMIRAN has designed the balloon system which measures the total magnetic field at three altitudes with separations of 3 and 6 km. Twelve testing flights (1986-2010) at stratospheric altitudes have proven the reliability of the system. There are a few launching pads (Sweden, Norway, Russia, Antarctica and so on) where balloons with long duration of flight could start on a regular basis. IZMIRAN plans to launch a few flights of balloons with magnetic gradiometer onboard during Swarm mission (Our team is included in the list of principal investigators of Swarm mission). However, efforts of only IZMIRAN will be far insufficient for proper solution of aforementioned problems. In this context, we invite geomagnetic and balloon communities to think about: how people can use available experience of long duration balloon missions for geomagnetic research, in particular, for supporting Swarm mission?

J1-1p SWARM L2PS EQUATORIAL ELECTRIC FIELD INVERSION CHAIN

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The day-time eastward equatorial electric field (EEF) in the ionospheric E-region plays a crucial role in equatorial ionospheric dynamics. It is responsible for driving the equatorial electrojet (EEJ) current system, equatorial vertical ion drifts, and the equatorial ionization anomaly (EIA). Due to its importance, there is much interest in accurately measuring and modeling the EEF for both climatological and near real-time studies. The Swarm satellite mission offers a unique opportunity to estimate the equatorial electric field from measurements of the geomagnetic field. Due to the near-polar orbits of each satellite, the on-board magnetometers record a full profile in latitude of the ionospheric current signatures at satellite altitude. These latitudinal magnetic profiles are then modeled using a first principles approach with empirical climatological inputs specifying the state of the ionosphere. Since the EEF is the primary driver of the low-latitude ionospheric current system, the observed magnetic measurements can then be inverted for the EEF.

This paper will detail the full algorithm for recovering the EEF from Swarm geomagnetic field measurements. The equatorial electric field estimates are an official Swarm level-2 product which will be produced inside the level-2 processing system (L2PS) and made freely available after the commissioning phase.

J1-2P MAGNETOSPHERIC ULF WAVE STUDIES IN THE FRAME OF SWARM MISSION:

A WAVELET ANALYSIS TOOL FOR MULTIPOINT OBSERVATIONS OF PULSATION EVENTS

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We combine the advantages of multi-spacecraft and ground-based monitoring of the geospace environment in order to analyze and study magnetospheric ultra low frequency (ULF) waves. In line with this aim, we also develop and deliver relevant analysis tools based on wavelet transforms and tailored to the Swarm mission. In the preparation phase as well as the lifetime of the Swarm mission, the analysis of isolated ULF wave events - especially those detected in the Pc3 frequency range (20--100 mHz) that a topside ionosphere mission efficiently resolves - can help to elucidate the processes that play a crucial role in the generation of waves and their most defining propagation characteristics. Additionally, we offer a useful platform to monitor the wave evolution from the outer boundaries of

Earth's magnetosphere through the topside ionosphere down to the surface. Data from a single Low Earth Orbit (LEO) satellite (CHAMP), a multi-satellite LEO mission (ST5) and the ongoing multi-satellite magnetospheric mission (Cluster) along with a ground-based magnetic network (CARISMA) are used to study wave evolution in detail. A better understanding of the generation and propagation of waves will also allow to geophysically validate some of Swarm's data products, especially those related to the magnetic and electric fields in geospace. With a carefully selected case study focusing on the recovery phase of a moderate magnetic storm (9 April 2006 with a minimum Dst value of -82 nT) as a starting point, we clearly demonstrate the capabilities offered by our wavelet analysis tools and highlight the options opened to treat various categories of multipoint multi-instrument measurements (both spaceborne and ground-based) for signatures of ULF wave signals as well as the effects of various other sources.

J1-3p SWARM L2PS DEDICATED IONOSPHERIC FIELD INVERSION CHAIN
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ESA's Swarm mission, to be launched in July 2013, is an optimized constellation of three low-Earth orbiting satellites providing measurements of the geomagnetic field with unprecedented precision. Over the last two and a half years, a consortium of research institutions has teamed up with ESA to set up the Swarm L2 Processing System (L2PS), a distributed processing facility that will produce level-2 data products during the Swarm mission. As a member of the consortium, the IPGP developed the Dedicated Ionospheric Field Inversion chain (DIFI). The DIFI algorithm produces global, spherical harmonic and time varying models of the geomagnetic Sq field, i.e., the magnetic field generated by electrical currents flowing in the conducting layers of the ionosphere, on the dayside of the Earth. It takes into account seasonal effects as well as solar cycle variability. It separates the observed Sq field in two parts: the primary field originating in the ionosphere, and the secondary field induced in the electrical conducting mantle. The obtained models are valid both on the ground and at satellite altitude, and at all latitudes within $\pm 55^\circ$. The DIFI algorithm was thoroughly tested during the development phase of the L2PS, using synthetic Swarm data. A first model based upon real Swarm data will be delivered about 6 months after the end of the Swarm commissioning phase.

J1-4p IN ORBIT ALIGNMENT OF THE SWARM ASM AND VFM MAGNETOMETERS
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The SWARM Absolute Scalar Magnetometer (ASM) is an optically pumped Helium-4 magnetometer developed by CEA-LETI, with CNES support, which will provide absolute scalar measurements of the magnetic field with high accuracy and stability on the three satellites of the mission. In addition, and on an experimental basis, these ASM instruments will be able to operate as vector field magnetometers.

This vector mode will make it possible to carry on comparisons of ASM vector field measurements with that of the nominal VFM vector magnetometers on each satellite, to both check the consistency of the field measured and assess the stability of the boom on which both instruments lie. For this to be possible, however, one must first align both instruments with respect to each other. This alignment process consists in finding the most accurate way to geometrically link the VFM and ASM frames, when the same natural field is simultaneously measured in both frames while the satellite is orbiting. This geometrical link is described by the Euler Angles. Here, we will describe the method that can be used for recovering these Euler angles and present results based on simulations, investigating the time needed to recover these angles with relevant accuracy, and assess the possibility of detecting, and taking into account boom perturbations.

J1-5p STUDY ON MAGNETIC RECONNECTION AT EARTH'S MAGNETOPAUSE USING POLAR SATELLITE
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In this work we analyzed some key parameters associated with magnetic reconnection at the Earth's magnetopause using data observed by the Polar satellite, i.e., reconnection rate, direction of the modeled X-line, electric field parallel to the X-line, and reconnection outflow (Alfvén) velocity for six selected reconnection events.

We find one event that we can't define the region that satellite Polar crossed. As a result for the other five events the reconnection rate was between 0.089 and 0.153. The reconnection is anti-parallel for two events and component for three events. The electric field parallel to the X-line is between 0.953 mV/m and 34.837 mV/m and Alfvén velocity is > 300 km/s which agrees with Mozer e Hull (2010).

J1-6p THE SWARM ABSOLUTE SCALAR MAGNETOMETER

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The Swarm mission, conducted by the European Space Agency (ESA), will provide the best ever survey of the Earth's magnetic field and its temporal evolution. This will be achieved by a constellation of three satellites to be launched by the end of 2013.

The Absolute Scalar Magnetometer (ASM), proposed by CNES and CEA-LETI with the scientific support from IPGP, was selected by ESA in 2005 as the Swarm magnetic reference. Its performances are therefore crucial for the mission's success. Thanks to a new dedicated design, the ASM will offer the best precision and absolute accuracy ever attained in space, with similar performances all along the orbit. This paper presents the new features, capabilities and performances of this instrument as well as the last status.

The ASM operating principle is based on the atomic spectroscopy of the helium 4 metastable state. It makes use of the Zeeman's effect to transduce the magnetic field into a frequency, the signal being amplified by optical pumping.

The ASM will thus deliver high resolution scalar measurements at 1 Hz for the in-flight calibration of the Swarm Vector Field Magnetometer (VFM) over the 4 year mission. It can also be operated at a much higher sampling rate (burst mode at 250 Hz).

In addition, thanks to an innovative architecture, the ASM will be able to carry out continuous vector measurements, hence delivering simultaneously both the magnitude and direction of the ambient magnetic field measured at the same point, which is a premiere on a single instrument. While the main advantage of this vector capability lies in the lack of offsets or drifts, its precision is by design significantly lower than the scalar's. This capacity will be used in flight on an experimental basis, the nominal Swarm vector data being delivered by the VFM.

Swarm will offer a unique opportunity to validate the ASM vector data in orbit by comparing them with the VFM's, thus opening the way for a potential in-space cross calibration. This will be done during the Swarm commissioning phase, in close partnership between CNES, CEA-LETI and IPGP.

J1-7p THE ROLE OF GEOMAGNETIC OBSERVATORY DATA DURING THE SWARM MISSION

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The scientific use of Swarm data and Swarm-derived products is greatly enhanced through combination with observatory data and indices. The strength of observatory data is that they are very stable over long periods of time with great care being taken with temperature control and correction, platform stability and magnetic cleanliness at each site. As part of the Swarm Level-2 data activities, plans are in place to distribute such ground-based data along with the Swarm data as auxiliary data products. We describe here the preparation of the data set of ground observatory hourly mean values, including procedures to check and select observatory data spanning the modern magnetic survey satellite era. Existing collaborations, such as INTERMAGNET and the World Data Centres for Geomagnetism, are proving invaluable for this.

In addition, we discuss other possible combined uses of satellite and observatory data. Quasi-definitive 1-second data are now available from a number of observatories worldwide. A preliminary study using Champ satellite data has shown that these observatory data could prove beneficial as a secondary tool for Swarm magnetic data validation; however, to avoid ionospheric and magnetospheric interference requires satellite-observatory crossings to occur during quiet, local night time. Whether or not such passes will transpire during the period of Swarm Calibration/Validation is highly dependent on the initial timing of orbital insertion and how active the magnetic field is. Alternatively, we consider exploiting 1-minute data, collected from a much larger global network of observatories. Removing an estimate of the main field from both the observatory and satellite observations during crossings could provide a baseline for detecting abnormalities and aid with Swarm measurement validation, whilst differences observed with solar zenith angle may constrain thermal fluctuations not otherwise accounted for. It is possible that early validation results with magnetic data from the Swarm mission will be presented if launch is successful in the preceding months.

J1-8p INVESTIGATION OF INTENSE GEOMAGNETIC STORMS AND THEIR SOLAR/INTERPLANETARY CAUSES DURING SOLAR CYCLE 23

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The present study discuss intense geo-effective events occurred during solar cycle 23 and analyzing their solar and /or interplanetary drivers. Shocks driven by energetic coronal mass ejections (CME's) and other interplanetary (IP) transients are mainly responsible for initiating large and intense geomagnetic storms. Observational results

indicate that galactic cosmic rays (CR) coming from deep surface interact with these abnormal solar and IP conditions and suffer modulation effects. The current solar cycle has provided a long list of these highly energetic events influencing the Earth's geomagnetic field up to a great extent. We have selected an intense geo-effective event which depressed the Dst index more than -300nT, and studied it using the hourly values of IMF data obtained from the NSSD Center. Solar wind data obtained from various satellites as well as the super neutron monitor data obtained from Kiel, Oulu and Huancayo stations, well distributed over different latitudes has been used in the present study. It is found that AP and AE indices show rise before the forward turnings of IMF and both the Dst index and cosmic ray intensity show a classic decrease. The analysis further indicates the significant role of the magnitudes of Bz component of IMF substantiating the earlier results. It is further inferred that the magnitude of these responses depends on BZ component of IMF being well correlated with solar maximum and minimum periods. Transient decrease in cosmic ray intensity with slow recovery is observed during the storm phase duration.

J1-9p SWARM L2PS DEDICATED LITHOSPHERIC FIELD INVERSION CHAIN

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The forthcoming Swarm satellite mission is a constellation of three satellites dedicated to the study of the geomagnetic field. The orbital characteristic of the mission, which includes a pair of satellites flying side by side, has prompted new efforts in data processing and modeling. A consortium of several research institutions has been selected by the European Space Agency (ESA) to provide a number of Level-2 data products which will be made available to the scientific community. Within this framework, specific tools have been tailor-made to better recover the lithospheric magnetic field contribution. These tools take advantage of gradient properties measured by the lower pair of Swarm satellites and rely on a regional modeling scheme designed to better detect signatures of small spatial scales. We report on a processing chain specifically designed for the Swarm mission. Using an End-to-End simulation, we show that the tools developed are operational. The chain generates a model that meets the primary scientific objectives of the Swarm mission. We also discuss refinements that could also be implemented during the Swarm operational phase to further improve lithospheric field models and reach unprecedented spatial resolution.

SESSION J2

DIV. I/VMOD GEOMAGNETIC SECULAR VARIATION AND RAPID CORE DYNAMICS FROM SATELLITE AND OBSERVATORY MEASUREMENTS

J2-1 IRREGULARITIES AND DYNAMICS OF THE CORE-MANTLE BOUNDARY

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The last decade has been a flourishing era for gravity and magnetic satellite data, with GRACE and CHAMP missions. Models of the gravity and magnetic fields have reached an unprecedented resolution and accuracy, allowing new insights in the core dynamics.

On the other hand, it has been argued that there may be a small roughness at the core-mantle boundary, invisible to the seismology. There is indeed a striking contrast between the mantle and the core, and this frontier is expected to be the site of physical-chemical interactions between core and mantle. The hot liquid core can corrode the overlying mantle, preferentially dissolving the silicates and oxides along the grain boundaries and infiltrating upward into the mantle by capillarity. The core-mantle boundary does not move upward or downward as a whole, but acquires a roughness which has fractal properties. As a result gravimetric anomalies can be generated by this relief and be observable, thanks to the new data, at the Earth's surface (a few hundreds nGal) for scales of the order of some 1000 km. Such a relief also exerts a pressure distribution at the core-mantle boundary which is accompanied by a flow at the top of the core; this flow generates an additional secular variation of the geomagnetic field, which might be observable at the Earth's surface.

J2-2 AN ATTEMPT TO BUILD A MAGNETIC FIELD MODEL UNDER PURE TOROIDAL FLOW CONSTRAINT

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A magnetic field model spanning the CHAMP satellite era will be presented where the magnetic field is co-estimated together with a large-scale flow at the top of the liquid outer core. The technique has been proposed in Lesur *et al.* (2010) and applied to observatory data in Wardinski and Lesur (2012). We develop further this approach to

handle possible interactions between the small scales of the field and the flow that may generate large-scale secular variation. Additionally, in order to be able to impose a strong convergence of the flow spectra, we work with a version of the induction equation filtered for large-scales of the field and the flow. Under the hypothesis of pure toroidal flow the model fails to fit the observed magnetic field at satellite altitude, even if there is no restriction imposed on the flow temporal variability. Preliminary results will be shown for magnetic field models co-estimated with general flow models where contributions from poloidal flows are minimized.

Lesur, V., Wardinski, I., Asari, S., Minchev, B., and Manda, M. (2010). Modelling the Earth's core magnetic field under flow constraints. *Earth, Planets and Space*, 62:503-516.

Wardinski, I. and Lesur, V. (2012). An extended version of the C3FM geomagnetic field model - application of a continuous frozen-flux constraint. *Geophys. J. Int.*, 189:1409-1429.

J2-3 SYMMETRY PROPERTIES AND RAPID CHANGES IN CORE MOTIONS OVER THE OBSERVATORY ERA

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We reconstruct the core flow evolution over the period 1840-2010 under the quasi-geostrophic constraint, from the stochastic magnetic field model COV-OBS and its full model error covariance matrix. We make use of a prior knowledge on the flow temporal power spectrum compatible with that of observed geomagnetic series. We employ an iterative scheme together with an ensemble approach to estimate the errors of representativeness that arise from the interaction of the core flow with the unresolved field at small length-scales. Allowing such errors to be time correlated, we manage to retrieve rapid flow changes, and in particular rapid torsional waves predicting correctly interannual length-of-day variations from 1950 onward. Large length-scales flow features are naturally dominated by their equatorially symmetric component from about 1900 when the symmetry constraint is relaxed. Equipartition of the kinetic energy in both symmetries coincides with the poor prediction of decadal length-of-day changes in the XIXth century. We interpret this as an evidence for quasi-geostrophic rapid flow changes, and the consequence of a too loose data constraint during the oldest period.

J2-4 DO ACCELERATED CORE FLOWS PRODUCE BETTER MAGNETIC FIELD MODEL FORECASTS?

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The IGRF-11 model released in 2010 includes a description of the geomagnetic field and a prediction of its annual secular variation (SV) over the subsequent five years from up to 2015. While retrospective modelling of the field has greatly improved in the past decade with the availability of satellite magnetic field measurements, the ability to correctly predict SV has not. For example, the root-mean-square (RMS) difference between the prediction of the previous IGRF-10 model and the IGRF-11 model for 2010.0 was 119nT.

We investigate how well core flow modelling can improve our forecast of SV compared to essentially linear extrapolation currently used in IGRF modelling. Previously it has been shown that using a steady flow, derived from the inversion of SV data prior to the period of interest, can improve the prediction. After five years, the RMS difference between the forecast model using steady core flow modelling and the 'true' field was 85nT, illustrating that we can potentially improve on current prediction methods.

We now adapt our core flow prediction method to include an estimate of core flow acceleration in addition to a steady flow model. We show that jointly inverting for core flow and acceleration from SV and secular acceleration data produces a better prediction of the SV over five years than compared to using steady flow alone. We compare the RMS and spatial differences between retrospective models of the magnetic field for 2005.0-2010.0. We also investigate how well the current IGRF model forecasts and how our method compares with observatory data up to 2013.5.

J2-5 JERKS ABOUND: OBSERVATIONS OF GEOMAGNETIC JERKS AND IMPLICATIONS FOR CORE DYNAMICS

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The geomagnetic field is generated by the constant evolution of the fluid outer core. The secular variation of the geomagnetic field describes the variation of the field at time scales on the order of months to decades and is attributed primarily to flows near the surface of the outer core. The secular variation, at any point on the Earth's surface, is often characterised as a series of linear trends separated by abrupt turning points known as geomagnetic jerks. These rapid variations in the secular variation are linked to accelerations of flow in the outer core. Various generation mechanisms for these rapid changes have been suggested but none have conclusively explained the phenomena. Our recent study of geomagnetic jerks in observatory data over the period of 1957-2008 indicates that jerks are far more frequent an occurrence than previously suggested and perhaps part of the more rapid end of a spectrum of core

dynamics. Whilst jerks are seen to be common, relative peaks in the global number of jerk occurrences are seen in 1968-71, 1973-74, 1977-79, 1983-85, 1989-93, 1995-98 and 2002-03 with the suggestion of further poorly sampled events in the early 1960s and late 2000s. We do not find consistent patterns in the spatial distributions of occurrences suggesting complex origins or the superposition of several discrete individual events. We observe that jerk amplitudes vary through time and their variations are potentially periodic in Europe and North America. This may have implications which help to constrain a source mechanism in the dynamics of the outer core. These signals may be related to the 6yr periods detected independently in the secular variation and length-of- day.

J2-6 GEOMAGNETIC SECULAR ACCELERATION, JERKS AND WAVES AT THE CORE SURFACE

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Subdecadal variations of the Earth's core magnetic field are difficult to detect, due to their small amplitude with respect to slower core field variations. The signal in the subdecadal frequency band can be amplified by taking the second order time derivative of the core field, i.e., the secular acceleration. We use a new method to directly derive secular acceleration models from 2002 to 2009, by steps of 30 days, from CHAMP satellite data. This method does not rely on the use of splines for representing temporal variations. Analysis of the time variation of the secular acceleration power spectra and maps at the core surface reveals the existence of two secular acceleration pulses, in 2005 and 2009. These pulses are centered in the Atlantic hemisphere, at low-latitudes, and are anticorrelated in time. We discuss the physical interpretation of these two pulses in terms of magnetohydrodynamic waves within the core.

J2-7 MODELLING AND ANALYSIS OF SOUTHERN AFRICA'S GEOMAGNETIC FIELD AND SECULAR VARIATION SINCE 2005

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Secular change is a comparatively local phenomenon that does not proceed in a regular and uniform pattern all over the Earth, giving rise to regions where the field changes more rapidly than elsewhere, like for instance southern Africa.

Geomagnetic field observations over southern Africa, including countries like South Africa, Namibia, and Botswana, have been conducted annually since 2005. For this purpose a total of 40 repeat stations were identified, separated by distances ranging between 300 and 400 km. Due to the rapid secular variation change over this region, it is necessary to conduct annual surveys at these repeat station positions.

These measurements were processed to remove daily variations etc., and then modelled using various techniques like polynomial fitting and spherical cap harmonics to derive geomagnetic field models for southern Africa. In addition, mean monthly field components recorded at magnetic observatories such as Hermanus, Hartbeesthoek, Tsumeb and Keetmanshoop provide an excellent opportunity to investigate the temporal changes at these locations. These quiet time series have been analyzed to detect possible secular variation impulses, an abrupt jump in the second time derivative of the magnetic field.

J2-8 ILLUMINATING THE ELECTRICAL CONDUCTIVITY OF THE LOWERMOST MANTLE FROM BELOW

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The complexity of the lowermost mantle structure as it is emerging from seismological observations is fascinating. There is growing evidence of compositional and thermal heterogeneities on a variety of length scales. In particular, past and present chemical reactions between the core and the mantle may be conducive to the presence of metallic oxides in the lowermost mantle.

The main tool to investigate how electrically conducting materials affect the transmission of the magnetic signal from the core has been the mantle filter theory of Backus (1983) and Benton and Whaler (1983). It amounts to calculate a perturbation solution with signal frequency as small parameter. According to this theory, the electrical conductivity of the rocks just above the core-mantle boundary has no influence on the transmission of the signal.

I will give examples showing that the theory cannot be extended to signals with period comparable to the zero-frequency electromagnetic delay time of the mantle. Specifically, I will discuss how to couple transport by highly fluctuating core motions and induction in the solid mantle.

J2-1p MODELING THE GEOMAGNETIC SECULAR VARIATION IN MEXICO BASED ON MAGNETIC CHARTS AND SURFACE SURVEYS**Aviles, Thalia; Hernández Quinteto, Esteban; Cifuentes-Nava, Gerardo,**

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The first magnetic observations known in Mexico were made by Cavendish in La Paz, Cabo Corrientes, and Manzanillo in 1587. In the Gulf of Mexico the oldest magnetic measurement was made by Sir Arthur Dudley in 1625. Observations since 1830, were made in order to produce magnetic charts, with two main desired results: knowledge of the magnetic phenomena, and for navigation purposes. During 1906 and 1907 the first magnetic survey was carried out by the Observatorio Astronómico de México (Astronomical Observatory of Mexico). This first attempt to obtain a rational magnetic chart was supported by the Carnegie Institution of Washington D.C. In 1948, Geophysics Institute started its operation, into National University of Mexico. The department of Geomagnetism was in charge of several magnetic surveys in 1950, 1951, 1952, 1960, 1965, 1970, 1975 besides scarce and isolated surveys in the eighties (Hernández-Quintero *et al.*, 2009). An important effort made possible a national survey during 1990-1992.

By the other hand, the westward drift of the geomagnetic field has been interpreted to imply that the outer core is rotating more slowly than the mantle; resulting in an apparent westward drift of the core produced field. Other specific manifestations of secular variation are, for example, changes in local declination or inclination, in scales of 100 years or so with changes of 30° or more (Backus *et al.*, 1996).

Between 2009 and 2011 a series of field trips were carried out in order to acquire geomagnetic data over the area of México. A number of 36 repeat stations were visited and the data were reduced to 2010.0.

According with such view we present an analysis of this information in order to observe the steady westward drift that is modeled by polynomial equation in time (Bloxham *et al.*, 2002); nevertheless some quite sudden changes in the records due to diverse phenomena (such as a sudden change of more or less one year of duration) are generating several puzzles still under debate.

A model of Geomagnetic Secular Variation is proposed for the area of Mexico in order to improve the lack of detail description of global models such as IGRF and considering possible sources of local variation.

J2-2p BOTTOM-UP CONTROL OF GEOMAGNETIC SECULAR VARIATION BY THE EARTH'S INNER CORE**Aubert, Julien; Finlay, Christopher C., Fournier, Alexandre**

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Changes in the Earth's magnetic field occur most prominently at low latitudes in the Atlantic hemisphere (-90E to 90E), while the Pacific is comparatively quiet. This is a consequence of the geographical localisation of intense, westward drifting, equatorial magnetic flux patches at the core surface. Despite successes in explaining the morphology of the geomagnetic field, numerical models of the geodynamo have so far failed to systematically account for this striking pattern of geomagnetic secular variation. Here we show that it can be reproduced provided two mechanisms relying on the inner core are jointly considered. First, gravitational coupling aligns the inner core with the mantle, forcing the coupled outer core flow into a giant, westward, sheet-like gyre. The resulting shear concentrates azimuthal magnetic flux at low latitudes close to the core-mantle boundary, where it is expelled by core convection and subsequently transported westwards. Second, differential inner core growth, fastest below Indonesia, causes an asymmetric buoyancy release in the outer core which in turn distorts the gyre, forcing it to become eccentric in agreement with recent core flow inversions. This bottom-up heterogeneous driving of core convection dominates top-down driving from mantle thermal heterogeneities, and localises magnetic variations in a longitudinal sector centered beneath the Atlantic, where the eccentric gyre reaches the core surface. In order to match the observed pattern of geomagnetic secular variation, the solid material forming the inner core must currently be in a state of differential growth rather than growth and melting induced by full translation.

J2-3p ASSESSING THE IMPORTANCE AND EXPRESSION OF THE 6-YEAR GEOMAGNETIC OSCILLATION**Silva, Luis; Jackson, Luke; Mound, Jon**

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The first time derivative of residual Length-of-Day observations is known to contain a distinctive 5.9-year periodic oscillation. This period is thought to result from the exchange of axial angular momentum between the Earth's core and mantle. Changes in the axial core angular momentum result from cylindrical flow accelerations of the fluid inside the core. Provided that such cylindrical motions within the core have a corresponding acceleration in the zonal flow at the top of the core, then there will be a corresponding 5.9-year periodic signal in the geomagnetic secular acceleration. We analyse the frequency content of the secular acceleration of the CHAOS-3 and CM4 geomagnetic

field models through both a traditional Fourier analysis and an Empirical Mode Decomposition. We identify the 5.9-year periodic signal in the geomagnetic secular acceleration and characterise its spatial behaviour. The secular acceleration signal peaks predominantly at low latitudes and may be related to recent geomagnetic jerks.

J2-4p MODELING THE TOTAL FIELD GEOMAGNETIC SECULAR VARIATION FROM CROSS-OVER MARINE DATA

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In this work, we propose a regional model for the secular variation of the total geomagnetic field from 1960.0 to 2000.0. The main goal of the study is the inclusion of cross-over marine data in the modeling approach covering areas lacking of observatory and repeat station data, i.e. the oceanic regions. The model, which is valid for the Northern Atlantic region during the temporal interval 1960-2000, was obtained using the spherical cap harmonic analysis in space and penalized cubic B-splines in time. The maximum spatial expansion is equivalent to degree 9 ordinary spherical harmonic analysis. In order to improve the spatial and temporal distribution of the cross-over data, we also used annual mean intensity data from different geomagnetic observatories falling into the spherical cap. The model uncertainty is provided by using a bootstrap approach. Results show that the use of the cross-over marine data is crucial in producing a better model for the Northern Atlantic region. The proposed regional model improves, in terms of the root mean square error, the prediction given by the IGRF11 and CM4 global models, especially for the geomagnetic observatories considered. The model is available at <http://earthref.org/ERDA/1728/>.

J2-5p EMPIRICAL MODE DECOMPOSITION: A TOOL TO SEPARATE INTERNAL AND EXTERNAL COMPONENTS OF THE EARTH'S MAGNETIC FIELD?

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Magnetic field recorded at the Earth's surface results from the overlap of contributions from various sources both internal and external to the planet. Different methods have been proposed to achieve the separation of these contributions. An example is the application of spherical harmonic expansion directly on worldwide magnetic data without a priori knowledge on the spatial structure of the magnetic field. Another example is the direct physical modeling of the sources based on the knowledge of the time-space structure of the magnetic field and of the currents that generate it.

Here we test Empirical Mode Decomposition (EMD) as method to straightforwardly separate internal and external components of the geomagnetic field. The main feature of EMD is that it allows splitting a non-stationary signal into a series of monocomponents and a residual. With respect to spherical harmonic expansion this EMD-based procedure has the advantage to permit the separation of contributions also for a single observatory. With respect to methods based on magnetic modeling the procedure here proposed has the advantage to be easily implemented even on real time data. Indeed, separation based on physical modeling of the sources could suffer from the time limits imposed by the time extension and from the availability of updated releases of the model.

Separation of internal and external contribution is presented for data of a number of magnetic observatories. To test the validity of this procedure of internal/external separation, the different contributions are compared, for instance, with those provided by CM4 magnetic model.

J2-6p CHINESE AND MONGONLIAN GEOMAGNETIC REFERENCE FIELD

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As a basic technological production describing geomagnetic spatial distribution, geomagnetic reference field should choose appropriate method to describe the geomagnetic field on standard epoch truly. Based on geomagnetic data on 851 sites in China in 2008&2009 and 119 sites in Mongolia in 2011&2012, we obtained the geomagnetic normal and abnormal spatial structure in China Mongolia using Spherical Cap Harmonic (SCH) method and Surfer Spline method. Furthermore, we get the crust magnetic field based these 2 method.

The mean separations between two adjacent sites are ~70 km in the east and middle and ~150 km in the west. We also used the geomagnetic data on 35 geomagnetic observatories, 34 in China, 1 in Mongolian, and those on observatories in other countries. The data of the three geomagnetic components on all sites were reduced as the mean values of the geomagnetic field at 00:00-03:00 (Beijing time, Ulaanbaatar time) on January 1, 2010 after correction of the diurnal variations and correction of the secular variations. The reference data used in the correction of the diurnal variations are the minute mean values on the 35 observatories. The reference data used in the correction of the secular variations are the hourly mean values of the 35 observatories.

Results show the errors of the geomagnetic field by IGRF could be $\sim 5'$ for the declination D and the inclination I and ~ 100 nT for the total intensity F in the main region. Because the geomagnetic survey data with new and better resolution were used in the calculation, the geomagnetic reference field for 2010.0 by the SCH method can better describe the space distribution of the geomagnetic field than the IGRF.

J2-7p LONG TERM VARIATIONS OF SQ AND GEOMAGNETIC ACTIVITY AT ILE-IFE

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The Earth's magnetic field is a time varying field exhibiting both short and long term variations. Efforts are in progress to model and take it into account in the studies of the crustal and main fields. The 11-year sunspot cycle effects are currently in attention of modelers. The long-term variation of the geomagnetic activity, as described by the aa, IHV and IDV indices, and of the solar quiet daily variation, as described by the x, y, z, r indices, is analyzed in comparison with the solar activity as described by the sunspot number R .

Geomagnetic data (1995 - 2007) dataset from the Intermag Geomagnetic observatory at Ile-Ife that is located at $7^{\circ}30'$ North and $4^{\circ}30'$ East has been used in this research to study the diurnal variation. Thus providing data for the correction of magnetic data that were acquired in the region. The average Sq variation at Ile-Ife was observed and used in developing the Sq shape after identifying the magnetic disturbed days. Correlation analysis was adopted to obtain the variation of Sq. Also, we observed that the amplitude of the Sq reaches the maximum or the minimum during the main phase of magnetic storms. It suggests the geomagnetic effect of the focus of Sq moving along latitude. An average combination of the observed Sq values was used to identify the Sq shape over the investigated area.

From this study, we have observed that the variation depicted by 11-year running averages of the indices mentioned, defining a so-called centennial increase of geomagnetic activity in the 20th century and a so-called overall trend of the geomagnetic field evolution in the same time interval, debated in the literature, results from the superposition of Hale and Gleissberg cycles signatures in the corresponding time series. The two signals have a substantial contribution, amounting to 12-207% of the 11-year cycle.

SESSION J3

DIV. I/V ASSIMILATION OF GEOMAGNETIC OBSERVATIONS IN DYNAMICAL MODELS OF THE EARTH'S CORE

J3-1 STOCHASTIC MODELING OF REGIONAL ARCHEOMAGNETIC FIELD

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Modeling of the archeomagnetic field relies on indirect estimations of the ancient field recorded both in archeological artifacts and lake sediments. Models are generally built using a cubic spline expansion for time. Because archeomagnetic and sedimentary data are sparsely distributed in time and affected by large dating and measurement errors, models are generally regularized to alleviate the non-uniqueness problem. This regularization, which consists in penalizing the second time derivative of the magnetic field, leads to models that are generally too smooth and do not reproduce well the rapid variations observed in geomagnetic time-series. Moreover, such regularizations prevent correct estimation of uncertainties on model parameters, which is required information for core dynamic studies.

The aim of this study is to perform a stochastic inversion of archeomagnetic data in order to build an ensemble of regional models covering the past few millennia. The inverse problem is solved using a priori information on the Gauss coefficients. We rely on a time correlation function, which is compatible with present knowledge about the geomagnetic spectra and also with the discontinuities observed in the geomagnetic time series. Both means and covariance matrices are estimated using the BLUE (Best Linear Unbiased Estimator) method. Such a method allows us to avoid the use of spline functions and to account for dating errors in the inversion. The resulting ensemble of models may help to better characterize the evolution of the dipole amplitude before 1840 or to determine the degree of spherical harmonic expansion necessary to reproduce the relatively rapid changes in the archeomagnetic data.

J3-2 ENSEMBLES OF LOW DEGREE ARCHEOMAGNETIC FIELD MODELS FOR THE PAST THREE MILLENNIA

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We introduce the concept of ensemble of time-varying geomagnetic field models, consisting of a reference model, a mean model and a thousand individual models. We present a set of three such ensembles, built from archeomagnetic, volcanic and sedimentary data sets, that cover the past three millennia. These ensembles can be used to

both describe the field at any location from the core surface to the magnetosphere, and assess the way uncertainties due to the limited distribution and quality of the data affect any of its component or parameter, such as individual Gauss coefficients. They provide alternative - and, we argue, more complete - descriptions of the archeomagnetic field to those provided by previously published archeomagnetic field models, being better suited to existing and emerging needs, in particular those of geomagnetic data assimilation. We will briefly discuss the data sets we rely on (essentially the same as those used by other recent archeomagnetic field models), explain our modeling strategy and motivation for building low degree spherical harmonic degree ensembles of models, and provide practical illustrations of what can be done with these three ensembles of models.

J3-3 BAYESIAN INVERSION OF THE LARGE SCALE FLOW AT THE EARTH'S CORE MANTLE BOUNDARY.

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The electrically conducting fluid evolving within the outer core of the Earth allows to sustain its magnetic field. Although the flow itself cannot be directly observed, magnetic field measurements at the Earth's surface may be used to obtain some information on it. In particular, the magnetic field can be downward continued to the core mantle boundary, a place where it is coupled to the velocity field of the flow through the radial induction equation. By inverting this equation, the flow, in this thin layer of the core, can be determined. Nevertheless, to perform this operation two main issues have to be treated. First, the inverse problem is ill-posed, and then, only the large scale magnetic field is known. In our approach, to account for the small scales of the magnetic field, we statistically modeled them. Furthermore, to reduce their impact on the velocity field, we filtered the entire magnetic field with a low pass filter and derived the equation for the large remaining scales. We then used this equation in a Bayesian framework to evaluate the most probable velocity field at a given epoch as well as its uncertainties.

J3-4 VARIATIONAL DATA ASSIMILATION: TOWARDS IMAGING THE INTERIOR STRUCTURE OF PLANETARY CORES

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How should we best treat the rich record of geomagnetic and archaeomagnetic data? To date, most efforts are directed towards a parametric description of the data in time and space, with no reference to the internal fluid dynamics responsible for the changes in time (the secular variation). Beginning in 2007, the first efforts were made to couple the dynamics with the data analysis. Since then, various flavours of data assimilation have been developed, using either sequential or variational methods. For the pure prediction problem, relevant to meteorology, both methods are equally effective. But when the interest is in the interior structure of the planet, we find that the variational strand has its benefits.

In our work we seek to find a model of the magnetic field inside Earth's core that evolves in a way compatible with the observations of the field taken purely on the boundary. We need versions of the Navier-Stokes equation and the induction equation, that together determine the entire evolution of the system. To show how this can work under certain conditions, we will show the results of several end-to-end simulations in which exact boundary data are assimilated into a dynamical model. The unknown is the magnetic field configuration at the initial time, but by dint of the known forward problem, the magnetic field is known everywhere over all times. We will show the problems one may encounter with ambiguities that may exist in the inverse problem, and how they might be circumvented.

J3-5 GEOMAGNETIC DATA ASSIMILATION WITH EMPIRICALLY MODELED ERROR ESTIMATES

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Geomagnetic data assimilation is the optimal estimation of the state of the Earth's core obtained by combining information from geomagnetic observations and the output of a numerical geodynamo model (the geomagnetic forecast). This requires estimates of both the forecast and observation error covariances. We have developed a data assimilation system in which the forecast error covariance can be modeled or estimated from an ensemble of geodynamo model runs. The observation errors are also modeled to account for the historical improvements over the geomagnetic observations and field models, and the decreasing accuracy at higher spherical harmonic degrees. We test the assimilation system using observing system simulation experiments (OSSE's), in which the observations are produced from a long model run.

J3-6 DEVELOPMENT OF VARIATIONAL DATA ASSIMILATION FOR THE MOSST GEODYNAMO MODEL**Egbert, G.D.; Erofeeva, S.Yu.; Kuang, W.; Tangborn, A.; Dimitrova, L.**Oregon State University; Oregon State University; NASA/GSFC; NASA/GSFC; Oregon State University
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A number of research groups are currently developing methods for assimilation of data into numerical geodynamo models, using approaches ranging from sequential schemes based on approximate covariances of various degrees of sophistication, to variational methods for models of varying degrees of physical completeness. Variational methods require development of adjoint (and possible tangent linear) variants on the forward code. While this represents a challenging task for a fully self-consistent modern dynamo code, the variational approach may ultimately offer significant advantages. For example, adjoint based approaches allow initial, boundary, and forcing terms to be explicitly adjusted (together or in isolation) to combine data from modern and historical eras into dynamically consistent maps of core state (flow and magnetic fields). Adjoint may also be useful beyond data assimilation, e.g. to characterize fast-growing modes and study predictability, as is now commonly done in atmospheric sciences. Here we describe development of tangent linear and adjoint codes for the Modular Scalable Self-consistent Three-dimensional (MoSST) geodynamo simulator. Our approach is to develop the exact linearization and adjoint of the actual discrete functions represented by the computer code. To do this we use a “divide-and-concur” approach: the code is represented abstractly as the sequential action of a series of linear and non-linear procedures on specified inputs. Non-linear procedures are first linearized about a pre-computed input background state (derived by running the non-linear forward model), and a tangent linear time-step code is developed. Adjoint for each linear (or linearized) procedure are developed and tested separately, and then merged into adjoint procedures of increasing complexity. We will overview development of the adjoint, explore time limits of forward operator linearization, and discuss next steps towards use of the code for variational assimilation.

J3-7 AN ENSEMBLE KALMAN FILTER FOR THE TIME-DEPENDENT ANALYSIS OF THE GEOMAGNETIC FIELD**Fournier, Alexandre**Institut de Physique du Globe de Paris (IPGP)
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The ensemble Kalman filter is a sequential data assimilation method suitable for large dimensional systems, in which the covariance needed for the analysis is approximated by a sample covariance based on an ensemble of model states evolving concurrently.

This study deals with its application to the time-dependent analysis of the geomagnetic field over the past few millennia. It is based on the implementation of a slightly modified version of the parallel data assimilation framework of Nerger & Hiller (Computers & Geosciences, 2013) on top of a buoyancy-driven numerical dynamo model.

I will first present the results of a series of closed-loop (twin) experiments used to validate this implementation. These tests show in particular that the ensemble size need be $O(400)$ to ensure statistical convergence.

I will also present results obtained by assimilating geomagnetic observations in the form of parameterized time-dependent models of the geomagnetic field spanning the past few millennia. I will show in particular how the response of the system to the stream of observations can be used to detect biases in the model forecast, and how one should use this information to improve the geomagnetic semblance of the candidate dynamo model.

J3-8p DIFFUSIVE PROCESSES AND EARTH'S MAGNETIC FIELD CHANGES**Wardinski, I.; Wicht, J.;**GFZ Potsdam; MPS Katlenburg-Lindau
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We developed a scheme of forecasting Earth's magnetic field changes based on stochastic models, non-parametric regression and singular spectrum analysis of the observed past field changes. One strategy to forecast field changes assumes the secular variation to be entirely determined by the advection of the magnetic field at the core surface. As it could be expected, these forecasts become more uncertain towards longer forecast periods. The main reason for this is the disregard of magnetic diffusion. But also the interaction of unobservable small scale core field and all scale core flow unsettle the forecasting scheme. Therefore, numerical simulations of the geodynamo are analysed to quantify different diffusive processes and multi-scale interaction between core field and flow.

SESSION J4

DIV. I/V STRUCTURE, GEOMETRIES AND PROPERTIES OF THE CONTINENTAL MANTLE LITHOSPHERE AND ASTHENOSPHERE CONSTRAINED BY GEO- AND ELECTROMAGNETISM

J4-1 WEDGING STRUCTURE AT THE EASTERN MARGIN OF THE TIBETAN PLATEAU REVEALED BY MAGNETOTELLURIC DATA

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Geoscientists have shown increasing interest in studies on the geology and tectonics of the eastern margin of the Tibetan Plateau since the Ms8.0 Wenchuan earthquake happened in 2008. Under the auspices of SinoProbe Project, a new ~800 km long MT profile across the eastern margin of the Tibetan Plateau and the whole Sichuan Basin was acquired for the study of the dynamics of Songpan-Ganze Block, Longmen Shan fault zone, Sichuan Basin, and East Sichuan decollement fold belt. Based on the results of dimensionality analysis, both 2D and 3D inversions were conducted on the dataset. 3D inversion model is used as a constraint to determine a better model from a pair of 2D inversion models, and interpretations were made on the basis of the selected 2D model. The lithospheric electrical structure along the profile could be divided into three major blocks: The Songpan-Ganze block with conductive mid-lower crust to upper mantle and resistive upper crust, the Sichuan Basin with conductive shallow sediments and relatively resistive basement, and the highly resistive part of the Yangtze craton to the east of the Huaying Shan fault. The tectonic pattern in the Longmen Shan range can be described as thin-skinned structure in the upper crust and wedging structure in the mid-lower crust and upper mantle. Electrical structure in the Sichuan Basin displays strong one-dimensional character with a conductive sedimentary layer lying above the resistive Yangtze basement. To the east of the Sichuan Basin, the Huaying Shan fault performs as a southeastward dipping conductor that cuts into the resistive basement of the Yangtze craton and marks the eastern boundary of the Sichuan Basin.

J4-2 PETROLOGICAL-GEOPHYSICAL SELF-CONSISTENT MODELING OF THE LITHOSPHERIC MANTLE

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Modelling and inferring the continental lithosphere's physical properties must be done within a self-consistent petrological-geophysical framework, not from one or two data types in isolation that may lead to internal inconsistencies. The LitMod modelling framework models the lithosphere within the CFMAS oxide system, and derives surface observables - topography, geoid, gravity, seismic parameters, MT responses, surface heat flow, etc. - in a manner that precludes varying geometries and oxide compositions arbitrarily to fit one data type. Examples will be shown from various regions of the application of LitMod. In one example, prior interpretation from seismic S Receiver Functions of a thinning Lithosphere-Asthenosphere Boundary from 85 km in southern Ireland to 55 km in northern Ireland is shown to require topographic uplift that is not observed, and hence that interpretation can be discounted. Magnetotelluric studies are particularly aided by the LitMod approach, as electrical conductivity is primarily a function of temperature and water content, and the temperature is controlled by seismic velocity.

J4-3 CRUSTAL AND UPPER MOST MANTLE 3-D RESISTIVITY STRUCTURE OF THE ATLAS MOUNTAINS OF MOROCCO REVEALED BY MAGNETOTELLURIC DATA

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The overarching objective of the second phase of the PICASSO (Program to Investigate Convective Alboran Sea System Overtake) project and the concomitant TopoMed (Plate re-organization in the western Mediterranean: Lithospheric causes and topographic consequences an ESF EUROSCORES TOPO-EUROPE project) project, is to provide new electrical conductivity constraints on the crustal and lithospheric structures of the Atlas Mountains, and to test the hypotheses for explaining the observation of a missing mantle root inferred from surface heat flow, gravity and geoid anomalies, elevation and seismic data modelling (i.e. Zeyen *et al.*, 2005; Teixell *et al.*, 2005; Fullea *et al.*, 2010). We present the results from three-dimensional (3-D) MT inversion of two single MT profile data employing the parallel version of Modular system for Electromagnetic inversion (ModEM; Egbert & Kelbert, 2012) code. The distinct conductivity difference between Middle-High Atlas (conductive) and Anti Atlas (resistive) correlates with the South Atlas Front fault, the depth extent of which appears to be limited to the uppermost mantle (approximately 55 km). In all inverse solutions, the crust and the upper mantle show resistive signature (750 Ωm - 1,000 Ωm) beneath the Anti Atlas which is the part of stable West African Craton. For the first time, the electrical resistivity distribution in the crust and in the upper mantle of Western High Atlas has been studied. Our 3-D model shows that conductive (1-20 Ωm) western High Atlas is confined by two resistive basins (>1,000 Ωm), Souss basin to the south and Houz

basin to the north. At the southern boundary of the western High Atlas, the conductor is located at the shallower depth and it is deepening to the north.

J4-4 IMPEDANCE DECOMPOSITION AND GEOELECTRIC STRUCTURE ESTIMATED FROM MAGNETOTELLURIC DATA RECORDED FROM GARHWAL HIMALAYAN REGION, UTTARAKHAND, INDIA

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We have estimated geoelectrical strike and its variation with depth in the different Himalayan litho-tectonic domains from magnetotelluric (MT) data recorded along extended Roorkee-Gangotri profile. Subsequently, 2D geoelectric model was obtained by 2D smooth inversion of different combination of TE and TM-modes responses. Twelve MT stations data spread over four litho-tectonic units of Garhwal Himalaya were selected for the detailed strike analysis using maximum phase split orientation (MPSO), Groom-Bailey (GB) and Bahr decomposition methods. These schemes have been implemented in a MATLAB code. Consistent values of average geoelectric strike variation with depths, derived using the Niblett-Bostick transform, for each Himalayan litho-tectonic unit along the profile was obtained. The zones represented by one dimension (1D) structure have been identified in the period range for which MPSO is small (< 5 degree). For this zone GB and Bahr strikes are unstable. The strike direction is also unstable for zones of strong 3D effects. For the zones which are approximated reasonably by 2D structure, all approaches generate a consistent geoelectric strike direction showing variations with period as well as with different litho-tectonic units along the profile. Southern most zone of the profile is lying in Indo-Gangetic plain for which near surface is represented by 1D sedimentary structure. The deeper zone has an average geoelectric strike of N80W which is slightly rotated to the north (N75W) in deeper zone. Further north in the Sub Himalayan domain the average geoelectric strike is N66W. Higher Himalayan zone indicates strong 3D nature. After impedance decomposition, 2D smooth inversion has been done for TE and TM mode responses in different combinations and a final geoelectrical model has been presented. The electrical image of the shallow and deeper crustal structure shows major features of the Garhwal Himalayan tectonic configuration. Electrical image also show a low resistivity ($< 10 \text{ } \Omega\text{m}$) zone near Main Central Thrust (MCT) which appears to be related with the intense micro-seismic activity in the region.

J4-6 GEOELECTRIC STRIKE ESTIMATED USING MOHR CIRCLE FROM MAGNETOTELLURIC DATA RECORDED FROM GARHWAL HIMALAYAN REGION, UTTARAKHAND, INDIA

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We have estimated geoelectrical strike direction for magnetotelluric data recorded along extended Roorkee-Gangotri profile in Garhwal Himalayan region, India. For this purpose, good quality 37 stations broad band MT responses have been used. Tensor decomposition theory based on Mohr circle is used to extract decomposition parameters: local and regional strike, twist, major and minor impedances for each site. To give geological meaning to the estimated parameters, the study area along the profile length is divided into four concentric litho-tectonic domains which are separated by three north verging thrusts: Himalayan Frontal Thrust (HFT), Main Boundary Thrust (MBT) and Main Central Thrust (MCT). Looking from south to north these four concentric litho-tectonic zones are: Indo-Gangetic Plains (IG), Sub Himalaya (SH), Lesser Himalaya (LH) and Higher Himalaya (HH). MT stations were selected from each litho-tectonic unit for the estimation of decomposition parameters. It has been observed that the strike derived from imaginary component of impedance tensor is generally unstable, whereas the real component shows stable strike direction. Frequency and spatial variations have been observed in the strikes estimated from real components. Also, the strike is unstable in the frequency bands which either represent 1D geoelectric structure or for which response is noisy. In IG region, all local and regional strikes are unstable in high frequency band (1000- 1 Hz), which stabilize to an average value of 10 degree NE in long period band (150-2048s) with maximum twist < 6 degree. Complexity of geological structure increases toward the northern region and this is reflected in the higher value of twist 14 degree. In Sub-Himalayan and Lesser Himalayan region, the strike shows slight rotation towards east with higher value of twist. Towards the northern end of the profile two geoelectric strikes directions (local and regional strike) observed are 48 degree and 2 degree. The detailed analyses of local and regional strike reflect the geological complexities in the region.

J4-7 TIDAL SIGNALS IN OCEAN BOTTOM MAGNETIC MEASUREMENTS OF THE NORTHWESTERN PACIFIC: OBSERVATION VERSUS PREDICTION

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Motional induction in the ocean by tides has long been observed by both land and satellite measurements of magnetic fields. While these signals are weak (~10 nT) when compared to the main magnetic field, their persistent nature makes them important for consideration during geomagnetic field modeling. Previous studies have reported several discrepancies between observations and numerical predictions of the tidal magnetic signals and those studies were inconclusive of the source of the error. We address this issue by 1) analyzing magnetometer data from ocean-bottom stations, where the low-noise and high-signal environment is most suitable for detecting the weak tidal magnetic signals, and 2) by numerically predicting the magnetic field with a spatial resolution that is 16 times higher than the previous studies. We use vector magnetic data from six ocean bottom electromagnetic (OBEM) stations located in the Northwestern Pacific Ocean (Toh *et al.*, 2006; Baba *et al.*, 2010). The OBEM tidal amplitudes were derived using an iteratively re-weighted least squares (IRLS) method and by limiting the analysis of M2 and N2 tidal modes to the nighttime (the O1 mode was not limited to the nighttime due to its period of 25.819 h). Using a 3-D electromagnetic induction solver (Kuvshinov *et al.*, 2002) and the TPX07.2 tidal model, we predict the tidal magnetic signal in Earth models with nonuniform oceans and four 1-D mantle sections underneath taken from Kuvshinov & Olsen (2006), Shimizu *et al.* (2010), and Baba *et al.* (2010) to compare the effect of upper mantle conductivity. We also compare the results using a 1×1 degree global grid, and found that the higher resolution grids more closely matched the observed values in regions of rugged bathymetry. The models produced by Shimizu *et al.* (2010) and Kuvshinov & Olsen (2006) were respectively based on Pacific Ocean and global conductivity data, however, they both produced similar predicted values. As these two models both used similar conductivity for the upper 100km and then very different conductivity for the layers below that depth, this result suggests that for the periods considered here (M2 T = 12.421 h, N2 T = 12.658 h, and O1 T = 25.819 h) the conductivity of the upper 100 km is more important than the deeper conductivity.

J4-8 KOLA SUPER DEEP DRILLING AND RESULTS OF THE DEEP SOUNDINGS WITH POWERFUL CONTROLLED SOURCES

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The main aim of the Kola super deep drilling (SG-3 borehole) was to cross the Conrad boundary which has been predicted at the North-West of the Kola peninsula at the anomalously shallow depth of about 7 km according to DSS data. Four attempts had been undertaken to drill up to the depth of 15 km. But all of them have been ended without success because of “sharp worsening of drilling conditions” at the depth of about 12 km. There are several types of electromagnetic soundings was performed in vicinity of SG-3. It was the soundings with powerful controlled sources: MHD generator Khibiny (40 MW power), VLF antenna ZEVS (about 5 MW), industrial power lines FENICS experiment and others. New model of the deep structure of Fennoscandian lithosphere has been developed according to these data. New estimation of the Earth’s crust thickness is about 10-15 km. The main electrical features of the crust is the sharp electrical heterogeneity, increased fragility (brittle zone), the presence of fluids (DD-layer) and widespread of electronically conductive sulfide-carbonaceous rocks (“SC-layer” by A.S. Semenov). Resistivity sharply increases, the substance of lithosphere is plasticized (ductile zone), porosity and content of free fluids are dramatically reduced deeper then 10-15 km. Electrical properties of the lithosphere at these depths are determined mainly by pressure, temperature, viscosity and increasing of mafic rocks with depth. According to this model Kola SG-3 has crossed the upper, brittle crust, and stopped on the top of pseudo-plastic crust, which can be attributed to the upper mantle. So, the Conrad boundary is the transition zone between the upper, brittle part of lithosphere (crust) and the lower, pseudo-plastic part (upper mantle). This boundary is identified from geoelectrics by the sharp increasing of the electrical resistivity. In this case, the Conrad boundary can be defined as the boundary of changes in the physical state of rocks. I conclude that the Kola SG-3 completed its task and has reached the Conrad boundary at the depth of around 12 km. Kola SG-3 also can be attributed as the first discoverer of the intermediate fluid containing conductive layer of dilatancy-diffusion nature (DD-layer) at the depth range of 6.8-9 km.

J4-9 STRUCTURE OF THE CENTRAL AND EASTERN ALTYN TAGH FAULT AT THE NORTHERN TIBETAN PLATEAU FROM MAGNETOTELLURIC STUDIES

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The active sinistral strike-slip Altyn Tagh Fault (ATF) forms the northern margin of the Tibetan Plateau and plays a significant role in accommodating the convergence between the colliding Indian and Eurasian plates. To determine

the crustal structure of the ATF, magnetotelluric (MT) data were collected on two profiles that crossed the central and northeastern segments of the fault. Time series data processing used robust algorithms to give high quality responses in the period range 0.003 to 2000 s. Dimensionality analysis showed that a 2D approach is generally valid for the western profile and northern section of the eastern profile with geoelectric strike directions of N70°E and N60°E, respectively. 2D inversions of the MT data showed different resistivity structures on the western and eastern profiles. The western profile is characterized by a large-scale south-dipping conductor that extends from the surface to the Moho. The low resistivity was interpreted as a region with high fluid content formed by metamorphism in a thickened, underthrust crust. Significantly, a major conductivity was not observed beneath the surface trace of the ATF. A similar feature was not observed in the eastern profile, and the fault only appears to be crustal in vertical extent. This difference suggests accommodation of strike slip motion by thrusting within the Qilian Block. 3D inversions were conducted on both profiles to further constrain the 2D models and investigate off-profile resistivity features. Locally distributed east-dipping conductors were observed in the 3D inversion model for eastern profile, which indicate the eastward thrust of the Qaidam Block beneath the Qilian Block. Localized deformations in the area adjacent to the eastern profile further indicate the lithospheric structure is varying not only vertically but also laterally. This observation does not support the existence of crustal flow beneath the northeastern segment of the Altyn Tagh Fault.

J4-9p THE GEOMAGNETIC DISTURBANCE FIELD AS A MEANS TO INFER INFORMATION ON UNDERGROUND ELECTRICAL STRUCTURE. CASE STUDY - EUROPE

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The variable current systems that develop as a result of the magnetosphere interaction with the solar wind and the heliospheric magnetic field create the geomagnetic disturbance field which, in turn, induces a response of the Earth's internal magnetic and conductive structures. The geomagnetic variations at storm timescales (minutes - days) provided by the network of European geomagnetic observatories have been used for inferring information on the electrical structure of the underground. Based on a magnetic induction model, that assumes the induced field as a linear combination of the components of the inducing field, applied to geomagnetic observatory data recorded during several intense geomagnetic storms ($Dst < -200$ nT) in the solar cycle 23 (1996-2008), the induced response of the Earth's interior by electromagnetic induction could be obtained. As the inducing external source, the magnetic field of the ring current at each observatory location was used, inferred from the Dst geomagnetic index (minute). The resistance and the inductance of conductive crustal and mantle structures are derived in terms of current loops surrounding the observation point. Their mapped lateral variation is discussed and a comparison with distributions resulted in case of other variable sources is shown.

J4-10p INFLUENCES OF SOLAR CYCLES ON EARTHQUAKES

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This research inspects possible influence of solar cycles on earthquakes through of statistical analyses. We also discussed the mechanism that would drive the occurrence of increasing of earthquakes during solar maxima. The study was based on worldwide earthquakes events during approximately four hundred years (1600-2010). The increase of earthquakes events followed the Maxima of Solar cycle, and also depends on the tectonic plate location. From 1600 until 1645 events increased during the Maxima in some of the tectonic plates as Pacific, Arabian and South America. The earthquakes analyzed during two grand solar minima, the Maunder (1645-1720) and the Dalton (1790-1820) showed a decrease in the number of earthquakes and the solar activity. It was observed during these minima a significant number of events at specific geological features. After the last minima (Dalton) the earthquakes pattern increased with solar maxima. The calculations showed that events increasing during solar maxima most in the Pacific, South America or Arabian until 1900. Since there were few records during these three centuries we needed additional analysis on modern data. We took the last four solar cycles events (1950-2010) and made similar calculations. The results agreed with the former calculations. It might be that the mechanism for the Sun-Earth connection relies on the solar wind speed. In both records (1600-1900) and (1950-2010) the results showed a significant increase in earthquakes events in some of the tectonic plates linked to solar maxima. The Solar wind energy striking the Earth's magnetosphere affects the entire environment because the pressure on the region increases and the magnetosphere shrinks sometimes four Earth's radii. This sudden compression causes earthquakes in specific plates. During the times of solar minima the pressure from the solar wind on the earth decreases, then the magnetosphere expands and earthquakes happen in a different pattern according to the geological feature on Earth's surface less frequently. Solar driven events include coronal mass ejections (CME) and coronal holes, which are at a maximum during the descending phase of solar activity. The tectonic are important because there is heterogeneity in the crust and the tectonic stress depends on each region. The geo-effectiveness of solar wind from a coronal hole only depends on the position of the hole relative to the Earth and for the CMEs an additional factor is their velocity. The influence

of these solar events could be detected from electromagnetic variations on the ground prior the earthquakes. The goal in this research was to show the solar events influenced the earthquakes and seismologic events following some special display and also how the Sun's activity played to make earthquakes events increased.

SESSION J5

DIV. I/ III CONTRIBUTIONS OF ELECTROMAGNETIC ARRAY STUDIES TO UNDERSTANDING SOLID EARTH AND MAGNETOSPHERIC PROCESSES. IN MEMORY OF IAN GOUGH

J5-1 THE PROGRESS AND PRELIMINARY RESULTS OF CONTINENTAL CHINA MAGNETOTELLURIC OBSERVATION NETWORK

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The project Experimental Study of the Continental Standard Grid of Electromagnetic Parameters (Sinoprobe-01) is the first project which belongs to SINOPROBE, whose execution period is from 2008 to 2012. The main purpose of this project is studying the observation method of MT array in continental China and preparing techniques for next stage.

We did experimental observation of MT Array in two way: for whole continental China, the 4 by 4 graphical degree MT Array was designed, and for North China and Tibetan plateau, the 1 by 1 graphical degree MT Array was designed.

Because the station spacing is huge and the regional structure of continental China is very complex, we designed a new multi-site, facet-element MT survey method after modeling. A standard grid node is placed on every integer Latitude and Longitude crossing point to establish a Standard Grid Network. The node consists of one central station, 6 north-south auxiliary stations and 4 east-west auxiliary stations, which make a facet instead of a single station point. Both broad-band and long period observation were done for the central stations, but only broad-band observation was done for the auxiliary stations. With these 11 MT stations for each 4 by 4 degree node in whole continental China and each 1 by 1 degree node, discrete conductivity models for each standard grid node were obtained, finally 3D lithospheric conductivity models will be established for continental China, North China, and Tibetan plateau after comparing and analyzing discrete conductivity models with regional structure.

Furthermore, with this observation scheme, the averaged station spacing of 1 by 1 degree MT Array is ~20km, rough 3D lithospheric models of North China and Tibetan plateau could be obtained using Bostick inversion with all stations.

All observation finished at the end of 2012, and 64 4 by 4 degree nodes, altogether 640 MT stations were obtained for whole continental China as well as 232 1 by 1 degree nodes, altogether 2469 MT stations for North China and Tibet plateau. The data quality is well as the data processing work was also finished.

Rough 3D lithospheric models of both North China and Tibetan plateau were also obtained using Bostick inversion with all broad-band stations. We also got real 3D model of North China by 3D inversion using all central stations in North China with period range from 0.01s to 10 000s. Further research work is still ongoing.

J5-2 THE SOUTHERN CAPE CONDUCTIVE BELT ~ REVISITED

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Magnetometer array studies in 1971 and 1977 by Ian Gough, Johan de Beer and Jan van Zijl have led to the discovery of the Southern Cape Conductive Belt (SCCB) - a zone of electrically conductive material in the crust or upper mantle, elongated east-west in South Africa. Magnetograms and maps of Fourier transform amplitudes and phases of 77 stations deployed with a spacing of 50-150 km across entire southern South Africa show a large anomaly in the vertical variation fields in the period range of 1000-15000 s. The spatial relation of the SCCB with the static Beattie Magnetic Anomaly (BMA), supported the interpretation that both anomalies have a common source in the lower crust. Several geological models were derived, explaining the up to 150 km wide SCCB as a paleo-oceanic sliver in the crust or alternatively as a major thrust zone. Due to the sparse station spacing, however, the extent and internal structure of the SCCB could not be resolved in detail.

Between 2004 and 2006 we collected magnetotelluric data at approximately 350 sites along a number of dense profiles within the Cape Fold and the Namaqua Natal Mobile Belts and across the southern edge of the Kaapvaal Craton. The data confirm the existence of confined zones of high conductivity within the crust, a common source for high conductivity and the much broader magnetic anomaly, however, can be ruled out.

Our recent finding seem to contradict the existence of the regional SCCB, but by means of 2D and 3D modelling and inversion we can identify and resolve how local and regional high conductivity anomalies contribute to the entire Southern Cape Conductive Belt.

J5-3 ELECTRIC PHASE TENSORS: REVIVAL OF TELLURIC METHOD?**Kuvshinov, Alexey; Pankratov, Oleg; Bakker, Jenneke**

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We introduce two new inter-site transfer functions which relate electric fields at survey sites with the electric (or magnetic fields) at a reference site. The idea of using only electric fields for EM studies is not new. The inter-site horizontal electric tensor (HET) formed the basis of the telluric method, which was rather widely used in the middle of 20-th century. That time the method was favored for its simplicity and low cost. However, the telluric method those years provided only qualitative information about subsurface structures. One of the reasons for this was that electric fields are unpredictably distorted by local galvanic effects which, by no means, could neither be taken into account in HET nor corrected for. In this abstract we propose to revive studies based on solely electric field measurements at survey sites by constructing two inter-site phase tensors which are almost free, or completely free from distortion effects. The first one (we call it as an electric phase tensor) is the HET phase tensor and is only distorted by galvanic effects (if existing) at a reference site. This effect can be readily accounted for during 3-D inversion by simultaneous determination of the conductivity distribution and (only) four additional parameters the real-valued elements of distortion matrix at a reference site. The second tensor (we call it as a quasi-electric phase tensor) is the inter-site MT phase tensor which is entirely free from galvanic effects. We compare the sensitivity of these new tensors with the sensitivity of the MT phase tensor and the (inter-site) horizontal magnetic tensor.

J5-4 FEATURES OF THE LONG-TERM VARIATIONS OF THE EARTH'S IMPEDANCE AND ITS GRADIENTS**Petrishchev, Maxim S.; Semenov, Vladimir Yu.**

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Approximately 30 of induction soundings were carried out analyzing data of 34 geomagnetic observatories for 1960 ~ 2010 years situated principally along mid-latitudes of the Europe-Asia continents. The monitoring soundings were made by the magnetovariation method for the long period variations: from 8 hours to 30 days. The deep sounding results were obtained for shorter and longer periods separately with periods of 8 –28 hours and 10 - 30 days separately using two different source fields: ionospheric and magnetospheric ones correspondingly. The obtained results have shown a valuable variability of averaged annual apparent resistivities and induction arrows for decadal time-scales, although the possible changes in the source signals through an uncorrelated parts of the observed field were mainly suppressed by robust, coherence-based statistical data processing.

he 11-year time variations of apparent resistivities are correlated between different regions and with the solar activity. However, the variations with longer periods - secular variations can be connected somewhere with the cumulative seismicity (depths less than 40-50 km, in the crust). The sharply changing's of induction arrows are sensitive to the time of the geomagnetic jerk registration. The regional features of the phenomenon exist. They could be correlated with the regional tectonic plates and/or with their boundaries. The nature of other peculiarities is under consideration.

J5-5 PROCESSING OF ELECTROMAGNETIC ARRAYS WITH MISSING DATA. SOURCE FIELD STRUCTURE AND SOURCE FREE TRANSFER FUNCTIONS**Smirnov, Maxim Yu.; Egbert, Gary D.**

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Electromagnetic arrays play an important role in studying Earth's structure as well as bring valuable information in solar-terrestrial and magnetospheric physics. For instance, synoptic magnetotelluric (MT) arrays can reduce bias, improve signal-to-noise ratios, and provide better control over source effects and coherent noise contamination in estimates of EM transfer functions (TFs). Furthermore, within an array framework one is not limited to the classical uniform source magnetotelluric (MT) impedance and geomagnetic vertical field TFs, but can also include inter-station horizontal magnetic TFs which can be used to map anomalous induced currents, as well as hybrid impedance tensors between electric and magnetic fields from any pair of stations. EM arrays make it possible to separate internal (anomalous fields due to induction within the Earth) and external (primary source filed associated with magnetospheric currents) components of the EM field, and can contribute to better understanding of magnetospheric phenomena, their morphology and evolution in time.

To make practical processing of electromagnetic (EM) array data we have developed a new algorithm for robust principal component analysis (PCA) , extending previously developed multivariate methods to deal with missing data. Our new algorithm combines modern robust methods for covariance matrix estimation with a criss-cross regression scheme in which polarization parameters and spatial modes are alternately estimated with robust regression procedures. The latter scheme can be viewed as an expectation robust (ER) algorithm, of the sort that has been widely discussed in the statistical literature in the context of robust principal components analysis, but with a number

of adaptations to the physical specifics of EM array observations.

We will present example applications of this scheme to several recent synoptic MT arrays from Scandinavia and North America, as well as geomagnetic observatories data. In particular, we present results from application to a merged analysis of the semi-permanent IMAGE observatory array and a campaign-style MT array (MaSca) to study source complexity and impacts on MT data at high latitudes.

J5-6 MULTIVARIATE ARRAY ANALYSIS OF 1 HZ GEOMAGNETIC OBSERVATORY DATA IN COMBINATION WITH LONG-PERIOD MT DATA

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The US EarthScope project has collected long period magnetotelluric (MT) data in the continental US since 2006, both at a small number (seven) of widely spaced semi-permanent back-bone sites, and a much larger (>500 and growing) number of sites occupied (for ~ 3 weeks each) with a rolling array of roughly 20 systems. Eight geomagnetic observatories have also been operational in this area, sampling at 1 Hz, throughout the EarthScope occupations. Here we use programs developed for electromagnetic (EM) Principal Components analysis with missing data (MsDEMPCA; Smirnov and Egbert, 2012) for a unified multivariate analysis of these temporally overlapping arrays. The analysis allows us to summarize dominant temporal and spatial patterns of external sources in the period range 10-100,000 s over the continental US, to characterize noise in these data, and to study impacts of source spatial complexity on EM induction transfer functions. We quantify impacts of violations of the uniform source MT approximation (which are detectable, but very minor except at the longest periods), and construct merged array response maps of anomalous internal current systems and EM fields corresponding to idealized simplified sources. Potential applications to maintaining a permanent optimal array remote reference system, and to improved mapping of geomagnetically induced currents (GIC) will be discussed.

J5-7 AN EXAMINATION OF METEOROLOGICAL CHARACTERISTICS OF STORM-TIME ULF WAVES IN THE INNER MAGNETOSPHERE

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During magnetic storms, the inner magnetosphere can undergo many types of ultra-low-frequency (ULF) oscillations, some driven by external forces and others excited within the magnetosphere. These ULF waves are known to contribute to the acceleration, transport, and loss of electrons in the outer radiation belt. The known characteristics of ULF waves are mostly obtained through climatological studies that can be made by using the observations from a handful of ground-based magnetometers. These long-term characteristics, however, may not reflect the short-term evolution of storm-time ULF waves that can differ from one storm to another. Modern ground magnetometer arrays operated by multiple groups around the globe allow us to examine the meteorological features of storm-time ULF waves in different corners of the inner magnetosphere. In this study we use the combined observations by magnetometer arrays associated with the ULTIMA consortium during the March 2012 magnetic storm. We find that the Pc 5 power can vary by more than 5 orders of magnitude between quiet times and storm times. In this storm event, the Pc 5 wave power at Dst maximum peaked at highest latitudes. In comparison, the Pc 5 wave power at Dst minimum was strongest at auroral and sub-auroral latitudes. Simultaneous, global magnetometer observations have confirmed that the enhancement in wave power can be highly variable in the inner magnetosphere.

J5-8 USING GROUND-BASED AND IN-SITU MAGNETOMETER ARRAYS TO DIAGNOSE THE EPICENTRE OF SUBSTORM ONSET

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Ground-based magnetometer networks have made a remarkable contribution to recent advances in substorm physics. ULF waves in the long-period Pi1/short-period Pi2 ULF period band have recently emerged as a robust and repeatable diagnostic for determining the epicentre of substorm onset in the ionosphere. By combining ground magnetometer and auroral imaging arrays, it is possible to find this epicentre, and demonstrate that whatever causes the magnetospheric substorm has both a magnetic and particle signature since wave and auroral growths are remarkably well correlated. We then utilise a space-based array of magnetometers from THEMIS, Cluster and GOES and other platforms to probe the magnetospheric counterpart of the ground-based signatures through onset. We find that there is strong evidence of magnetospheric counterpart to the ULF wave activity, and that the substorm is initiated in a localised epicentre in space. Using the combined ground and space-based magnetometer networks, we can diagnose the timing, location and dominant plasma physics linking onset arcs to their energy sources in the tail.

J5-9 ROLE OF MAGNETOSPHERE-IONOSPHERE COUPLING IN DESTABILISATION OF THE EARTH'S MAGNETOTAIL**Mann, Ian; Murphy, Kyle; Rae, Iain; Anderson, Brian; Waters, Colin; Milling, David; Korth, Haje**

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Recent combined ground-based and satellite observations of the magnetic (Pi1-2) and optical disturbances surrounding auroral substorm onset have suggested a close correspondence between both their temporal evolution and frequency content. A challenge for determining whether there is a causal role for such near-Earth disturbances and/or instabilities in triggering the onset process relates to the extension and magnetic mapping of the auroral onset region into the magnetotail. Wave propagation, as well as field-aligned current (FAC) structures, enable the timing and energy transport between the magnetotail and the ionosphere to be examined. Using data from the AMPERE experiment on-board the Iridium satellite constellation, combined with optical and Pi1-2 magnetic waves observed from the ground, we present analysis of the FAC structure during substorm expansion phase onset. Our results show, at least for some substorms, a clear local decrease in FAC strength in a small region collocated with but observed several minutes prior to - the auroral onset in the ionosphere. Our results suggest that M-I coupling, and perhaps more likely de-coupling, may play a strong role in destabilising the magnetotail. In particular, our results indicate the potential importance of M-I coupling via FACs in triggering the destabilisation of the tail. Certainly our observations are very difficult to reconcile with auroral poleward boundary intensification (PBI) related onset hypotheses and paradigms. Our results may also provide a natural answer to the rarely asked question what determines the localised region in the ionosphere where auroral onset is first initiated? We present a series of examples of such FAC and M-I coupling onsets and examine their relationship to subsequent expansion phase magnetotail destabilisation. We further offer a strawman physical model for a plausible sequence of events creating MI coupling destabilisation of the Earth's magnetotail and the triggering of the following sequence of substorm expansion phase dynamics.

J5-10 3-D EM INVERSION OF GROUND BASED GEOMAGNETIC SQ DATA. CONCEPT AND FIRST RESULTS USING AUSTRALIAN AWAGS ARRAY DATA**Koch, Stephan; Kuvshinov, Alexey**

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We present a numerical solution to the problem of 3-D EM inversion of observatory geomagnetic Sq data with the aim to recover the electrical conductivity distribution at upper mantle depths. The solution works on a global or semi-global scale. It includes two main steps. The first step is the determination of the Sq source. It makes use of a 3-D Earth model which consists of a surface shell of known laterally variable conductance and a global 1-D structure underneath. The source is parameterized by spherical harmonics (SH). The SH coefficients are obtained by iteratively reweighted least-square fitting of the time spectra of Sq variations from mid-latitude geomagnetic observatories. The second step - the recovery of the 3-D conductivity model - is based on a quasi-Newton method with efficient calculation of the misfit gradient using the adjoint sources approach. The forward engine to calculate magnetic fields exploits an integral equation formulation. We apply the semi-global variant of the solution to the Australian AWAGS array data. This uniquely regular observation network, maintained in the years 1989-1990, consists of 58 stations. With this excellent coverage we are trying to obtain the distribution of the 3-D upper mantle conductivity beneath the Australian mainland.

J5-11 THE THREE DIMENSIONAL CURRENT SYSTEM DURING SUBSTORMS**Hoffman, Robert A.**

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We present results from a comprehensive statistical study of the ionospheric current system and its coupling to the magnetosphere during classical bulge type substorms. We identified 116 substorms and determined the global ionospheric current system before and during the substorm using the SuperMAG initiative and global auroral images obtained by the Polar VIS Earth camera. The westward electrojet (WEJ) is centered around 65 / 72 deg magnetic latitude post-midnight / pre-midnight. Thus, we find a distinct latitudinal shift between the locations of the westward electrojet at these local times. The spatiotemporal behavior of the WEJ differs at these two local times. Attempting to explain this significant finding we propose two possible simple current systems. 1) The classical substorm current wedge, which is a single 3D current system. The distinct poleward kink and the different spatiotemporal behavior, however, present considerable complications for this solution. 2) A new 3D current system that consists of 2 wedge type systems: the classical substorm current wedge in the pre-midnight region and another current wedge in the post-midnight region. The latter maps to the inner magnetosphere. To support the empirical modeling we performed Biot and Savart integrations to simulate the ground perturbations. We present results of the statistical study, show typical events, results from the simulations, and discuss the implications for our understanding of the 3D current system associated with substorms.

J5-12 MAGNETOSEISMOLOGY: REMOTE SENSING THE MAGNETOSPHERE WITH MAGNETOMETER ARRAYS**Menk, Frederick**

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Earth's magnetosphere forms a vast and dynamic plasma physics laboratory, home to space weather and satellite technology that is essential to modern society and commerce. The outer boundary of the magnetosphere interfaces with the solar wind, while the ionosphere and atmosphere form the lower boundary. The various magnetospheric regions and processes map to the ground along geomagnetic field lines, producing signatures on ground-based magnetometers. Comparison of spectral power, phase and polarization between closely-spaced magnetometers permits identification during local daytime of the field line eigenfrequency and hence estimation of the plasma mass density near the equatorial crossing of the field line. Magnetometer arrays thus permit remote sensing of spatial and temporal variations in magnetospheric density, and when combined with ground-based VLF or in situ electron density measurements the plasma composition can be estimated. This presentation presents examples illustrating the detection and monitoring of features such as the plasmopause, plasma plumes and biteouts, the magnetopause, effects of ionospheric mass loading at low latitudes, and estimation of plasma composition.

J5-13 A MODERN MAGNETOMETER ARRAY TO MONITOR THE ELECTRICAL CONDUCTIVITY STRUCTURE OF THE SOUTH AMERICAN SUBDUCTION SYSTEM IN NORTHERN CHILE**Ritter, Oliver; Brändlein, Dirk; Araya, Jaime; Weckmann, Ute**

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A permanent network of electromagnetic (EM) observatory stations is deployed in Northern Chile, covering an area of approximately 250 x 100 km², to monitor the electrical conductivity structure associated with the deep hydraulic system of a subduction zone. Time-series of vertical magnetic transfer functions (VTF) examined over a period of four years reveal systematic seasonal variations with amplitudes changing by more than 100 % of their absolute values. These changes are caused by an ionospheric current system which is generated by the direct penetration of interplanetary electric fields to low geomagnetic latitudes. After removal of this source field effect, we evaluate residual VTF time-series with periods longer than one year. We observe a significant variation of the VTFs in the southern part of the network at periods between 1500 and 4000 seconds. We also show time-series of impedance tensor data which is available since 2011 after we solved problems with electrodes in the extremely dry conditions of the Atacama Desert. 3-D inversion of magnetotelluric (MT) and VTF data from eight stations of the network results in an image of the deep electrical conductivity structure. A region of high conductivity matches spatially with the hydrated mantle wedge. To explain temporal variations in the VTFs similar to our observations requires modifications of the electrical conductivity structure in a region which coincides roughly with the plate interface directly down-dip of the M7.7 2007 Tocopilla earthquake. We speculate that the anomalous temporal variations of the VTFs may be caused by large scale fluid relocation in the aftermath of the seismic event.

J5-14 THE ELECTRICAL RESISTIVITY OF CANADA'S LITHOSPHERE: IAN GOUGH'S LASTING LEGACY TO CANADIAN GEOSCIENCE**Jones, Alan G.; Ledo, Juanjo; Ferguson, Ian J.; Craven, James A.; Unsworth, Martyn J.; Chouteau, Michel; Spratt, Jessica E.**

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Ian Gough was one of the driving forces behind the inception and initiation of the LITHORPROBE programme in the early-1980s. His vision - that EM studies could add a wealth of information both unique and also complementary to that of seismology - resulted in major MT efforts on almost all of the LITHORPROBE transects for twenty years that the next generation of scientists benefitted from hugely. Some twenty-six international journal papers have been published using LITHORPROBE MT data, with almost 400 citations to them and a h-index of 13.

Through the LITHORPROBE and other programmes, modern, high-quality magnetotelluric (MT) measurements probing deep into the lithosphere and underlying asthenosphere have been made at over 6,000 sites across Canada in all Provinces and Territories, with the sole exception of Nova Scotia. Some regions are well covered, particularly Alberta, southern British Columbia and western Ontario, whereas others remain poorly covered, such as Quebec and Nunavut. Prior publications from the individual studies have added significantly to the wealth of Canada's geoscience knowledge, and have demonstrated that MT can aid in understanding tectonic processes. However, to date no continent-scale maps of lithospheric electrical parameters have been constructed from the extensive MT database.

Herein we present maps of various electrical parameters at crustal and upper mantle depths for the whole of Canada. From those maps we develop derivative information on petrophysical properties, including predictions of seismic velocity, temperature and water content.

These maps are Ian's legacy to Canadian geoscience.

J5-10p WORLD MAP OF MAGNETIC OBSERVATORIES: 2013

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This poster presents the locations of all active magnetometer observatories in the world at the time of the 2013 IAGA Assembly. Constructed and maintained by many organizations and projects across the globe, these magnetometer stations collect magnetic field measurements that are invaluable to both geomagnetic and Heliophysics research. This world map of magnetometer observatories is created in part to facilitate collaborations in the IAGA ULF Waves Working Group and the Ultra Large Terrestrial International Magnetometer Array (ULTIMA). Corrections and suggestions to this map can be directed to the author for future updates.

J5-11p THE ENIGMA PROJECT: A GROUND-BASED MAGNETIC ARRAY FOR SPACE RESEARCH

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National Observatory of Athens (NOA) currently operates ENIGMA (HellENic GeoMagnetic Array), an array of 3 ground-based magnetometer stations in the area of south-eastern Europe (central and southern Greece). The current stations are latitudinally equi-spaced between 30° and 33° corrected geomagnetic latitude. In the near future two more stations will be installed in western Peloponnese and Crete. One of the primary research objectives assigned to ENIGMA is the study of geomagnetic field line resonances (FLRs).

Magnetic field measurements are essential for correlative satellite and ground-based studies of various magnetospheric phenomena. The ENIGMA data combined with the magnetometer measurements performed onboard ESA's Cluster mission provide the unique opportunity to study the following scientific objectives:

- Determine how Pi2s are produced by substorms.
- Determine how Pc3-4 magnetic pulsation energy enters the magnetosphere and propagates along magnetic field lines to low latitudes.

J5-12p MAGNETOTELLURIC EVIDENCE OF REGIONAL LITHOSPHERIC MODIFICATION IN THE ORDOS BLOCK, NORTH CHINA

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The Ordos Block (OB), which is located in the western part of the North China Craton, is one of the oldest and most stable cratonic blocks in Asia. To study the lithospheric-scale structure of Ordos block, long period magnetotelluric (MT) array data from project SINOPROBE were acquired and modeled using three-dimensional (3D) MT inversion. For the first time a high resolution 3D resistivity model of the lithosphere is acquired in the region. The lithosphere beneath the northern part of the OB and bounding Hetao Graben is revealed to be geo-electrically distinct from that beneath the middle and southern OB. Contrary to what would be expected for a stable cratonic block, compelling evidence is presented of a large scale conductive complex in the lower crust and upper mantle beneath north Ordos and Hetao Graben. The abnormally conductive structure indicates the presence of aqueous fluids and/or interconnected sulphides, possibly resulting from an upwelling of mantle material beneath the region. Correlating well with results of seismic studies, the evidence from independent magnetotelluric data supports a regional modification and thinning of the lithosphere, which might contribute to the extension of Hetao Graben started in late Miocene to Pliocene, as well as the uplifting of the north the Ordos Block since Neogene.

J5-13p DEEP CONDUCTIVE STRUCTURE OF THE PACIFIC NW DERIVED FROM 3-D INVERSION OF USARRAY MAGNETOTELLURIC DATA

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Long period (10-20,000s) magnetotelluric (MT) data are being acquired in large footprints across the continental USA on a quasi-regular grid (nominal ~70 km spacing) as a part of the USArray component of EarthScope. These data are highly sensitive to fluids, melts, and other orogenic indicators, and thus provide a valuable complement to other observational components of EarthScope. Here we present and interpret results from 3D inversion of MT data from 325 sites acquired in 2006-2011 to provide a regional scale view of electrical resistivity from the middle crust to nearly the transition zone, covering a rectangular area from NW Washington to NW Colorado. Extensive areas of low resistivity are imaged in the lower crust and uppermost mantle beneath the extensional Basin and Range, High Lava Plains, and Snake River Plain provinces, most plausibly explained by underplated, hybridized magmas, and

associated exsolved highly saline fluids. These pervasive low resistivity layers generally have a streaky appearance where lateral scale is similar to site spacing, and where the elongate zones of lowest resistivity tend to align with seismic fast-axes. This suggests that finer scale electrical anisotropy, most likely resulting from alignment of melt flow induced by slab roll-back, may be widespread in the uppermost mantle in this area. Thick sections of resistive lithosphere are found in the eastern and northeastern part of the domain, coinciding spatially with the Wyoming and Medicine Hat Cratons. Several deep conductive sutures bound these cratonic blocks; these most likely represent meta-sediments emplaced during ancient collisions. Oceanic lithosphere of the subducting Juan de Fuca and Gorda Plates beneath the Coast Ranges appears highly resistive. Other resistive zones in the northwestern part of the domain may represent relict oceanic lithosphere: the accreted Siletzia terrane beneath the Coast Ranges and Columbia Embayment, and a deep vertical resistive feature just to the east, spatially coincident with the seismically fast slab curtain beneath eastern Idaho interpreted by others as stranded Farallon lithosphere. Quasi-horizontal patches of low resistivity are common in the deep crust beneath the Cascade Volcanic Arc, typically extending into the near fore-arc region. These features likely represent fluids evolved from thermally induced breakdown of hydrate minerals in the down-going slab. In the backarc, low resistivities concentrate in plumes connecting into a deeper asthenospheric layer to the east, consistent with subduction-driven upwelling of hot, probably hydrated (and possibly melting), asthenospheric mantle. There is substantial heterogeneity along the arc, which may in part reflect flow control by more impenetrable upper mantle structure, relict from past subduction. East of the backarc, mantle resistivities are consistent with a thermal lithosphere only ~50-60 km thick in the active provinces of the west, increasing to around 200-250 km under the cratonic stable areas. Beneath the active region, asthenospheric resistivities are near 100 Ω m above 150-200 km depth, consistent with laboratory results for dry olivine. Lower resistivities (15-20 Ω m) at greater depth require moderate hydration (~350 ppm). Resistivities are lower (< 10 Ω m) immediately beneath the stable cratons, suggesting either higher levels of hydration in these areas, especially east of the Rocky Mountain Front, or influence of poorly resolved structures outside our array.

J5-14p IONOSPHERIC TRAVELLING CONVECTION VORTICES OBSERVED BY THE GREENLAND MAGNETOMETER CHAIN

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The Greenland magnetometer array continuously provides geomagnetic variometer data since the early eighties. With the polar cusp passing over it almost every day, the array is suitable to detect ionospheric traveling convection vortices (TCVs), which were first detected by Friis-Christensen *et al.* [1988]. A climatological assessment of their occurrence properties using Greenland data in 1996 has been presented by Clauer and Petrov [2002]. In our ongoing study, a detection algorithm for TCVs in Greenland magnetic data is being developed and the first results of their climatological assessment are discussed. Specifically, three years of magnetometer data, from 1986 to 1988, collected at seven stations at the West coast of Greenland are analysed and TCV events are identified and isolated. The events are classified with respect to their intensity, duration and time of occurrence and they are correlated with values of the interplanetary magnetic field (IMF), solar wind velocity and Kp index. The results indicate that TCVs occur usually around magnetic local noon with a typical duration of approximately 15 minutes. TCV detection is clearly facilitated during times of low geomagnetic background activity.

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J5-15p MAGNETIC DIP POLES AT DIFFERENT ALTITUDES FOR THE AURORA AND CUSP MODELING **Zvereva, Tatiana; Starchenko, Sergey**

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Based on vector magnetic data from the CHAMP satellite, average daily spherical harmonic models of the main geomagnetic field to $n = m = 10$ have been constructed for the period from May 2001 to the end of 2009 at an interval of 4 days. The geomagnetic dip poles (the points where magnetic field lines are vertical to a sphere centered in the Earth's center) were modeled on different altitudes starting from the surface and up to 10 Mm for each half year average with Gaussian decomposition degree n from 1 till 10. Final result is that realistic magnetic field lines near those dip poles are sufficiently shifted and different in shape from the lines near the pure geomagnetic dipole that is with $n=1$ only. This affects the modeling of the magnetosphere formation near its cusp that was considered only with $n=1$ yet. We found that accounting only a few more (just up to $n=2-4$ depending on the required accuracy) Gaussian harmonics could greatly improve the active magnetosphere, aurora and cusp modeling.

J5-16p SOME RESULTS OF MONITORING THE MAGNETIC FIELD VARIATIONS OF EARTH IN THE VICINITY OF NORTH CAUCASUS (ELBRUS VOLCANO)**Zaitsev, Alexandr; Kanonidi, Konstantin ; Petrov, Valeriy; Sobisevich, Alexey; Sobisevich, Leonid**

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In the paper we present the results of experimental observations of the Earth's magnetic field and other geological and geophysical processes which reflect some geophysical disturbances, connected with seismic events in different regions of Earth. The set of instruments of the North Caucasus Geophysical Observatory of Otto Schmidt Institute of Physics of the Earth (IPE) include the magnetovariational stations of the Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation (IZMIRAN) recorded the multiscale disturbances of geophysical fields in the periods of preparation and development some seismic events. The anomalous quasi-harmonic magnetic disturbances have been distinguished which were observed during all the stages of catastrophic tsunami-producing earthquakes in the area of Indonesia, the core level earthquakes in North Caucasus and in some other regions. We observed specific ultralow frequency waveforms preceding strong distant seismic events in the structure of electromagnetic signals.

The data base of experimental results collected during recent years allow us to propose the general scheme of some induced geodynamical processes and about anomalous geomagnetic activity before the large seismic events in active seismic regions of Earth. We do not consider the short-time forecast of earthquakes right now, because even if we can distinguish in geomagnetic field some specific indications preceding the start of seismic event, its coordinates, the scale and time are left uncertain so far.

The experience for development the ground-based network of magnetometers confirm its prospects as the monitoring system in the task study of geophysical phenomena in global and regional scale during periods of large seismic events.

SESSION J6**DIV. II/ICMA AND CAUSES-II/SCOSTEP LONG-TERM CHANGES AND TRENDS IN THE UPPER ATMOSPHERE-IONOSPHERE SYSTEM****J6-1 PROGRESS IN TREND STUDIES IN THE UPPER ATMOSPHERE AND IONOSPHERE****Lastovicka, Jan**

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This talk will report progress reached in the last ~two years in the field of long-term trend investigations in the mesosphere, thermosphere and ionosphere. First information appeared about trends in electron temperature (positive trend), thermospheric neutral wind (complex pattern), and total electron content (non-negative trend). Some new information created partial apparent discrepancies, particularly in the case of ion temperature trends. The quantitative discrepancy between observation-based and model-based trends in mesospheric temperatures and in polar mesospheric clouds has largely been removed. Some progress has been reached in trends in the ionospheric F2 region. The role of ozone in upper atmospheric trends has better been specified. The first observations of trends in CO₂ concentration in the lower thermosphere suggest a way how to reduce the observation-model difference in the thermosphere and ionosphere. In other important areas like wind and atmospheric wave activity trends the progress was rather little. The scenario of trends in the upper atmosphere and ionosphere is now more complete than it was two years ago but still some gaps and discrepancies occur for further investigations.

J6-2 LONG TERM CHANGES OF POLAR MESOSPHERE SUMMER ECHOES AT 69°N**Latteck, Ralph; Bremer, Jürgen**

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Polar mesosphere summer echoes (PMSE) are strong enhancements of received signal power at very high radar frequencies occurring at altitudes between about 80 and 95km at polar latitudes during summer. PMSE are caused by inhomogeneities in the electron density of the radar Bragg scale within the plasma of the cold summer mesopause region in the presence of negatively charged ice particles. Thus the occurrence of PMSE contains information about mesospheric temperature and water vapour content but also depends on the ionisation due to solar wave radiation and precipitating high energetic particles. Continuous and homogeneous observations of PMSE have been done on the North-Norwegian island Andøya (69.3°N, 16.0°E) from 1994 until 2008 using the ALOMAR SOUSY radar and the ALWIN radar at 53.5 MHz. In 2009 the Leibniz-Institute of Atmospheric Physics in Kühlungsborn, Germany (IAP) started the installation of the Middle Atmosphere Alomar Radar System (MAARSY) at the same location. The observation of mesospheric echoes could be continued in spring 2010 starting with an initial stage of expansion of MAARSY and is carried out with the completed installation of the radar since May 2011. Since both the ALWIN

radar and MAARSY are calibrated, the received echo strength of PMSE from 14 years of mesospheric observations (1999 - 2012) could be converted into absolute signal power. This data series could be extended to the years 1994 until 1997 on the basis of SNR values derived during the years between 1994 and 2008. The PMSE occurrence rate is positively correlated with the solar Lyman γ radiation (however low significance level $>70\%$) and the geomagnetic Ap index ($>97\%$). After elimination of the solar and geomagnetically induced parts the PMSE data show a significant positive trend during the time interval from 1994 until 2012 ($>99\%$).

J6-3 A PRELIMINARY COMPARISON OF THE UPPER ATMOSPHERIC LONG-TERM COOLINGS OBSERVED BY MULTIPLE INCOHERENT SCATTER RADARS

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Ionospheric ion temperature is an excellent approximation to neutral temperature in the upper atmosphere, especially, for altitudes below 300km during quiet geomagnetic activity. We report an analysis of long-term trends in the ionospheric ion temperature above 3 incoherent scatter radar (ISR) sites. These three sites are Millstone Hill (1960s-), a mid-/subauroral latitude site in America Sector, Sondrestrom (1990-), a high latitude site, and St Santin (1966-1988), a mid-latitude site in European Sector. The midday ISR observations at Millstone Hill indicate a cooling trend at altitudes above 200 km and an apparent warming trend below 200 km, in addition to an accompanying decrease in electron density in the upper F region and an increase in the E and lower F region. These features agree with the trends derived over St. Santin. More recently, we examined the midday Sondrestrom data. The long-term changes and their variations with height in ion temperature and electron density are found to be very similar to earlier results given by other sites. These ISR long-term observations provide a unique contribution to improving our understanding of the global change in the ionosphere and thermosphere system.

J6-4 CLIMATOLOGY OF GLOBAL ELECTRON CONTENT DERIVED FROM GIM-TEC MAPS

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The Global Electron Content, GEC, derivation is initiated by integrating up the Total Electron Content of each cell of Global Ionospheric Map, GIM-TEC, over the area [Afraimovich et al., 2006, 2008]. Algorithm of GEC calculation is improved in this study using the electron density varying with height through the total volume of a spherical layer in near-Earth space up to 20,200 km (GPS orbit). To this end 3-D electron density distribution is reconstructed from GIM-TEC with the International Reference Ionosphere model extended to the Plasmasphere, IRI-Plas, and Ne(h, phi, theta) profiles are integrated over the globe through the ionosphere and plasmasphere altitudes. The hourly, daily, monthly, annual and 12-monthly smoothed values of GEC are derived from JPL GIM-TEC maps for the period 1999-2012 representing the temporal changes of GEC for the different time scales. It is shown that GEC simulation with IRI-Plas model using ITU-R (CCIR) prediction of the F2 layer peak parameters closely resembles variation of GEC data with RMS error less than 5%. As a result, the 12-monthly smoothed GEC12 simulated by IRI-Plas is used for reconstruction of GEC12 for the past (1958-1998) and its prediction for 2013-2015. Properly calibrated GEC12 is investigated as the IRI-Plas driving parameter for the better representation of IRI-TEC through the ionosphere and plasmasphere along with IG12 and R12 indices used presently by IRI and IRI-Plas models for representation of the solar activity.

This study is supported by the joint grant of TUBITAK 112E568 and RFBR 13-02-91370-CT_a.

J6-5 PROJECTIONS OF THE RESPONSE OF THE MESOSPHERE AND LOWER THERMOSPHERE TO ANTHROPOGENIC CLIMATE CHANGE

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This talk describes transient simulations from present day to the end of the 21st century using the Community Earth System Model version 1 that includes the Whole Atmosphere Community Climate Model (WACCM). The simulations are conducted as part of phase 5 of the Coupled Model Intercomparison Project (CMIP5) and follow several Representative Concentration Pathway (RCP) scenarios. They are perhaps unique among simulations for CMIP5 in that they include an atmospheric model that extends into the lower thermosphere and incorporate interactive neutral and ion chemistry. The RCP scenarios cover a range of CO₂ concentrations ranging from one that peaks at approximately 490 ppm before 2100 and then declines, to one that reaches over 1370 ppm by 2100. All scenarios also include the eventual recovery of the stratospheric ozone layer. They therefore provide a new opportunity to study the expected response of the composition and dynamics of the upper atmosphere to future anthropogenic climate change.

J6-6 TEMPERATURE TRENDS IN THE 35-65 KM ALTITUDE RANGE FROM RAYLEIGH LIDAR TEMPERATURE MEASUREMENTS FROM 1993 TO 2012 AT SÃO JOSÉ DOS CAMPOS, BRAZIL (23°S, 46° W)**Batista Prado, Paulo; Clemesha Barclay, Robert; Simonich, Dale**

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A lidar tuned to sodium resonance line at 589 nm has been operated at São José dos Campos, Brazil (23°S, 46° W) since 1972. Beginning in 1993, the improved laser capability has enabled also the processing of the Rayleigh signal from which the temperatures from ~35 to ~65 km are retrieved in a nightly mean basis. In order to remove tidal effects only profiles obtained from 18:30 LT to 23:30 LT were considered in this analysis. We used these nightly profiles to determine the monthly temperature profiles from April 1993 to June 2012. The mean temperature characteristics for every year and for the whole period are obtained and do not differ too much from the previous climatology using shorter data series. A model including solar cycle, southern oscillation index, QBO, Annual and Semiannual oscillations and Linear trends has been fitted to the monthly temperatures every 3 km from 36 to 63 km. Variable linear trends with altitudes are determined with a maximum negative trends at 54-55 km attained 3.15 K/decade.

J6-7 NUMERICAL MODELLING OF THE EARTH'S OZONE LAYER EVOLUTION IN THE 21ST CENTURY**Zadorozhny, Alexander; Dyominov, Igor**

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A numerical 2-D zonally averaged interactive dynamical radiative-photochemical model of the ozonosphere including aerosol physics is used to examine the long-term changes of the Earth's ozone layer in the 21st century caused by anthropogenic pollution of the atmosphere by the greenhouse gases CO₂, CH₄, N₂O, by ozone-depleting chlorine and bromine compounds, and by H₂O emitted from engines of supersonic aircrafts. The model takes into account also an increasing of the ocean surface temperature caused by greenhouse effect and accompanying increase of water vapour influx into the atmosphere from the ocean. The model allows calculating self-consistently diabatic circulation, temperature, gaseous composition of the troposphere and stratosphere at latitudes from the South to North Poles, as well as distribution of sulphate aerosol particles and polar stratospheric clouds of types I and II. The model time-dependent runs were made for the period from 1975 to 2100 using two scenarios depicting maximum and average expected increases of CO₂, CH₄ and N₂O concentrations.

The model calculations showed that by the middle of 21st century the total ozone changes caused by the greenhouse gases are predicted to be comparable in absolute value with those due to chlorine and bromine species. Abundance of the greenhouse gases in the atmosphere will be the main anthropogenic factor controlling the state of the ozone layer in the second half of the 21st century. For example, it is shown that in accordance with maximum scenario changes of annual average global total ozone in 2100 in comparison with 1980 are equal to approximately 5,21% for anthropogenic growth all greenhouse gases, and to 1,69%, 3,38% and 7,31% for values of CO₂, CH₄ and N₂O fixed at 2000 level accordingly.

Anthropogenic increasing of water vapour abundance in the atmosphere due to heating of the ocean surface caused by greenhouse effect as well as due to emission from engines of supersonic aircrafts is shown to give a sensible contribution to the calculated ozone changes. This occurs due to additional cooling of the stratosphere, which leads to a weakness in efficiencies of all gas phase catalytic cycles of the ozone destruction. The processes, which determine the influence of the greenhouse gases on the Earth's ozone layer evolution, have been studied in details. The contributions of different pollutions to the predicted ozone changes have been estimated.

J6-8 MEAN WINDS AND GRAVITY WAVES DURING SUMMER AT MIDLATITUDES AS ME**Jacobi, Christoph; Ern, Manfred**

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SABER gravity wave (GW) momentum fluxes (MF) and temperature analyses are used together with mean winds and vertical wind shear from the Collm VHF meteor radar to analyse the variability of the mesosphere-lower thermosphere (MLT) mean circulation and the effect of GW in the course of the last solar cycle. The results are compared with long-term LF wind and GW proxy analyses from LF wind registrations. Generally, the mesospheric easterly wind jet is stronger during solar maximum than during solar minimum, which is accompanied by stronger GW MF then. At greater altitudes, this effect reverses, so that stronger westerlies and weaker GW MF are found during solar maximum. An exception is found during the extreme solar minimum 2008/2009, with stronger/weaker zonal winds above/below 90 km. This is caused by an upward shift of the height of maximum MF divergence from 82 to 84 km altitude. At altitudes around 90 km this leads to a reversal of the correlation between GW amplitudes and zonal mean wind.

J6-9 MUTUAL MESOPAUSE AND SURFACE TEMPERATURE VARIATIONS FROM OBSERVATIONS AND MODEL SIMULATIONS**Mokhov I.I.; Semenov A.I.; Volodin E.M.**

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Temperature variations at the mesopause T_m from measurements during 1960-2012 at the Zvenigorod Scientific Station (56N, 37E) of the A.M. Obukhov Institute of Atmospheric Physics (ZSS IAP RAS) are analyzed in comparison with variations of temperature at the surface T_s (Mokhov and Semenov, 2013). These data were obtained by measurements of the hydroxyl rotational temperature at the ZSS since 1957. Also, long-term simulations with the INM-CM3.0 global climate model for 20th-21st centuries were analyzed. Interannual variations show strong general T_m decrease during last half a century from observations in winter (December-January-February) with a significant slowing of this cooling during last 3 decades. The most significant relationship of T_m and global surface air temperature T_{gs} was obtained for the total analyzed time interval (1960-2012). For shorter analyzed intervals such relationship is less significant and there are essential differences for various decadal-scale intervals. The abrupt T_m decrease between 1976 and 1979 with a transition to new conditions since 1980s was noted for dependence of T_m variations at the ZSS on T_{gs} anomalies. Cross-wavelet analysis exhibits significant differences in local coherence between T_m and T_{gs} for interannual and decadal variations and for various time intervals. Results of similar analysis for long-term model simulations with SRES-A2 anthropogenic scenario for the 21st century show statistically significant negative coherence of T_m and T_{gs} variations with periods larger than 3 decades. To display such a coherence from observations it is necessary to have twice longer data set for T_m .

J6-10 ON UNDERSTANDING THE SHIFT IN TENDENCY OF TREND IN MESOPAUSE REGION TEMPERATURE?**Bei, Gufran**

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Recent data sets on the temperature of MLT region, indicates an emergence of trends which are contrary to the earlier perceptions. This has again pushed the trend community back to the basic in understanding the mechanism in temperature variability. There used to be a growing number of experimental results centered on, or consistent with no trends near the mesopause which is no more valid in recent time. A tendency of continuation of cooling temperature trends from upper mesosphere till mesopause region is now clearly evident which was not the case earlier. The question whether the ozone recovery in the stratosphere has any effect in the such kind of shift in temperature trends of the mesospheric region or it is something else is not clear. The role of gravity wave in modulating the mesopause region temperature trends has also been a challenging task.

SESSION J7**DIV. II/III LOW LATITUDE ATMOSPHERE-IONOSPHERE COUPLING PROCESSES AND RESPONSES TO FORCING FROM LOWER ATMOSPHERE AND MAGNETOSPHERE****J7-1 PLASMA BUBBLE MONITORING BY GNSS BASED TEC MAPPING AND 6300 OPTICAL IMAGER OVER BRAZIL****Takahashi, H.; Costa, S.; Paulino, I.; Wrasse, C.M.; Nogueira P.; Nardin, C.M.D.; Gargarella, W. Jr.; Otsuka, Y.; Shiokawa, K.; Medeiros, A.F.; Buriti, R.**

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Total electron contents (TEC) in the equatorial and low latitude ionosphere over Brazil have been monitored by ground-based GNSS receiving network (RBMC/IBGE) since 2011. It was possible to monitor continuously spatial and temporal variations of TEC over Brazil with a spatial resolution of 100-300 km and by 10 minutes time interval. Daytime equatorial ionization anomaly (EIA) and post sunset EIA could be monitored over the area of 4000 km longitudinal extension in the South America. Plasma bubble activities after sunset could also be mapped in 2-D form. The depletions were extending along the magnetic field line by more than 2000 km, and drifting eastward. Simultaneous observation of the plasma bubbles by a 6300 optical imager also detected the depletions with higher spatial resolution. We present the dynamical movement of the plasma bubbles in a visual form and discuss the seeding mechanism.

J7-2 GRAVITY WAVE SEED PERTURBATION AND PREREVERSAL VERTICAL DRIFT IN EQUATORIAL SPREAD F/PLASMA BUBBLE DEVELOPMENT UNDER SOLAR MAXIMUM AND MINIMUM CONDITIONS

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The post sunset development of the equatorial spread F/plasma bubble irregularities is known to be driven primarily by the evening (prereversal) enhancement in vertical drift/zonal electric field (PRE) and precursor seed perturbations in electron density/polarization electric field at the steep density gradient of the bottomside F layer. In this work we address the issue of the complementary influences from the PRE and seed perturbation in the ESF development process, during solar activity maximum and minimum conditions. The F layer heights at specific plasma frequencies as measured by Digisondes operated at equatorial and low latitude sites, including magnetic conjugate sites, in Brazil are analyzed to extract the characteristics of gravity wave oscillations in the F layer heights, of 0.5-1.5hrs periods, in the afternoon hours leading to possible post sunset ESF occurrence. The amplitude of these oscillations appears to undergo amplification just prior to the ESF onset in the ionograms of the solar maximum epoch. The importance of the seed perturbations relative to that of the PRE in the ESF instability initiation appears to vary significantly from the solar maximum to minimum epochs. While the solar cycle dependence of the PRE is fairly well known, that of the seed perturbation is poorly understood. The present analysis, complemented by simulation study of coupled Gravity wave-Interchange instability dynamics, is an attempt to understand better the importance of the instability seed perturbation relative to the PRE as the solar activity decreases from its maximum to minimum epochs.

J7-3 NUMERICAL STUDIES OF GRAVITY WAVE SEEDING OF EQUATORIAL PLASMA BUBBLES

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We describe recent numerical studies employing a high-resolution model of gravity wave (GW) propagation and instability in the neutral atmosphere and the SAMI3/ESF global ionosphere model addressing plasma dynamics responses to neutral forcing to explore GW seeding of equatorial plasma bubbles (EPBs). Inputs range from highly idealized GWs having only prescribed 2D linear structures to numerical simulations of superposed GWs exhibiting breaking, instabilities, and 3D turbulence in the lower thermosphere and larger-scale GWs that readily penetrate to the bottomside F layer. Results suggest that EPBs are readily excited at the imposed forcing scales, and 3D neutral instabilities in the lower thermosphere can initiate 3D plasma instabilities accompanying the seeding process extending to much high altitudes.

J7-4 TOPSIDE IONOSPHERE PLASMA BUBBLES SEEN AS HE+ DENSITY DEPLETIONS: ESTIMATIONS AND MODELLING

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The question about an opportunity to detect the topside plasma bubbles of equatorial origin in their separate plasma component (He⁺) is investigated. There are the indications [1, 2, 3, 4] that there is genetic connection between the He⁺ density depletions (subtroughs) and the equatorial plasma bubbles. For validation of this idea the characteristic times of the main photochemical and electro-dynamical processes, in which the plasma bubbles and their minor ion component (He⁺) are involved, have been calculated and compared. The conditions and factors, connected with solar activity, which are more favorable in the detection of the topside ionosphere plasma bubbles as He⁺ depletions, are under consideration. The numerical calculations, obtained in SAMI3 model (3D model of equatorial spread F) and kindly presented by J. Huba (USA) [5], are used for this study. It was revealed that the plasma bubbles, reaching the ceiling heights, can exist within several days and that there is principal opportunity to observe them in the separate plasma component (He⁺).

J7-5 STUDY OF IONOSPHERIC STRUCTURES BASED ON DUAL-BAND BEACON OBSERVATIONS OF TEC

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There are several satellites in low-earth orbit (LEO) that transmit dual-band beacon of 150/400 MHz to the ground. By chasing phase differences between two signals along the satellite pass, we can measure total electron content (TEC) of the ionosphere. This is an old but still important technique to monitor spatial structure of the ionosphere. We have developed a simple digital receiver called GRBR (GNU Radio Beacon Receiver), and deployed the GRBR network in wide area. Now the network grew to total about 30 sites including about 15 sites in southeast Asia. Main research topic in the low-latitude area is Equatorial spread F (ESF). The ESF is intense ionospheric irregularity

that occurs around the geomagnetic equator, and can cause problems to satellite-ground communications and/or GPS navigations. By using the GRBR network with several polar-orbiting satellites and C/NOFS satellites in the very low-inclination orbit, we are studying ionospheric structures before and during ESF events along latitude and longitude, respectively. On the other hand, the GRBR network over Japan is used for tomography analysis. In the presentation we overview technical aspects of the GRBR and current status of the network together with scientific outcome from our efforts.

J7-6 TIME-GCM TIDAL SIGNALS ALONG LEO SATELLITE ORBITS

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The Thermosphere-Ionosphere-Mesosphere-Electrodynamics General Circulation Model (TIME-GCM) is used to support tidal diagnostics for GOCE measurements. The GOCE satellite itself provides unique measurements of the neutral density and zonal wind near 270 km altitude, and complements measurements by the CHAMP satellite at about 300 km. However, the sun-synchronous orbit of GOCE allows measurements only in two local time sectors, which complicates tidal analysis. In this paper we present TIME-GCM results for the time periods mid-November to mid-December 2009 and May 2010 when GOCE and CHAMP were in a near co-planar orbit. The chosen time periods also denote geomagnetic quiet (2009) and geomagnetic disturbed (2010) conditions. Tidal and planetary wave forcing that represents prevailing atmospheric conditions was applied at the lower boundary of TIME-GCM. The TIME-GCM outputs are sampled along the GOCE and CHAMP orbits, and analyzed for longitudinal dependences and in terms of ascending/descending orbit node differences to identify tidal signatures. The complete model outputs are used to unambiguously characterize the simulated atmospheric tides. Depending on data availability the TIME-GCM results will be compared with the satellite data.

J7-7 ROLE OF IONOSPHERE-THERMOSPHERE COUPLING IN UPPER ATMOSPHERE DATA ASSIMILATION

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J7-8 GLOBAL EMPIRICAL BACKGROUND TEC MODEL BASED ON THE CODE DATA

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A global background TEC model is built by using the CODE TEC data for full 13 years, January 1999- December 2011. It describes the climatological behaviour of the ionosphere under both its primary external driver, i.e. the direct photo-ionization by incident solar radiation, and regular tidal forcing from the lower atmosphere. The model construction is based on the significantly different time scales of the solar cycle, seasonal and diurnal TEC variabilities (at least an order of magnitude); this leads to modulations of shorter-period variabilities with periods of the longer ones. In this case the TEC spatial-temporal variability is presented as a multiplication of three separable functions. The solar activity is described by both parameters: F10.7 and its linear rate of change KF while the seasonal variability is presented by sine functions including 4 subharmonics of the year. The diurnal variability of the TEC model is described by 2D (longitude-time) sine functions which include 4 subharmonics of the solar day with zonal wavenumbers up to 4. The model offers TEC maps which depend on geographic coordinates (50x50 in latitude and longitude) and UT at given solar activity and day of the year. The presented background model fits to the CODE TEC input data with a zero systematic error and a RMS error of 3.387 TECU. It is able to reproduce the well-known ionospheric structures as Weddell Sea Anomaly and some longitudinal wave-like structures.

J7-9 WAVE 4 SIGNATURE IN EQUATORIAL SPORADIC E OCCURRENCE RATES AND S

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Sporadic E (Es) layer occurrence rates at equatorial latitudes have been obtained from the Signal-to-Noise Ratio (SNR) profiles of the GPS L1 signal during radio occultations (RO), measured by the U.S./Taiwan FORMOSAT-3/COSMIC six-satellite constellation. Sudden changes in the vertical electron density gradients, which indicate the presence of a sporadic E layer, appear as strong fluctuations in the SNR above 85 km altitude. These disturbances are caused by signal divergence/convergence which leads to a decrease/increase of the signal intensity at the receiving GPS occultation antenna. The maximum SNR deviation from the mean profile is observed at the approximate altitude of the Es layer. If arranged according to local time, at equatorial latitudes the Es occurrence rates show a strong zonal wavenumber 4 signature, which has been already observed in different both mesospheric and thermospheric

parameters and is known to be connected with an eastward propagating diurnal tide with zonal wavenumber 3 (DE3). Frequency-wavenumber analysis of the Es signals indeed reveals the dominance of the DE3 signature in Es, which is the most prominent signal second to the westward propagating wave 1 (DW1) signal connected with the diurnal cycle. Comparison with SABER temperature analyses of the DE3 shows excellent agreement with the DE3 analyses from GPS RO, indicating that the Es DE3 is probably caused by neutral middle atmosphere dynamics.

J7-10 INITIAL RESULTS OF THE SPACE-BORNE IMAGING OBSERVATION BY ISS-IMAP

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ISS-IMAP (Ionosphere, Mesosphere, upper Atmosphere, and Plasmasphere mapping) mission is a space-borne mission on the International Space Station (ISS) to elucidate the mesoscale structures in the ionosphere, the mesosphere, and the plasmasphere by imaging observations. ISS-IMAP is on the Exposed Facility of Japanese Experiment Module of the International Space Station (EF of ISS-JEM). Its observation was commenced in October 2012 after its initial check out. It consists of VISible-light and Infrared spectrum imager (VISI) and Extra UltraViolet Imager (EUVI). VISI observes the airglow in 730nm (OH, Alt. 85km), 762nm (O₂, Alt 95km), and 630nm(O, Alt.250km) in the nadir direction. EUVI observes the resonant scattering of 30.4nm (He⁺) and 83.4nm (O⁺) in the limb direction. The objective of this mission is to clarify the energy transport process by the structures whose horizontal scale is 50-500km in the Earth's upper atmosphere, and the effect of the structures and disturbances on the space-borne systems. ISS-IMAP measures the following three parameters in the lower latitude region than 51 degrees in geographic: (1) distribution of the atmospheric gravity waves in the mesosphere and the lower thermosphere, (2) distribution of the ionized atmosphere in the ionospheric F-region, (3) distribution of O⁺ and He⁺ ions in the ionosphere and plasmasphere. Initial results of the ISS-IMAP mission will be introduced in the presentation.

J7-11 LARGE MESOPAUSE BRIGHTNESS EVENTS, OBSERVATIONS AND AN EXPLANATION

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Observations of a number of 'bright night' airglow events describe a large bright event preceded by an extended 'dark zone in OH airglow. The period of the events are ~1-2 hours. The direction and period are coincident with the presence of a medium scale gravity wave (GW). The bright event sequence has the intrinsic phase speed as, and evolves within a single period of the GW. The explanation is that an instability forces a large overturning, with the upwelling phase (cooling, and dimming the airglow), and the downwelling (heating and brightening the airglow). The energy responsible for the heating and cooling events is explained as a forced instability. The instability 'surfs' on the medium scale wave, producing a trigger dynamic setting off the overturning event(s). Data for a number of events will be shown from lidar and imager observations.

J7-12 RAY-TRACING FOR MEDIUM-SCALE GRAVITY WAVES OBSERVED AT 7.4° S

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Data collected during the Spread F Experiment (SpreadFEx) from September to November 2009 have been used to study the vertical propagation of 26 medium-scale gravity waves. These waves were observed in airglow images over Sao Joao do Cariri (7.4°S; 36.5°W). Their trajectories in the atmosphere have been assessed by ray-tracing. A wind and temperature database from the surface up to 400 km altitude was necessary for the ray-tracing. The wind profiles were estimated using data from a meteor radar and a Fabry-Perot interferometer, and complemented by the HWM-93 and TIE-GCM models where experimental data were not available. The temperature profiles included TIMED/SABER and FPI measurements, and NRLMSISE-00 and TIE-GCM models. The reverse path for the MSGWs reveals convective complexes as likely sources for two MSGWs. In another case, a cold front over the north of the state of Espirito Santo was at the tropospheric position for an MSGW. Ray-tracing for the thermosphere-ionosphere (TI) region shows a linear relationship between: (1) gravity wave periods and travel times prior to dissipation, (2) horizontal wavelengths and horizontal travel distances, and (3) horizontal phase speeds and heights prior to dissipation. Gravity waves Doppler up-shifted, in the mesosphere and lower thermosphere region, reached higher altitudes in the TI. A gravity wave observed on 09 November 2009 reached ~200 km height with expressive amplitude which could affect the generation of F region plasma irregularities.

J7-13 CHARACTERISTICS OF GREEN LINE AND RED LINE AIRGLOWS OBSERVED BY ISUAL INSTRUMENTNee, J.B.; *et al.***J7-14 VARIABILITY OF THE GRAVITY WAVE FORCING FROM TROPOSPHERE TO MESOSPHERE: BY MOMENTUM FLUX ESTIMATION**

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Using long-term data (1998 to 2008) collected from Mesosphere-Stratosphere-Troposphere (MST) radar and Rayleigh Lidar located at a tropical station, Gadanki (13.5oN, 79.2oE), India, variability of the gravity wave forcing from troposphere to mesosphere is investigated by estimating the momentum flux associated with the gravity waves of periods 20 min. to 2 h, for the first time. The emphasis is on seasonal variability of mean zonal and meridional momentum fluxes in mesosphere and troposphere and vertical flux of zonal momentum in the stratosphere. An effort is made to examine the variations in momentum flux for different cases, viz., during the occurrence of mesospheric temperature inversion and convection events. At tropospheric altitudes of 11-16 km large enhancement in flux is noticed during equinoxes. In the stratosphere the maximum values of flux ($\sim 2.8 \text{ m}^2/\text{s}^2$) are pragmatic in winter and spring at the altitude region 58-62 km. Interestingly, the vertical flux of zonal momentum estimated from lidar is in the range of those estimated from radar data in the overlap altitude region, though the estimates are from two different techniques. In the mesosphere, in summer large variations with altitude in zonal momentum flux are noticed with a magnitude $\sim 0-4 \text{ m}^2/\text{s}^2$. The meridional fluxes in the mesosphere are higher in equinoxes ($\sim 10-12 \text{ m}^2/\text{s}^2$). The two case studies showed that during mesospheric temperature inversion due to large wave breaking at mesosphere, momentum fluxes are raised up to $\sim 7-10 \text{ m}^2/\text{s}^2$ and during deep convection, large variations in troposphere momentum fluxes are noticed than in mesosphere and the variations in mesospheric momentum fluxes due to tropospheric convection are noticed at earlier times than overhead convection period in troposphere, the possible reasons are discussed.

J7-15 GRAVITY WAVES AT MID AND LOW-LATITUDE IONOSPHERE

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Multi-point observations by Doppler sounding system make it possible to investigate propagation of Gravity Waves (GWs) in the ionosphere. The system operating at two different frequencies ($\sim 3.59 \text{ MHz}$ and $\sim 4.27 \text{ MHz}$) is located in the Central Europe, Czech Republic. Similar multi-point system operating at only one frequency was also installed in Western Cape in South Africa ($f \sim 3.59 \text{ MHz}$) and in Northern Argentina, in the vicinity of Tucuman ($f \sim 4.63 \text{ MHz}$). Simultaneous measurements of near-by ionosondes are used to estimate reflection heights of the transmitted frequencies. The largest fluctuations of Doppler shift (wave activity) are observed when the sounding radio waves reflect at altitudes from ~ 150 to $\sim 250 \text{ km}$ (sometimes up to 300 km), i.e. mainly in the F layer.

A statistical study of propagation of small-scale GWs shows that the most frequently observed horizontal velocities of GWs ranged from ~ 100 to $\sim 160 \text{ m/s}$. At mid-latitudes (Czech Republic and Western Cape in South Africa), the analyzed GWs propagated roughly against the neutral winds obtained from the HWM07 model, so the intrinsic velocities were about 30 to 70 m/s higher than the observed velocities. The propagation directions of GW showed seasonal and diurnal dependence. The analyzed waves propagated roughly poleward in the local summer, whereas approximately equatorward propagation dominated in the local winter. The estimated horizontal wavelengths of the analyzed waves are $\sim 100-300 \text{ km}$. At low-latitudes, in the northern Argentina (Tucuman), in the vicinity of Andes, the seasonal (diurnal) dependence has not been observed; the observations however show clear preference for Northward or Southward direction of propagation.

Different reflection heights of two different sounding frequencies used in the Czech Republic ($\sim 4.27 \text{ MHz}$ system has been operating since the end of 2012) make it possible to analyze GW propagation in 3D. The preliminary results show that wave vectors have mostly downward oriented vertical components, indicating an upward flow of energy for GWs. The uncertainties in determining the values of vertical components of wave vectors are however usually large, often higher than their absolute values. The investigation and data analysis is continuing.

J7-16 SEASONALLY VARYING DISTURBANCE DYNAMO EFFECTS ON THE EQUATORIAL ELECTROJET: OBSERVATIONS AND TIEGCM SIMULATIONS**Yamazaki, Yosuke; Richmond, Arthur D.; Maute, Astrid**National Center for Atmospheric Research, High Altitude Observatory
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We use long-term records of ground magnetometer data (1958-2008) at the Indian and Peruvian sectors to determine the average response of the equatorial electrojet to geomagnetic storms ($Dst < -100$). At both longitudes, a decrease (~30%) in the daytime equatorial electrojet intensity from its quiet-day level is observed on the day of the minimum Dst and the following day, consistent with theory of the ionospheric disturbance dynamo [Blanc and Richmond, 1980]. It is found that the storm-time electrojet reduction is strongly seasonal dependent, indicating the importance of the seasonal variation in the storm-time ionospheric wind dynamo. We conduct simulations using NCAR's Thermosphere-Ionosphere-Electrodynamics General Circulation Model (TIEGCM) to study the mechanism of the seasonal variation in the disturbance dynamo effect.

J7-17 A STUDY ON VARIABILITY OF LOW LATITUDE AMBIENT IONIZATION IN RELATION TO EQUATORIAL ELECTRODYNAMICS**Chakraborty, S.K.; Chatterjee, S., Patahn, B.M.**Raja Peary Mohan College (RPMC); RPMC; IIG
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Ionospheric total electron content measured with GPS satellites from two locations: RPMC (22.66°N, 88.8°E) and KNC (24.1°N, 88.8°E) near equatorial ionization anomaly (EIA) crest of Indian longitude sector is investigated in conjunction with magnetometer data to study the electrodynamic aspect of low latitude ambient ionization distribution. Magnetometer H field values may be considered as proxy index of equatorial electric field responsible for fountain effect. Data for the equinoctial months of high solar activity year (2011) under quiet geomagnetic ($dst > -50$ nT) and both for normal and counter electrojet (EEJ and CEJ respectively) conditions are considered. Various parameters like ascending/ descending slope, diurnal peak/ secondary peak, integrated values, half widths of H_{eq} and EEJ are investigated in conjunction with the corresponding TEC values at two locations as well as latitudinal TEC obtained from IGS data. The rising slopes of equatorial H_{eq} rather than EEJ exhibit better correspondence with VTEC near the EIA crest. The days with faster fall in H_{eq} following diurnal peaks exhibit delayed or absence of diurnal peak in TEC. The integrated EEJ exhibit better correspondence with the instantaneous (nearly one and half an hour) TEC values at RPMC than at KNC. Post sunset secondary enhancement in TEC is found to significantly correlate with the afternoon enhancement in EEJ. A good correspondence between the two may fruitfully be utilized for development of TEC model.

Analysis of TEC and EEJ data on the days of CEJ events reflect prominent signatures of reversed fountain following CEJ peak at 750°E (the longitude of the magnetometer stations) compared to that at 900°E. A parameter, C_{pd} , obtained by multiplying the peak value with duration of CEJ field, significantly correlates (~0.7) with the latitudinal gradient in TEC at 750°E longitude implying perturbation of development of TEC dictated by the intensified CEJ. A somewhat lower correlation (<0.5) at 900°E may signify longitudinal confinement of CEJ field. Also the deviation in the ambient level on CEJ days is well correlated (~0.68) with C_{pd} . The results may be discussed in terms of perturbed fountain driven by CEJ field.

J7-18 IONIZING RADIATION AND ION INDUCED NUCLEATION (IIN) AS EFFECTIVE DRIVERS OF THE ATMOSPHERE-IONOSPHERE COUPLING THROUGH THE GLOBAL ELECTRIC CIRCUIT**Pulinets, Sergey; Ouzounov, Dimitar; Davidenko, Dmitry**Space Research Institute, Russian Academy of Sciences (IKI RAS); Chapman University; FIAG
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It was established recently that different sources of ionizing radiation (natural ground radioactivity, nuclear power plant disasters, and nuclear tests) produce local anomalies in the ionosphere. Their sizes can vary from few tens of kilometers (Fukushima NPP) up to almost global scale anomalies (large earthquakes with magnitude $M > 8$). Two types of anomalies are recognized: sporadic spatial scintillations and steady structures over the source of ionization lasting from 4 to 12 hours. In low latitudes the conjugated structures are observed as well because of electromagnetic coupling along the geomagnetic field lines. Strong modification of Equatorial anomaly is observed both in latitudinal and longitudinal directions. Stimulation of plasma bubbles was detected as well. The physical mechanism is developed using ionizing ionization as the source of ions, and ion induced nucleation process as the source of large, aerosol size ion particle creation. These particles drastically change the conductivity of boundary layer of atmosphere what leads to change of ionosphere electric potential in relation to ground within the Global Electric Circuit. Variations of the ionosphere potential lead to modification of electron concentration within the affected area of the ionosphere. The strength of ionization process is controlled by monitoring of thermal effects which accompany the process of ion induced nucleation.

J7-1p DETECTING LIGHTNING DISTRIBUTION CHANGES USING SATELLITE IMAGERY
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The distribution of lightning across the Earth's surface varies both with location and time. Seasonal changes in lightning activity recorded in Low Earth Orbit (LEO) satellite data have been studied by various authors, who used classical time series analysis techniques. We present an alternative analysis based on automated pattern recognition, which identifies the changing state of lightning distributions using computer vision techniques. Due to the large quantity of data available, machine learning algorithms were the most efficient way of achieving our goals. This model not only has significant application in the analysis of historical lightning data but also in the forecasting of future lightning distributions.

J7-2p SOLAR TERMINATOR GENERATED WAVE PACKETS AND ITS LATITUDINAL FEATURES, OBTAINED FROM TEC VARIATIONS DATA FOR 2008
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Earlier investigations of solar terminator ionospheric effects revealed that its motion generates middle-scale wave disturbances. These wave disturbances manifest themselves in total electron content (TEC) in a wave packet form. At least part of them has a magneto-hydrodynamic nature. We proposed a hypothesis that ST movement generates magneto-hydrodynamic waves. These waves propagate to another hemisphere and modulate electron density over the region. In this case, wave disturbances recording would start almost at the time of ST crossing the MC region. In this work, using South hemisphere sites data, we recorded wave disturbance distributions in ST local time system and made preliminary analysis of latitudinal features of them. An apparent behavior of the distributions does not agree well the generation mechanism suggested before. Distributions, calculated by using Brazilian data, show several clear peaks, but there is no pronounced connection with ST movement in MC region, especially for equatorial area. The work was supported by Russian Foundation for Basic Research (under grants Nos. 12-05-33032-a and 12-05-31069-a) and by the Ministry of Education and Science of the Russian Federation (under agreement No. 8699).

J7-3p GEOMAGNETIC CONJUGATE OBSERVATIONS OF A MIDNIGHT BRIGHTNESS WAVE AT LOW LATITUDES
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Plasma-neutral coupling in the ionosphere and the thermosphere plays a major role for dynamic variation of the equatorial ionosphere. We have been conducting observations of nighttime airglow images and thermospheric winds by using highly-sensitive all-sky airglow imagers and Fabry-Perot interferometers (FPIs) at Kototabang, Indonesia (0.2S; 100.3E; geomagnetic latitude (MLAT): 10.0S) and Chiang Mai, Thailand (18.8N; 98.9E; MLAT: 8.9N), which are geomagnetic conjugate stations. The combined observations of airglow images and thermospheric winds have carried out for the first time at geomagnetic conjugate stations. In this presentation, we report a large-scale wave event observed in the 630-nm airglow images at Kototabang on 7 February, 2011 from 1600 to 1730 UT (from 2300 to 0030 LT). The wave has amplitudes of 20-30% and propagates south-southwestward (poleward) with a velocity of 290 m/s only once at midnight. From these characteristics, this wave seems to be different from the equatorial medium-scale traveling ionospheric disturbances (MSTIDs), which have more than two wave phase fronts. Meridional thermospheric neutral winds simultaneously observed by the FPI at Kototabang turned from northward (equatorward) to southward (poleward) just before the wave passage. This fact is consistent with the idea that the observed wave is a midnight brightness wave (MBW) generated from a midnight temperature maximum in the thermosphere, as reported by previous studies (e.g., Colerico and Mendillo, 2002). We found, however, that similar wave was not simultaneously observed in the airglow images at Chiang Mai at the geomagnetic conjugate point. Eastward and southward thermospheric neutral winds observed by the FPI at Kototabang were 50-70 m/s and 30-50 m/s, respectively, when the MBW was observed. The bottomside heights of the F layer observed by ionosondes at a frequency of 2 MHz decreased from 230 km to 190 km at Kototabang and increased from 260 km to 280 km at Chiang Mai when the MBW was observed. The decrease of the F-layer height at Kototabang is probably due to the poleward winds observed by the FPI. The increase of the F-layer height at Chiang Mai may be due to the ExB drift generated by the polarization electric field projected from Kototabang in the airglow enhanced region. In the presentation, we discuss the ionospheric variation and their hemispheric coupling during the MBW event by using these comprehensive data obtained at low-latitude conjugate stations.

J7-4p IMPACT OF TROPOSPHERICALLY-GENERATED TIDES ON THE MEAN STATE OF THE IONOSPHERE-THERMOSPHERE SYSTEM**Jones Jr, McArthur; and Forbes, Jeffrey M.; Hagan, Maura E.; Maute, Astrid**

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It is now widely recognized that vertically-propagating tides exert significant variability on the ionosphere-thermosphere (IT) system. In particular, the impact of tropospherically-generated non-migrating tides on longitudinal variability of the IT system has been a topic of intense research in recent years. However, relatively little is known about how dissipation of these upward propagating waves affect the zonal mean state of the IT system. Herein we report on numerical experiments performed with the National Center for Atmospheric Research (NCAR) Thermosphere-Ionosphere-Electrodynamics General Circulation Model (TIE-GCM) that explore this topic using observationally based tidal lower boundary conditions near 97 km from the Climatological Tidal Model of the Thermosphere (CTMT after Oberheide et al., [2011]) for average solar conditions over a climatological year (i.e., steady-state monthly runs). A robust evaluation of the NCAR TIE-GCM close to the model lower boundary was performed to assess the validity of our results, since the TIE-GCM lower boundary is close to the height regime where many of these upward propagating tides dissipate and exchange energy and momentum with the background IT. Differences between simulations including and excluding CTMT tidal forcing reveal that tides of tropospheric origin are capable of altering the zonal mean zonal winds in the dynamo region by 25 m/s in the boreal winter months. Additionally, differences in the height of the F2 layer peak range from -25 to 50 km in equatorial and mid-latitude regions due to tidal driven dynamo-wind action. The eastward propagating diurnal tide with zonal wave number $s = 3$ (DE3) and migrating semidiurnal tide (SW2) are the two largest components of the tidal spectrum and appear to be the main drivers (also including the migrating diurnal tides (DW1) and stationary planetary wave with zonal wave number $s = 1$ (SPW1)) in the aforementioned zonal mean zonal wind differences. To substantiate the results above, multiple TIE-GCM numerical experiments are performed with several different combinations of tides and stationary planetary waves at the model lower boundary.

J7-5p PRELIMINARY MEASUREMENTS OF A SCHUMANN RESONANCE STATION LOCATED IN LOW LATITUDES**Mendoza, Blanca; Sierra, Pablo; Vázquez, Samuel; Andrade, Ernesto; Rodríguez, Daniel**

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The electromagnetic spectrum region between 3 and 50 Hz, known as the ELF band, contains among many others the so-called Schumann Resonances (SR) (7.8 Hz and its harmonics). These resonances are generated by atmospheric electric discharges during storms and also respond to changes in solar activity. They propagate with little attenuation along the cavity formed between the Earth's surface and the low ionosphere. At present there are several monitoring SR stations, mainly at high and middle latitudes. However, at lower latitudes this phenomenon is less explored. Here we present preliminary results of the SR observations in a station located in Coeneo, Michoacán, Mexico (latitude 19° 48' 19" N, longitude 101° 41' 39" W). This station is the first of its kind in the region that includes Mexico, the Caribbean and Central America. The station has three inductive antennas, one for each magnetic field component. We were able to measure SR harmonics at ~7.58, 19.91 and 32.46 Hz.

J7-6p A NONLINEAR TIME DEPENDENT NEUTRAL WIND MODEL APPLIED OVER TROPICAL REGION DURING STORM TIME PERIODS**Muella, Marcio T.A.H.; de Siqueira, Patricia M; Fagundes, Paulo R.; de Paula, Eurico R.**

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Nighttime variations of the magnetic meridional component of the thermospheric horizontal neutral winds have been estimated using a semi-empirical nonlinear neutral wind model. For this study the magnetic meridional winds were inferred over a low-latitude station during the two major events of geomagnetic storm (moderate-to-intense) that occurred between August and September, 2002. During the storms a chain of three digital ionosondes was operational in the tropical region of Brazil: two equatorial stations, Manaus (2.9 S, 60.0 W, dip latitude 6.4 N) and Palmas (10.2 S, 48.2 W, dip latitude 5.7 S), and one low-latitude station, São José dos Campos (23.2 S, 45.9 W, dip latitude 17.6 S). In the wind estimations the ionospheric base height variations $h'F$ (the minimum virtual height of the F-region) and h_pF2 (close to the actual height of the F2-peak) obtained at the three stations were used as data input in the neutral wind model based algorithm. The disturbed winds were compared with empirical horizontal wind model (HWM-90) outputs and with quiet night winds derived from the neutral wind model. The disturbed magnetic meridional winds are predominantly equatorward during the first night following the principal phase of the storm,

whereas during the recovery phase strong poleward winds are observed. This work is important to evaluate the behavior and response of the thermosphere-ionosphere system at equatorial and low-latitude regions during geomagnetically disturbed conditions, which is one of the most relevant themes in the space weather studies.

J7-7p THE EFFECT OF GEOMAGNETIC DISTURBANCES ON THE LOWER ATMOSPHERE

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It is known that there are various key factors of the Earth's climate change, and the terrestrial climate is continuation of a space climate. For research of probable effect of magnetospheric disturbances on character of development of meteorological processes in the atmosphere, remarkable events have been selected, each of which had features: 1) the chain of 4 substorms, CDAW9C, May 3, 1986, (0000-1100) UT; 2) super magnetic storm, March 13-14, 1989; 3) super storms, October 28-31, 2003; 4) event of stationary magnetospheric convection (SMC) on November, 24, 1981; 5) sawtooth event on August, 10-11, 2000; 6) extra-storm on August, 23-24, 2005.

The objective of this paper is to investigate effects of geomagnetic activity on meteorological processes and a possible effect of magnetospheric disturbances on the tropical cyclogenesis evolution character. The collected data on magnetic storms and tropical cyclones, which were observed in the North Atlantic, East Pacific, and West Pacific, are analyzed for understanding of the mechanism of magnetospheric disturbances effects on complicated nonlinear system of atmospheric processes.

Also, we discuss the problem of the effect of the solar wind electric field sharp increase via the global electric circuit during magnetospheric disturbances on the cloud layer formation. According to [Troshichev O. A., Janzhura A. Temperature alterations Antarctic ice sheet initiated by the disturbed solar wind // J. Atmos. Solar-Terr. Phys. 2004. V. 66. P. 1159-1172], the interplanetary electric field influence is realized through acceleration of the air masses, descending into the lower atmosphere from the troposphere, and formation of cloudiness above the Antarctic Ridge, where the descending air masses enter the surface layer. The cloudiness results in the sudden warming in the surface atmosphere, because the cloud layer efficiently backscatters the long wavelength radiation going from ice sheet, but does not affect the process of adiabatic warming of the descending air masses. Influence of the interplanetary electric field on cloudiness has been revealed for epochs of the solar activity minimum, when Forbush decreases effect is absent. The acceleration of the descending air masses is followed by a sharp increase of the atmospheric pressure in the near-pole region, which gives rise to the katabatic wind strengthening above the entire Antarctica. As a result, the circumpolar vortex around the periphery of the Antarctic continent decays and the surface easterlies, typical of the coast stations during the winter season, are replaced by southerlies. It is suggested (according to Troshichev et. al.) that the resulting invasion of the cold air masses into the Southern ocean leads to destruction the regular relationships between the sea level pressure fluctuations in the Southeast Pacific High and the North Australian Indonesian Low, since development the El-Nino event strongly follows anomalous atmospheric processes in the winter Antarctica.

J7-8p GLOBAL MAPS OF THE RELATION BETWEEN IONOSPHERIC ELECTRON DENSITY AND TEMPERATURE FROM 8 YEARS OF CHAMP OBSERVATIONS

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Eight years of continuous observations of electron density and temperature on board the CHAMP satellite have been used to compile global maps of the relation between electron density and temperature covering all magnetic latitudes and local times at an altitude of around 350km. Using a quadratic fit we found that at dayside low latitudes electron temperature and density are anti-correlated below an electron density threshold of about $5 \times 10^{11} \text{ m}^{-3}$ and positive correlations are found above. The anti-correlation is because electron cooling is quadratic in Ne and electron heating is linear in Ne. For high Ne, electrons, ions and neutrals have similar temperatures and all increase with increasing solar flux. However, at mid-latitudes Te decreases with increasing density at all levels also above a level of $5 \times 10^{11} \text{ m}^{-3}$. We are currently investigating this observations for explanations. During night Te and Ne are positively correlated for all levels in Ne at low and mid latitudes. With the absence of sunlight electron heating does not occur and the electron gas is closely coupled to the ion and neutral gas. Significant anti correlation is again seen in the subauroral through region where particle precipitation from the inner magnetosphere heats the low density plasma.

J7-9p IMAGING OF IONOSPHERE AND PLASMASPHERE COUPLING BY EUVI ON ISS

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The Extreme Ultraviolet Imagers (EUVIs) on International Space Station as payloads of the Exposed Facility of the Japanese Experiment Module (JEM-EF) was launched in 2012. EUVIs are parts of Ionosphere-Mesosphere-Atmospheric Plasmasphere cameras (IMAP). We built two independent and identical telescopes on the Exposed Facility of the Japanese Experiment Module of ISS. One instrument aims the photon detection at He+ (30.4 nm)

emission from singly ionized helium. The other is at O⁺ (83.4 nm) emission. Both emissions lie in the spectral range of extreme ultraviolet (EUV). Optics consists of a multilayer coated mirror to increase the reflectivity at 30.4nm, a metallic thin filter, and microchannel plates to pick up photon events. We will show the initial result of EUVI during the first 3-month.

SESSION J8

DIV. II/III EXTREME SPACE WEATHER: SOLAR WIND-MAGNETOSPHERE-IONOSPHERE UPPER ATMOSPHERE COUPLING

J8-1 MODELING THE RESPONSE OF THE THERMOSPHERE AND IONOSPHERE TO AN EXTREME SPACE WEATHER EVENT

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The sequence of physical process in the thermosphere and ionosphere during a geomagnetic storm are thought to be well understood. The physics-based coupled models, however, have been designed and somewhat tuned to simulate the response to events that have been observed in the last two solar cycles, such as the Halloween storm in 2003. For an extreme solar storm, it is unclear if the response would be a natural linear extrapolation of the response to more modest event or if non-linear processes would begin to dominate. A numerical simulation has been performed with the CTIpe coupled thermosphere ionosphere model to quantify the likely response to a extreme space weather, more attune to the Carrington type of event in 1859. The solar wind drivers of the system have been estimated so the total energy injection into the upper atmosphere can be quantified. However, there is still significant uncertainty in quantifying some of the other driver-response relationships such as the magnitude and shielding time-scale of the penetration electric field, the possible feedback to the magnetosphere, and the amount of nitric oxide production. Within the limits of uncertainty of the drivers, the magnitude of the response will be quantified and possible non-linear feedback will be elucidated.

J8-2 PREDICTION OF GEOMAGNETICALLY INDUCED CURRENTS IN THE UK HIGH-VOLTAGE NETWORK DURING EXTREME SPACE WEATHER EVENTS

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Geomagnetically Induced Currents (GIC) can be damaging to high-voltage power transmission systems. GIC are driven by rapid changes in the strength of the magnetic field external to the Earth's surface. Electric fields are produced in the ground by the interaction between this changing magnetic field and the local conductivity structure of the Earth. Using a technique known as the thin-sheet approximation we can determine the electric field at the Earth's surface, which in turn allows the calculation of GIC in the earthing connections of high-voltage transformers within a power grid. We describe two new developments in the modelling of GIC in the UK, though the results are applicable to GIC-related research in other regions. Firstly, we have created an updated model of the UK surface conductivity by combining a spatial database of the UK geological properties (i.e. rock type) with an estimate of the conductivity for specific formations. Secondly, we have developed and implemented a sophisticated and up-to-date model for the 400 kV and 275 kV electrical networks across the whole of Great Britain and, in addition, the 132 kV network in Scotland. We can thus deduce the expected GIC at each transformer node in the system based on the network topology from an input surface electric field. We apply these developments to study the theoretical response of the UK high-voltage power grid to modelled extreme 100- and 200-year space weather scenarios and to a scaled version of the October 2003 geomagnetic storm, approximating a 1-in-200 year event.

J8-3 IONOSPHERIC AND STRATOSPHERIC ELECTRIC FIELD RESPONSES TO AN EXTREME SOLAR ENERGETIC PARTIC

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This paper will report on the global effects of one of the most extreme space weather events of the spacecraft era. On January 20th, 2005, a solar energetic particle (SEP) event caused the largest recorded ground level event since 1956. Serendipitously, a balloon-borne experiment intended to measure relativistic electron precipitation and its

effects was aloft over Antarctica (~32 km; near 70° S, 345° W geographic) throughout the duration of the SEP event, including the fast (~6 minute) onset. The balloon instrumentation included an x-ray scintillation counter, dc electric field, and scalar electrical conductivity sensors. Intense worldwide energetic proton precipitation and large increases in the energetic proton population of the outer radiation belts were observed by a global array of observatories and spacecraft. The observed conductivity increased by nearly a factor of 20 above ambient with the SEP event onset and returned to within a factor of two above normal levels within 17 hours. Decreases to near zero of both the vertical and horizontal electric field components were also observed in conjunction with the increase in particle flux at SEP onset. Combined with an atmospheric electric field mapping model, these data are consistent with a shorting out of the global electric circuit and point toward substantial ionospheric convection modifications. Results from a newly developed, globally applicable atmosphere-ionosphere conductivity model based on the Sodankylä Ion and Neutral Chemistry (SIC) model suggest that proton-induced ionization was directly responsible for the observed conductivity increase at the balloon. This paper will summarize the current interpretation of the electric field observations. First, it is shown that the conductivity profile predicted by the model does not shield the balloon payload at 32 km from the ionospheric horizontal field. Thus, the data really do indicate a very low level of ionospheric convection over the balloon during the 6 hours following the SEP event. Second, we have tried to use the conductivity model and AMIE model outputs to interpret the changes in the vertical field as indicators of large scale convection changes. The results indicate that we have not yet understood all of the physics responsible for the observations.

J8-4 EFFECTS OF SOLAR AND MAGNETOSPHERIC FORCING ON THE IONOSPHERE AND UPPER ATMOSPHERE

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Earth's ionosphere and upper atmosphere are subject to several geophysical forcings originating from the Sun. The interaction between the solar wind and the Earth's magnetosphere results in a fraction of the solar wind energy and plasma being transmitted into the magnetosphere, and subsequently into the ionosphere and upper atmosphere in the forms of auroral precipitation and Joule frictional heating. Solar energetic particles penetrate into the upper and middle atmosphere to cause significant ionization and chemical effects. Solar UV and EUV radiation is the main source of energy for heating, ionization, and photochemical reactions in the upper atmosphere and ionosphere. This paper will highlight some salient features of the ionosphere and upper atmosphere in response to the various solar and magnetospheric forcings, and discuss their relative impacts on the upper atmosphere. Observational and numerical modeling results from a number of recent geomagnetic storms will be presented.

J8-5 FRACTAL ANALYSIS EVALUATION OF THE IMPACT OF INTENSE GEOMAGNETIC STORMS ON THE MID LATITUDE IONOSPHERE

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One of the main mechanisms causing disturbances in the ionosphere is the Prompt Penetration Electric Fields (PPEFs) into the magnetosphere during geomagnetic storms when CMEs arrive to the Earth's environment. The purpose of this paper is to show results of the analysis we made of the impact of all major geomagnetic storms (Dst < -200nT) at mid latitudes, which have occurred since 2000. The analysis consists in calculating the total electron content (TEC) of the ionosphere using data from several Mexican GPS stations. We then quantified the degree of impact in the ionosphere to these latitudes, through variations in amplitude, and by changes in the roughness of the time series of TEC. We found that when the ionosphere presents a perturbation due to geomagnetic storm, the roughness of the time series of TEC seems to increase.

J8-6 HIGHLY GEO-EFFECTIVE SOLAR TRANSIENTS AND THEIR ASSOCIATED SPACE WEATHER ACTIVITIES

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The solar Cycle 23 has shown some peculiar features, i.e. slow and prolonged decline phase. It is when combined with the ascending phase of Cycle 24, it provides us a long phase during which the overall solar activity was very low. During this interval the average sunspot number appeared on the solar disk were also very low and the solar wind streams mainly originating from the coronal holes. The study investigate the relationship between these solar transients and their influence on Earth's geomagnetic field, as well as on the cosmic ray intensity. We have studied cosmic ray ground level enhancement (GLE) events occurred during the selected study period (cycle 23-24). The

disturbance storm time index Dst is taken as an indicator of geomagnetic activity by setting a value of $Dst_{min} \approx 200$ nT as threshold. We have utilized the solar/ Interplanetary data obtained from the omniweb provided by various space missions. It is found that the GLE's are well associated to X-class solar flares.

J8-7 THE ESTIMATION OF PLASMASPHERIC BEHAVIOR DURING STRONG GEOMAGNET

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The characteristics of the Earth upper atmosphere ionized part are responding on variations of solar and magnetic activity. Nowadays the measurements of Global Positioning System (GPS) are widely used by the scientific community for the Earth's atmosphere studies. The height of GPS/GLONASS orbits is about 20,200 km above the Earth's surface, and so most part of the propagation path of a radio signal from a GPS satellite to ground-based GPS receiver is mainly within the plasmasphere. As the electron densities in the plasmasphere are several orders of magnitude less than in the ionosphere, the plasmasphere is often ignored at analysis and estimation of GPS TEC data, however the plasmaspheric contribution to the GPS TEC can become significant under certain conditions, including during geomagnetic disturbances. The contribution of the plasmaspheric electron content (PEC) to the GPS TEC can be estimated from the simultaneous measurements of GPS TEC and ionospheric electron content (IEC). Estimates of IEC can be retrieved as a result of integration of ionospheric electron density profiles (EDP). For this aim one can use EDPs derived from ground-based radiophysical measurements ionosondes and incoherent scatter radars. One of the major advantage of IS radars is the ability to provide electron density profiles of both bottom-side and topside parts of the ionosphere with rather high temporal resolution during their measurement campaigns.

In the given paper it was considered strong geomagnetic storm occurred on November 7 - 10, 2004. The main phase of the storm began on November 7, 2004, Dst index reached the value of -383 nT on November 8, after that the recovery phase began. Geomagnetic storms caused severe ionospheric disturbances. Analysis of ionospheric variability was done on the base of co-located ionosonde and Kharkov IR radar (European mid-latitudes). During the main phase of storm NmF2 value was decreased with the factor of about 3.5. The F2 maximum height varied approximately from 230 km in the daytime to 380 km at night in comparison with nearest quiet days. PEC variations during strong geomagnetic storms at November 2004 were estimated by combining of Kharkov IS radar observations and GPS TEC data obtained from KHAR GPS station measurements. The comparison between two independent data sources was performed by analysis of the height-temporal distribution of electron density for specific point corresponded to the mid-latitudes of Europe. The obtained results demonstrate that percentage contribution of PEC to GPS TEC indicates the clear dependence from the time with maximal values (more than 70%) during night-time and lesser values (30-45%) during day-time for positive disturbance and quite time and rather high values during strong negative storm (up to 90%) with small changes in time. Physical mechanisms of the observed ionosphere/plasmasphere behaviour are discussed.

J8-8 UPPER ATMOSPHERE AND IONOSPHERE BEHAVIOR UNDER THE VERY LOW SOLAR FLUX CONDITIONS OF THE RECENT DEEP SOLAR MINIMUM

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The solar irradiance at extreme ultraviolet (EUV) wavelengths is the primary heat source of the thermosphere. The thermosphere responds to temperature changes expanding or contracting in such a way that the thermospheric density, at a fixed height is highly dependent on the solar EUV flux. The solar radiation is also the responsible for the ionospheric primary ionization and its layering structure. During the minimum of the solar cycle 23/24 the sun had a large number of spotless days as compared with previous periods. During this unusually deep and prolonged solar minimum the solar flux responsible for the thermospheric heating and ionospheric formation was very low. This provided a unique opportunity for the investigation of the thermosphere-ionosphere system under extremely low solar activity. Studies are indicating the need to review some proxies used to represent the solar irradiance in thermosphere-ionosphere models. The low density ionosphere has also provided good conditions for the study of waves propagating in the ionospheric F region.

J8-9 UNUSUAL DEPLETION OF OI 630.0 NM DAYGLOW AND SIMULTANEOUS MESOPAUSE

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On April 09, 2006 a significant and unusual decrease in the thermospheric OI 630.0 nm dayglow and an intense heating (~ 30 K) at OH emission altitudes over a magnetic dip equatorial station, Trivandrum (8.5° N, 77° E, dip 0.5° N), India were observed concomitant with the penetration of a noon time westward interplanetary electric field. The intensity of dayglow emissions from the thermosphere and the mesopause altitudes was measured using the

unique Multi wavelength Dayglow Photometer (MWDPM). The SABER observations onboard TIMED satellite also revealed a conspicuous enhancement in temperature at mesopause during this period. The ground based ionosonde and magnetometer observations vindicated the presence of strong penetration electric fields. The high cadence (at every 5 minutes) ionograms revealed the formation of F3 layer highlighting the combined action of equatorward wind and enhanced electric field due to penetration. It is being proposed that the strong heating at the mesopause resulted in the intrusion of additional neutrals like molecular N₂ into the emission altitudes and quenched the O(1D) atoms therein. The reduced Cowling conductivity at the E region as inferred using the magnetometer observations further supports this proposed mechanism. This study, for the first time, provides an evidence for simultaneous changes at the thermosphere/ionosphere and mesopause regions associated with penetration of interplanetary electric field, using optical and radio measurements from both ground/space based platforms. In author's view, such studies dealing with the concomitant variations in solar wind, interplanetary medium, equatorial ionosphere/thermosphere extending down to mesosphere are very important to get a comprehensive understanding of solar terrestrial coupling, particularly during geomagnetically disturbed periods.

J8-10 IONOSPHERIC DISTURBANCES UNDER LOW SOLAR ACTIVITY CONDITIONS

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J8-11 RESPONSE OF OI 557.7 AND 630.0 NM AIRGLOW TO SEVERE GEOMAGNETIC

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The atomic oxygen greenline (557.7nm) and redline emission (630.0 nm) are the most readily observed and prominent lines in the nightglow. These emissions can be used as precursors for a variety of physical and chemical processes in the upper mesosphere and lower thermosphere. There are a multitude of effects of space weather on the Earth's atmosphere. The decay of ring current is a very important parameter which can induce variation in the densities of few species in the atmosphere of airglow interest. The connection of variation of airglow emissions with the extreme space weather conditions is not very well established. In the present study, severe geomagnetic storms and their effect on the airglow emissions such as 557.7 nm and 630.0 nm emissions is studied. This study is primarily based on photochemical models with the necessary input being a combination of experimental observations and empirical models. We have tried to understand the effects on airglow emission rates, variation in the peak heights of these emissions and tried to understand the cause of the variation with the help of variations in the ring current and other parameters linked with the airglow chemistry. This study presents the results of calculations performed for the most severe geomagnetic storms occurred due to a variety of causes on Sun over the period of ten years.

J8-12 SEP'S DURING HALLOWEEN STORMS AND SPACE WEATHER

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The Solar Energetic Particles (SEP's) could be accelerated to higher energies of order of MeV per nucleon. A modified model for SEPs acceleration has been given and applied for Halloween storms event during the decline phase of solar cycle 23. The estimated values of the solar magnetic field during the solar particle event were introduced. The solar magnetic field describes a sophisticated feature of discrete sectors/regions over the period that starts from 28 October 2003 to 4 November 2003. The applications of the suggested model on the solar particle event show that a homogeneous structure is in agreement with the observations. The SEP and CME events lead to severe effects in geo-space and on earth, such as power blackouts, disruption of communications, and damage to satellites. Daily Geomagnetic storm changes, during Halloween storms were studied

J8-13 PLASMASPHERIC AND IONOSPHERIC RESPONSES TO THE GEOMAGNETIC STORM ON SEPTEMBER 26, 2011 AND THEIR INFLUENCE ON HF RADIO WAVE PROPAGATION

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Plasmaspheric and ionospheric responses to the geomagnetic storm on September 26, 2011 and their influence on HF radio wave propagation

This study presents the GSM TIP numerical simulations of the ionosphere-plasmasphere response to the geomagnetic storm on September 26-29, 2011. Recent modifications to the GSM TIP model include adding two new empirical models of high-energy electron precipitation and introducing a high-resolution (1-min) calculation of region 2 field aligned currents (R2 FAC) and a cross-polar cap potential. In order to examine the calculation results we used

the observation data of global network of ionosondes and GPS receivers. We investigated the disturbances in the different ionospheric and plasmaspheric parameters during this geomagnetic storm. We paid special attention to the main drivers of ionospheric disturbances during geomagnetic storm. Such drivers are the electric field of ionospheric dynamo and magnetospheric origin, thermospheric neutral wind, neutral atmosphere composition and heat balance of the upper atmosphere. In addition, we consider in more detail the geomagnetic storm influence on the ray paths of HF radio wave propagation. These investigations were carried out at financial support of Russian Foundation for Basic Research (RFBR) Grant No. 12-05-312171 and Program 22 RAS.

J8-14 ANISOTROPY OF MAGNETIC SUSCEPTIBILITY OF THE XIAGANCHAIGOU FORMATION AND XIAYOUSHASHAN FORMATION SEDIMENTS FROM THE Q Aidam BASIN, NORTHWEST CHINA: A CLUE FOR THE SEDIMENTARY CENTER MIGRATION

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Anisotropy of magnetic susceptibility (AMS) results are reported from 877 samples of Xiaganchaigou Formation and Xiayoushashan Formation sediments at eight locations (Xichagou, Gansen, Eboliang, Heishiqiu, Luluohe, Kushuiquan, Hong Shan and Gahai) within the Qaidam Basin, Northwest China. Rock magnetic measurement indicates that these AMS samples are dominated by magnetite except some samples from Gahai which are dominated by hematite. 16 lower hemisphere, equal area after bedding correction projections of the AMS data presents four sedimentary magnetic fabric projections, and 12 embryonic deformation magnetic fabric projections. Based on the AMS results, the Qaidam basin experienced an N-S compression no later than the Oligocene, which is much more intense in northern Qaidam basin than that in western Qaidam basin. The late NE compression which dominates the NW-trending folds in the modern Qaidam basin, is mainly recorded by AMS results in western Qaidam basin, indicating that this epoch of tectonic is more intense in western Qaidam basin than that in northern Qaidam basin. The stress strength transition gives a reasonable explanation of the eastwards migration of the deposition center during the Cenozoic. Diagrams of F-L, Pj-T and lower hemisphere, equal area after bedding correction projections of the AMS data all suggest that Kushuiquan is the site which experienced the strongest early N-S compression, and lineation degree and metamorphic degree decreases from Kushuiquan to both east and west sides.

J8-15 SEVERITY OF SPACE WEATHER EVENTS

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Though a large number of super geomagnetic storms (and CMEs) occurred in the past only a very small number of them are known to produce severe space weather effects. It is therefore important to know what controls the severity of space weather events. We analyze the intensity (minimum Dst or DstMin), strength (?Dst between main phase onset and DstMin) and mean strength (?Dst /MP duration) of over 35 super storms (DstMin < -250 nT) occurred since 1957, and their effects on the magnetosphere, ionosphere and thermosphere using available data. The results seem to suggest that the rapidness of the main phase development of the storms (or the rate of energy input at high latitudes) can indicate the severity of space weather events. When high amount of energy is input in a short duration (without fluctuations) and a long duration, the magnetosphere-ionosphere-thermosphere system will respond impulsively to the first case. The measurements of the rate of energy release during CMEs therefore seem useful to predict the severity of space weather events.

J8-16 OBSERVATION OF THE RADIATION ENVIRONMENT ON ISS DURING THE SOLAR PARTICLE EVENTS IN MARCH 2012

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The Liulin-5 charged particle telescope observes the radiation conditions in the spherical tissue-equivalent phantom of MATROSHKA-R international project on the International Space Station (ISS) since June 2007. In this paper attention is drawn to the results from measurements of the radiation parameters during the Solar Particle Events (SPEs) occurred 7-12.03.2012. During those SPEs the solar particles penetrated the ISS orbit at high geographic latitudes in the regions of the south and north Earth magnetic poles and at $3 < L$ they caused particle flux and dose rates increase in all three detectors of Liulin-5, located at 40, 60 and 165 mm depths along the phantom's radius. The

maximum flux at 40 mm depth observed outside the inner radiation belt in the region of South Atlantic Anomaly (SAA) during that SPE reached 7.2 part/cm².s and the dose rate reached 107.8 μGy/hour. The additional absorbed dose received from SPEs is approximately 180 μGy and additional dose equivalent is approximately 448 μSv. The additional exposures are comparable to the averaged daily absorbed dose and dose equivalent measured in the spherical phantom in ISS during quite radiation conditions.

Compared are the dose rates, particle fluxes, deposited energy spectra, linear energy transfer spectra, obtained radiation quality factors and dose equivalent values during the SPE and during quite conditions.

Compared are data from Liulin-5 charged particle telescope and from other particle and radiation detectors in space during those SPEs.

Compared are the results from radiation measurements on ISS during SPEs in March 2012 and data from SPE radiation environment investigations on Mir manned space station in 1989-1993 time periods, conducted with Liulin type dosimeters.

J8-17 LONG-TERM VARIATIONS OF DST-INDEX AND COSMIC RAYS IN 19-23 SOLAR CYCLES

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J8-18 EMPIRICAL STATISTICAL MODEL FOR PREDICTING GEOMAGNETIC STORM LEVELS BASED ON REMOTE SOLAR OBSERVATIONS

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One of main issues of space weather is prediction of strongly geoeffective events. Monitoring near-Earth interplanetary parameters can give a quite reliable prediction of the potentially harmful events, however the warnings precede the event only about 1 hour in advance (for monitoring spacecrafts at L1), providing very limited amount of reaction time. For early warnings one should try to employ remote solar observations instead. However, with current knowledge on the coronal mass ejections (CMEs), main drivers of largest geomagnetic storms, we are still not able to predict the arrival time, velocity and magnetic field, or even if it will entirely miss the Earth. Therefore, an empirical statistical model was established that can be used as an early geomagnetic storm warning.

For that purpose 211 front-sided, solar flare-associated CMEs with a minimal speed of 400 km/sec have been selected from the LASCO/SOHO catalog. Furthermore, association with a specific Dst (disturbance storm time) index was made. The resulting sample contains geoeffective and non-geoeffective CMEs, as well as CMEs that missed the Earth. An extensive statistical analysis was performed to determine the probability distributions for Dst depending on the CME and flare characteristics. Several CME and flare parameters were investigated, as well as the effect of successive CMEs occurrence to the change in the probability of certain Dst index values. The results confirmed some previously known connections between remote solar properties and geomagnetic storms, namely the importance of CME speed, apparent width, source position and associated solar flare type. For the first time we quantify these relationships and use them to construct a statistical model for predicting the probability of geomagnetic storm level based on remote solar observations of CMEs and flares.

This work has received funding from the European Commission FP7 Project COMESEP (263252).

J8-1p THE IONOSPHERE AND THE LATIN AMERICA VERY LOW FREQUENCY NETWORK MEXICO (LAVNET-MEX)

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The radiation emitted by the most energetic transient events in the solar system, solar flares, covers a wide range of wavelengths, from radio waves to gamma rays. When the transient excess of high energy radiation produced by solar flares reach the Earth environment, the upper layers of the Earth atmosphere are affected and highly disturbed. The dynamics (particularly the conductivity) of the ionosphere, is altered during solar explosive events. In order to detect and study the ionospheric response to the transient solar radiative input, we have constructed a VLF receiver station: the 'Latin American Very low frequency Network at Mexico' (LAVNet-Mex), which extends to the northern hemisphere the South American VLF Network. LAVNet-Mex detects electromagnetic waves generated by strong transmitters located around the world. These waves travel inside the Earth-Ionosphere waveguide, along the Great Circle Path formed between the emitter and the observer. By observing changes in the phase and amplitude of these

waves, it is possible to study the dynamics of the lower layer of the ionosphere during solar eruptive events. In this work we present preliminary results of the analysis of the effects of solar flares (class, C, M and X) occurred in the last three years and that were observed by LAVNet-Mex. We explore the relationship between VLF signals coming from different paths during these solar burst to infer the degree of correlation that can exist between different sectors of the ionosphere.

J8-2p THE CONTRIBUTION OF THE INTERPLANETARY OR IONOSPHERIC DISTURBANCES IN THE SCINTILLATION DETECTED IN 2012 BY MEXART

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The telescope MEXART running daily observations of stellar radio sources at 139.65 MHz, on several occasions we had the opportunity to detect almost simultaneously polar satellites transmitting in the band 137-142 MHz. We present observations, which were obtained during 2012 with these conditions and considering only stellar sources and polar satellite showed strong oscillations in their signals over the same period and located in the same region of the sky. Finally, we present a methodology that uses FFT and waves to analyze signals of oscillations of the stellar radio source and polar satellites associated with the aim of quantify the contribution of interplanetary or ionospheric events in the MEXART's observations.

J8-3p THE FAST SOLAR WIND AND CORONAL BRIGHT POINTS AT CORONAL HOLE...

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Nearly observations of ubiquitous coronal bright points (CBPs) in coronal holes (CHs) suggest that, perhaps they play an important role in coronal heating and solar wind (SW) acceleration. The study of CBPs inside coronal holes also helps to understand the magnetic field configuration in the coronal hole. Recent Karachik and Pevtsov (2011), show that the number of small magnetic bipolar structures also increases towards the center of CHs, which is typical of CBPs distribution. They found that although the reconnection processes occurring in CBPs may contribute to the fast SW, they do not serve as the main mechanism of wind acceleration.

In this paper we study temporal variation of parameters and number of CBPs at CH boundaries and identification maximums of the CBPs number and flux with solar wind data. We used calibrated full disk images for 2007 from the Extreme-ultraviolet Imaging Telescope (EIT) observed in 195 Å on board of the Solar and Heliospheric Observatory (SOHO). We used also data received from website ACE (Advanced Composition Explorer) and coronal mass ejection watch data from SOHO/LASCO.

J8-4p ON THE SENSITIVITY OF EXTRASOLAR MASS-LOSS RATE RANGES: HD 209458B A CASE STUDY

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We present a 3D hydrodynamic study of the effect that different stellar wind conditions and planetary wind structures have on the calculated Ly α absorptions produced by a cometary tail during transit. We concentrate, as a case study, on the known HD 209458b case. By comparing the numerically obtained Ly α absorption with the observations, we find that the planetary mass loss rate does not change dramatically for large changes in stellar wind speeds [400-1200] km s⁻¹ and temperature [0.1-2] 10⁶ K. The \dot{M} range found is $\sim[0.7-6.9] \times 10^{10} g s^{-1}$, with a smaller range, [3.9-4]10¹⁰ g s⁻¹, where there is no unique stellar wind speed. Several models with anisotropic evaporation profiles for the planetary escaping atmosphere were carried out, showing that both, the escape through polar regions, resembling the emission associated with reconnection processes, and through the night side, produced by a strong stellar wind that compresses the planetary atmosphere and inhibits its escape from the day hemisphere, yields larger absorptions than an isotropic planetary wind.

J8-5p A FIVE YEAR VALIDATION STUDY OF THE IRI-STORM MODEL

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The high degree of complexity which characterises physical interactions underlying the coupling of the magnetosphere-thermosphere-ionosphere system during geomagnetic storms is reflected on the spatial and temporal variations of ionospheric parameters. Despite the uniqueness of each event empirical modeling can encapsulate

and replicate underlying trends in the ionospheric response during these conditions. The International Reference Ionosphere (IRI) model includes an empirical Storm-Time Ionospheric Correction Model (STORM) extension to account for storm-time changes of the F layer peak electron density (NmF2) during increased geomagnetic activity. This model extension is driven by past history values of the geomagnetic index a_p (The magnetic index applied is the integral of a_p over the previous 33 hours with a weighting function deduced from physically based modeling) and it adjusts the quiet-time F layer peak electron density (NmF2) to account for storm-time changes in the ionosphere. In this investigation manually scaled hourly values of NmF2 measured during the main and recovery phases of selected storms during a six year period extending from 2008 to 2013 are compared with the predicted IRI-2012 NmF2 over ionospheric stations using the STORM model option. Based on the comparison a subsequent performance evaluation of the STORM option during this period is quantified.

J8-6p DEPENDENCE OF THE INJECTION BOUNDARY OF ENERGETIC IONS IN THE INNER MAGNETOSPHERE ON GEOMAGNETIC ACTIVITY

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The positions of the injection boundary for energetic (up to 50 keV) ions in the inner magnetosphere were determined using the data of AMPTE/CCE. Behavior of this boundary was analyzed for substorms of different intensity in the dusk-night sector of 18 - 02 MLT. It is revealed that the position of the injection boundary strongly depends on the value of AE index and is described by a power law function. Satellite measurements evidence that in the midnight sector energetic ions achieve a shell $L=3.0$ as soon as 20-30 minutes after the onset of substorm with $AE > 500$ nT. The work is partially supported by the RAS program P22.

J8-7p SPACE RADIATION ENVIRONMENT IN LOW EARTH ORBIT

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Space radiation environment in low earth orbit is less severe as compared with that at Geo-Stationary orbit because of shielding effects of the geomagnetic field and the atmosphere. However, space radiation environment both in the polar region and the horn region is sometimes strongly disturbed due to large solar and geomagnetic events, in addition that the South Atlantic Anomaly region always has radiation influence. In order to evaluate space radiation environment in low earth orbit, the Technical Data Acquisition Equipment for measurements of high-energy electrons and protons had been operated on board the Advanced Land Observing Satellite in polar earth orbit at 700 km altitude from 2006 through 2011. In this paper, space radiation environment in low earth orbit during influences from solar and geomagnetic events observed by this equipment is reported.

J8-8p GLOBAL EMPIRICAL MODEL OF TEC RESPONSE TO GEOMAGNETIC ACTIVITY

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A global TEC model response to geomagnetic activity described by the Kp-index is built by using the CODE TEC data for full 13 years, January 1999- December 2011. The model describes the geomagnetically forced changes of the TEC assuming that these changes at a given modip latitude depend mainly on Kp-index, LT and longitude. The geomagnetic changes are expressed by the relative deviation of TEC from its 15-day median, i.e. $rTEC = (TEC_{obs} - TEC_{med}) / TEC_{med}$. The rTEC response to the geomagnetic activity is presented by a sum of two responses with different time delay constants and with different sign of the cross-correlation function. It has been found that the mean dependence of rTEC on Kp-index can be expressed by a cubic function. The LT dependence of rTEC is described by Fourier time series which includes the contribution of four diurnal components with periods 24, 12, 8 and 6 hours. The rTEC dependence on longitude is presented by Fourier series which includes the contribution of zonal waves with zonal wavenumbers up to 6. The presented TEC model fits to the CODE TEC input data with small negative bias of -0.204 and RMSE=4.592 and STDE=4.588. The model offers TEC maps which depend on geographic coordinates (5x5o in latitude and longitude) and UT at given geomagnetic activity and day of the year.

J8-9p METHODS OF ANALYSIS OF IONOSPHERIC PARAMETERS AND DETECT ANOMALIES DURING PERIODS OF HIGH SOLAR AND SEISMIC ACTIVITY

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The work is focused on the development of technologies and software systems for the analysis of the ionospheric data and detect anomalies that occur during periods of ionospheric disturbances. The paper describes a method of

modeling and analysis of the ionospheric parameters which is based on the combination of multi-resolution analysis with autoregressive (AR) models. Models of calm (background) move the critical frequency of the ionosphere and the total electron content (TEC) over Kamchatka and Magadan were built. The method allows to make forecast with increments advance five hours and to detect anomalies that develop during increased solar activity and before strong earthquakes in Kamchatka. The method of modeling and analysis of ionospheric data can also be used to solve the problem of filling gaps in them with the diurnal and seasonal variation. The method is proposed for approximation of a time series of the critical frequency of the ionosphere, based on a combination of multiscale analysis and neural networks of variable structure. Method allows performing a detailed data analysis and localizing anomalies that arise during periods of increased solar and seismic activity in Kamchatka. Effectiveness of a method is proved on basis of processing the long time series of data.

J8-10p WAVELET ANALYSIS TO ELIMINATE THE CONTRIBUTION BY IONOSPHERIC DISTURBANCES FROM MEXART DATA

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In this work we will present a program that use wavelet tools to select those frequency ranges where ionospheric disturbances can have important effects on the observational data from the Mexican Array Radio Telescope (MEXART). We present some of the complications that we faced in this kind analysis also we will present specific examples where we have applied the program, and how there were cases where the geomagnetic indices, Dst, and the vertical Total Electron Content, vTEC, can play a role for discriminate largely ionospheric effects on the daily radio-sources observed with MEXART.

J8-11p ON THE PREDICTABILITY LIMIT OF A MEAN-FIELD FLUX TRANSPORT SOLAR DYNAMO MODEL AND ITS IMPLICATIONS FOR SOLAR ACTIVITY FORECASTING

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Space weather is a matter of practical importance in our modern society, challenging forecasters to predict future solar cycle amplitudes and duration. In many cases, predictions are based on mean-field solar dynamo models. Concerned with the forecast horizon of such studies, we quantify the predictability window of a mean-field dynamo model, by investigating its sensitivity to initial conditions through a perturbation analysis, which allows us to monitor the difference between the trajectories of two initially very close solutions (which we term the error growth). We measure the rate associated with the exponential growth of the error, leading to a characteristic time scale, known as the e-folding time. The e-folding time sensitivity to the control parameters is tested, showing a general anti-correlation with the dynamo numbers, which represent turbulence and non-linear coupling. Conversely, increasing the meridional circulation, meaning a more advection-dominated regime, stabilizes the system, leading to greater e-folding time. Comparing the dependency of the two main time scales of the problem - the e-folding time and solar cycle periodicity - on the control parameters, we propose an estimate of the e-folding time of 2.86 solar cycles. From a practical point of view, the perturbations carried out in this work can be interpreted as uncertainties in measurements and model errors, for which the predictability window is can be calculated. Taking into account the more representative errors embedded on the mean-field models typical parametrizations, the predictability window covers 3 solar cycles, while from the inherited observational uncertainties, the practical limit of predictability extends over 6 solar cycles. In light of these results and assuming i) that the model accounts for a good representation of the physics of the solar dynamo and ii) that it is placed at the heart of a robust data assimilation framework, the amplitudes of the activity of the solar cycle may thus be predicted over a range of 3 solar cycles (approximately 30 years).

J8-12p AUTOMATED TOOLS FOR ANALYSIS AND ASSESSMENT OF THE EARTH'S MAGNETIC FIELD

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The work is connected with the monitoring and prediction a state of the near-Earth space and aimed to creation tools for improving the methods and approaches to the tasks of research processes in the magnetosphere during disturbed periods. A wide network of stations recording data offers the prospect of getting a new knowledge about the processes in the magnetosphere and provides an opportunity to study their spatial and dynamic features. The complexity of the studied processes, their a priori uncertainty and, that's why- the complex structure of the registered data require a whole range of methods and technologies to perform modeling, structural analysis and interpretation of the results.

Based on the wavelet-packet authors have developed a method and the program system for calculating K-index by the method of Bartels. Approbation of the developed system for data from different stations has revealed that she can significantly improve the accuracy of calculation of the K-index in the automatic mode, compared with the system used in the global network of magnetic observatories.

Authors, based on wavelet transform, developed the method allocating local disturbances in the geomagnetic field and the evaluation of their intensity. The method allows to allocate the geomagnetic perturbations, proportional to the total power of magnetic disturbances in the magnetic station, and can be implemented in the automatic mode, close to real time. Unlike K-index, method allows the evaluation of perturbation for any interval of time (1 minute, 2.5 minutes and at hourly intervals), and provides the detailed information about the structure of the magnetic field fluctuations.

SESSION J10

DIV. II/III/ICMA ENERGETIC PARTICLE PRECIPITATION INTO THE ATMOSPHERE: SOURCES AND CONSEQUENCES

J10-1 EARLY RESULTS FROM THE BARREL 2013 BALLOON CAMPAIGN

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BARREL is a multiple-balloon investigation designed to study electron losses from Earth's Radiation Belts. Selected as a NASA Living with a Star Mission of Opportunity, BARREL augments the Van Allen Probes by providing measurements of relativistic electron precipitation. The first of two campaigns was completed in January - February 2013, with the second planned for the same time next year. A total of 20 small (~20 kg) stratospheric balloons were successively launched from two Antarctic research stations (SANAE IV and Halley VI) to maintain an array of 5-7 payloads in the region that magnetically maps to the radiation belts. Conjunctions between the balloons and the Van Allen Probes were obtained during storm-times. Each balloon carries an X-ray spectrometer to measure the bremsstrahlung X-rays produced by precipitating relativistic electrons as they collide with neutrals in the atmosphere, and a DC magnetometer to measure ULF-timescale variations of the magnetic field. BARREL provides the first balloon measurements of relativistic electron precipitation while comprehensive in situ measurements of both plasma waves and energetic particles are available. We present an overview of the mission and a summary of early results

J10-2 ENERGETIC ELECTRON PRECIPITATION CHARACTERISTICS OBSERVED FROM ANTARCTICA DURING A FLUX DROPOUT EVENT

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We compare and contrast AARDVARK ground-based observations of energetic electron precipitation events in Antarctica, which occurred over a moderately active 24-hour period on 27 February 2012, with POES and GOES satellite observations. The Autonomous AARDVARK systems (solar and wind powered, VLF receivers) installed in remote areas of the Antarctic are used to monitor very low frequency (VLF) signals from a powerful man-made transmitter located in Hawaii (NPM, 21.4 kHz, 600 kW) to observe changes in subionospheric radio wave propagation conditions caused by processes occurring in the outer radiation belt. In the first analysis of data from two Autonomous AARDVARK systems installed in the Antarctic in January 2012, we show that bringing together of all of the instruments to study individual events is a powerful technique, yielding significant insight into the radiation belt processes involved. The events studied here occurred during the onset and main phase of a moderate storm, during which the electron outer radiation belt flux declined at most energies. Different driving mechanisms were observed for the precipitation events with clear signatures in phase space density and electron anisotropy, evidence of weak and strong diffusion into the bounce-loss-cone, and energy-dependent variations in electron flux enhancements or losses as observed by the satellites.

J10-3 COMPARISON BETWEEN POES ENERGETIC ELECTRON PRECIPITATION OBSERVATIONS AND RIOMETER ABSORPTIONS; IMPLICATIONS FOR DETERMINING TRUE PRECIPITATION FLUXES
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Observations from the Polar Orbiting Environmental Satellites (POES) satellites Medium Energy Proton and Electron Detector (MEPED) are widely used to provide measurements of energetic electrons precipitating into the mesosphere. These satellites have provided one of the few long-lived datasets of electrons in the ~30keV to ~1 MeV range. Some studies have gone so far as to use the MEPED energetic electron observations to produce models of the time-changing electron precipitation input into the mesosphere. However, other studies have argued that there are significant issues with the MEPED telescopes, including contamination of the electron observations by low-energy protons, contamination of all observations during solar proton events, and uncertainties in the fraction of the total bounce loss cone observed by the MEPED telescopes.

Recently, correction algorithms have been put forward which purport to correct for low-energy proton contamination. By considering periods outside of solar proton events, we attempt to validate the POES/MEPED electron fluxes into the atmosphere. In particular we consider the importance of the viewing angle of the electron telescopes, which is a small fraction of the total bounce loss cone, such that the telescope may not detect all of the precipitation occurring. In this study we make use of the long-term cosmic noise absorption observations made by the IRIS riometers located at Kilpisjarvi, Finland, and contrast with the absorption changes predicted from the POES/MEPED electron precipitation observations.

J10-4 SOLAR TRANSIENTS DISTURBING THE HIGH LATITUDE MAGNETIC ENVIRONMENT

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In the present study we have investigated the geomagnetic field variations during five major Solar Energetic Particle (SEP) events of solar cycle 23. The SEP events of 01 October 2001, 04 November 2001, 22 November 2001, 21 April 2002 and 14 May 2005 were selected to study the geomagnetic field variations at two high-latitude stations, Thule (77.5°N, 69.2°W) and Resolute Bay (74.4°E, 94.5°W) of the northern polar cap. We used the GOES proton flux in seven different energy channels. All the proton events were associated with geoeffective or Earth directed CMEs that caused intense geomagnetic storms. We also used the high-latitude indices, AE and PC, for the study and correlated these with the ground magnetic field records during the five proton events. The departures of the H component during the events were calculated from the quietest day of the month for each event and have been represented as ?H_{THL} and ?H_{RES} for Thule and Resolute Bay respectively. We constructed the event integrated spectra for each particle event and then computed the spectral index or power law index by fitting each spectrum. The correspondence of spectral index, a parameter describing the particle flux characteristics, with ground magnetic signatures ?H_{THL} and ?H_{RES} along with Dst and PC indices were brought out. From the correlation analysis we found that a very strong correlation exists between the geomagnetic field variation (?H_s) and high latitude indices AE and PC. To find the association of geomagnetic storm intensity with proton flux characteristics we derived the correspondence between the spectral indices and geomagnetic field variations (?H_s) along with the Dst and AE index. We found that a strong correlation (0.88) exists between the spectral indices and ?H_s and also between spectral indices and AE and PC.

J10-5 PRECIPITATING RADIATION BELT ELECTRONS AND ENHANCEMENTS OF MESOSPHERIC HYDROXYL.

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Energetic particle precipitation affects the middle atmospheric neutral chemistry and ozone balance, e.g. through production of odd hydrogen (HO_x). Using measurements from the Microwave Limb Sounder (MLS/Aura) and Medium Energy Proton and Electron Detector (MEPED/POES) between 2004-2009, we study the effect of energetic electron precipitating from radiation belts on nighttime OH at geomagnetic latitudes 55 - 65°. Our correlation analysis indicates that electron precipitation has a clear effect on mesospheric OH mixing ratios during time periods when high electron count rates are observed. Because the time period 2004-2009 analyzed here coincided with an extended solar minimum, and the year 2009 was anomalously quiet, it is reasonable to assume that our results provide a lower-limit estimation of the importance of energetic electron precipitation at the latitudes considered. We also investigate

the longitudinal variations of the OH caused by energetic electron precipitation, compare the results with MEPED precipitation maps, and discuss the similarities and differences.

J10-6 DETERMINING FITS FOR PRECIPITATING ENERGETIC ELECTRON ENERGY SPECTRA FROM MULTIPLE SATELLITES

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There is a need to understand the physical drivers causing radiation belt electron flux dynamics, thus enabling the development of predictive models. This requires physical understanding of the drivers leading to the enhancements in radiation belt fluxes, as well as those of loss.

This study uses the DEMETER/IDP instrument to investigate energetic electron spectra in the bounce and drift loss cone at Low Earth Orbit. Observations of sampled electron flux are taken along each orbit (with equal time spacing) and combined to find the best fitting method to describe the precipitating electron energy spectra. The methods tested are exponential, power-law and kappa-type distribution.

Upon testing these methods we determine that the power law gives the best results over all. Values for the typical power law fitting parameters are given, linked to McIlwain L shell position and geomagnetic activity. The process of electron spectrum change and recovery after a geomagnetic storm is also examined and equations given to approximate the sharpness difference with time.

The kappa-type distribution is further investigated by fixing some of the three variables and re-fitting to determine how useful it will be in future studies. The method appears to work best when the DEMETER instrument is in 'burst mode' (high time and spatial resolution) but not in the usual 'sample mode'. The results of the DEMETER spectra are then used to compare to the much larger data set from the POES satellites. This comparison shows how the data sets can be combined to get an accurate fitting to the lower energy resolution observations given in the very long timeperiod POES dataset.

J10-7 ELECTRON PRECIPITATION OBSERVED BY A BROAD-BAND RIOMETER

J10-8 Kero, Antti; Vierinen, Juha; McKay-Bukowski, Derek; Enell, Carl-Fredrik; Sinor, Malefia; Roininen, Lassi; Virtanen, Ilkka

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The first broad-band riometer measurement on the energetic electron precipitation is presented. In this experiment, the cosmic radio noise is monitored by the LOFAR radio astronomy telescope with 244 narrow frequency bands ranging between 10-80 MHz. Inversion of the received radio noise power into the corresponding electron density profiles and characteristic precipitation parameters is discussed. The results are compared against a simultaneous and nearly co-located incoherent scatter radar measurement.

J10-9 WAVE-PARTICLE INTERACTION AND PRECIPITATING ENERGETIC IONS/ELECTRONS IN PLASMASPHERIC PLUMES

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The wave-particle interaction is an important candidate for the energy coupling between the inner magnetosphere and ionosphere in plasmaspheric plumes. In this report, we show our recent progress in wave-particle interaction and precipitating energetic ions/electrons in plasmaspheric plumes with conjugate observations of satellites and ground-based instruments. A direct proof has been shown that electromagnetic ion cyclotron (EMIC) waves can be generated in the plasmaspheric plume and scatter RC ions to cause subauroral proton arcs. Both EMIC waves and extremely low frequency (ELF) hiss were simultaneously observed in the plasmaspheric plume. In the region where the EMIC waves were observed, the pitch angle distribution of ions becomes more isotropic, likely due to the pitch angle scattering by the EMIC waves. It is shown that the ELF hiss and EMIC waves are spatially separated: the ELF hiss is located in the vicinity of the electron density peak within the plume while the EMIC waves are detected in the outer boundary of the plume because of the different propagation characteristics of the ELF hiss and EMIC waves. As a result, the peak of precipitating electron flux was equatorward to that of precipitating proton flux at ionospheric altitudes. In addition, we have also presented characteristic of precipitating ring current (RC) ions/electrons and precipitating radiation belt electrons associated with wave-particle interactions in the plasmaspheric plume.

J10-10 POES SATELLITE OBSERVATIONS OF EMIC-WAVE DRIVEN RELATIVISTIC ELECTRON PRECIPITATION DURING 1998-2010**Carson, Bonar R.; Rodger, Craig J.; Clilverd, Mark A.**

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Using six satellites that have carried the SEM-2 instrument package, a total of 436,422 individual half orbits between 1998 and 2010 were inspected by an automatic detection algorithm searching for EMIC-driven relativistic electron precipitation (REP). The algorithm searched for one of the key characteristics of EMIC-driven REP, identified as the simultaneity between spikes in the P1 (52 keV differential proton flux channel) and P6 (>800 keV electron channel). In all, 2,331 proton precipitation associated REP (PPAREP) events were identified. The majority of events were observed at L-values within the outer radiation belt ($3 < L < 7$) and were more common in the dusk and night sectors as determined by MLT. The majority of events occurred outside the plasmasphere, at L-values ~ 1 Re greater than the plasmopause location determined from two different statistical models. The events make up a subset of EMIC-driven proton spikes investigated by Sandanger et al. [2009], and potentially reflect different overall characteristics compared with proton spikes, particularly when comparing their location to that of the plasmopause, i.e., EMIC-driven proton precipitation inside the plasmopause, and potentially EMIC-driven REP outside the plasmopause. There was no clear relationship between the location of plasmaspheric plumes and the locations of the PPAREP events detected. Analysis of the PPAREP event occurrence indicates that high solar wind speed, and high geomagnetic activity levels increase the likelihood of an event being detected. The peak PPAREP event occurrence was during the declining phase of solar cycle 23, consistent with the 2003 maximum in the geomagnetic activity index, A_p .

J10-11 UTILISING POES SATELLITE OBSERVATIONS TO ESTIMATE TYPICAL ENERGETIC PARTICLE FLUXES FOR EMIC-WAVE DRIVEN PRECIPITATION EVENTS**Hendry, Aaron; Rodger, Craig; Carson, Bonar; Clilverd, Mark**

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For some time theoretical modelling has shown that electromagnetic ion cyclotron (EMIC) waves should play an important role in the loss of relativistic electrons from the radiation belts, through precipitation of the electrons into the atmosphere. The same wave will also resonant with comparatively low-energy protons, precipitating them into the atmosphere. Proton resonance with counter-streaming EMIC waves is much like the electron-cyclotron resonance common with whistler mode waves, though with different interaction energies. Relativistic electron resonance takes place through “anomalous resonance” where the electron overtakes the wave. Until recently, it was thought that EMIC wave scattering interactions were limited to electrons with energies $>1-2$ MeV. Recent calculations [Omura et al., JGR, 2012] have suggested that this lower limit may be as small as 100 keV when considering EMIC waves which are more like those experimentally observed (i.e. non constant frequency which ramps with time). We have recently begun a study to determine the typical flux seen by the ionospheric D-region during an EMIC driven precipitation event, in order to link this to plasmaspheric conditions. In this presentation we will investigate a very large set of EMIC-driven relativistic electron precipitation events detected using data from the POES satellite constellation [Carson et al., JGR, 2013]. As part of this study, we investigate the response of the MEPED instruments on-board the POES satellites to better characterise the EMIC-driven precipitation. Using the results of a previously reported Monte-Carlo simulation of the MEPED electron and proton telescopes [Yando et al., JGR, 2011], we produce an estimate of the typical precipitating electron and proton fluxes in the bounce loss cone for these events. While the precipitating proton energy range is as expected, the observed MEPED observations can only be reproduced if we allow electron energies <100 keV, as well as a significant relativistic electron component. We go on to show that such events will produce very significant D-region changes.

J10-12 OBSERVATIONS OF EMIC WAVES IN THE RADIATION BELTS USING GROUND INSTRUMENTS, BALLOONS, AND SATELLITES: STATISTICAL RESULTS AND CIR/CME CASE STUDIES.**Weaver, Carol; Lessard, Marc; Engebretson, Mark; Millan, Robyn; Halford, Alexa; Lindgren, Erik; Horne, Richard; Singer, Howard; Mann, Ian; Usanova, Maria**

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The spatial and temporal extent of electromagnetic ion-cyclotron (EMIC) waves has been investigated for many years. Three new observational studies are calling into question the current understanding of EMIC waves being detected primarily in the dusk region and the conditions under which the waves can be generated. In April 2010, a CIR-type storm led to global (ground based) observations of EMIC waves at local magnetic noon. The generation of the waves continued for three to four days in very quiet conditions, leading to the question of how a temperature

anisotropy persisted for days around magnetic noon with little solar wind input. During a recent CME-driven storm (17 January 2013), EMIC waves were detected on the nightside at GOES 13 & 15, Van Allen Probes A & B, Halley, and several CARISMA ground stations, across at least 10 hours of MLT and 4 L-shells, in conjunction with a solar wind pressure increase. The waves were accompanied by electron precipitation detected by Balloon Array for RBSP Relativistic Electron Losses (BARREL) balloons mapped to near geosynchronous orbit. The temporal and spatial range of the generation region appears to be much larger than suggested by previous studies. Statistical data from Halley, Antarctica show that since 2008, EMIC waves occur more often and are detected at higher frequencies (> 1 Hz), contrary to previous studies stating EMIC waves peak at solar minimum. It is suggested that increased solar activity is driving temperature anisotropies closer to Earth (at larger magnetic field strength), thus elevating the wave frequency. All three studies call into question the canonical understanding of EMIC waves.

J10-13 INITIAL RESULTS FROM THE ELECTRIC AND MAGNETIC FIELD INSTRUMENT SUITE AND INTEGRATED SCIENCE (EMFISIS) ON THE VAN ALLEN PROBES

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The physics of the creation, loss, and transport of radiation belt particles is intimately connected to the electric and magnetic fields which mediate these processes. A large range of field and particle interactions are involved in this physics from large-scale ring current ion and magnetic field dynamics to microscopic kinetic interactions of whistler-mode chorus waves with energetic electrons. To measure these kinds of radiation belt interactions, NASA implemented the two-satellite Van Allen Probes mission. As part of the mission, the Electric and Magnetic Field Instrument Suite and Integrated Science (EMFISIS) investigation is an integrated set of instruments consisting of a tri-axial fluxgate magnetometer (MAG) and a Waves instrument which includes a tri-axial search coil magnetometer (MSC). These wave measurements include AC electric and magnetic fields from 10 Hz to 12 kHz and single-axis electric field measurements from 10–400 kHz. We show examples of plasmopause identification and variation determined by the upper hybrid resonance, low frequency ULF pulsations and EMIC waves, and whistler mode waves including upper and lower band chorus. These data are compared with particle measurements to show relationships between wave activity and particle energization.

J10-14 PERIODIC STRONG RADAR ECHOES IN SUMMER POLAR D-REGION (PMSE) CORRELATED WITH THE OSCILLATIONS OF HIGH SPEED SOLAR WIND STREAMS AND AE INDEX.

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Periodic oscillations of polar mesospheric summer echoes (PMSE) are observed as correlated with, and in phase with, oscillations of high speed solar wind streams (HSS) and AE index between June 1–August 8 in the solar minimum years 2006 and 2008. PMSE (80–90 km altitude) were observed by 52 MHz VHF radar measurements at Esrange (67.8°N, 20.4°E). The correlation between PMSE counts, AE and HSS is primarily found at 7-, 9- and 13-day and 5.5-, 9- and 13.5-day periodicities in 2006 and 2008, respectively. The observations show that the effects of HSS penetrate down to the polar D-region to at least 80–90 km altitude. The effect on PMSE is likely due to precipitation of energetic particles, and may also be associated with optical emissions. PMSE measurements offer new possibilities to determine the footprint of high-energy electrons precipitating into the polar middle atmosphere caused by high-speed solar wind streams.

J10-15 A STATISTICAL APPROACH TO DETERMINING ENERGETIC OUTER RADIATION-BELT ELECTRON PRECIPITATION FLUXES

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This work builds on the preliminary study undertaken by Clilverd et al. [2011] in which trans-Atlantic VLF radio waves were used to estimate the flux of energetic electrons precipitating into the D-region of the ionosphere. The great circle sub-ionospheric propagation path from the NAA transmitter in Cutler, Maine, USA, to a receiver in Sodankylä, Finland, provided some estimate of precipitating electron fluxes which had originated from the

outer radiation belt ($3 < L < 7$). Obliquely propagating VLF radio waves can be used to monitor electron precipitation through changes in the ionization rate at altitudes of 50-90 km. However, Clilverd et al. [2011] identified several limitations in the analysis technique used, particularly in assuming uniform precipitation over the whole propagation path, and an unchanging energy spectral gradient of the incident electrons. A further limitation of the analysis was not providing a robust error estimate for the derived fluxes, nor a check of the reliability of the electron precipitation flux calculations. In this study we analyse data from an AARDDVARK receiver located in Churchill, Canada, and concentrate on signals from two US transmitters (call signs NAA, and NDK). We show analysis from a period of enhanced geomagnetic activity, which induced changes in the radiation belt environment through enhancing relativistic electron fluxes, in July-August 2010. We combine the data from the two transmitters in order to confirm estimated fluxes, calculate the error bars, and inter-compare the results.

J10-16 LONGITUDINAL DEPENDENCE OF PRECIPITATED ELECTRONS FLUXES OVER THE AUSTRAL AURORAL ZONE

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The existence of a longitudinal dependence of precipitated electrons over the austral auroral zone has been suggested for many years. The suggestion follows from the known longitudinal dependence of energetic particles at middle latitudes over the south Atlantic geomagnetic anomaly. A climatology for the austral auroral zone is usually built binning together observations from different longitudes for a given local time, thus precluding the determination of a possible longitudinal dependence. This binning is sometimes needed to achieve adequate spatial and temporal resolutions. Here, a longitudinal dependence of the precipitated electron flux is determined using observations made by the SEM-2 instrument on board NOAA_POES satellites over 13 years. Energy spectra of the directional differential electron flux are determined assuming a Maxwellian distribution applies. Fluxes for 10, 20 and 30 keV are binned for corrected geomagnetic latitude and longitude (altitude dependent version), magnetic local time and geomagnetic and solar activity levels. A Gaussian latitudinal variation of fluxes is assumed to apply for all cases. Longitude dependencies of the maximum flux latitude and latitudinal spread are then determined for all three energy levels corresponding to each magnetic local time and geomagnetic and solar activity levels. A weak longitudinal dependence is found for 10 keV electrons with a broad maximum between 275° y 325° and minimum between 100° y 150° for the 18:00 - 22:00 MLT interval. An even weaker dependence is found for the 22:00 - 02:00 interval; the extremes being nearer 0° . No clear longitudinal dependence is apparent during daytime. This dependency is not consistent with previous results for the Meteor and Intercosmos-Bulgaria satellites. Results for larger energy and geomagnetic activity level are not systematic. An attempt is made to associate satellite results with radio wave absorption observations using Antarctic riometers.

J10-17 EXTERNAL ELECTRON RADIATION BELT: DISCOVERY, MODELS AND MECHANISMS OF ACCELERATION OF RELATIVISTIC ELECTRONS - "SATELLITE KILLERS"

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The nature of the formation of the external electron radiation belt and appearance of extremely large fluxes of relativistic electrons (satellite killers) continues to be one of the most intriguing and unsolved problems of magnetospheric dynamics. The history of the discovery of the external radiation belt and different periods of its study are analyzed. The main attention is concentrated on the researches made in Skobeltsyn Institute of Nuclear Physics Lomonosov Moscow State University. One of the most important results of such research is the proof of the inner magnetosphere position of the region of acceleration of relativistic electrons. Such position is determined by the minimal value of Dst variation during magnetic storm in accordance with Ludmila Tverskaya relation. The suggested explanations of such dependence are discussed taking into account the nonlinear distortions of the magnetic field by increased plasma pressure during magnetic storms. The appearance of the seed population of relativistic electrons, stochastic and regular mechanisms of electron acceleration are discussed. Results demonstrating the role of the processes at the regions mapped at the auroral oval latitudes in the acceleration of relativistic electrons are analyzed.

J10-18 ON THE FULL-WAVE APPROACH TO THE PROBLEM OF LOWER HYBRID REFLECTION OF WHISTLER-MODE WAVES IN THE IONOSPHERE

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Quasi-resonance whistler-mode waves propagating in the magnetosphere are known to be reflected from the region where the local lower hybrid resonance frequency (LHR frequency) is above the wave frequency. Such

LHR reflection gives rise to the well-known wave phenomenon called magnetospherically reflected whistlers. The peculiarity of LHR reflection is that the perpendicular (with respect to the external magnetic field) component of wave vector remains, in a sense, large in the process of reflection. Thus, this process is a kind of refraction which can be described in the framework of geometrical optics. Indeed, LHR reflection has been comprehensively studied using this approach. But its applicability is not so obvious. The point is that LHR reflection can occur at the heights about 300 km. At such heights the collisional damping of the wave should be taken into account. Although there are some extensions of geometrical optics to the cases when the anti-Hermitian part of dielectric tensor is of the order of Hermitian part, the calculations, especially for the wave amplitude, become not straightforward.

In present work, we propose a full-wave approach which allows to avoid the aforementioned difficulties and takes into account the damping of a wave in a natural way. Using this method we have calculated the reflection coefficient as a function of wave frequency for different profiles of the ionospheric plasma parameters. Dependency of the reflection coefficient on wave frequency was found to be nonmonotonic, thus pointing out to the presence of interference between incident and reflected waves in the region where absorption is not negligible. Besides, we have performed calculations of the transmission coefficient at the height of 350 km. The point is that the quasi-resonant waves, if not reflected above such heights, can be attenuated very significantly already in the F-layer. So it could be a problem for the models of whistler-mode wave propagation which explain whistler exit to the ground as a result of scattering from the F-region irregularities. Our results show that the damping is very intense for the day-time ionosphere, but it is not essential for the night-time ionosphere, thus not posing a problem for scattering in this case.

J10-19 VARIATIONS IN CUTOFF LATITUDE AND IMPLICATION FOR THE DISTRIBUTION OF PARTICLE DEPOSITION DURING SOLAR PROTON EVENTS

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The access of solar protons into the Earth's magnetosphere is mainly controlled by the magnetospheric magnetic field and the particle cutoff energy. In particular, protons with energies less than 20 MeV are known to have a complicated dynamics with e.g. strong day-night asymmetries. These protons will deposit most of their energies in the middle atmosphere (60-100 km), and knowledge of their latitudinal and local time distribution is crucial for determining their effect on the chemistry and dynamics in the atmosphere.

NOAA/POES 15-19, and the METOP02 satellites are orbiting the Earth in polar, sun-synchronous orbits. Combined measurements from the Medium Energy Proton and Electron Detector (MEPED) and the OMNI detectors cover the proton energy range: 30 keV-70 MeV. We investigate the latitudinal cutoff and the energy deposition during several solar proton events. The energy deposition predicted by the POES satellites at different latitudes and local times are compared to the energy deposition estimated from the energetic particle measurement from the geostationary GOES satellites. The strengths and weaknesses of the different measurements are discussed in respect of how to best quantify the particle energy deposition into the middle atmosphere.

J10-10p CORRELATION BETWEEN MESOSPHERIC OZONE AND ENERGETIC PARTICLE PRECIPITATION OVER TROLL, ANTARCTICA IN THE YEARS 2008 AND 2009

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The British Antarctic Survey radiometer stationed at Troll, Antarctica (72S, 2.5E, L=4.76) measured ozone in the lower mesosphere and upper stratosphere from February 2008 until February 2010. By looking at anomalies in the polar-winter nighttime ozone, we are able to quantify the influence of Energetic Particle Precipitation (EPP) on ozone during these two years. Time-lagged correlations between geomagnetic indices (AE, Kp and Dst) and ozone anomalies as a function of height have been calculated to quantify which of the indices best accounts for the variability in the ozone. In addition, the MEPED instruments aboard the NOAA satellites have been used to quantify the EPP flux precipitating over Troll. Since the solar activity in 2008 undergoes a strong periodicity, which is linked to rotating coronal holes, this periodicity is also manifested in the EPP and the geomagnetic indices. A correlation analysis between the ozone over Troll and the periodic solar activity that is reflected in the EPP is also carried out, resulting in a statistical quantification of the EPP effects on mesospheric ozone as measured over Troll, Antarctica.

J10-11p A CASE STUDY OF ENERGY DEPOSITION BY MAGNETIC CLOUD ELECTRONS AND PROTONS IN THE ANTARCTIC ATMOSPHERE

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Several possible characteristics of magnetic cloud (MC) have been discussed in the literature, but none seem to explain all the effects from accumulated observations. The characteristics range from low proton temperature and

plasma beta, to high magnetic field magnitude, to smooth rotation in the magnetic field direction, thus, results to strong geomagnetic disturbances. The varied instrumentation which is located not only at SANAE IV, Antarctica, but also those at Halley, another L= 4 location in the southern hemisphere, and other locations at the vicinity of its conjugate in northern hemisphere provide an opportunity to test the theories applied to high latitude energy deposition on arrival of MC. The Halley riometer is used to monitor coincidences of absorption with arrival of MC that was observed on 8 November 2004. Precipitating particles were also monitored to test a large uncertainty as to which energy range of precipitating electrons or protons is more important in terms of their effects on atmospheric chemistry. The energy deposited by electrons and protons in the atmosphere during this event was studied by using the NOAA/POES satellites measurements over regions of interest as input into the Monte Carlo Energy Transport Model (MCETM). Based on preliminary analysis, it was found that the mean electron energy deposition peaks at 90 km for Antarctic atmosphere whereas it is 100 km for conjugate. The corresponding heating rates of energy deposited indicate importance of MC triggered geomagnetic storm on mesosphere dynamics.

J10-12p DETERMINATION OF NOAA MEPED CORRECTION FACTORS - EVALUATION OF DIFFERENT METHODS

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The MEPED instruments onboard the NOAA/POES satellites have continuously been measuring energetic particles since 1978. However, degradation of the detectors over time lead to an increase in the energy thresholds of the instrument and imposes great challenges to long term studies as well as a general quantification of the particle fluxes. An earlier attempt at correcting the MEPED proton measurements by Asikainen et al (2011 and 2012) are largely based on criteria which identifies events where two satellites are sampling the same region of space at the same time. The criteria are not fulfilled for all satellite pairs, and generally, few conjunctions are identified.

We will present multiple methods that stray from the criteria of being in the same space and time to obtain correlation factors for the MEPED particle detector. The different approaches target different latitudes intervals, magnetic local times, and geomagnetic conditions. They are both event based and statistical. The results for the different methods, as well as the results of Asikainen, will be compared and discussed.

J10-13p IONOSPHERIC RESPONSE TO INTENSIFICATION IN ENERGETIC PARTICLE PRECIPITATION IN THE SAMA/BRAZILIAN REGION DURING A MAGNETIC STORM

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In this work we investigate the influence of the enhanced energetic particle fluxes in the South Atlantic Magnetic Anomaly (SAMA) region, on the dynamic of the equatorial ionosphere over Brazilian sector during a magnetic storm event. Due to the weaker intensity of the geomagnetic field over the SAMA the energetic particles of the Van Allen radiation belt can penetrate into the lower altitudes of the ionosphere (~100 km). In this range of altitude these particles can cause enhanced ionization and consequently modify the conductivity spatial distribution in the E region (Abdu et al. 2005). Considering that the E and F ionospheric regions are connected through highly conducting magnetic field lines, the storm induced conductivity distribution can modify the electrodynamics of the equatorial ionosphere. The main focus of this study is to examine what is the response of the F region to an increase in the Hall conductivity of the E region possibly caused by intensification in the particle precipitation over SAMA region during a disturbed time.

J10-14p MONITORING OF IONIZING RADIATION FROM RADON GAS (RN 222) IN THE SÃO JOSÉ DOS CAMPOS - BRAZIL REGION

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INTRODUCTION:

Ionizing radiations are present in our daily lives, they are originated by nature or manmade. This job presents results of ionizing radiation dose from Radon gas (Rn 222). Radon is a natural gas that originates by the decay series of Uranium and Thorium, it is in all locations of the Earth's crust. The isotope Rn 222 is alpha and gamma emitter and a half-life of 3.82 days ($E_{\alpha}=5.49$ MeV), from its decay originate Po 218 and Po 214 which are responsible for around 50% of natural ionizing radiation on Earth. According to the American Journal of Epidemiology (2002), radon gas must cause lung cancer in humans, if exposure to large amounts of gas, experimentally proven with tests on animals. However, a study published in 2003 by the journal German Springer Verlag proves the therapeutic properties of Radon, in which patients are exposed to small amounts of gas in deactivated uranium mines to reverse cases

of arthritis and skin diseases. These facts become relevant to observe the dynamics of this type of ionizing radiation, it can directly affect the structure of our DNA.

METHODS

Gamma radiation measurements was realized with a crystal scintillator of NaI(Tl) mounted in an aluminum cell and connected to a photomultiplier tube (Aware Electronics, USA). This detector was coupled to a PC for storing the data series. The scintillator, coupled to the photomultiplier and associated electronics, was previously calibrated only in energy range using standard radioactive in a laboratory. The background radiation measurement is collected each minute uninterruptedly during one day or until three months. The methods used to study the data sets are statistics and Fourier analysis.

RESULTS AND DISCUSSION

Measurements of gamma radiation were performed at the Physics Department of the ITA in São José dos Campos-Brazil, from January 1st to March 25th 2013 with a count interval of 1 in 1 minute throughout this period. From the monitoring of precipitation and radiation, noted a positive correlation between the rainfall intensity during this period and gamma radiation intensity (0.30 to 10.0 MeV) at the same location. Gamma radiation dose is highly sensitive to relative humidity, rainfall and dry weather. There are higher concentrations of radon gas when heavy rains occur mainly those resulting from the cold fronts. Furthermore, well-defined one cycle in 24 hours at a dose of radiation.

CONCLUSION

Due to the fact ionizing radiation directly affect the life of the whole planet, it is essential monitoring and analyze ionizing radiation concentration in the environment and correlation between natural phenomena and its dose. This branch of research is scarcely studied in Brazil, however with the sponsorship of the Institute of Technology Aeronautics (ITA) and National Counsel of Technological and Scientific Development (CNPq), it was possible to monitor the concentration of ionizing radiation on the Earth's surface using the equipment most suitable for this purpose.

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SESSION J11

DIV. II/III THE EARTH'S PLASMASPHERE: MODELLING AND REMOTE SENSING

J11-1 PLASMASPHERE DATA ASSIMILATION USING GROUND-BASED DATA AND THE ENSEMBLE KALMAN FILTER

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VLF and magnetometer observations can be used to remotely sense the plasmasphere. VLF whistler waves can be used to measure the electron density and magnetic Field Line Resonance (FLR) measurements can be used to measure the mass density. These can then be used to create a map of the plasma density and thus the extent of the plasmasphere. When observations are incomplete it is necessary to interpolate between them. Data Assimilation performs this interpolation in space and time in a more physically consistent way than simple grid interpolation. The PLASMON project, funded by the EU FP-7 program is using VLF and FLR measurements to map the plasmasphere with data assimilation. A growing world-wide network of VLF stations produce electron density and a magnetometer chain through Central Europe produces mass density observations in that sector. These observations are ingested into a Ensemble Kalman Filter data assimilation scheme using the Dynamic Global Core Plasma Model and other models, to produce plasma density maps. We will present plasmasphere data assimilation results using data from the PLASMON project as well as other data, for different events.

J11-2 INVESTIGATION OF PLASMASPHERE WITH CLUSTER**Darrouzet, F.; De Keyser, J.; Pierrard V.; Ranvier, S.; Benck, S.; Décréau, P.; Lichtenberger, J.; Matsui, H.; Usanova, M.**

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The four Cluster spacecraft cross the plasmasphere around perigee since their launch in Summer 2000. The variations of their perigee altitude during the entire mission (from 4 to 1 Re) allow different types of crossings and different types of plasmaspheric studies. During the plasmaspheric crossings with higher perigee (around 4 Re), plasmaspheric plumes are frequently observed in the inner magnetosphere by the Cluster satellites. They are formed after an increase of geomagnetic activity and corresponding modifications in the convection electric field. We present a statistical analysis of plumes based on 5 years of Cluster data. We also examine some small-scale structures and waves inside plumes. We present in particular a statistical analysis of EMIC waves inside and near plumes. With the lower perigee (around 2 Re), the radiation belts are also crossed by the Cluster satellites. This offers an exceptional opportunity to analyze the position of the plasmopause and the position of the radiation belts boundaries with identical spacecraft. The relation between those two regions is of fundamental importance because of their relation in terms of scattering of energetic particles. We present a statistical analysis of the locations of those boundaries based on 2 years of Cluster data. Density measurements obtained from the Cluster satellites can also be compared with ground-based determination of the density from whistlers waves, which are VLF emissions initiated by lightning, propagating along magnetic field lines. We present the first results of whistler occurrence obtained from a recent VLF antenna installed in early 2011 in Belgium, as well as the first comparison with density measurements made with Cluster. Those measurements are also compared with density data obtained from a 3D model of the plasmasphere.

J11-5 GLOBAL DISTRIBUTION OF THE PLASMASPHERIC IONS AND ELECTRIC POTENTIAL ESTIMATED WITH DATA ASSIMILATION OF THE IMAGE/EUV DATA**Nakano, Shinya; Fok, Meiching, Brandt; Pontus C.; Higuchi, Tomoyuki**

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The remote observation from EUV imaging data from the IMAGE satellite provides global images of the ultraviolet from helium ions in the plasmasphere. Since the spatial structure of the plasmasphere is strongly controlled by the electric field in the inner magnetosphere, the global imaging data of the plasmasphere provides valuable information on the global structure of the electric field in the inner magnetosphere. We are developing a data assimilation technique which incorporates the IMAGE/EUV data into a two-dimensional fluid model of the plasmasphere to estimate the global distribution of the electric potential as well as that of the plasmaspheric ions. In our approach, we first estimate the initial state of the plasmasphere by the using a linear inversion. We then estimate the temporal evolution of the plasmasphere from a sequence of IMAGE/EUV data by using the ensemble transform Kalman filter, which is one of a sequential data assimilation algorithms. By combining a sequence of EUV images and the dynamical model of the plasmasphere, we can also estimate the spatial distribution of the electric potential. We will discuss about the potential patten and the temporal evolution of the plasmasphere estimated with the data assimilation technique for some events.

J11-6 PLASMASPHERIC ULF WAVES OBSERVED FROM THE VAN ALLEN PROBES**Takahashi, Kazue; Wygant, John; Kletzing, Craig; Singer, Howard; Dai, Lei; Denton, Richard; Min, Kyungguk**

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The Van Allen Probes, with their low inclination elliptical orbits with apogee at 5.8 Re, are ideal for studying ULF waves in the plasmasphere. In this paper we show data acquired by the spacecraft on November 8, 2012 to illustrate the capability of the spacecraft in studying ULF waves in the plasmasphere and how the waves can be used to determine the plasma mass density. On the selected day, the spacecraft were located in the dawn sector and detected intense ULF waves in the 0-50 mHz band in the region outside of $L \sim 2$. The dynamic spectrum of the magnetic and electric fields is characterized by toroidal waves consisting of several harmonics. There were broadband compressional waves covering the band of the toroidal waves, which implies that the former represent fast mode waves of an external origin that drive the latter. The toroidal waves, unprecedented in terms of the number of the harmonics detected inward of $L \sim 6$, allow us to infer the mass density in that region quite accurately. We compare the inferred mass density with the electron density measured on the same spacecraft to gain information on the ion composition. We also apply the same magnetoseismology technique to GOES magnetometer data to infer the radial density structure for $L = 2-7$.

J11-7 BEHAVIOR OF PLASMASPHERIC PLASMA AT THE BOUNDARY OF THE EARTH'S OPTICAL SHADOW**Kotova, G.A.; Verigin, M.I.; Bezrukikh, V.V.; Remizov, A.P.; Khalipov, V.L.**

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Spacecraft charging plays a crucial role in direct onboard measurements of thermal plasma, especially in the Earth's plasmasphere. We will discuss how the problem of spacecraft potential was solved in INTERBALL mission, where wide-angle analyzers were used for thermal plasma measurements. Ion spectra change rapidly every time when the spacecraft moves into the optical shadow of the Earth that provides possibility to determine sudden potential drop at this boundary. On the other hand, ion density, evaluated by ion spectra disturbed by spacecraft potential, remains changing smoothly at the shadow crossings. Such predictable variations of spacecraft charging and undisturbed plasma density, evidences on the reliability of the parameters determined from onboard measurements in INTERBALL mission. Proton temperature measurements in the plasmasphere are used further to study the effect of illumination of the feet of magnetic field line passing through the measurement point, thus providing observational support on the influence of ionospheric photoelectron fluxes onto the thermal balance in the plasmasphere. The work is partially supported by the RAS program P22.

J11-8 MOON-BASED EUV IMAGING OF THE EARTH'S PLASMASPHERE: MODEL SIMULATIONS**Zhang, XiaoXin; He, Fei; Chen, Bo; Fok, M-C**

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The EUV imager onboard the ChangE-3 lunar lander will image the Earth's plasmasphere for the first time to focus on some of the open questions in plasmaspheric researches (i.e., global structures, erosion and refilling of plasmasphere). In order to achieve the understanding of the plasmasphere dynamics in relation to these EUV images in lunar perspective, the He II (30.4 nm) emission intensities and global structures of the plasmasphere viewed from the moon are investigated using a dynamic global core plasma model (DGCPM) embedded with TS07 magnetic field model and Weimer-2005 electric field model. Two typical storms observed by the IMAGE EUV Imager are systematically simulated from the perspectives of the Moon. It is found from the simulations that the maximum emission intensity of the plasmasphere is ~ 12.3 Rayleigh which is greater than that detected from polar orbit, and the global shapes and temporal evolutions of large scale plasmaspheric structures (plasmopause, shoulder, plume) also have different patterns in moon-based simulated images. It is also shown that the plasmaspheric structures extracted from moon-based EUV images are in agreement with those from IMAGE EUV images. Systematic simulations demonstrate that specific latitudinal distribution of plasmaspheric structures can only be imaged at specific positions in lunar orbit. It is expected that this investigation provides for the first time with an overall understanding on moon-based EUV images, and helps to identify the plasmaspheric structures and evolution patterns in future moon-based EUV imaging.

J11-9 REMOTE SENSING OF THE MAGNETOSPHERIC PLASMA MASS DENSITY BY ULF FIELD LINE RESONANCES: EFFECTS OF USING DIFFERENT MAGNETIC FIELD MODELS**Vellante, Massimo; Piersanti, Mirko; Heilig, Balazs**

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The technique for remote sensing the plasma mass density in magnetosphere by ULF field line resonances detected at ground stations is becoming more and more popular after the establishment in the last few years of extended magnetometer arrays, such as the EMMA network recently formed in the framework of the european FP7 PLASMON project. It is important therefore to quantify the level of accuracy associated to such technique. In this talk we examine the effect of using different magnetic field models.

First the equatorial plasma mass density estimates obtained using the dipole approximation are compared with those obtained using the IGRF model for low-mid latitudes. It is found that the use of the dipole model may result in an error in the inferred density appreciably larger than what is usually assumed. In particular it has a significant longitudinal dependence being, for example, of the order of +30% in the american sector and -30% at the opposite meridian for field lines extending to a geocentric distance of 2 Earth radii. This may result in an erroneous interpretation of the longitudinal variation in plasmaspheric density when comparing results from ground-based arrays located at different longitudes. A simple modification of the technique is proposed which allows to keep using the dipole approximation but with a significant error reduction.

Then the results of using the T01 Tsyganenko model are compared with those based on dipole/IGRF models. With respect to previous evaluations of the differences in the inferred equatorial density we take into account the different equatorial crossing points of the IGRF and T01 field lines traced from a given ground position by considering reasonable radial gradients of the equatorial density. For average solar wind/magnetospheric conditions, mass

densities computed using the IGRF model result to be moderately overestimated (less than 20%) for L values < 4 . The uncertainty obviously increases for higher L values and the bias may become negative for steep radial variations of the equatorial density. For storm-time conditions the error dramatically increases beyond $L = 4$, but may remain within 20% for $L < 4$ assuming radial variations of the equatorial density which are typical for such magnetospheric conditions.

J11-10 THE ANNUAL AND LONGITUDINAL VARIATIONS IN PLASMASPHERIC ION DENSITY
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Due to the tilt of the geomagnetic field, there is a longitude-dependent asymmetry in ionospheric solar illumination at opposite ends of magnetic field lines in winter and summer months. This difference is greatest at American longitudes, where, for example, the 300° longitude field line extending 2.5 Earth radii into space has its southern hemisphere footprint in Antarctica near 65° geographic latitude and in the northern hemisphere at 42° latitude. We combine ground-based observations of ULF field line eigenoscillations with in situ measurements from the IMAGE spacecraft of electron and He⁺ densities to determine the annual and longitudinal variation in electron and ion density in the equatorial plane. We find that at American longitudes the electron and ion mass densities at 2.5 Earth radii are 1.5 to 2.2 times larger in December at solar maximum than in June. Over the Asia-Pacific region there is little difference between summer and winter densities. Models of plasmaspheric density should be modified accordingly. By comparing the electron, helium and mass densities we also estimate the seasonal variation in H⁺, He⁺ and O⁺ concentrations.

J11-11 TITLE: FIELD LINE RESONANCE SOUNDING OF THE PLASMASPHERE: AN ASSESSMENT OF TWO-DIMENSIONAL GROUND-BASED OBSERVATIONS

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Using the gradient technique for field line resonance (FLR) detection, ground-based magnetometers have been providing valuable, robust measurements for plasmaspheric sounding. Previous studies on this topic focus mainly on the observations along a single or a handful of meridians. It has recently been found that FLR frequencies can also be detected successfully by a two-dimensional network of magnetometers. In this study we discuss some technical aspects of the “two-dimensional FLR sounding” and the observations of the storm-time plasmasphere. A systematic assessment of two-dimensional observations is enabled by the recently developed algorithm for automated FLR detection. The ~50 magnetometers in North America jointly operated by multiple projects can easily form more than 100 station pairs for FLR sounding. An analysis of the spatial distribution of phase shows that the azimuthal phase drift for less than 2 hours in local time is small and does not affect the determination of FLR frequencies in the plasmasphere. The two-dimensional FLR sounding has revealed longitudinal structures of the storm-time plasmasphere that cannot be observed by magnetometers along a single meridian.

J11-12 FIELD ALIGNED PLASMASPHERIC DENSITY DISTRIBUTIONS: COMPARISON OF MODELS AND OBSERVATIONS

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Since the first hydrostatic models of plasma density distribution in diffusive equilibrium (DE) within the topside ionosphere and plasmasphere proposed by Angerami and Thomas (1964), many alternative single fluid or multi-fluid hydrostatic models have been proposed during the last decades. Since Eviatar, Lenchek and Singer’s (1964) first ion-exospheric model of the protonosphere, a number of other kinetic models have also been worked out. Recently, a new empirical model for the field aligned electron density distribution in the plasmasphere has been developed by Ozhogin et al. (2009, 2013). It is based on data from the Radio Plasma Imager (RPI) instrument on board the IMAGE satellite. We will compare these different types of models with each other, as well as with a novel “?-exospheric” model taking into account the effects of a plasmaspheric wind expansion, both along geomagnetic field lines, as well as across them.

J11-13 PLASMASHERE-IONOSPHERE COUPLING FLUXES BASED ON ELECTRON DENSITIES OBTAINED FROM VLF WHISTLER DATA**Lichtenberger, Janos; Ferencz, Csaba; Hamar, Daniel; Steinbach, Peter; Clilver, Mark; Rodger, Craig; Collier, Andrew**

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The Automatic Whistler Detector and Analyzer Network (AWDANet) is able to detect and analyze whistlers in quasi-realtime and can provide equatorial electron density data. The plasmaspheric electron densities and ionosphere-plasmasphere coupling fluxes are key parameters for plasmasphere models in Space Weather related investigations, particularly in modeling charged particle accelerations and losses in Radiation Belts. The global AWDANet [1] detects millions of whistlers in a year. The system has been recently completed with automatic analyzer capability in PLASMON (<http://plasmon.elte.hu>) project. It is based on a recently developed whistler inversion model [2], that opened the way for an automated process of whistler analysis, not only for single whistler events but for complex analysis of multiple-path propagation whistler groups [3]. In this paper we present the first results of quasi-real-time runs processing whistlers from quiet and disturb periods. Refilling rates, that are not yet known in details are also presented for the various periods.

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J11-14 SOME SIMULTANEOUS OBSERVATIONS OF VLF EVENTS AT TWO RECEIVERS SEPARATED BY 400 KM IN LONGITUDE**Manninen, Jyrki; Kleimenova, Natalia; Kozyreva, Olga; Fedorenko, Yury; Turunen, Tauno**

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Since November 2012 a 3-component digital VLF receiver has been in operation at Lovozero in Kola Peninsula. Altogether 3 measurement campaigns were held at Kannuslehto in Northern Finland between December 2012 and April 2013. These two stations (KAN and LOZ) are located roughly at same magnetic latitude, $\lambda = 64.2$ and $\lambda = 64.1$, respectively. In this presentation we will show how similar or totally different are some VLF events at these two stations.

J11-15 EQUATORIAL ELECTRON DENSITIES AND LIGHTNING-WHISTLER CORRELATION FROM KAMCHATKA AWDANET STATION**Lichtenberger, Janos; Ferencz, Csaba; Hamar, Daniel; Steinbach, Peter; Sannikov D.V.; Cherneva N.V., Sivokon' V.P.; Agranat I.V.; Druzhin G.I.; Collier, Andrew**

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The Automatic Whistler Detector and Analyzer Network (AWDANet) [1] has recently been extended with a far-eastern station at Karymshina, Kamchatka, Russia (latitude: 52.83, longitude: 158.13, L=2.13). The whistler activity is unusually high, the highest in AWDANet, apart from the Antarctic peninsula stations. During the first five months of operation, more than 200000 whistler events were recorded.

In this paper we present statistics on whistler occurrences as well as correlation with WWLLN lightning data. The global AWDANet The system has been recently completed with automatic analyzer capability in PLASMON (<http://plasmon.elte.hu>) project. It is based on a recently developed whistler inversion model [2], that opened the way for an automated process of whistler analysis, not only for single whistler events but for complex analysis of multiple-path propagation whistler groups [3]. We present a series of equatorial electron densities obtained from whistlers recorded at Karymshina.

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J11-1p INVESTIGATING DUNEDIN WHISTLERS USING VOLCANIC LIGHTNING

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Whistlers recorded at Dunedin, New Zealand, are anomalous: rather than being caused by lightning close to the magnetic conjugate point, they appear to be statistically linked to lightning on the west coast of Central America, several thousand km away. This conclusion, however, is the result of a global correlation analysis, which is complicated by the fact that there is a lot of lightning close to the proposed source region. This makes the chance of spurious coincidences between lightning and whistlers quite likely.

Our aim was to find a direct link between individual whistlers and their causative lightning strokes. We focused our attention to sites of rare lightning activity: the electrified plumes of high-latitude volcanoes. By limiting our search to these locations, we succeeded in identifying individual lightning discharges which could be linked directly to whistlers at Dunedin. Two volcanoes on the Aleutian Islands, Mount Redoubt and Mount Okmok, were found to have had a prominent effect on Dunedin's whistler count. These are the first observations of whistlers linked to volcanic lightning.

J11-2p MONITORING LAND-COVER CHANGES USING SATELLITE IMAGERY

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Several regions around the World are currently undergoing rapid, wide-ranging changes in land cover due to human activities and natural events. These changes can have significant effects on regional and even global climate change. In this paper the focus is on urbanization in South Africa. Two major factors drive urbanisation: population expansion and the wider range of employment opportunities in urban areas. We employ a post-classification approach to detect land cover changes on a specific area from a time series of satellite images. Variance in spatial resolution and radiometric resolution between images was taken into account using radiometric normalization and geometric registration. We then used a maximum likelihood classifier to distinguish between the different land use classes. We are able to quantify the proportions of each land use class for every image and monitor the change over time. This information highlights the physical growth rate of a specific urban area caused by urbanization and it will allow environmental experts to diagnose the effects of these changes.

J11-3p VALIDATION OF A NEW PLASMAPAUSE MODEL DERIVED FROM CHAMP FIELD-ALIGNED CURRENT SIGNATURES

Heilig, Balázs; Lühr, Hermann; Vellante, Massimo

We introduce a new model for the plasmopause location in the equatorial plane. The determination of the L-shell bounding the plasmasphere is based on magnetic field observations made by the CHAMP satellite in the topside ionosphere. Related signals are medium-scale field-aligned currents (MSFAC) (some 10km scale size). The mid-latitude boundary of these MSFACs is used for determining the plasmopause. The radial distance of the MSFAC boundary is closely controlled by the magnetic activity index Kp. This Kp and local time dependent feature is used for predicting the location of the MSFAC boundary at all MLTs based on a single L-value determination by CHAMP. We compared the location of the MSFAC boundary during the years 2001-2002 with the L-value of the plasmopause, determined from in situ observations by the IMAGE spacecraft. By considering this systematic displacement and by taking into account the diurnal variation and Kp-dependence of the residuals we are able to construct an empirical model of the plasmopause location that is based on MSFAC measurements from CHAMP. The new CHAMP PP model was validated using in-situ and ground based plasma density observations.

J11-4p TEMPORAL CHANGE OF VLF POLARIZATION: A CASE STUDY

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A VLF hiss burst lasting for two hours was observed on 12 April 2011 at 04-06 UT at Kannuslehto in Northern Finland. The event occurred in the end of the initial phase of a small magnetic storm. At the beginning, the polarization of the event was left-handed, which can be interpreted as the long-distance travelling of the waves in the Earth-ionosphere waveguide. The arrival direction was mostly from south. After one hour, the polarization gradually turned to right-handed, which can indicate that the ionosphere wave exit point was nearly overhead of the receiver. In this poster we will show geophysical conditions, which may be related to this polarization change.

J11-5p AMPLITUDE MODULATION OF WHISTLERS**Sivokon', V.; Lihtenberger J.; Cherneva N.; Sannikov, D.**

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In the result of experimental observations on Kamchatka peninsular ($L=2.3$) analysis of records, obtained by VLF recorder of the Institute of Cosmophysical Research and Radio Wave Propagation, has been carried out (<http://ru.www.ikir.ru>). In some cases the analysis has revealed a nonstandard form of whistlers. To exclude the possibility of registering instrumentation nonlinearity, frequency distribution of dispersive spectrogram lines has been carried out. It was found out that the lines are not multiple in frequency and can not be harmonics determined by reception path nonlinearity. Most likely, whistler amplitude modulation by unmodulated pulse harmonics takes place. Supposing, that a whistler and a disturbing pulse propagate through the magnetosphere region simultaneously, then pulse time is equal to the time from the beginning of a whistler till the end of modulation, i.e. about 1 second.

SESSION J13**DIV. IV/ III/ II FROM MICRO- TO MACRO-SCALES IN THE HELIOSPHERE AND MAGNETOSPHERES****J13-1 ON THE KINETIC AND MULTI-FLUID MODELING OF THE SUPERSONIC SOLAR WIND EXPANSION****Lemaire, Joseph F.; Echim, Marius; Lie-Svendsen, Oysten**

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We review the main advantages and limitations of the kinetic exospheric and fluid models of the solar wind (SW). The general theoretical background is outlined: the Boltzmann and Fokker–Planck equations, the Liouville and Vlasov equations, the plasma transport equations derived from an “equation of change”. We discuss the key-elements of the kinetic models: the computation of the electric field, the role of kappa velocity distribution functions (VDF) at the exobase and of a non-monotonic variation of the electric potential with the radial distance. We also discuss the kinetic treatment of the Coulomb collisions based on the Fokker–Planck approach. Multi-fluid models of the solar wind provide a coarse grained description of the system and reproduce with success the spatio-temporal variation of SW macroscopic properties (density, bulk velocity). We address key-features of the 5-moment, or Euler, models, the 8-moment and 16-moment fluid models. We emphasize the limitations introduced by the Chapman-Enskog expansion of the VDF, $f^{(n)}(r,v,t)$, implying explicitly that the next higher order approximation of the velocity distribution function does not change the values of the density, $n(r,t)$, bulk velocity, $u(r,t)$, nor $T(r,t)$ the temperature of any particle species. The latter are completely determined by $f^{(0)}$, the zero order approximation of the actual VDF, $f(r,v,t)$, which is solution of the Boltzmann equation for given boundary conditions at some initial time t_0 . Usually is postulated that $f^{(0)}$ is an isotropic Maxwellian distribution function. This is, however, a convenient (a-priori) assumption, and not necessarily the best and most appropriate choice, in certain specific cases or conditions. This arbitrary restriction is a limitation of the “normal solutions” of the Boltzmann equation. Indeed, in situations when the Knudsen number of the gas/plasma becomes of the order of unity or larger these restrictive conditions are not appropriate and justified from a physical point of view. This appears to be the case in the collisionless region of the interplanetary medium at large radial distances (beyond 3-5 RS), where the VDFs of electrons, protons and other ions depart significantly from usual displaced Maxwellians. Although for decades the kinetic and fluid approaches were seen opposed, we point out their complementarity, and we formulate open issues that needs to be addressed in future solar wind modeling efforts.

J13-2 THE INNER HELIOSPHERE IN 3D - THE STEREO VIEW**Volker, Bothmer**

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The STEREO observatories were launched in October 2006. Since then they have provided the first 3-Dimensional view of the Sun and the first direct images of the evolution and impact of solar plasma flows on comets and planets. Solar storms were tracked all the way from the Sun to Earth. STEREO results have provided a fundamentally new understanding of the large-scale physical processes in the Sun-Earth-System and how they determine space weather conditions, including the 3D structure of coronal mass ejections. This presentation provides a selected summary of mission highlights, information on STEREO's current status and upcoming research challenges together with the SDO and SOHO perspective.

J13-3 HELIOSPHERIC STRUCTURE: THE BOW WAVE AND THE HYDROGEN WALL**Zank, G.P.; Heerikhuisen, J.; Wood, B.E.; Pogorelov, N.V.; Zirnst, E.**

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Recent IBEX observations indicate that the LISM flow speed is less than previously thought (23.2 km/s). Reasonable local interstellar medium (LISM) parameters show that the LISM flow may be either marginally super-fast magnetosonic or sub-fast magnetosonic. We address the questions of 1) can a LISM model that is barely super-fast or sub-fast magnetosonic account for Lyman-alpha observations that rely critically on the additional absorption provided by the hydrogen wall? and 2) if the LISM flow is weakly super-fast magnetosonic, does the transition assume the form of a traditional shock or does neutral hydrogen (H) mediate shock dissipation and hence structure through charge exchange? using three 3D self-consistently coupled MHD - kinetic H models with different LISM magnetic field strengths (2, 3, and 4 mG) and plasma and neutral H number densities. The 2 mG model admits a broad bow shock-like structure, the 3 mG model a very broad smooth super-fast-sub-fast transition resembling a bow wave. For both the 2 mG and the 3 mG models, the super-fast magnetosonic LISM flow passes through a critical point. Hot and fast neutral H can completely mediate a weak transition and impose a charge exchange length scale on the structure, making the solar wind - LISM interaction effectively bow shock-free. The charge exchange of fast and hot heliospheric neutral H therefore provides a primary dissipation mechanism at the weak heliospheric bow shock, in some cases effectively creating a one-shock heliosphere (i.e., a heliospheric termination shock only). We model the observed Lyman-alpha absorption profiles along the four sightlines finding that both super-fast magnetosonic models can account for the Lyman-alpha observations, with possibly the bow shock-free 3 mG model being slightly favored.

J13-4 HIGH-LATITUDE CORONAL MASS EJECTIONS AND SOLAR POLARITY REVERSAL DURING SOLAR CYCLE 24**Gopalswamy, Nat**

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Cessation of high-latitude coronal mass ejections (CMEs) was found to be an important time marker of the reversal of polarity at solar poles (Gopalswamy et al. 2003, *Astrophys. J.* 598, L63). During solar cycle 23, prominence eruptions observed by the Nobeyama Radioheliograph and the white-light CMEs from the Solar and Heliospheric Observatory (SOHO) mission were used to identify the time of polarity reversal. These two data sources continue to provide data during solar cycle 24. In addition, we have data from the Solar Dynamics Observatory (SDO) and the Solar Terrestrial Relations Observatory (STEREO), which provide excellent information on prominent eruptions and the associated CMEs. Making use of the combined data set and the microwave and magnetic butterfly diagrams, it is shown that the polarity reversal has taken place in the northern hemisphere. In the southern hemisphere, the solar maximum phase began about six months ago and is likely last for another 1-2 years before the reversal occurs. This paper describes the properties of high latitude solar eruptions and how they vary over the solar cycle to mark the times of polarity reversal.

J13-5 MULTI-SCALE SIMULATIONS OF MAGNETIC RECONNECTION IN MAGNETOSPHERES AND SOLAR CORONA**Kuznetsova, Maria; Evans, Rebekah; Gloer, Alex; Hesse, Michael; Toth, Gabor**

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Magnetic reconnection is a key element in many phenomena in heliosphere, e.g. such as coronal mass ejections or plasmoid releases and flux transfer events in the magnetosphere. One of the major challenges in modeling large scale dynamical systems involving magnetic reconnection is to quantify the interaction between global evolution of the system and microphysical kinetic processes in diffusion regions near reconnection sites. In collisionless magnetospheric plasma, the primary mechanism controlling the dissipation in the vicinity of the reconnection site is non-gyrotropic pressure effects with spatial scales comparable with the particle Larmor radius. We utilize the multi-scale and multi-species global MHD code BATSRUS to analyze the relative contribution of solar wind conditions, ionosphere conductance pattern, plasma composition in inner magnetosphere and local conditions at the reconnection sites on the global magnetosphere dynamics. Kinetic effects in the vicinity of the reconnection site are incorporated into MHD description in terms of non-gyrotropic corrections to induction and energy equations. The non-gyrotropic terms reflecting ion kinetic effects depend on the local plasma and field parameters and ion Larmor radii. The varying plasma composition is incorporated into the multi-species description through the effective ion mass. Transitions between different modes of convection are analyzed. The approach is also applied to magnetospheres of other planets and to modeling of coronal mass ejections.

J13-6 CONCERNING THE ROLE OF THE FORESHOCK IN THE SOLAR WIND-MAGNETOSPHERE INTERACTION**Sibeck, D.G.**

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One of the distinguishing characteristics of space physics is role that microphysical processes play in generating meso- and macroscale phenomena. Nowhere is this more evident than in the foreshock, where a host of recent hybrid simulations and multipoint observations demonstrate that kinetic processes generate large-amplitude global density and magnetic field structures that then sweep through the magnetosheath to generate pressure pulses propagating through the magnetosphere, initiate pulsations capable of energizing radiation belt particles, and drive field-aligned currents and transient auroral brightenings in the polar ionosphere. This presentation reviews the processes by which these structures form and their important role in the solar wind-magnetosphere interaction.

J13-7 HOW TO PREDICT GEO-EFFECTIVENESS OF CORONAL MASS EJECTIONS (CMES): A MULTI-SCALE GUIDE TO CME ORIGIN AND PROPAGATION**Panasenco, Olga**

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We will show how the direction of the axial component of the magnetic field of a pre-eruptive filament and of the corresponding CME caused by filament eruption may be established observationally. This is a fundamental component in determining the geo-effectiveness of Interplanetary (I)CMEs. Filament channels, filaments, and the CME and ICME are all part of a multi-scale chiral system (i.e. possessing chirality) and the analysis of such chiral systems is a powerful tool to determine the topology of the magnetic fields involved in eruptive solar events later seen in space as ICMEs.

We will also describe how to determine the direction of erupting filaments (prominences at the limb) and corresponding CMEs deflection in the corona. A detailed analysis of the location of CME sources (filament channels) and of the magnetic coronal structure above and around them allows predicting the CME direction. We find that in the early stages of a filament eruption the filament moves in the direction of the closest magnetic null points, and later the CME flux rope tends to be deflected toward the null points of the larger scale magnetic configurations above.

Knowing the extent of non-radiality in CME propagation, together with the direction of the CME axial magnetic field, we can predict the relative strength of southward and northward components of the magnetic field in ICMEs and therefore their geo-effectiveness.

J13-8 A SOLAR WIND MODEL WITH RADIANT LOSSES**Pisanko, Yuri V.**

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To take into account radiation, which is among plasma heat loss main mechanisms, a solar wind model is presented. Mass and momentum equations are taken from [Parker, 1958] without any modification and the energy equation taken from [Chamberlain, 1961] is added by two terms for radiant losses, namely, thermal bremsstrahlung and recombination radiation [Artsimovich, 1966]. The model describes the rapid temperature increase with height above photosphere and connects the temperature minimum region electron concentration ($\sim 10^{11} \text{ cm}^{-3}$) to the Earth orbit one ($\sim 7 \text{ cm}^{-3}$). If one wrote the Chamberlain equation in its original form (i.e. without radiant loss terms) no solutions for temperature growth with height would exist. In the model the solar wind mass flux is specified a priori and this automatically specifies its directed motion kinetic energy flux – the energy source for heating via the Kolmogorov-Obukhov process of cascade energy transfer from large-scale to small-scale motions down to the smallest viscous scales. The transonic inviscid flow permits heating via viscosity only in the Parker singular point where the flow obeys the limited acceleration asymptotic instead of model equations. So the model with lumped heat source describes the solar wind heated by a solar centered sphere of the radius equal to the Parker critical point heliocentric distance ($\sim 2.75 R_s$) where the temperature reaches its maximum ($\sim 1.8 \cdot 10^6 \text{ K}$). As previous flow evolution determines which stationary state will eventually be realized, the solar wind can be a solar history relic so that coronal heating can be related to the coronal expansion transonic regime. The work is partially supported by the RFBR grant 13-02-00461

J13-9 PROPERTIES OF HIGH HELIOGRAPHIC LATITUDE MAGNETIC DECREASES AND ENERGETIC CHARGED PARTICLE CROSS-FIELD DIFFUSION**Echer, Ezequiel; Tsurutani, Bruce T.; Lakhina, Gurbax S.; Alves, Maria V.; da Costa Jr., Edio**

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Magnetic decreases (MDs) are pressure balance structures that show abrupt decreases of the magnetic field magnitude. In this paper, properties of interplanetary MDs at high heliographic latitudes ($>78^\circ$) are studied for more than one solar cycle (1994 to 2008). MDs are unbiasedly identified from $\sim 1 \text{ sec}$ Ulysses magnetometer data using

an automatic detection program (IMDAD). The interval of analysis are the six Ulysses polar passes that occurred during/near solar minimum (1994, 1995, 2007 and 2008) and during solar maximum (2000 and 2001). Both polar passes (north and south) were analyzed. The MD occurrence rates, the distribution of their temporal thicknesses, and the distribution of their magnetic field angular changes are determined. The average for the above parameters for solar maximum was 9.8 MDs.day⁻¹, of 19.5 s and 20.1 \circ , respectively, in comparison to those of solar minimum: 14.6 MDs.day⁻¹, 19.1 s and 24.4 \circ . The characteristics of MDs during these different solar polar passes and solar cycle phases are compared and discussed. The MD characteristics obtained in this paper have been used to determine energetic proton cross-field diffusion rate due to their nonresonant interactions with the MDs. Monte Carlo simulations for MDs observed during the 1994 polar pass showed that ~ 2 MeV protons diffuse across the magnetic field lines at $\sim 10\%$ of the Bohm diffusion rate.

J13-10 SELF-ORGANIZATION OF DIRECT AND INVERSE ENERGY CASCADES IN SPACE

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Nonlinear and intermittent energy cascades from large to small scales and from small to large scales in the phase space and time are ubiquitous for cosmic plasmas due to available free energy reservoirs of plasma kinetic and electromagnetic degrees of freedom. Dimensionless scaling is useful for their classification and ordering. Self-organization under given initial and boundary conditions is typically unstable and eroded, which means not unique solutions of governing equations describing the dynamical evolution of the open physical systems under consideration like separate plasma and magnetic domains, waves and transient phenomena. Strict election rules for different scenarios can be formulated only in simplest cases. We interpret the coronal heating problem and the solar wind origin problem as one task with no unique solution for the dominant mechanism. Many physically different regimes are involved simultaneously and intermittently in space and time. One of the regimes is poorly investigated and understood: coexistence of direct and inverse energy cascades. The outer boundaries of the heliosphere with the interstellar medium are essentially non-steady state and turbulent with no clear dominance of the relevant structures and processes as well.

J13-11 SOLAR WIND STREAM ACTIVITY DURING THE MODERN GREAT MAXIMUM: DIRECT SUPPORT FOR SOLAR DYNAMO THEORY

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We present and use a novel method to find the years with the largest amounts of fast solar wind streams at the Earth's orbit during the last 85 years, i.e., during most of the Modern Great Maximum (MGM) of solar activity. Two independent series of observations agree that the strongest solar wind speeds occurred in the declining phase of solar cycle 18. Since high solar wind speeds indicate strong solar polar magnetic fields, we find that cycle 19, which formed the peak of solar activity during MGM, was preceded by a time with the strongest poloidal field of MGM. According to the solar dynamo theory, strong solar polar magnetic fields (poloidal magnetic field) during a solar minimum should lead to an intense sunspot activity (toroidal magnetic field) during the next solar maximum. While this basic tenet has earlier been proven statistically, it has remained untested for the highest activity period of measured history until now.

J13-12 FROM SOLAR ERUPTION TO TRANSFORMER SATURATION

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In the last several decades term "space weather" became well known to a wide variety of specialists in different areas of human activities: from space physicists and satellite designers to electrical engineers and aircraft pilots to governmental officials. Presentation is describing the chain of the events from the Sun (interplanetary scale) to the effects on the particular transformer at a particular power grid (regional scale). While following the propagation of the solar disturbance (CME), the multiple factors will be named which are not well understood and far from being properly modelled and forecasted. These not well understood processes exist not only at the Sun, but also during propagation of the eruption, interaction with the Earth magnetosphere and the resulting effects in the ionosphere, variations of the geomagnetic field and geoelectric field at a particular region of the Earth. Even the response of the infrastructure components is not understood with enough certainty. It is of great practical importance to identify and solve these unknowns which will help in predictability of solar eruptions from the time of their launch on the Sun to the exact time and size of its impact on ground infrastructure.

J13-13 SMALL/LARGE TIME-SCALE VARIATIONS OF PARTICLE FLUXES IN THE RADIATION BELTS**Nikitina, L.; Trichtchenko, L.**

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Dynamics of the slot region during a magnetic storm was studied based on the analyses of data on the highly elliptical (Molniya) orbit (<http://virbo.org.HEO>). It has been identified, that significant particle fluxes can present in the slot regions for several days following the space weather event. Thus, short-time variations of the energetic particle fluxes distribution along the satellite orbit have a complex dynamical structure, which includes shifts of the radiation belts maxima, variation of the flux intensity and movement of the slot region location. These variations of are significant, but they are not described by the models of the magnetosphere which provide the radiation environment averaged on large time-scales (years). To provide an assessment of the radiation environment during a magnetic storm we have to include short-time variations into consideration.

J13-14 SUPER-MAGNETOSONIC JETS: FROM DISCRETE CASCADES TO TURBULENCE**Savin, S.; Amata, E.; Kozak, L.; Zelenyi, L.; Safrankova, J.; Nemecek, Z; Buechner, J.; Daly, W.P.; Kronberg, E.A.; Blecki, J.; Budaev, V.; Krasnosielskikh, V.**

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An important discovery of INTERBALL and CLUSTER missions is the Supermagnetosonic Plasma Streams (SPS) associated with Hot Flow Anomalies. The interaction of such supersonic plasma flows with planetary and astrophysical magnetospheres and in laboratory plasmas can be inherently non-local and non-equilibrium, and even explosive due to self-generation of coherent structures in the multiscale system with the scales ranging from the micro to global scales. The main objective of our proposal is to study the fundamental processes arising from SPS cascading and interactions with surface and cavity resonances in the Earth's magnetosphere, using multi-spacecraft data (DOUBLE STAR, CLUSTER, GEOTAIL, ACE). We will address the following key problems to advance our understanding of anomalous transport and boundary dynamics:

Generalizations of the SPS generation mechanisms, e.g., triggering by interplanetary shocks, solar wind (SW) dynamic pressure jumps, foreshock nonlinear structures, bow shock (BS) surface or magnetosheath (MSH) cavity resonances, etc.

The clarification of BS rippling mechanisms requires base on the relevant databases from the CLUSTER/DOUBLE STAR/ GEOTAIL/RADIOASTRON spacecraft, which will be used for a statistical analysis targeting the SPS statistical features as extreme events.

Substantial part of the SW kinetic energy can be pumped into the BS membrane and MSH cavity modes and initiate further cascades towards higher frequencies. Accordingly we present the multipoint studies of the SPS and of related nonlinear discrete cascades (carried generally by the SPS), along with the transformation of discrete cascades of the dynamic pressure into turbulent cascades.

Investigation of spectral and bi-spectral cross-correlations in SW, foreshock, MSH and in vicinity of BS and magnetopause (MP) would demonstrate that both inflow and outflow into/ from magnetosphere can be modulated by the SPS and by the related outer magnetospheric resonances as well. Preliminary case studies show that a direct penetration of SPS under flank MP can strongly dominate over anomalous diffusion and magnetic reconnection as an input in the mass and energy inflow.

Preliminary survey of the DOUBLE STAR data shows that in more than 50% cases the SPS are modulated by the outer magnetospheric resonances.

J13-6p MULTIPLE SUPRA-ARCADE DOWNFLOWS IN SOLAR FLARES**Cecere, M.; Schneider, M.; Costa, A.; Elaskar, S.; Maglione, S.**

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In later papers we have shown that sunward, generally dark, plasma features originated above posteruption flare arcades are consistent with a scenario where plasma voids are generated by the bouncing and interfering of shocks and expansion waves upstream of an initial localized deposition of energy which is collimated in the magnetic field direction. In this paper we analyze the multiple production and interaction of supra--arcade downflows (SAD) and the structure of individual SADs that make them relatively stable features while moving. We compare our results with observations and with the scenarios proposed by other authors.

J13-7Pp NUMERICAL SIMULATION OF COSMIC RAYS MODULATION IN CORATATING INTERACTION REGIONS

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The associated shock pairs of Coratating Interaction Regions(CIRs) in the solar wind are believed to play an important role in the transport of galactic cosmic rays (GCRs) particles. In this investigation, we will carry out the three-dimensional simulation of the GCRs modulation in the CIRs region. First, we will obtain the CIRs by means of a time-dependent global MHD simulation code. Based on the plasma background of CIRs, we can calculate the corresponding diffusion information of the entire CIRs region. Second, we can investigate the cosmic rays particle transports through the Parker transport equation, the latter is numerically solved using the Alternative Direction Implicit (ADI) scheme. Finally, we will have the global distribution of the GCRs information, and derive the correlation between the characteristics of time-dependent CIRs and the rate of decrease of the GCRs intensity that can be obtained from observation.

J13-8P PARTICLE FLUX FORECAST USING SPACE WIND PARAMETERS IN A MULTIVARIATE AUTOREGRESSIVE MODEL WITH KALMAN FILTERING

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Particles from the solar wind penetrate into the Earth's radiation belts where they can have a detrimental effect on the operation and lifetimes of satellites as well as influencing terrestrial communications and power lines. Forecasting conditions in the solar wind is thus an important problem. Previously this has been approached with various techniques including Kalman filtering and neural networks. We combine a Kalman filter with a multivariate autoregressive model based on pertinent features of the solar wind. In line with the findings of Sakaguchi et al (2013) this is expected to provide superior forecasting of solar wind conditions.

J13-9P STATISTICAL ANALYSIS OF MAGNETIC CLOUD EROSION BY MAGNETIC RECON

Ruffenach, A.; Lavraud, B.; Farrugia, C.J.; Démoulin, P.; et al.

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Magnetic clouds (MCs), described as large-scale toroidal magnetic structures, interact with the surrounding interplanetary medium during propagation. It has been suggested in particular that magnetic reconnection, involving micro-scale processes, may peel off their outer magnetic structure. Recently, Ruffenach et al. (2012) confirmed the occurrence of MC erosion thanks to a multi-spacecraft study combining a set of key signatures expected from this process. The aim of the present study is to extend previous works on the topic to all MCs of solar cycle 23 in order to quantify this phenomenon. This statistical analysis, primarily carried out with WIND and complemented with recent STEREO data, focuses on three signatures. First, based on careful determination of the MCs main axes, we estimate the amount of magnetic flux eroded for each event by analysing the azimuthal flux imbalance during the spacecraft sampling of the flux rope. We also search for magnetic reconnection signatures at the front boundary of the MCs. Finally, we investigate the characteristics of suprathermal electrons in the back region of the MCs. Those electrons are considered to signal potential large-scale topological changes expected from the erosion process.

SESSION J14

DIV. IV/II/III HELIOSPHERIC STRUCTURE DURING THE ASCENDING PHASE OF SOLAR CYCLE 24

J14-1 THE 3D STRUCTURE OF CMES OBSERVED WITH STEREO/SECCHI

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Since launch of the STEREO mission in 2006, more than 1000 large-scale CMES were identified in SECCHI COR2 observations until end of 2011. The set of events covers the full range of spacecraft separation angles between 0 and 180 degrees, including CMES tracked sun to earth. For about a third of these events the CME's 3D structure has been analyzed with the GCS modeling technique. This presentation summarizes the key results of this study and our present understanding of the 3D structure of CMES.

J14-2 THE EFFECT OF CMES ON HELIOSPHERIC STRUCTURE DURING THE ASCENDING**Webb, David F.**

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The frequency of occurrence of CMEs observed in white light (WL) tends to track the solar cycle in both phase and amplitude, which varies by an order of magnitude over the cycle. Since WL CMEs have been counted since Skylab in the 1970s, we now have observations extending over the last four solar cycles. LASCO has now observed the entire Cycle 23 and continues to observe through the current rise to maximum of Cycle 24. It has detected CMEs at a rate slightly higher than earlier observations, varying from $\sim 0.3/\text{day}$ around solar minimum to $\sim 4/\text{day}$ at maximum. Running averages of the CME rate vs. sunspot number show that both have double cycle peaks, with the CME peak lagging sunspots by many months. This lag is likely related to observations that high latitude CMEs arise from polar crown filaments which have a rush to the poles' near maximum and disappear (erupt) with a frequency that slightly lags sunspot numbers at low latitudes. Cycle 23 had an unusually long decline and flat minimum. Since 2006 we have been able to image and count CMEs in the heliosphere, and can determine rates from both LASCO and STEREO coronagraphs and from the Solar Mass Ejection Imager (SMEI) and the SECCHI Heliospheric Imagers in the heliosphere. Manual rates estimated by observers are now supplemented by counts from identifications made by automatic programs, such as in the SEEDS, CACTus and ARTEMIS catalogs. There is some indication that the CME rate is diverging somewhat from the sunspot number since about 2010. We will discuss these rate estimates, both for the Cycle 23-24 period and over the last four cycles for which we have WL CME observations.

J14-3 SOLAR ERUPTIONS AND ENERGETIC PARTICLES DURING SOLAR CYCLES 23 AND 24**Gopalswamy, Nat**

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J14-4 LONG-TERM SOLAR EXTREME ULTRAVIOLET IRRADIANCE VARIATIONS AND EUV FEATURE OF THE FLARE**Zhou, Zhenjun; Wang, Yuming; Shen, Chenlong; Liu, Kai**

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Abstract: As The Solar Dynamics Observatory (SDO) Launched on February 11, 2010, the instrument EVE aboard on it has measured the solar extreme ultraviolet irradiance variations for nearly three years. Due to flares solar radiation varies rapidly and for different spectrums has different responses. So the different type flares viewed by the EVE present different morphology. And for a longer term, the solar radiation also changes for solar rotation in 28 days and solar cycles for 11-year sunspot cycle. This paper briefly reviews our study done on the classification of the solar flare base on the EVE spectral data and shows the long-term EUV background emission variations of recently three years during the Solar Cycle 24.

J14-5 INTERPLANETARY SHOCKS IN THE ASCENDING PHASE OF THE SOLAR CYCLE**Kajdic, Primoz**

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The start of observations of the two STEREO spacecraft coincided with the minimum of solar activity between the solar cycles 22 and 23. During the period from January 2007 to December 2011 the STEREO spacecraft together observed 236 interplanetary (IP) shocks. Most of them were driven by stream interaction regions, although as the solar activity rose, so did the number of shocks driven by interplanetary coronal mass ejections. In this talk we will review the observational properties of IP shocks from the minimum throughout the rising phase of the current solar cycle. We will examine how their strengths, their Mach numbers and criticality varied during this period. We will also take a look at the perturbed foreshock regions observed upstream of some of the shocks and the properties of waves and particles therein.

J14-6 REVIEW OF MAGNETIC CLOUD EROSION BY MAGNETIC RECONNECTION**Ruffenach, Alexis; Lavraud, Benoit**

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Magnetic clouds (MCs), described as large-scale structures with a flux-rope magnetic topology, interact with the surrounding interplanetary medium during their propagation. McComas *et al.* (1988), and later Dasso *et al.* (2006), were the first to propose that magnetic reconnection might peel off the outer magnetic structure of CMEs. Recently, Ruffenach *et al.* (2012) confirmed the occurrence of MC erosion thanks to a multi-spacecraft study combining a set of key signatures expected from this process. In order to quantify this phenomenon, a statistical analysis of all MCs of solar cycle 23 has also been performed. In this presentation, we will first review the original works on this topic,

followed by the latest advances, new signatures expected from this process, as well as recent statistical results. We will also discuss the expected radial evolution of the process within the inner heliosphere. Since the erosion mechanism can lead to the removal of part of the southward oriented magnetic field at the front of MCs, we will finally highlight the impact of this mechanism on their geo-effectiveness.

J14-7 SOLAR WIND STRUCTURES ASSOCIATED WITH MAJOR GEOMAGNETIC STORMS OVER THE SOLAR CYCLE 24

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The on-going Solar Cycle has brought a low geomagnetic activity compared with the previous one. A lower number of fast coronal mass ejections as well as the large scale configuration of the background corona may be the cause of this phenomenon. In this study, we present the main characteristics of the large scale solar wind structures associated with the major Geomagnetic Storms ($Dst < -100nT$) over the ascending phase of solar cycle 24 (2009-2012). This work is based on the low corona and interplanetary medium observations through white light images, type II radio burst, interplanetary scintillation and in-situ measurements.

J14-8 THE OUTER HELIOSPHERE REVEALED BY RECENT VOYAGER AND ENERGETIC NEUTRAL HYDROGEN OBSERVATIONS

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The in-situ exploration of the interface between the Local Interstellar Medium (LISM) and the heliosphere in the nose region by Voyagers 1 and 2, and through the first global observations of Energetic Neutrals (ENAs) by IBEX and Cassini yielded numerous surprises: (1) the termination shock (TS) did not accelerate the Anomalous Cosmic Rays (ACRs); (2) the unexpected discovery of the ENA ribbon and belt; (3) contrary to expectations, north or south solar wind flows decreased with radial distance to 0 ± 20 km/s about 30 AU downstream of the TS in the Voyager 1 (V-1) direction; (4) at a sharp boundary (the heliocliff), V-1 entered a new, entirely unexpected region, still part of the heliosheath, where ACRs (that had finally reached maximum intensity in the prime acceleration region just before the heliocliff was crossed) disappeared entirely, the Galactic Cosmic Rays reached and stayed at their maximum intensity, and the magnetic field, while retaining the Parker spiral (nearly azimuthal) direction, became extremely smooth (nonturbulent) and doubled its strength. In view of these unexpected findings, we reexamine our current concepts concerning the nature of the LISM-Heliosphere interface and how and where particles are most efficiently accelerated, and present a model for the outer heliosphere that can account for all of the puzzling Voyager observations as well as the IBEX ribbon. We predict that, although the motion of the Sun relative to the LISM is only ~ 26 km/s, the nose region of the heliosphere must be surrounded by jets of supersonic solar wind with speeds of many hundred km/s flowing opposite to the direction of motion of the sun through the local interstellar medium. Decisive V-2 observations of the plasma flows near the heliocliff will be essential for validating our model.

J14-11p ICMES DETECTED BY THE MEXICAN ARRAY RADIOTELESCOPE (MEXART) EMPLOYING THE INTERPLANETARY SCINTILLATION (IPS) TECHNIQUE

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The interplanetary scintillation (IPS) technique is employed for monitoring the solar wind and large-scale structures (e.g. ICMEs), observing far radio sources signals. The Mexican Array Radiotelescope (MEXART) is an IPS observatory which is realizing its first ICME tracks. In this work, we report recent ICMEs observed by MEXART during the period April to June, 2013. We show the variation of scintillation index, and the ICMEs velocity calculated by a spectral analysis of different radio sources.

J14-12p COMPARATIVE STUDY BETWEEN THE MICRO-STRUCTURE OF MAGNETIC CLOUDS IN COMPLEX EVENTS AND ISOLATED MAGNETIC CLOUDS.

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Complex events are formed by two or more large-scale structures which interact in the solar wind. Typical cases are interactions of: (i) a magnetic cloud/interplanetary coronal mass ejection (MC/ICME) with another MC/ICME transient; (ii) a MC/ICME embedded within a stream interaction region (SIR); and (iii) a MC/ICME followed by a fast stream. Using data from the STEREO mission during the years 2007-2011 we found 17 ICMEs forming complex

events with an associated shock wave. All the ICMEs included in this study showed a smooth rotation of the magnetic field and low proton beta plasma, and were classified as MCs. We use magnetic field and plasma data to study the waves observed within these MCs. To determine wave characteristics we perform Fourier Power Spectra and Minimum Variance Analysis. We also analyze 9 MCs driving shocks which were not associated with complex events. We compare wave characteristics within the Magnetic Clouds forming Complex Events (MCCE), with those waves observed within the Magnetic Clouds that were isolated (IMC), i. e., not associated with complex events. Transverse, almost parallel propagating and nearly circularly polarized ion cyclotron waves (ICWs) were observed within both, MCCE and IMC. We find that both, left-handed ICWs and right-handed ICWs were present within MCCE and IMC. Compressive mirror mode waves (MM) were observed only within MCCE. We study plasma conditions inside the MCs to get insight about wave origin. Most of the mirror mode events found within MCCE, were observed in regions with enhanced plasma beta. This is in agreement with kinetic theory, which predicts that mirror mode growth is favored by high plasma beta values.

J14-13p STEREO OBSERVATIONS OF LARGE-SCALE SOLAR WIND STRUCTURES IN 2007 - 2012

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We have observed the solar wind extensively using the twin STEREO spacecraft in 2007 - 2012, covering the deep solar minimum 23/24 and the rising phase of solar cycle 24. Hundreds of large-scale solar wind structures have been surveyed, including stream interaction regions (SIRs), interplanetary CMEs (ICMEs), and interplanetary shocks. The difference in location can cause one STEREO spacecraft to encounter 1/3 more of the above structures than the other spacecraft in a single year, even of the quasi-steady SIRs. In contrast with the rising phase of cycle 23, SIRs and ICMEs have weaker field and pressure compression in this rising phase, and ICMEs drive fewer shocks. Although the majority of shocks are driven by SIRs and ICMEs, we find about 13% of shocks without clear drivers observed in situ. We report the annual variation of shock parameters and also compare the ICME-driven and SIR-driven shocks. According to our study in 1995 - 2009 using Wind/ACE spacecraft, on average 40% of SIRs do not occur near heliospheric current sheet and are probably attributed to pseudostreamers. We report the change of this rate in STEREO mission time.

J14-14p INVESTIGATION OF NESTED CME PROPAGATION DURING THE ASCENDING SOLAR CYCLE 24

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The coronal mass ejections have been widely observed with SOHO-LASCO and STEREOA&B Coronagraphs. The CMEs tend to be faster, wider and denser as the Sun approaches to the solar maximum. The active regions on the Sun tend to produce multiple CMEs as well as stronger CMEs that cause long lasting impacts at the Earth. Some of these multiple CMEs form a nested structure with bright radial cores with successor and predecessor leading edges from the same source region, which can reside in the former one's vicinity or separate in time. In this study the 17 May 2012 CME event that caused the first Ground Level Enhancement Event of Solar Cycle 24, has been investigated. The source region properties of the proposed nested CME were derived using the Triangulation Method. Its propagation through the Interplanetary Medium to Earth has been studied as well as the associated phenomena such as solar energetic particles, radio bursts and flares. The Event has been associated with a type-II radio burst according to the SWAVES, BIRS and Learmonth data. An M-class flare is also related with the Event as a result of GOES-15 flux data. The ENLIL model from NASA Community Coordinated Modeling Center has been run for the event and a comparison with real time data is provided for the propagation of the CME. The study is in accordance with former studies that propose a twin CME scenario for the event and associates the nested and twin CME phenomena.

J14-15p SPATIAL DISTRIBUTION OF SMALL-SCALE MAGNETIC BIPOLES

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We study the latitudinal distribution of the small - scale magnetic bipoles observed in photospheric and chromospheric bands during the declining phase and minimum of cycle 23 and the recent rise of cycle 24 are compared with the cyclic variations of solar activity.

In the scope of our research, we used longitudinal full-disk magnetograms from the Synoptic Optical Long-term Investigations of the Sun (SOLIS) vector spectro-magnetograph (VSM), in the time interval from 2003 to 2012 years. It is found that the temporal variation of number of chromospheric and photospheric bipoles be different. Also, there more narrower latitudinal profile of photospheric bipoles observed in minimum. We discuss how these results impact the magnetic fields configuration at the Sun.

Keywords: Sun: small scale magnetic field, magnetic bipole, photosphere, chromosphere, solar activity.

SESSION J17

DIV. II/IDCH HISTORY OF IONOSONDE RESEARCH

J17-1 FROM GUGLIELMO MARCONI TO NOWDAYS: A LONG TRADITION OF IONOSPHERIC MEASUREMENTS AT ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA**Zolesi, Bruno**Istituto Nazionale di Geofisica e Vulcanologia,
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Guglielmo Marconi, Nobel prize in 1909 for his contribution to the development of wireless telegraphy, realizing on 12th December 1901 a transoceanic radio link, was the first to provide the experimental proof of the existence of the Ionosphere, postulated during the eighteenth century by various scientists like Balfour Stewart and Arthur Schuster.

In 1936 he was the founder of the former Istituto Nazionale di Geofisica, a government institution with the main mission of the monitoring of geophysical phenomena in both the solid and fluid components of the Earth, giving there the initial study of the radio propagation.

After the first experiments performed in 1938 a prototype of an homemade ionosonde was built by the ionospheric group of ING in 1940. Then the years after the second world war to the international geophysical year were characterized by the need to organize an ionospheric observatory in Rome to provide a continuous and systematic monitoring of the in the ionospheric characteristics according the URSI specifications.

A short history of the ionospheric studies at INGV that followed the evolution of the ionospheric vertical sounding are here shortly reported. Since the first ionosondes Union Radio and Bibl Panorama used during 50 and 60 years to define the morphology and the normal ionosphere over Rome to the development of the digisondes, the digisonde 128P and digisonde 256 in 70 and 80 years and the recent and modern digisonde DPS4 in the last decades. Finally the automatic scaling methods applied to the digisondes and to the INGV homemade AIS ionosonde, able to provide a now casting picture of the ionosphere over the station.

J17-2 THE FEATURES IN GLOBAL DISTRIBUTION OF THE IONOSPHERIC PLASMA**Karpachev, A.T.; Ratovsky, K.G.; Klimenko, M.V., Klimenko, V.V.**Institute of Earth magnetism, ionosphere and radiowaves propagation named after Nikolay Pushkov of the Russian Academy of Sciences (IZMIRAN); ISTEP SB RAS; WD IZMIRAN
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We present the study of the different ionospheric layers (F1, F2 and F3), their diurnal and seasonal variations, and the dynamics of local and global ionospheric structures. It is well known that the main ionospheric trough, Weddell Sea anomaly, Yakutsk anomaly, nighttime mid-latitude electron density enhancements, and equatorial ionization anomaly have been discovered using ionosonde measurements. We discussed these main large-scale features of the 3D global ionospheric structure based on topside sounding data obtained onboard the Interkosmos-19 satellite (~3600 passes) and different digital ionosondes. Another main objective of our studies is to describe the main formation mechanisms of all these structures using the Global Self-consistent Model of the Thermosphere, Ionosphere and Protonosphere (GSM TIP). We compared the GSM TIP model results with IRI empirical model, and different observation data (Interkosmos-19 satellite, DPS-4 ionosondes).

These investigations were carried out at financial support of Russian Foundation for Basic Research (RFBR) Grant No. 12-05-312171 and Program 22 RAS.

J17-3 IONOSONDE BASED IONOSPHERIC RESEARCH AT ILORIN**Adeniyi, J.; Oladipo, O.; Adimula, I.; Olawepo, A.; Reinisch, B.; McHarg, M.**University of Ilorin (UNILORIN), UNILORIN, UNILORIN, UNILORIN, Lowell Digisonde International (LDI), USAF academy
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Measurement of ionospheric parameters at the University of Ilorin, Nigeria (longitude 4.57°E, latitude 8.53°N, dip 4.1°S), an equatorial station, started with the use of the ionospheric sounder APS 42 more than a decade ago. The measurements were few and not continuous. Some data obtained in 2002 and 2006 were used for the study of variability of ionospheric electron density at fixed heights, solar activity effects, and the validation of the IRI model. The effect of the 29 March 2006 eclipse was observed over this station. The eclipse effects on the E, F1 and F2 layer were documented, and ionisation and loss rates at various heights were obtained. In 2010, the Digisonde Portable Sounder DPS-4 was installed at Ilorin. The automatic data processing of the Digisonde is a great advancement in ionosonde based research. The data acquired with the Digisonde have been used for the study of the variations of minimum frequency recorded on ionogram trace (Fmin), modelling of the F1 ionisation density, spread F occurrence, magnetic storm effects, and the characteristics of the F2 layer. Some of the scientific results are presented in this paper.

J17-4 INVESTIGATION OF EQUATORIAL SPREAD F DEVELOPMENT CONDITIONS USING CONJUGATE POINT OBSERVATION BY DIGISONDES**Abdu, M.A.; Kherani, E.A.; Batista, I.S.; Reinisch, B.W.**Instituto Nacional de Pesquisas Espaciais (INPE); (INPE); (INPE); Lowell Digisonde International (LCC)
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The plasma structuring of the equatorial nighttime ionosphere, widely known as equatorial spread F (ESF) irregularities, results primarily from rapid changes in the post sunset ionosphere arising from E- and F- region electrodynamic coupling processes. The key drivers and control parameters of the instability growth leading to ESF development are: the enhanced evening plasma vertical drift (that is, the prereversal enhancement of the zonal electric field), the bottom side density gradient of a rapidly rising F layer, a precursor seed perturbation for instability initiation in the form of gravity wave induced oscillations in the F layer height with associated polarization electric fields, and meridional/trans-equatorial winds. The day-to-day variability in these parameters is responsible for the widely observed short term ESF variability. All these parameters can be measured by ionosondes/Digisondes operated in the equatorial and low latitude sites. In particular, observations by meridionally spaced Digisondes with the conjugate E layer field lines coupled to dip equatorial F layer bottom side provide a unique database addressing some outstanding issues of the ESF mechanism and its day to day variability. In this presentation we will discuss results on ESF/plasma bubble development conditions from the COPEX (conjugate point equatorial experiment) campaign conducted in Brazil in 2002. Using the observational results and model simulation of the ESF instability process, we aim at clarifying the important roles of precursor large-scale wave structures and ionogram satellite traces, the prereversal vertical drift, and trans-equatorial winds in the growth, development, and day-to-day variability of the ESF during the COPEX period.

J17-5 DEVELOPMENT OF AUTOMATIC IONOGRAM SCALING TECHNIQUES AND ITS SIGNIFICANCE FOR IONOSPHERIC RESEARCH**Galkin, Ivan; Reinisch, Bodo; Huang, Xueqin**University of Massachusetts; Lowell Digisonde International, (LCC); Lowell Digisonde International, (LCC)
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The difficulty of analyzing ionograms in terms of physical ionospheric quantities has hampered ionospheric research. Development of intelligent software systems that automate the interpretation and scaling of the ionogram images began in the post-IGY era. The early reports of autoscaling advances (1962-1965) were met with enthusiasm and hope that they would quickly evolve to a reliable replacement of the subjective, prone-to-error, time-consuming human analysis of the ionosonde measurements. However, the autoscaling pioneers were also to discover, like in many other ambitious artificial intelligence (AI) projects at that time, the Vital Few Dilemma: computer models of the human vision and reasoning fared well only in a number of compatible ionogram examples, while correct interpretation of the remaining vital few types demanded new, increasingly greater level of AI, unreachable with the technology at hand. Fifty years after the pioneering publication, the ionogram autoscaling is still an open research problem. This paper reviews notable advances of the ionogram autoscaling techniques, inspired by both bio-plausible modeling of the human intelligence, physics-based modeling of the wave propagation in the ionosphere, and progress in ionosonde engineering. More importantly, the paper discusses the intrinsic uncertainty of autoscaled data, and important ways to deal with unavoidable errors of intelligent system and sounding equipment in order to provide useful data for ionospheric research and applications. Modern autoscaling, armed with the metrics of its uncertainty and confidence, protected against the real-life imperfections of the observation, and enhanced with new ways to address the Vital Few Dilemma, has become the essential technology that enables the global, detailed, and prompt view of ionospheric plasma conditions affected by space weather events.

J17-6 GLOBAL MAPPING OF FOF2 FOR IRI USING THE DIGISONDE GIRO NETWORK**Reinisch, Bodo; Galkin, Ivan; Huang, Xueqin; Vesnin, Artem; Bilitza, Dieter**LDI; UML; LDI; UML; GMU
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The ionosonde has been the workhorse of ionospheric exploration for almost a century. From the discovery of the different ionospheric layers to the calculation of the vertical electron density profiles (EDPs), ionosondes provided the measured data. When COSPAR in 1968, later joined by URSI, initiated the development of the International Reference Ionosphere (IRI) it were the ionosondes that provided the majority of the input data required to build the IRI electron density model, primarily foF2, hmF2, foF1, hmF1, foE, hmE. Rocket and satellite data and incoherent scatter radar data added important information about the electron density in the topside ionosphere which is not accessible to ground-based ionosondes. Reliable topside electron density profiles were derived from topside sounder measurements (like Alouette and ISIS). The IRI electron density model is an empirical model based on the monthly median values of the ionospheric characteristics foF2, hmF2, etc. We have now started the development of the IRI Real Time Assimilative Model, IRTAM. The Global Ionospheric Radio Observatory (GIRO) determines the layer characteristics in real time, and the majority of the worldwide GIRO Digisonde stations feed the data every 15 min

into the Lowell DIDBase system. This presentation discusses the assimilation of foF2 into IRI for the construction of IRTAM. A new IRTAM foF2 map is specified in near real time every 15 min. Similar procedures are developed for all other characteristics to finally specify the global assimilative IRI electron density model.

J17-7 NEAR-REAL-TIME FORECASTING TOOL FOR ELECTRON DENSITY PEAK HEIGHT BASED ON IONOSONDE NETWORK DATASETS

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The worldwide network of digisondes provides suitable datasets for analyzing changes in electron density height distribution during both quiet and disturbed conditions making possible studies of the global ionosphere at climatological and meteorological time-scales. The ionospheric data sets obtained by ionosondes have been used to obtain an analytical formulation for predicting the quiet pattern of the electron density peak height (hmF2Q) at global scale, which is bounded to the local time, season and solar activity, as well as an analytical formulation to forecast its disturbed pattern during intense geomagnetic storms (?hmF2) at mid-latitudes, which is bounded to the local-time, season and to the conditions of the interplanetary magnetic field. This contribution aims also to show that by combining both models hmF2Q and ?hmF2 it is possible to build a tool that successfully forecast hmF2 at mid-latitudes in near-real-time. Examples of the model performance comparing its prediction with ionosonde observations under both quiet and disturbed conditions of the current solar cycle 24 will be presented.

J17-8 SPREAD-F OBSERVED BY DIGISONDES IN LOW LATITUDE REGIONS AND ITS CORRELATION WITH IONOSPHERIC SCINTILLATION

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In this study, we use the data from Digisondes and ionospheric scintillation monitors co-located both at low latitude station Hainan in northern hemisphere (109.1° E, 19.5° N geogr., dip lat. 9° N) and Vanimo in southern hemisphere (141.3° E, 2.7° N geogr., dip lat. 11° S) to study the ionospheric spread F (SF) and its correlation with the scintillation. By analyzing, we divide the SF as four types: frequency SF (F-SF), mixed SF (M-SF), range SF (R-SF), and strong range SF (S-SF). The S-SF is characterized by extended range spread on F layer echo traces that significantly extend beyond the local foF2 and made the foF2 could not be definable. For the Hainan station, the maximum and the minimum of the occurrences of the S-SF appeared in nearly the same as those of the GPS L-band scintillations. The variation of the S-SF occurrence was also similar to that of the scintillation. From 2003 to 2007, both the S-SF and the scintillation occurrences decreased from the high solar activity year to the low solar activity year. The correlation coefficient between the occurrences of the S-SF and the GPS L-band scintillation was as high as 0.93 suggesting associated mechanisms producing S-SF and scintillation. For the Vanimo station, the occurrence variation of the S-SF was also similar to that of the scintillation. The correlation coefficient between the two phenomena was as high as 0.88, which supports the view of the associated mechanisms to produce S-SF and scintillation. The electron density depletions extending from the bottomside to the topside ionosphere are the most likely cause explaining the high correlation.

J17-9 RECENT IONOSONDE STUDIES OF SPORADIC E LAYERS

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The midlatitude sporadic E layers (Es) are dense plasma layers which form in the lower E region ionosphere between about 90 and 130 km when metallic ions of meteoric origin are converged vertically in a wind shear. Since the invention of ionosonde in the nineteen thirties, sporadic E has been investigated extensively from the ground using analog and digital ionosondes and incoherent scatter radars, in situ measurements with rocket-borne sensors, and from space using satellite GPS occultation records. In this paper we introduce the phenomenon by reviewing briefly the basic physics of Es formation (windshear theory), and then discuss selected results we have obtained the last several years with ionosondes. The emphasis is placed on the tidal wind shear control of the diurnal and semidiurnal variability and altitude descent of sporadic E layers and how this variability can be investigated by applying a height-time intensity (HTI) technique on continuous digital ionosonde recordings. Furthermore, the paper describes how global ionosonde observations have been used (and can be used) to establish (to further investigate) the planetary wave role in sporadic E layer occurrence and longer-term variability. Finally a brief mention is made on recent findings which provide physical insight into the seasonal dependence and global occurrence of sporadic E that have been monitored by ionosondes for many years. Amazingly, after 80 years of ionosonde observations and studies of sporadic E, digital ionosonde systems and their records still remain valuable components in the research efforts to increase our understanding of a prominent ionospheric phenomenon.

J17-10 COMPARISON OF DPS-4 OBSERVATIONS OVER CENTRAL PAKISTAN WITH IRI-2007 & IRI-2011 DURING THE DEEP SOLAR MINIMUM BETWEEN 23RD AND 24TH SOLAR CYCLES**Ayyaz Ameen, Muhammad; Raza, Kazim; Ayub, Muhammad**

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Digisonde DPS-4 data of Multan (geog coord. 30.18°N, 71.48°E) is being reported for the first time. The variations in F2-layer peak electron density (NmF2), its height (hmF2) and the F2-layer thickness parameter (B0) have been studied during the deep solar minimum between 23rd and 24th solar cycles along their comparisons with IRI-2007 & IRI-2011 predication. The observation results show that the NmF2 values are greater and smaller during daytime and nighttime, respectively. The hmF2 and B0 observations show sunrise peaks along with some prominent pre-sunrise peaks in some months. Seasonal variations show that the daytime NmF2 are greater in the equinox and summer months, while the daytime hmF2 and B0 are slightly greater in the equinox and winter months. For the comparison of observation with IRI-2007 and IRI-2011, the observed hmF2 values are closer to IRI-2007 than to IRI-2011. The NmF2 of URSI map of IRI-2011 agrees well with the observations in equinox. The IRI-2007 agrees better with the NmF2 observations for winter and summer than IRI-2011, whereas IRI-2011 is closer to the observations for equinox months. Regarding the B0 comparison, the Gulyaeva option gives better agreement with the observations for IRI-2007 except a prominent peak in observation during equinox months. The table option of both IRI-2007 and IRI-2011 give the similar set of model values. The CCIR map and Gulyaeva option produce a slightly better predication of NmF2 and B0, respectively.

J17-13p A COMPARISON BETWEEN AUTOMATICALLY AND MANUALLY SCALED IONOSPHERIC CHARACTERISTICS OVER CYPRUS FROM 2009 TO 2012**Haralambous, Haris; Vryonides, Photos**

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The challenge for provision of accurate operational nowcasting and short-term forecasting ionospheric services based on ionogram-derived products has greatly increased during the last decade with a clear future trend to evolve into real time assimilation services. This fact, coupled with internet bandwidth expansion and enhanced capabilities of modern ionosondes to operate on a high time resolution (a significant number of Digisonde ionospheric sounders contributing to GIRO -Global Ionospheric Radio Observatory provides data at 5 min resolution) has significantly increased the demand for reliable and consistent automatic scaling for the purpose of determination of ionospheric characteristics derived from ionograms (Reinisch *et al.*, 2011). This demand has been constantly driving the development and continuous improvement of existing programs in order to provide accurate automatically scaled data. The ARTIST software developed at the University of Lowell, Center for Atmospheric Research, is an automatic scaling program widely used and has undergone several upgrades (Galkin *et al.*, 2008). This study attempts to quantify the quality of all the key ionospheric characteristics scaled automatically from ionograms from the low to mid latitude Nicosia ionosonde in Cyprus by performing a comparison with manual scaled values. The data for the study encompass a period of four years covering the rising phase of solar cycle 24 from 2009 to 2012.

SESSION J18-J15**CHARACTERIZATION OF IONOSPHERIC AND MAGNETOSPHERIC PROCESSES FROM GROUND AND SATELLITE OBSERVATIONS - PLASMA INTERACTIONS AT SOLAR SYSTEM BODIES WITHOUT OR WITH WEAK INTRINSIC MAGNETIC FIELD****J18-1 STUDIES OF GEOMAGNETIC PULSATIONS USING MAGNETOMETER DATA FROM THE CHAMP LOW-EARTH-ORBIT SATELLITE AND GROUND-BASED STATIONS IN AFRICA****Sutcliffe, Peter; Lühr, Hermann; Heilig, Balázs**

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The German satellite CHAMP was launched on 15 July 2000 into a near polar circular orbit at an initial altitude of 454 km. The low orbit is rather special, being roughly a similar distance above the ionosphere as ground stations are below the ionosphere. This provides a unique opportunity to study geomagnetic pulsations and the effects of the ionosphere on their propagation by utilizing the low-Earth-orbit (LEO) satellite data in combination with ground-based data. In this presentation we show how research on geomagnetic pulsations can be carried out using magnetic field data from CHAMP and two ground-based stations in South Africa.

The high quality magnetic field measurements from CHAMP enabled us to clearly resolve Pi2 pulsations in the LEO magnetometer data. Consequently, we used the opportunity to make a comparative study of Pi2 pulsations

observed above and below the ionosphere in order to clarify the wave nature of these pulsations at low-latitudes. The good correlation that we found between the H-component at the ground stations and the compressional and poloidal components at CHAMP, are indicative of a cavity mode resonance for nighttime Pi2s.

We also studied the structure of low-latitude Pc3 pulsations by comparing magnetic field measurements for times when CHAMP was passing over the ground stations. We found that different types of field line resonant structure appear to be observed at CHAMP; discrete frequencies are observed for some events while L-dependent frequencies are observed for others. Notable features of field line resonances observed in our investigations are a Doppler shift in the satellite azimuthal component and an approximately 90° rotation of the polarization ellipse between CHAMP and the ground.

J18-2 DAY-TO-DAY VARIABILITY OF THE QUIET-TIME EQUATORIAL AND LOW LATITUDE GEOMAGNETIC FIELD

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Ground-based magnetometer measurements of the horizontal component H at an equatorial station and at a station just outside the influence of the equatorial electrojet (EEJ) have been used in recent times to derive the daytime vertical ExB drift velocity in the equatorial F region of the ionosphere. There are significant day-to-day variations in the daily patterns of H at equatorial and low-latitude stations even for the international quiet (IQ) days in a month in addition to seasonal changes. Modeling this variation is important for modeling the quiet-time variability of the daytime zonal electric field in the equatorial F region, and for improved estimates of storm-time penetration electric fields in the equatorial ionosphere. Measurements of H from equatorial stations and a low-latitude station outside the influence of the EEJ in the Indian region, for the IQ days of the years 1985-1989 and 2001-2005, have been separately subjected to Principal Component Analysis to determine the principal components (PCs) that describe the data. It is found that for both data sets nearly 90% of the variability is explained by the first three PCs, with PC1 itself representing about 70% of the variations. Moreover, PC1, PC2, and PC3 for the equatorial stations are nearly identical for the two periods, while for the off-equatorial station PC1s are nearly identical but the differences for the two periods increase progressively for PC2 and PC3. The amplitudes or scores for PC1 show a clear tendency to increase with daily F10.7. Near the dip equator, the solar influence is strongest for the vernal equinox, followed by the autumnal equinox, June solstice, and December solstice in decreasing order. At the low latitude station, vernal equinox and December solstice show the maximum and minimum solar influence, while autumnal equinox and June solstice are about the same. The day-to-day variations in the amplitudes for the first three PCs at these stations are parameterized using a model to describe the seasonal and solar flux dependence of the variations and the implications of these results are discussed.

J18-3 LOW-LATITUDE PC3/PI2 WAVES OBSERVED IN THE UPPER IONOSPHERE BY CHAMP AND ON THE GROUND

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The spatial structure of Pc3-5 and Pi2 waves throughout the Earth's surface is very inhomogeneous and demonstrates a localized amplitude enhancements, attributed to the Alfvén field line resonance. However, at near-equatorial latitudes the field lines are totally submerged into the ionospheric plasma and Alfvén field line oscillations are strongly damped. Nonetheless, clear monochromatic pulsations are often observed at near-equatorial latitudes. However, a possible mechanism of equatorial ULF enhancement is still unresolved problem. Several different mechanisms can be involved:

- Enhancement of the ionospheric currents induced by ULF wave which spread into the equatorial region with elevated ionospheric Cowling conductance;
- Direct penetration of ULF compressional wave energy towards the near-equatorial region without conversion into Alfvén field line oscillations;

To resolve them can be achieved with the comparison of simultaneous low-orbit satellite observations (CHAMP) and ground magnetometers SAMBA. Pc3 and Pi2 waves show up very clearly in the compressional component of the satellite magnetic field data, whereas on the ground, their signature is found in the H component. The coherence between ground and satellite wave signatures is high over wide latitude and longitude ranges. The observational results have been compared with possible scenarios. According to the predictions of the thin ionosphere model upon the transmission of the compressional fast mode through the equatorial ionosphere the wave attenuation is to be weak. The latitudinal distribution of compressional wave power is determined by the diffraction of a large-scale fast mode on a relatively small conductive sphere.

J18-4 TOTAL ELECTRON CONTENT VARIATIONS DURING GEOMAGNETIC STORM OVER INDIAN SECTOR**Shetti, D.J.; Patil, P.T.**

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The GPS data of Kolhapur station (16.8°N, 74.2°E) have been used to measure Total Electron Content (TEC) of the ionosphere during the May 15-17, 2005 magnetic storm and compare this with Hyderabad station (17.410N, 78.550E) and Bangalore (13.020N, 77.570E). Possible sources of error in GPS measurements such as satellite and receiver biases are removed using UNB Ionospheric Modelling Techniques and RD_RINEX slant TEC software. Storm positive and negative effects on temporal changes in TEC were investigated. On May 15, the shock was observed around 0600UT i.e. 1130LT (Local Time). The effect of the magnetic storm on May 15, 2005 shows an increase in the VTEC values, followed by sudden decrease in Dst values which was found to be lowest (-256nT) at 0900 UT. In daytime, the percentage deviation of TEC relative to their quiet time values was 120% while at night time it was only 40% relative to the earlier quiet night and it changes latitude wise. We also observed that the rate of loss of TEC ($d(\text{TEC})/dT$) was also more on May 15, 2005 during local noon time relative to their quiet time values and there was slight increase in their values observed at night and behavior of TEC changes with latitude.

J18-5 SPORADIC E LAYER DEVELOPMENT AND DISRUPTION OVER LOW LATITUDES BY ELECTRIC FIELDS, DURING QUIET TIMES AND MAGNETIC STORMS**Abdu, M.A.**

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Sporadic E layers are formed dominantly by wind shear mechanism, but their formation and dynamics are driven also by ionospheric electric fields. Under quiet conditions, the equatorial evening prereversal enhancement electric field has been known to control the post sunset formation/disruption of sporadic E layers. New investigation of low latitude sporadic E layers during magnetic storms show that the formation and disruption of these layers are strongly controlled by the magnetospheric electric fields that penetrates to equatorial ionosphere. It has been observed that a prompt penetration electric field (PPEF) of westward polarity that dominate the night side ionosphere can cause sporadic E layer formation near 100 km, while a PPEF of eastward polarity that dominate the day- and evening hours can lead to disruption of an Es layer in progress. Such effects are produced by a vertical Hall electric field, induced by the primary zonal PPEF, in the presence of storm associated enhanced conductivity of the night E layer. A downward (upward) polarity of the Hall electric field can cause vertical convergence (divergence) of the ionization leading to Es layer formation (disruption). An interplay of magnetic storm associated prompt penetration electric field and energetic particle precipitation appears to be present in the Es layer response features during magnetic storms, particularly in the region of the South Atlantic Magnetic Anomaly.

J18-6 THE GEOMAGNETIC SEMIANNUAL ANOMALY ON THE FOUR DST-FUNDAMENTAL OBSERVATORIES: DEPENDENCES WITH SUN-EARTH PHYSICAL PARAMETERS**Azpilicueta, Francisco; Brunini, C.**

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The semiannual anomaly (also known as semiannual variation) on the magnetic activity is a phenomenon that produces clear minima during March and September and maxima in June and December on the horizontal components of the geomagnetic field. This phenomenon has been known since the middle of the nineteenth century, but in spite of the accumulation of measurements and the development of three theoretical models, a conclusive physical explanation for it has not been developed. The usual approach to study the semiannual anomaly is by means of geomagnetic indices like the disturbance storm time, Dst, which is based on combining measurements registered on four magnetic observatories. This work follows a different approach based on the raw horizontal components registered at the four observatories. The analyses performed aimed to study and assess the impact of several external parameters, characteristics of the Sun-Earth environment, on the semiannual anomaly. The influence of the global geomagnetic activity level, the solar activity level, the solar magnetic polarity, and the rising/declining phase of the solar radiation cycle is analyzed in detail. The most important finding is that the semiannual anomaly is always present and that none of the previously mentioned parameters significantly favor the development of it. A second result is the presence of a 27 day signal superposed to the semiannual anomaly which is significantly affected by the solar activity level.

J18-7 THE CRITICAL FREQUENCY FOF2 AND VIRTUAL HEIGHT h•F ANNUAL VARIAT**Biktash, Lilia**

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We have analyzed annual ionospheric variations of the critical frequency foF2 and virtual height h•F at the equatorial stations during the solar minima. There are essential distinctions between the global TEC (total electron content) and foF2 annual variations during the last two solar minima. Many authors concluded that the annual means of foF2 and the global TEC were reduced, while others investigations no found essential variations as compared with the previous solar minimum. Most if not all of authors suppose that the possible source of this phenomenon is the low level of the EUV (extreme ultraviolet) during the solar minima. The aim of our paper is to amplify these conclusions or to propose new factor which can change ionosphere parameters during the solar minima. We have calculated the critical frequency foF2 and virtual height h•F annual variations at the equatorial stations Vanimó and Huancayo. These data have been compared with annual variations of Dst-index and EUV at the minimum phases of the solar cycles 22 and 23. We have found that in addition to low level of the EUV during the solar minima, the equatorial Dst-index as effect of geomagnetic field variations has to be included as the influencing factor on annual ionospheric variations. In addition, we have calculated annual variations of the solar wind parameters to show that ionospheric variability at the equator is influenced also by geomagnetic activity due to different macro-scale structure of the heliosphere during the solar minima.

J18-8 IMPACT OF THE SOLAR MINIMUM ACTIVITY ON THE BRAZILIAN IONOSPHERE**Candido, Claudia M.N.; Batista, I.S.**

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The minimum period of the solar cycle 23/24 was abnormally deep and extended have been inspiring several studies on solar physics, on ionosphere/thermosphere system and on climate. In this work we present some results for this period extracted from ionospheric data over Brazilian region at two equatorial sites, Sao Luis (44.2° W, 2.33° S, dip angle: ?6.9°) and Fortaleza (38.45°W, 3.9° S, dip angle: ?16°) and at the low latitude station Cachoeira Paulista, CP (22.4° S, 45° W, dip angle: -37°). It was observed that the plasma densities during the last solar minimum were lower than that observed in the previous period in 1996, but only for some periods. An abnormal occurrence rate of spread-F/plasma irregularities over CP was observed during June solstice of solar minimum. Besides, the ionograms acquired in all stations revealed distinct patterns of spread-F associated with midnight/post-midnight irregularities. Over the equatorial region, it was observed significant decreases in the plasma densities during nighttime periods with no-echoes in the ionograms lasting for several hours. Afterwards, the same distinct spread-F patterns were observed during the ascending phase (2011) of the current solar cycle over the equatorial region, both with Digisondes and coherent backscatter radar. It will be discussed the nature of the observed plasma irregularities and of the ionosphere behavior under the influence of the solar minimum activity.

J18-9 EQUATORIAL 150-KM ECHOES AND DAYTIME F-REGION VERTICAL PLASMA DRIFTS IN THE BRAZILIAN LONGITUDE SECTOR**Rodrigues, F.S.; de Paula, E. R.**

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Previous studies showed that conventional coherent backscatter radar measurements of the Doppler velocity of the so-called 150-km echoes can provide an alternative way of estimating the average ionospheric vertical plasma drift during daytime hours (Kudeki and Fawcett, 1993; Chau and Woodman, 2004).

Using observations made by a small, low-power 30 MHz coherent backscatter radar located in the equatorial site of Sao Luis, we were able to detect and monitor the occurrence of 150-km echoes in the Brazilian sector. Using these measurements we estimated the local time variation of daytime vertical ionospheric drifts in the Eastern American sector.

Here, we present and discuss a few interesting cases of 150-km echoes observations made by the Sao Luis radar and estimates of the diurnal variation of vertical drifts. These cases exemplify the variability of the vertical drifts in the Brazilian sector. Using same-day 150-km echoes measurements made at the Jicamarca Radio Observatory in Peru, we also demonstrate the variability of the equatorial vertical drifts across the American sector. The stations are only ~30o longitude apart. We also present observations of abnormal drifts detected by the Sao Luis radar that were associated with the 2009 major sudden stratospheric warming event.

We conclude this presentation with our plans for new coherent backscatter radar measurements of E- and F-region ionospheric irregularities in Brazil.

J18-10 THE WEDDELL SEA ANOMALY OBSERVED IN THE VTEC MEASUREMENTS**Meza, Amalia; Natali, M. Paula; Fernandez, Laura Isabel**

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The Weddell Sea Anomaly (WSA) was discovered in the early 1960 (Bellchambers and Piggott, 1958; Penndorf, 1965), but it has not received much attention till the last fifteen years (Horvath and Essex, 2003; Horvath, 2006).

The WSA is defined when the nighttime plasma density is greater than the daytime density in the area near the Weddell Sea, more specifically a region about 55 S to 66 S/ 85 S (the latter limits are the southern boundary of satellite orbits and IONEX bins respectively), and about 225 E - 315 E in longitude.

The WSA morphology was analyzed using the Vertical Total Electron Content (VTEC) during high (2000) and low (2008) solar activity. In this work we use Global IGS VTEC maps (GIM) and Principal Component Analysis to study spatial and temporal ionospheric variability. The IGS VTEC maps are reorganized, and from each daily data set, two maps were constructed: one at noon and the other at night in order to analyse the behaviour

Using the GIM VTEC maps and the PCA technique our results highlight the WSA in summer for low solar activity and in summer and spring equinox for high solar activity.

J18-11 DYNAMICS OF POLAR CAP BOUNDARY AND ASSOCIATED EFFECTS IN THE PLA**Lukianova, Renata; Kozlovsky, Alexander**

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We used the dataset obtained from the EISCAT Svalbard Radar to study statistically the ionospheric convection in a vicinity of the polar cap boundary (PCB) as related to IMF conditions. The effect of IMF B_y is observed in the intensity and direction of the azimuthal component of ionospheric flow. The most significant effect is on the day and night sides whereas on dawn and dusk the effect is essentially less prominent. An asymmetry is revealed with respect to the noon-midnight meridian: the magnetospheric response to IMF B_y is stronger in the 00-12 MLT sector compared to the 12-24 MLT sector. Quantitative characteristics of the IMF B_y effect are presented and explained by (1) the magnetospheric electric fields generated due to the solar wind, (2) the displacement of PCB for different IMF orientation and (3) the magnetospheric plasma distribution. In order to estimate the polar cap shift the statistical model of the position of PCB depending on the IMF B_y and B_z is constructed using the database of the auroral oval boundaries from the IMAGE satellite. Also, the PCB dynamics during magnetic storms is analyzed. In particular, it is shown that after northward turn of the IMF during the storm's recovery phase on the dayside, the PCB is shifted to the north practically without time delay. The night boundary requires many hours to be shifted to the pole.

J18-12 STRUCTURE AND DYNAMICS OF IONOSPHERIC DISTURBANCES AT MIDLATITUD**Cherniak, Iu; Zakharenkova, I.; Krankowski, A.; Shagimuratov, I.**

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The knowledge about ionosphere is necessary for design and operation of space vehicles, remote sensing, navigation and communication. One of the most challenging tasks in upper atmosphere physics is the proper representation of the ionospheric response to space weather changes. The last extended solar minimum conditions and the beginning of the new 24th solar cycle give us an opportunity to investigate the ionosphere disturbances at background of extremely low electron density values. For study of global structure of ionospheric disturbances was used the different data provided by ground-based and satellite ionosphere measurements. It was processed the data from European, American, Japanese, and Australian ionosonde networks as benchmark data source. The ionosphere modification on a global scale have been checked with use of Global Ionospheric Maps, provided by international GNSS Service, and data from FORMOSAT-3/COSMIC RO mission. Additionally for estimation of the electron density dynamic at high latitudes was analyzed TEC fluctuations map, created by IGS/EPN, PBO and POLENET data.

As case study events have been selected geomagnetic disturbances occurred on October 2008, July 2009, May 2010 and September 2011, when observed more essential ionospheric responses. The global maps of TEC were used in order to estimate large scale storm effects, ionosonde data gives possibilities to study the local peculiarities of the ionosphere disturbances (two parameters have been processed the NmF2 and hmF2). Additionally for analysis of the height ionospheric structure we combined ionosonde-derived data with the Ne profiles from FORMOSAT-3/COSMIC RO measurements and global distribution of electron density at selected altitudinal intervals.

It was resulted that selected moderate geomagnetic storms ($K_p \sim 6$) lead to the different ionospheric response (positive and negative) over European, American, Japan and Australian areas. The global pattern and local temporal and quantitative characteristics of the ionosphere disturbances during selected storms were revealed. For example geomagnetic storm October 11, 2008 lead to short time positive ionospheric disturbance over Europe in TEC values with factor 2, foF2 - with factor 1,5-1,8 and uplifting of F2 layer maximum up to 100 km.

Additionally it was carried out the comparison of ionosonde derived foF2 values with IRI-2007 model, that have the storm-time option. It was obtained the qualitative agreement between the ionosonde-derived foF2 values and

model calculations for cases of negative ionospheric storms. The best agreement between model and observations results corresponds to the Northern Hemisphere mid-latitude stations.

We acknowledge the Australian IPS Radio and Space service and the National Institute of Information and Communications Technology (NICT) in Japan for providing ionosonde data. The authors would like to thank B.W. Reinisch and the Center of Atmospheric Research, University of Massachusetts Lowell for the ionogram data of DIDBase. We are also grateful to International GNSS Service (IGS) for GPS TEC products.

J18-13 SUPERMAG: GLOBAL OBSERVATIONS OF EARTH-SPACE COUPLING

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SuperMAG is a worldwide collaboration of organizations and national agencies that currently operate more than 300 ground based magnetometers. This vast data set is truly unique since it allows continuous and nearly global measurement of a fundamental parameter, the ground level magnetic field, thereby allowing studies of the global electric current system and its coupling to near-space. SuperMAG is currently funded by NASA, NSF and ESA. In this presentation we focus on two recent studies enabled by this global collaboration: 1) A generalization of the traditional 12-station auroral electrojet (AE) index to include more than 100 magnetometer stations, SME, was shown to be an excellent predictor of global auroral power and it was shown, contrary to common opinion, that substorms do not have a preferred recurrence rate but instead have two distinct dynamic regimes, each following a power law. 2) Earth's ring current studies revealing consistent local time asymmetries in the net current which suggest that part of the current closure takes place in other regions of space. Measurements from the Cluster spacecraft was found to indicate the role of magnetopause surface currents for ring current closure.

J15-14 OBSERVATIONS OF NARROWBAND WAVES ON THE SURFACE OF THE MOON IN THE TERRESTRIAL MAGNETOTAIL

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By examining the data collected by the Apollo 15 and 16 Lunar Surface Magnetometers between April and July of 1972, we have found a type of narrowband waves observed on the surface of the Moon. With frequencies ranging from 0.04 to 0.17 Hz, these narrowband waves are present only when the Moon was in the terrestrial magnetotail, and the wave properties are consistent with those of ion cyclotron waves. We propose that anisotropy of ion temperature can exist in the vicinity of the Moon, exciting the ion cyclotron instability and resulting in the narrowband waves observed on the lunar surface. Simultaneous observations at the Apollo 15 and 16 sites reveal a small but noticeable difference in wave amplitude and phase, suggesting that the variations in the interior electrical conductivity alter the wave signals observed on the Moon.

J15-15 SIMULATIONS OF ION ACOUSTIC WAVES IN SATURN'S MAGNETOSPHERE

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Existence domains and characteristics of ion acoustic waves are studied in a two-temperature electron, adiabatic ions and low density ion plasma with the electron components being kappa-distributed. Such an environment has been found in Saturn's magnetosphere. Using a Particle-in-Cell (PIC) simulation, the evolution of the spatial electric field is tracked during the entire simulation, after which a dispersion diagram is constructed to study the dispersion characteristics of the ion acoustic mode

J18-16 TIME-DEPENDENCE IN THE JOVIAN AND SATURNIAN MAGNETOSPHERES: MASS-LOADING AND MAGNETOSPHERE-IONOSPHERE COUPLING

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The neutral mass sources for the jovian and saturnian magnetospheres are recognised as being time-dependent. However, the extent of this variability, and the variability this then produces in magnetospheric fields and particles is not well understood from a theoretical or observational perspective. In this paper we present a time-dependent two-dimensional model of the jovian and saturnian magnetospheres. This model combines physical chemistry from neutral cloud theory, diffusive radial transport of mass and angular momentum, magnetosphere-ionosphere coupling to enable angular momentum transport between the magnetosphere and the planet, and coupling to an Euler potential model of the magnetospheric magnetic field. Model outputs, including in situ fields and particles, and energetic

neutral atom and optical emissions are described and examples presented. We present an application of this model to understand the consequences of impulsive volcanism at Io and also to establish what can be inferred from remote ground-based images of the Io plasma torus in S+.

J18-15p EFFECTS OF ELECTRIC FIELD AND NEUTRAL WIND ON THE EQUATORIAL AND LOW LATITUDE IONOSPHERE DURING GEOMAGNETICALLY DISTURBED PERIODS.

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Solar events generate geomagnetic disturbances on Earth. Furthermore, changes in the electrical current system and in the circulation of winds in the upper atmosphere are produced. These changes disturb the ionosphere, for example, intensifying or inhibiting the Equatorial Ionization Anomaly, introducing anomalous variations in the amplitude and height of the F-layer peak, in the E-layer and in the occurrence of sporadic layers, among others effects.

The disturbed electric fields will generate disturbed $E \times B$ drifts, which are very important for the electrodynamic processes at the equatorial regions. Furthermore, as one of the transport mechanisms for the charged particles is neutral wind drag, the plasma transport will also be modified by the disturbed wind.

During magnetically disturbed periods, disturbances in several ionospheric parameters measured by Digisonde are observed, but the existing ionospheric models are unable to represent the observations properly.

In this work we will use the ionospheric model SUPIM (Sheffield University Plasmasphere Ionosphere Model) in order to simulate the ionospheric behavior at different stations in the equatorial and low latitude regions in Brazil during some geomagnetically disturbed events.

To find a pattern in these circumstances, we will adjust the input parameters, in this case, electric field and neutral winds, because we know that these parameters vary in these periods, until the results of the model can explain the electron density variations observed on Digisonde data at various stations.

J18-16p CHARACTERISTICS OF GEOMAGNETIC PULSATIONS AT GROUND AND SPACE

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Ultra-low-frequencies (ULF) waves observed in the magnetosphere manifest themselves as geomagnetic pulsations at the ground. The main objective of this work is twofold. Firstly we have used satellite observations to study magnetosphere-ionosphere coupling and its effect on geomagnetic pulsation. The study reveals that the ionosphere plays a major role in supporting different types of standing Alfvén wave structures depending on the ionospheric conditions. Secondly, we study the Field line Resonance (FLR) mechanism in the subtropical regions ($L < 1.4$). FLR mechanism is responsible for coupling the incoming fast mode with that of the standing oscillations on the geomagnetic field lines. For this purpose, we have analyzed low latitude ground magnetometer data from Indian sector.

J18-17p FIRST RESULTS OF DOPPLER EXPERIMENT IN HF BAND UNDER THE SOUTH CREST OF EQUATORIAL ANOMALY

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Gravity waves (GWs) transfer energy and momentum between lower and upper atmosphere. The coupling between different regions of the atmosphere has been studied by means of several methods. Using a multi-point continuous Doppler sounding system, operating in HF band, it is possible to observe GWs with a good time resolution, and to determine GW velocities and propagation directions. Such observations have been carried out in the Czech Republic and in South Africa, and since 2012 also in Argentina. A Doppler radar system, developed at the Institute of Atmospheric Physics of Academic of Sciences (Czech. Rep.), has been deployed in the vicinity of Tucuman within a joint project between the Czech Republic and Argentina in order to study GWs under the South crest of Equatorial Anomaly. The system is composed of three transmitters of highly stable frequency and one receiver placed at UNT campus (26.8435 S; 65.2299 W). In this paper the first observational results of the Argentinian Doppler network are presented.

J18-18p ORIGIN AND INFLUENCE OF THE EXTERNAL MAGNETIC FIELD DISTURBANCES THROUGH TERRESTRIAL SURFACE DATA: CASE STUDY IN MEXICO.

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The Earth's magnetic field reaches far above into the space and is confined within the magnetosphere, bounded by the magnetopause. The Solar Wind cannot easily penetrate the terrestrial magnetic field, even though it is one of

the sources of the plasma in this cavity. In the magnetosphere, ions and electrons are not immobile, but rather move in different directions, creating electric currents. As a result, there are a variety of electric current systems inside the magnetosphere, and as a consequence, magnetic field disturbances are produced. The patterns of these currents depend mostly on the state of the changing solar wind. Effects of these systems are recorded on the surface through magnetometers in observatories, and the processes that produce them can be interpreted from these data.

In this study, we use data supplied by some American magnetic observatories, and along with geomagnetic indices and ground magnetic recordings, we describe the origin of the external magnetic fields. We carry out this for two states of the Sun, quiet and disturbed, and therefore establish a criterion for distinguishing the origin of the disturbed states. We also identify magnetic disturbances in magnetograms and interpret them in terms of the current systems considered.

At Mexican latitudes, the influence of these current systems and the effect of geomagnetic storms, considering geomagnetic indices, have not been studied yet. The most important reason is the reliance on electric infrastructure and navigation and communication systems. Besides, solar activity of cycle 24 began last year, and several effects on technology have been reported for more northward and southward latitudes. The study of these electric current systems, which enhance as solar activity increases, is relevant for defining its effect on the area of Mexico.

J18-19p THE IONOSPHERIC BEHAVIOR OVER THE BRAZILIAN REGION DURING SSW EVENTS

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This study refers to the connection between the stratosphere and ionosphere, investigating, specifically, the behavior of the equatorial ionization anomaly (EIA) and ionospheric effects over the Brazilian region during sudden stratospheric warming (SSW) events that occurred in northern hemisphere winter (2005-2006 and 2008-2009) and a stratospheric warming period that occurred in the southern hemisphere winter in 2010, when, in both cases, the solar activity was low. During SSW events, through mechanisms not yet well known, planetary waves can be amplified and cause disturbances in the upper atmosphere winds. As it is already known, the winds are responsible for the dynamo mechanism which generates the ionospheric electric fields. These fields, in turn, are fundamental in the formation of the EIA. In this study the ionospheric behavior was investigated using a parameter $??$, which express the EIA relative intensity for the Brazilian sector. This parameter is calculated from the ionospheric F2 layer critical frequency relative variation, which is obtained from Digisondes installed nearby the geomagnetic equator, São Luís (2.6° S, 44.2° W) or Fortaleza (3.8° S, 38° W) and near the EIA southern crest, Cachoeira Paulista (22.5° S, 45° W). The results for the Brazilian region show, mainly after SSW temperature peak, an increase in the EIA intensity in the morning, followed by a decrease in the afternoon. This behavior is preserved for a number of days equal to the polar region thermal stabilization phase and it is very similar to the results obtained in pioneering studies in the Peruvian sector, in which TEC data was used. In the Brazilian case, the negative variation is stronger than the positive, being noticeably more intense around the pre-reversal enhancement time, when the EIA is strongly suppressed.

J18-20p ENHANCING THE CHARACTERIZATION, UNDERSTANDING AND FORECASTING OF MAGNETOSPHERIC PROCESSES THROUGH ADVANCED DATA ROUTING PROTOCOLS

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The comprehensive characterization of magnetospheric processes has received a boost through the transition from single spacecraft to multi-spacecraft observations. This evolution has set the foundations for the deeper understanding and eventual forecasting of magnetospheric processes and the Sun-Earth connection and space weather in general. However, multi-spacecraft distributed observation methods and adaptive mission architectures require computationally intensive analysis methods. Moreover, accurate space weather forecasting and future space exploration far from Earth will be in need of real-time data assimilation technologies. The most important capability requirements in this effort are:

Simultaneous sampling of space plasmas from multiple points with cost-effective means and measuring of phenomena with higher resolution and better coverage to address outstanding science questions;

Achieving unique vantage points such as upstream at L1, solar polar orbit, or, desirably, beyond the edge of the heliosphere;

Enabling the prompt, light-speed return of vast new data sets from anywhere in the solar system;

Synthesizing to enrich our understanding by means of system-wide measurements exploiting new data analysis and visualization techniques.

From the above, it is evident that data sharing and data access are major issues in space sciences, as they influence the degree of data exploitation. The collaborative research project Space-Data Routers, has the aim of allowing space agencies, academic institutes and research centers to share space-data generated by single or multiple missions,

in an efficient, secure and automated manner. The approach of Space-Data Routers relies on space internetworking and in particular on Delay-Tolerant Networking (DTN), which marks the new era in space communications, unifies space and earth communication infrastructures and delivers a set of tools and protocols for space-data exploitation.

The project has defined limitations currently imposed by typical space mission scenarios and aims at surpassing them. In the case of the Sun-Earth connection scenario, we plan to test and validate the capabilities of Space-Data Routers in providing: a) Simultaneous real-time sampling of space plasmas from multiple points with cost-effective means and measuring of phenomena with higher resolution and better coverage to address outstanding science questions and b) Successful data transmission even in hostile communication conditions.

The work leading to this paper has received funding from the European Union's Seventh Framework Programme under grant agreement no. 263330 for the SDR (Space-Data Routers for Exploiting Space Data) collaborative research project. This paper reflects only the authors' views and the Union is not liable for any use that may be made of the information contained therein.

J18-21p BEHAVIOR OF THE SOUTHERN CREST OF THE EQUATORIAL ANOMALY DURING DISTURBED CONDITIONS: A CASE STUDY

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During magnetically quiet conditions, the electron density of the ionospheric F2 region has a depression or "minimum", centered around the geomagnetic equator, and two peaks (crests) around 100-200 latitude on both sides of the equator. This is so-called the equatorial or Appleton anomaly (AE). Changes in this structure are produced during geomagnetic storms, which have been subject of extensive research for many decades.

In this paper, the behaviour of the ionospheric F2-region observed in the equatorial anomaly region during an intense geomagnetic storm occurred on October 29, 2003 (peak Dst= - 350 nT) is studied. For that, foF2 and hmF2 data from Jicamarca (0.60S), Ascensión Is. (2.50S) and Tucumán (10.50S) are used. The results show that during the initial stage of the storm, increases of electron density are produced in the equatorial region and decreases at low latitudes. During the recovery of the storm, it remains this kind of behaviour. The possible physical mechanisms working during the different phases of the storms are considered.

J18-22p ECHO OF RING CURRENT STORMS IN THE IONOSPHERE AND PLASMASPHERE

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Prompt the ionosphere and plasmasphere planetary storm occurrence associated with intense ring current storms is investigated. Evaluation is based on the ionospheric weather W-index generated from JPL Global Ionospheric Maps of Total Electron Content, GIM-TEC, for a period of 1999-2012. Magnitude of W-index at each grid point of a map varies from the quiet state ($W=+-1$) to intense storm ($W=+-4$). The superposed epoch analysis is performed for the total 79 intense ring current storms (Dst<-100 nT) during 1999-2012 by defining the start time of the epoch at the peak of Dst index. Occurrence of positive phase of W-index storm ($W = 3$ & 4) and the negative phase ($W = -3$ & -4) is calculated for hourly-daily GIM-TEC maps encapsulated in IONEX format (-87.5:2.5:87.5° in latitude, -180:5:180° in longitude). It is found that the positive phase of W-index storm mirrors the main phase of Dst storm with its maximum observed 2 hrs prior the Dst peak. The negative phase of W-index storm originates at onset of Dst storm with the peak of the occurrence observed 6 to 12 hours later than the storm onset. Model of probability of occurrence of the W-index storm is produced which can be implemented for the ionosphere-plasmasphere storm prediction incorporating forecast of Dst index provided online by the different institutions.

This study is supported by the joint grant of TUBITAK 112E568 and RFBR 13-02-91370-CT_a.

J18-23p INVESTIGATION OF DECADEAL SCALE CHANGES IN THE AURORAL OVAL USING MAGSAT, OERSTED, AND CHAMP DATA

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The magnetic field sources inside the Earth play an important role in determining the long-term patterns in space weather and influence the magnetic field variations from sources external to the Earth. For example, current systems in the auroral region, which produce large magnetic disturbances during sub-storms, are strongly ordered by the Earth's internal magnetic field via the latter's interaction with solar wind.

It has been known for some time that processes in the Earth's fluid outer core result in changes in the magnetic field, known as secular variation, that are most visible on decadal and longer timescales. Measurements over the past two centuries suggest the dipole moment has decreased by about 10% over that period. Some changes in the non-dipolar field are seen to vary even more quickly. For example, the north dip-pole has shifted hundreds of kilometres

over the past century and with increasing rapidity over the past two decades.

We present the results of a search for decadal changes in the auroral ovals commensurate with the evolution of the main field over the satellite era using a combination of MAGSAT (1979-80), Oersted (1999-), and CHAMP (2000-10) magnetic data. As well as providing good along-track spatial resolution, satellites also provide equal coverage of data for northern and southern auroral zones.

J18-24p NANOSATC-BR1 CONTRIBUTIONS FOR GEOMAGNETIC MEASUREMENTS

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The space region over the Brazilian territory is of significant physical importance. In it, two intriguing phenomena occur: the South Atlantic Magnetic Anomaly (SAMA) and the Equatorial Electrojet. Many details related to them are still poorly known and, in principle, those electrodynamical processes are of considerable scientific impact. NANOSATC-BR1 is a Brazilian nanosatellite with a magnetometer sensor, as one of its payloads, which will measure the intensity of the geomagnetic field along its orbit. In this work, the objective is to show measurements of geomagnetic field on the ground collected in four different South America sites. The period includes some magnetic disturbance originated mainly by the effects of magnetosphere-ionosphere system. November 8th, 2004, was the day chosen to illustrate the proposed analysis procedure. The experimental places are Tatuoca Magnetic Observatory - National Observatory (ON), Belém - Brazil, under the effects of the Equatorial Electrojet, Vassouras Magnetic Observatory, ON, Rio de Janeiro, Brazil, between the SAMA and the Equatorial Electrojet, Magnetic Station at the Southern Space Observatory, São Martinho da Serra - OES/CRS/INPE-MCTI, RS, Brazil, under de SAMA's region, and Trelew Magnetic Observatory, Argentina, in the SAMA's south border. The NANOSAC-BR1 will provide data from an altitude around 600Km orbiting over the two regions, that way offering a different point of view concerning of the phenomena that occur in the SAMA and above the Ionosphere Equatorial Electrojet regions. The use of a low orbit satellite measurement together with those data from the ground will improve the information on those processes.

J18-25p IONOSPHERIC SLAB THICKNESS IN THE EAST SECTOR OF SOUTH-AMERICA DURING ONE YEAR OF LOW SOLAR ACTIVITY

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This paper reports the first results of equivalent ionospheric slab thickness estimated in the Brazilian longitudinal sector. The ionospheric slab thickness is a measure of the shape of the ionospheric profile and can be obtained from the ratio of the total electron content (TEC) to the F-region peak electron density (NmF2). The ionospheric slab thickness was studied during one year of low solar activity (from March 2009 to February 2010). The period analyzed were separated in three seasonal groups; Equinoxes, June solstice (winter) and December solstice (summer) months. The ionospheric slab thickness was studied at the equatorial station of Palmas (10.12 S, 48.21 W, 7.73 S dip lat) and in the low latitude station of Sao Jose dos Campos (23.07 S, 45.52 W, 19.61 S dip lat). The TEC data have been obtained from dual-frequency GPS receivers and the NmF2 data were calculated from the foF2 parameter scaled from ionograms recorded by simultaneous measurements of digital ionosondes. The minimum values of TEC and NmF2 were observed in both stations during the early morning and the maximum values during afternoon hours. The diurnal, seasonal and latitudinal variations of the ionospheric slab thickness were then analyzed. The thickness of the ionosphere increased during daytime if compared to the nighttime values. During the summer and the equinoctial periods the slab thickness reached the higher values if compared to those observed during the winter solstice months. The equatorial site of Palmas showed values of daytime slab thickness larger than those observed at the low-latitude station of Sao Jose dos Campos, except during the June solstice months. At Sao Jose dos Campos, a pronounced pre-dusk increase in the equivalent slab thickness is observed during the winter solstice months. From the calculated slab thickness we also estimated the atmospheric neutral temperature (Tn) over both stations. Other relevant aspects of the ionospheric slab thickness behavior will be presented and its comparison with atmospheric and ionospheric model results.

J18-26p EFFECTS OF EVENTS IN HILDCAA IN THE EQUATORIAL IONOSPHERE OVER THE BRAZILIAN REGION: A CASE STUDY

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HILDCAA (High Intensity, Long Duration, Continuous AE Activity) is a geomagnetic phenomenon, during which the AE index displays intense and continuous amplitude during the recovery phase of a magnetic storm. It

generally occurs during geomagnetic quiet time during solar minimum and declining phase of the solar cycle. This work presents an analysis of the effects of penetration of interplanetary electric field to the equatorial ionosphere during a HILDCAA event. Then, we examine how the equatorial ionosphere over the Brazilian region behaves in terms of the peak height of the F2 layer (hmF2) during the occurrence of a series of events HILDCAA. For this purpose,

Digisonde data from the equatorial station São Luís (44,60, 2,33S, dip angle 1,5S) observed during the occurrence of the three distinct periods of HILDCAA events in the year of 2006 will be used.

J18-27p EVALUATION OF AN IONOSPHERIC 3D-INTERPOLATION PARAMETERS FOR THE BRAZILIAN IONOSPHERE DYNAMICS FORECASTING SYSTEM BASED ON RADIO OCCULTATION DATA

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The Brazilian operational ionosphere dynamics forecasting system, developed at National Institute for Space Research by the Space Weather team (INPE/EMBRACE) has made predictions of the 3-dimensional ionosphere behaviour in terms of the concentrations, field-aligned fluxes, and temperatures of the electrons and the O⁺, H⁺, N⁺, He⁺, N₂⁺, O₂⁺ and NO⁺ ions, and provides vertical total electronic content (TEC) maps for South America region with almost 24 hour ahead. Recently, efforts have being made to simulate the predictions in a global scale.

A first principles model is used to estimate ionospheric parameters aligned with geomagnetic field lines. This spatial grid becomes non-homogeneous when converted to geographic coordinates. To generate TEC maps, a 3-dimensional homogeneous grid is used, and for every grid location, Inverse Distance Weighting (IDW) interpolation procedure is applied using the simulated values in the neighbourhood. The grid altitude ranges from 90km to 1000km with step of 10km, and the grid latitude and longitude covers the hole Globe using step of 1 degree. The problem that arises from this procedure concerns the number of nearest neighbours that should be used in the interpolation. We have experienced that different number of neighbours used in grid interpolation led to very different TEC maps.

In this study we have used Radio Occultation (RO) remote sensing technique, that measures physical properties of a planetary atmosphere, including electron density. Data from Constellation Observing System for Meteorology, Ionosphere and Climate (COSMIC) was compared with several grids interpolated using different number of nearest neighbours for IDW interpolation. Considering observations at the same Coordinated Universal Time (UTC), with 5 minutes of tolerance, every RO measurement was compared with its closest grid value. Mean Squared Error (MSE) was then calculated for all available data, since the most representative grid minimizes the MSE.

Preliminary results for julian day 80 of 2012 indicate that a wide range, between 100 and 500, for the number of nearest neighbours used in IDW shows an approximately equal and maximal similarity when interpolated grid values are compared with RO observations. In order to minimize the computational load, an appropriate IDW interpolation would consider around 100 nearest neighbours.

J18-28p RADIO OCCULTATION METHODS FOR MONITORING ATMOSPHERE AND IONOSPHERE OF THE EARTH

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The remote sensing satellite radio occultation method elaborated for monitoring of the Earth's atmosphere and ionosphere with a global coverage is described. Comparison of theoretical results with experimental observations of radio wave propagation effects in the Earth's atmosphere and ionosphere in the communication links satellite-to-satellite is provided. Directions in application of the radio occultation method are discussed: measuring vertical gradients of the refractivity in the atmosphere and electron density in the lower ionosphere, determination of the temperature regime in the stratosphere and troposphere, investigation of the internal wave activity in the atmosphere, and study of the ionospheric disturbances on a global scale. The radio occultation technique may be applied for investigating the relationships between processes in the atmosphere and mesosphere, study of thermal regimes in the intermediate heights of the upper stratosphere-lower mesosphere, and for analysis of influence of space weather phenomena on the lower ionosphere. Radio-holographic methods are considered as a tool for determination of the altitude profiles of temperature, pressure, refractivity, internal wave activity in the atmosphere, and electron density in the ionosphere with usage of the radio links satellite-to-satellite. Results of radio occultation measurements of the atmospheric and ionospheric parameters are described. Comparative analysis of effectiveness of the radio occultation and other remote sensing methods is conducted.

Key words: ionosphere, satellite, interactions, radio occultation

J18-29p IONIZATION GROWTH IN THE NIGHT OBSERVED WITH GPS AND DIGISONDE STATIONS ON THE EQUATORIAL REGION

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True height electron density profiles observed with the digisonde and GPS stations were analyzed together with geomagnetic data indices for different period of 2011 in an afford to define the ionospheric structure during events of nighttime ionization enhancements and to discuss the physical processes that may cause them. An upwelling of the F2 layer, limited to the dark hemisphere, was evident in all events, but nighttime positive effects and nighttime enhancements are attributed to two distinct mechanics, according to our findings. Height enhancements are wave-like disturbances and the time delay of their occurrence at middle latitudes depends on the increase rate of the AE index, and consequently, on the rate that the solar wind input energy dissipates in the auroral ionosphere. Thus, they most probably originated in the auroral oval region and propagated toward the equator-like TIDs disturbances, with a periodicity that depends on the ionization density. On the other hand, foF2 and TEC increases do not share the same wavy appearance, with could mean that they are not connected to TIDs and are not of auroral oval origin. The increased nighttime density can only be speculated to be due to increased downward fluxes from the plasmaphere.

Key words: ionosphere, plasmasphere, interactions, disturbances

J18-30p LATITUDINAL EXTENT OF EQUATORIAL PLASMA BUBBLES IN THE SOUTH AMERICAN SECTOR

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At equatorial and low latitude regions, the all-sky imaging observations of the OI 630 nm emission show quasi north-south aligned intensity depletion bands, which are the optical signatures of large scale F-region plasma irregularities. These large scale ionospheric irregularities (plasma bubbles) are regions where the plasma densities are much less than the ambient plasma densities and are initially generated in the bottomside of the equatorial F-region. These irregularities result from a non-local plasma process involving collisional and collisionless Rayleigh-Taylor instability. These depletion regions are generated after sunset and as they move upward, they map along the magnetic field lines to high latitudes. In this study we use images taken by “all sky” cameras at Cachoeira Paulista (22.7o S, 45o W) and São Martino da Serra (29.3o S, 53.8o W) with ionograms obtained at stations located at higher latitudes. Important features from these set of observations are presented and the Latitudinal extent of equatorial plasma bubbles in the South American sector is discussed.

J18-31p DEVELOPMENT OF THE STORM-TIME TEC FLUCTUATION IN HIGH LATITUDE...

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One of the well-known indicator of space weather is amplitude and phase scintillations of the trans-ionospheric signals that propagated through high latitude ionosphere.

Nowadays, regular monitoring of fluctuation activity can be provided by GPS observations. We use GPS measurements of Greenland network to analyze the occurrence of GPS TEC fluctuations in sub-auroral, auroral and polar ionosphere during 9, 17 and 26 September 2011 geomagnetic storms. These storms were started on different UT. The development of the isolated storm on 17 September 2011 was classical. The storms occurred on 9 and 27 September were complicated with presence of sub storms on the recovery phase.

It is obtained that TEC fluctuation activity strongly depends on geomagnetic storm intensity. The essential increasing of fluctuation activity level was observed over all considered latitudes. The fluctuation activity correlates with changes of IMF Bz component. The sub storm activity was well recognized in behavior of TEC fluctuations. The observations provided by high latitude IGS stations were used to visualize the irregularity oval and to study its structure. It was revealed that irregularity oval structure was very sensitive to solar/geomagnetic changes and information about it can be served as an effective indicator of space weather state.

J18-32p INVESTIGATION OF HIGH LATITUDE IONOSPHERE BY GPS TEC OBSERVATION

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The GPS observations of Greenland network were used TEC variations in high latitude to study. This network provides unique opportunity to monitor TEC variability in polar ionosphere on a regular base. GPS stations are arranged along the latitude over the range 60-83°N (65-87° Corrected Geomagnetic Latitude) near of 30-40 longitudes. It covers subauroral, auroral and polar ionosphere. In contrast to the ionosonde measurements, GPS provides ionospheric measurements with high temporal resolution with no dependence on geomagnetic conditions. Though

the GPS satellite orbit inclination is 55° , ground-based GPS measurements can be effectively used for imaging of the high latitude ionosphere.

In the report the observations of TEC for quiet and disturbed ionosphere during several geomagnetic storms in September 2011 are presented. TEC variations for discussed equinox period demonstrated diurnal course until 87° geomagnetic latitude, that was more pronounced towards lower latitudes. During September 2011 it was revealed the trend in TEC variability of the high latitude ionosphere. It was associated with change of solar radiation which was varied from 100 to 140 sm.

The Greenland GPS stations are located closely with one another along latitude. The distance between stations is about 1-2o. Such spacing provides detailed structure of latitudinal TEC profiles to be analyzed. During quiet condition night profiles showed increase of TEC towards the higher latitude, daytime profiles revealed TEC decrease from latitude of $70-75^\circ$ and higher. During storm the structure of latitudinal TEC profiles was essentially changed with agreement to the development of geomagnetic storm. In the report features of TEC behavior at high latitude ionosphere for September 2011 events were discussed.

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J18-33p SOME NIGHT AIRGLOW OI630 NM OBSERVATIONS FROM LOW LATITUDE STATION, INDIA

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Ground based photometric observations of OI 630.0 nm emission line have been carried out from Kolhapur station (Geog. Lat. 16.8°N , Geo. Long 74.2°E). The photometer is having a field of view (overall) of about 1° in diameter so that it could be used to monitor the intensities coming from 5 Km diameter at F-region height 250 with zenith. Total Electron Content (TEC) and OI 630 nm airglow emission both these phenomena are dependent on the electron density of the ionosphere F-region. So the observed OI 630 nm emission compared with GPS-TEC of Hyderabad (17.410°N , 78.550°E) and Bangalore station (13.020°N , 77.570°E) on the night of 30 December 2002. The variations in 630 nm and $d(\text{TEC})/dT$ of Hyderabad are well co-related than Bangalore. The magnetic activity on 30 December 2002 was moderately quiet ($K_p = 1 - 4$). On the night of 30 December, 2002, a distinct wavelike structure was observed for whole night in the OI 630 nm intensities and $d(\text{TEC})/dT$ showed their maximum and minimum, respectively. It was found that a large-scale structure seen in 630 nm airglow emission coincide with the TID structure seen in the TEC and $d(\text{TEC})/dT$ with time period about 2 hours. It may be due to the passage of a large-scale gravity wave, with a period much longer than -3 hours, and a phase propagating downwards through the emission heights.

J15-34p TOPSIDE IONOSPHERIC MIDLATITUDE ELECTRIC CURRENT DENSITY INFERRED FROM MULTIPLE MAGNETIC SATELLITES

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A method for inferring zonal electric current density in the mid-to-low latitude F-region ionosphere is presented. We describe a method of using near-simultaneous overflights of the Ørsted and CHAMP satellites to define a closed circuit for an application of Ampère's integral law to magnetic data. Zonal current density from sources in only the region between the two satellites is estimated for the first time. Six years of mutually available vector magnetic data allows overlaps spanning the full 24-hour range of local times twice. Solutions are computed on an event-by-event basis after correcting for estimates of main and crustal magnetic fields. Current density in the range $\pm 0.1 \mu\text{A}/\text{m}^2$ is resolved, with the distribution of electric current largely matching known features such as the Appleton anomaly. We also resolve a new ionospheric feature: persistent current intensifications between geomagnetic latitudes of 30 and 50 degrees in the post-midnight, pre-dawn sector. We compare our results with current density predictions made by the Coupled Thermosphere-Ionosphere-Plasmasphere (CTIP) model, a self consistent, first-principles, 3-dimensional numerical dynamic model of ionospheric composition and temperatures. This independent validation of our current density estimates highlights good agreement in the broad spatiotemporal trends we identify, which increases confidence in our results.

J18-35p REAL TIME SPECIFICATION OF MAGNETIC DISTURBANCE FIELD

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A significant part of time variation of geomagnetic field is due to the currents in the magnetosphere. Using NGDC's Potsdam Magnetic Model of the Earth, we implement a geomagnetic disturbance field calculator in the real-time. The model is driven in real time by the disturbance storm time index (Dst) data from the United States Geological Survey (USGS) and solar wind data measured by the Advanced Composition Explorer (ACE) satellite.

We have implemented the model as a cloud application for its high reliability and low cost of operation. The predicted fields compare favorably with measurements at observatories in the mid-latitudes, and start to deteriorate at higher latitudes as the un-modeled polar currents become more relevant. Real-time specification of the geomagnetic field can play important for role in several applications such as navigation, survey and space weather.

J18-36p SATELLITE MAGNETIC DATA: A NEW KEY TO STUDY EXTERNAL CONTRIBUTIONS

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Since recently, the geomagnetic field spatial and temporal variations have mainly been studied using data provided by ground observatories. However, their geographical distribution is irregular on the Earth's surface, and a global study of geomagnetic temporal variations encounters difficulties. Considering the newly magnetic satellite missions it makes it possible to get a global coverage of geomagnetic data and to deeply investigate the external phenomena, linked to temporal evolution and interaction of the ionosphere and magnetosphere systems.

We have been interesting to analyze the Earth's magnetic data provided by the CHAMP satellite over its full flying period, indeed the decade 2000-2010. The very first step in our analyze has consisted in a data selection, in order to identify and minimize any undesirable effects. Specifically, we have used the following selection criteria: 1) a selection of magnetic data depending on the local time (day-time data and night-time data); 2) a selection considering the geomagnetic indices Kp and Dst, to identify ionospheric and magnetospheric fields variations (quiet data and disturbed data). The first selection criterion allows us to study separately the two datasets (day-time and night-time) to characterize the diurnal effects. A statistical analysis of Kp and Dst indices over the CHAMP period allows us to detect the most geomagnetically quiet and disturbed periods. This analysis indicates that 2003 is the most disturbed year and particularly, November 2003 is the most disturbed month over the investigated decade. Contrary, 2009 is the quietest year and December 2009 the quietest month.

In our study, we have firstly estimated the geomagnetic residual values by subtracting synthetic values computed for the same given positions and times by using the GRIMM magnetic field model (up to degree/order 16) from the satellite measurements. The GRIMM model also describes the secular variation and acceleration of the core field, and the lithospheric field. Here, the core variations are considered, but not the lithospheric field, seen as a static component over a decade, and then without influence in geomagnetic temporal variations. We are then able, through the computed residuals to investigate the temporal changes of the external sources. A statistical analysis based on the geomagnetic indices (Kp and Dst) and an analyses of the temporal behavior of the residuals are presented. A specific interest is given to the distinctiveness of residual fields over the quieter months and the more disturbed months over the investigated CHAMP period.

J18-37p LATITUDINAL VARIATION OF THE IONOSPHERIC DISTURBANCE DYNAMO

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During magnetic storms, the auroral electrojets intensification affects the thermospheric circulation on a global scale. This process which leads to electric field and current disturbance at middle and low latitudes, on the quiet day after the end of a storm, has been attributed to the ionospheric disturbance dynamo (Ddyn). The latitudinal variation of the Ddyn disturbance dynamo magnetic signature exhibits an eastward current at mid latitudes and a westward one at low latitudes with a substantial amplification at the magnetic equator. Such current flow reveals an anti-Sq system established between the mid latitudes and the equatorial region and opposes the normal Sq current vortex. However, the localization of the eastward current and consequently the position and the extent of the anti-Sq current vortex change from one storm to another. Indeed, for a strong magnetic storm, the eastward current is well established at mid latitudes about 45°N and for a weak magnetic storm, the eastward current is established toward the high latitudes (about 60°N), near the joule heating region, resulting in a large anti-Sq current cell.

J18-38p SPECTRAL VARIATIONS OF TETHYS' SURFACE - RELATIONSHIPS TO THE INTERACTION WITH SATURNS MAGNETOSPHERE

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Studying the recent Cassini-VIMS data set of Saturns satellite Tethys showed that despite the spectral dominance of water ice on Tethys surface distinct spectral variations exist, which are surprisingly very different from what was expected from the visible albedo derived from Voyager and Cassini camera data. These spectral variations can not be explained by Tethys' surface geology. Thus, two relatively narrow N/S-trending bands characterized by larger ice

grains rather than the higher abundance of water ice separate the Saturn-facing and the anti-Saturnian hemisphere of Tethys. So far, larger ice grains could only be found in geologically young, less weathered portions of the surfaces. Since Tethys orbits around Saturn within its extended magnetosphere larger ice grains could also appear in regions that are shielded from impacting particles originating from Saturn's magnetosphere. Possible relationships of Tethys' spectral properties to the interaction between the surface material and the impacting magnetospheric particles will be presented.

J18-39p QUASI-BIENNIAL OSCILLATION IN GPS VTEC MEASUREMENTS

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The quasi-biennial oscillation, QBO, a well known periodicity in the equatorial stratospheric zonal winds, is also found in ionospheric parameters and in solar and geomagnetic activity indices. Many authors speculated about the link between the QBO in solar and geomagnetic activity and the QBO in atmospheric parameters. In this work we analyze the presence of the QBO in the ionosphere using the Vertical Total Electron Content (VTEC) values obtained from Global Navigation Satellite System (GNSS) measurements during the period 1999-2012. In particular, we used IONEX files, i.e. the International GNSS Service (IGS) ionospheric products. IONEX provide VTEC values around the world at 2-hour intervals. From these data we compute the global average of VTEC and the average of VTEC at different local times for a band of grid points at mid geomagnetic latitude. The series are analyzed using a wavelet multi resolution analysis. In all cases the QBO is detected among other expected periodicities. The EUV solar flux and other indices related to solar emission (from Solar2000 software) are also analyzed in order to extract the QBO signal using the wavelet technique. The association between the QBO in solar indices, in VTEC and in the stratosphere is analyzed.

J18-40p CHARACTERISTICS OF THE QUIET EQUATORIAL F2 IONOSPHERIC LAYER

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The F2 layer is useful in high frequency (HF) communication due to its presence at all seasons and at all times. This work is aimed at studying the diurnal and seasonal variability of the equatorial F2-layer; peak electron density (NmF2), the corresponding peak ionization height (hmF2) and the occurrence of the Equatorial spread F (ESF) during magnetic quiet days.

Data from three equatorial stations namely; Ilorin, Nigeria 8.5oN, 4.5oE; Fortaleza, Brazil 3oS, 38oW; and Jicamarca, Peru 12oS, 76.8 oW were used for this study.

The result obtained is showed that the hmF2 rises sharply within the time interval 0600-1000 LT (local time). It has a smaller range of variation between 1100-1400 LT, after 1400 LT, it begin to decrease and get to a minimum at 1700 LT.

Generally, the NmF2 diurnal variations are similar to those of hmF2. A midday bite-out occurs between 1200-1500 LT. The study shows the general departure of the F2-layer from the Chapman layer between the height of 190 - 230 km from the three stations studied.

The occurrence of ESF was observed at all the three stations, showing both diurnal and seasonal variations. At Ilorin, it was observed between 2200-0500 LT. The observation at Fortaleza and Jicamarca showed that ESF was observed between 2200-0600 and 0000-0800 LT respectively.

It was observed that the characteristics of hmF2 and NmF2 at Ilorin and Jicamarca are similar. The peculiarity at Fortaleza is attributed to its closeness to the crest of the equatorial anomaly than these other two stations.

J18-41p ANALYSIS OF ELECTRON CONTENT VARIABILITY: OBSERVATION AND MODELL

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In the present study we used two independent data sets to examine the variations of bottom-side and topside ionospheric electron content, as well as to estimate its relative contribution to GPS TEC. We estimate the ionospheric electron content (IEC) on the basis of electron density profiles (EDPs) retrieved from the FORMOSAT-3/COSMIC Radio Occultation measurements. Joint analysis of GPS TEC and COSMIC data allows us to extract and estimate electron content corresponded to the ionosphere (its bottom and topside parts) and the plasmasphere ($h > 700$ km) for different conditions. In order to analyze seasonal behaviour of ionosphere/plasmasphere electron content contribution to GPS TEC at the different regions we selected several specific points with coordinates, corresponded to the approximate positions of different, mid-latitude and low-latitude, ionospheric sounding stations. For each specific points GPS TEC, COSMIC IEC and PEC estimates were analyzed. During solar minimum conditions percentage contribution of PEC to GPS TEC indicates the clear dependence from the time and varies from a minimum of about

25-50% during day-time to the value of 50-75% at night-time. Contribution of both bottom-side and topside IEC has minimal values during winter season in compare with summer season (for both day- and night-time). Several case-studies of geomagnetic storms were analyzed in order to estimate changes and redistribution of electron content between ionosphere and plasmasphere. The obtained results were compared with TEC, IEC and PEC estimates retrieved by IRI-Plas Model that has the plasmasphere extension up to 20,000 km (GPS orbit).

J18-42p COMPARISON OF THE ELF TURBULENCE FEATURES IN THE DIFFERENT IONOSPHERIC REGIONS— RESULTS OF DEMETER MISSION

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We report the global picture of the observation of ELF plasma turbulence registered by DEMETER satellite in different regions of the ionosphere. The intensification of the variations of the electric field are seen in the trough region, in auroral region and sometimes, when DEMETER was operating there, in polar cusp. Some stochastic bursts of this turbulence have been seen around the world and were associated with the thunderstorms. Other are associated with the seismic activity and with fluxes of the energetic electrons registered in the polar cusp at the ionospheric altitude and south Atlantic anomaly. We apply to study this turbulent processes wavelet, bispectral analysis and statistical description of the electric field fluctuations. These registrations are correlated with the plasma parameters measured onboard DEMETER satellite and with geomagnetic indices.

J18-43p CORRELATION ANALYSIS OF TOTAL ELECTRON CONTENT AND F2 CRITICAL FREQUENCY

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The use of the international ground-based network of two-frequency receivers of the navigation GPS system makes possible a global, continuous and fully computerized monitoring of ionospheric disturbances of a different class. One of the applications of GPS-data for ionosphere research is Global Ionospheric Maps (GIM). The GIM-technique allows to produce global maps of absolute vertical value of total electron content (TEC) using GPS data.

The problem of GIM-data is spatial interpolation for mapping. The TEC-values on global maps are accurate for regions with many GPS-receivers and unreliable for regions where GPS-receivers are not enough. One of such regions is European Region of Russia. In this case it is reasonable to use ground-based ionosonde data for correction of regional component of global TEC distribution. It needs preliminary analysis of data compatibility.

Correlation analysis of GIM-data and vertical sounding data was made. The aim of the study is to determine effective approach to the problem of join use of these data. We use the data from CODE, JPL, UPC, ESA (<ftp://cddis.gsfc.nasa.gov/gps/products/ionex/>) and ionosonde Cyclone of Kazan University (Russia). fxF2 series collected in 2011- 2012 were the base of a study. Correlation coefficients are different for different time of day. Minimal coefficients were obtained for daytime, about noon. So these GIM-data needs improvement. Correlation coefficients for GIM-data of different laboratories are different. Maximal coefficients were obtained for UPC and JPL. Probably this result is attributed to using of more effective algorithm of spatial interpolation.

SESSION 1.1-1.2

PLANETARY DYNAMOS AND CORE DYNAMICS - EXPERIMENTAL MHD AND HYDRODYNAMIC PROCESSES

1.2-1 INVESTIGATION OF THE MAGNETOSTROPHIC REGIME IN THE DTS EXPERIMENT

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The DTS experiment has been designed to investigate the magnetostrophic regime, in which the Coriolis and the Lorentz forces are comparable. This situation probably prevails in the core of the earth and planets. The experiment consists of a rotating spherical Couette flow in a shell filled with 50 litres of liquid sodium, submitted to a strong dipolar magnetic field. The shell is between a 210mm-radius outer sphere and a 74mm-radius inner sphere carrying a permanent magnet.

We retrieve the mean axisymmetric flow and the magnetic field it induces by inverting simultaneously ultrasound Doppler velocity profiles, electric potentials, and measurements of the induced magnetic fields inside the fluid and at the surface. The mean azimuthal flow is characterized by a super-rotating Ferraro region, around the equator of the inner sphere, and a geostrophic region from the edge of the Ferraro region to the outer sphere, where the imposed magnetic field gets weaker.

Frequency spectra of the induced magnetic field reveal that fluctuations around this mean state are dominated by

modes of increasing azimuthal mode number m . Numerical simulations produce similar bumpy frequency spectra and indicate that fluctuations originate in the outer boundary layer. The Lorentz force strongly damps these instabilities inside the shell, but their magnetic signature increases there.

Our next step is to explore whether the coupling of the small-scale velocity and magnetic fluctuations contribute to the induced large-scale magnetic field. Results obtained at moderate magnetic Reynolds number ($Rm=10$) suggest that this effect remains small compared to the contribution of the meridional flow. Analysis at higher Rm is under way.

A key observation is that when the outer sphere spins rapidly, fluctuations are drastically reduced under the combined effect of the resulting Coriolis force and the Lorentz force. This suggests that turbulence could be very weak inside planetary cores in the magnetostrophic regime, resulting in low dissipation.

1.2-2 MHD SPHERICAL COUETTE FLOW AT FIFTY MILLION REYNOLDS NUMBER

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The University of Maryland Three Meter experiment is currently operational in novel regimes of turbulent rotating flow at low magnetic Prandtl number, with and without an imposed external magnetic field. We have reached magnetic Reynolds number $Rm = \Delta\Omega (r_o - r_i)^2 / \eta$ up to 700 in many different hydrodynamic states that arise at different $Ro = \Delta\Omega / \Omega$. With applied field, we reach Elsasser number $\Lambda = \sigma B_0^2 / \rho\Omega$ near unity in some of the experimental volume.

So far we have not found dynamo action, but we have made important progress in characterizing the MHD behavior of the system with both weak and strong applied fields. We will present results regarding internal toroidal and poloidal mean field induction from a dynamically weak axisymmetric applied field over a very wide range of Ro . We will also discuss the effects of strong, dynamically important applied field on known hydrodynamic states. We observe instabilities that transport significant extra angular momentum and also the emergence of new wave modes that may be magnetocoriolis modes.

1.1-3 CONVECTION AND DISSIPATION

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As many studies of stellar or planetary dynamics consider thermal convection as a main source for dynamo action, it is worth investigating the modelling of convection and I will focus on the amount of dissipation - viscous or Ohmic - associated with it. First, its exact expression will be derived and discussed with respect to alternative expressions from the literature. Next, within the anelastic model, it will be shown that dissipation provides a rigorous criterion for the validity of the anelastic liquid approximation, $\gamma - 1 \ll 1$, where γ is the ratio of the heat capacities. Besides, a typical scaling for pressure fluctuations is obtained, which does not uniformly converge towards the classical scaling of the Boussinesq modelling as the dissipation number goes to zero. Moreover, the linear stability analysis of a layer of fluid heated from below will be used to evaluate when the Boussinesq model is appropriate. Finally, I will initiate a discussion on which model should be used for different cases: planetary cores, planetary mantles, gas giants, stars, so that dissipation is correctly evaluated.

1.1-4 HYDROMAGNETIC DYNAMOS AT LOW EKMAN AND MAGNETIC PRANDTL NUMBERS

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The dependence of hydromagnetic dynamos on the Ekman and magnetic Prandtl numbers is investigated. In all the investigated cases, the generated magnetic fields are dipolar and neither transition to hemispherical dynamos nor weaker magnetic fields (which are less dipole dominated) were observed. The magnetic field becomes weak in the polar regions only for low Prandtl numbers, when the inertia becomes important. It is a basic condition. However, whether the magnetic field gets weak in the polar regions or not depends also on the magnetic Prandtl number. The magnetic Prandtl number has to exceed a minimum value in order to sustain dynamo action. If the magnetic diffusion is small (large magnetic Prandtl numbers) then this phenomenon does not exist but if it is large (small magnetic Prandtl numbers) it exists because the strong magnetic diffusion significantly weakens the magnetic field inside the tangent cylinder. The magnetic diffusion and inertia seem to act in the same direction as to weaken the magnetic field inside the tangent cylinder.

1.2-5 VKS : A LABORATORY DYNAMO EXPERIMENT**Gissinger, Christophe**

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The magnetism of the planets, including Earth, is generated by dynamo action, i.e. self-generation of a magnetic field due to the fluid motion of liquid iron inside the planetary cores. During the last decades, laboratory experiments became an essential part of the research on dynamo action, complementing both observations and theory.

In this talk, I will review some results of the Von-Karman Sodium (VKS) experiment. The VKS experiment has been designed to achieve dynamo action in a turbulent flow of liquid metal. In this experiment, 150 liters of liquid sodium are stirred by the counter-rotation of two bladed discs in a cylindrical tank. When the discs are rotating sufficiently fast, a dipolar magnetic field, aligned with the axis of rotation, is generated by dynamo action. In addition, a lot of dynamical regimes can be observed, like chaotic polarity inversions of the field very similar to geomagnetic reversals. In some cases, the experiment can also generate hemispherical dynamos similar to some planetary fields. These different behaviors will be described within the framework of simple theoretical models. I will discuss how these results, and the corresponding theoretical descriptions, can provide a better understanding of some aspects of the geomagnetic field dynamics. Finally, I will present current perspectives for the next generation of laboratory dynamo experiments.

1.2-6 MEASUREMENT OF TURBULENT MAGNETIC FLUX TRANSPORT IN LIQUID SODIUM**Nornberg, Mark; Rahbarnia, Kian; Taylor, Zane; Kaplan, Elliot; Forest, Cary**

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Astrophysical dynamos arise in highly turbulent flows where the eddies can contribute to the time averaged behavior of the magnetic field through a turbulent emf. We have directly measured the vector turbulent emf in a driven two-vortex flow of liquid sodium in the Madison Dynamo Experiment. The measured turbulent emf is anti-parallel with the mean current and is almost entirely described by an enhanced resistivity predicted from quasi-linear theory. We have demonstrated that this enhanced resistivity can be mitigated by eliminating the largest-scale eddies by introducing baffles. By tailoring the large-scale flow, we have reduced the power required to drive the impellers, doubled the magnetic flux generated by differential rotation, and reduced the magnetic fields induced by flow fluctuations by an order of magnitude. The amplification of an applied magnetic field is now consistent with our laminar flow models suggesting we are just below the threshold for exciting a laboratory homogenous dynamo.

1.1-7 POLARITY REVERSALS VERSUS THE PRANDTL NUMBER AND STRATIFICATION**Simkanin, Jan; Hejda, Pavel**

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We investigate the dependence of polarity reversals on the Prandtl number and stratification. The magnetic field is dipole-dominated in the stable polarity state and during the reversals it is multipolar. Polarity reversals occur at higher values of the Rayleigh number, while at its lower values the magnetic field does not undergo reversals. Our results indicate that at a low Prandtl number the period of reverse polarity is shorter than when the Prandtl number equals one and excursions are at a low Prandtl number less intensive. Magnetic fields during the reversals are much stronger at a low Prandtl number, which is probably due to strong quadrupole and octupole components of magnetic fields in this case. The appearance of the non-uniformly stratified sub-shell near the CMB inhibits the reversals and excursions. Thus, a coupled influence of the non-uniform stratification and inertial forces could be responsible for the irregular character of polarity reversals.

1.1-8 THE INTERIOR STRUCTURE AND CONVECTIVE DYNAMICS OF MERCURY'S CORE: CONSTRAINTS FROM GRAVITY AND ROTATION OBSERVATIONS**Dumberry, Mathieu**

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Mercury, the closest planet to the Sun, remains enigmatic. First, its large mean density suggests that the radius of its metallic core is approximately 4/5th of the planetary radius, a ratio much larger than for other Terrestrial planets. Second, one may expect Mercury's core to have fully solidified by now from heat loss through its thin silicate (mantle) shell; yet, we now know that the outermost part of the core is fluid. Third, Mercury has a global, dipole-dominated magnetic field (most likely powered by convection in the fluid core), although its strength is approximately 100 times smaller than that of Earth. The dynamo mechanism that can generate such a field has not yet been fully elucidated. Mercury's dynamo is intimately connected to its convection regime, which may contain exotic features such as precipitating iron snow in parts or in all of the fluid core. In this work, I show how information on Mercury's gravity field and rotation can be combined to yield constraints on its interior structure, including the size

of its solid inner core. The latter is tied to the temperature gradient inside the planet and can inform us on whether Mercury's dynamo is powered by crystallization at the inner core boundary (similar to Earth) or in the volume of the fluid core (snow).

1.1-9 THE THREE-DIMENSIONAL QUASI-GEOSTROPHIC CONVECTION MODEL FOR THE ROTATING CYLINDRICAL ANNULUS

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The rotating cylindrical annulus with sloping endwalls has served as a useful analogue for understanding convection in planetary cores. We present a three-dimensional model of the rotating cylindrical annulus that maintains geostrophic balance at leading order and is valid for endwalls with steep (i.e. ~order one) slopes. This extension allows for better comparison to the more realistic case of rapidly rotating spheres and spherical shells where strongly sloping boundaries are present. In addition, we have extended the model to include a spherical gravity vector, and fluid compressibility via the anelastic approximation. We will discuss new findings from both linear stability analysis and direct numerical simulations of this new model.

1.1-10 DYNAMIC COUPLING OF THE CORE-MANTLE AND INNER CORE BOUNDARIES

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The geodynamo is likely powered by buoyancy flux generated at both the core-mantle and inner core boundaries. Both boundary fluxes are believed to contain some amount of spherically heterogeneous buoyancy flux superimposed on a homogeneous background. However, the observed symmetries of these two boundary buoyancy fluxes seem to be at odds. Seismic tomography indicates that a predominantly equatorially symmetric mode 2 heterogeneity exists at the base of the lower mantle. The top of the inner core contains a N-S (mode 1) seismic anisotropy that is stronger in the western hemisphere, most likely generated by an equatorially symmetric mode one forcing. The existence of these boundary heterogeneities are generally agreed upon, but their amplitudes are poorly constrained. If these heterogeneities are large enough amplitude then they would likely be observable in either outer core flow inversions or in a dynamic coupling between the inner and outer core boundaries. We present numerical dynamo models with heterogeneous outer core boundary forcing over a range of amplitudes to explore the influence on outer core dynamics and inner core growth. We find that time average ICB heat flux maps reflect the same pattern as the CMB heterogeneity, but shifted 20 degrees west due to a westward zonal flow. We infer that preserving an inner core mode one growth structure constrains the CMB mode 2 heat flux heterogeneity to be less than 30% of the total convective heat flux.

1.1-11 THE INFLUENCE OF HETEROGENEOUS THERMAL BOUNDARY CONDITIONS ON OUTER CORE CONVECTION

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Convection in the fluid, outer core of the Earth is responsible for the continual generation of the Earth's magnetic field through the geodynamo process. Secular variation of the geomagnetic field provides information on flows at the top of the core, which may be linked to the dynamics of the core's interior. The pattern, and temporal evolution, of convection in the core will be influenced by the boundary conditions imposed at the CMB and ICB. Temperature, and compositional, differences at the base of the slowly convecting mantle impose a laterally varying heat flux condition at the top of the outer core. The recently proposed translation motion of the inner core results in a hemispheric pattern of flux at the bottom of the outer core. We have used numerical models of both non-magnetic convection and the geodynamo to investigate the relative influence of these different boundary conditions on the flow in the outer core.

1.1-12 SUBDECADAL VARIATIONS OF EARTH'S ROTATION AND CORE FLOW

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We perform a spectral analysis of the length of day variations (LOD) and the temporal variability core flow and the related relative core angular momentum (CAM) using the multi-taper method. The CAM estimation is based on time-dependent core surface flow models which are derived from a recent geomagnetic field model (the C3FM2) covering the period 1957 to 2008. These data are jointly analysed with Observation of the LOD covering the period 1963 to 2010. The analysed core flow solutions comprise a purely toroidal, a magnetostrophic and a azimuthally regularised flow. These flows are expected to represent different possibly scenarios of the outer core dynamics. The

analysis of the observed LOD reveal basically two significant periods of 6 and 9 to 10 years. However, the flow solutions consistently show the longer periodicity, where the 6 years period is not conclusively detected. The flow velocity for 6 years period is too small (of order 0.1 km/yr) to resolve robustly even from the latest magnetic models, particularly when a weak assumption as a flow constraint, such as magnetostrophic or azimuthally regularized flow, is made. A strong 9 to 10 years period and a lesser pronounced 6 years period may allow insights to the coupling processes between the core and the mantle.

1.1-14p **SOME RESULTS OF PALEOZOIC PALEOMAGNETIC RESEARCH**

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Some results of paleozoic paleomagnetic research Minasyan J. H., Karakchanyan A. K., Vardanyan A.A. Paleomagnetic investigation of rocks in Armenia made it possible to provide magnetic and paleomagnetic characteristic of subdivisions of Paleozoic. To determine composition and structure of the ferromagnetic following methods were used: the method of thermo-differential analysis, the method of saturation parameters, the diagram of Ziydervild for temperature. The results of laboratory investigations made it possible to prove the paleomagnetic usability of rocks Paleozoic in Armeni. On the basis of paleomagnetic research of Triassic, Permian, Devonian, Carbonian rocks there has been made the preliminary conclusion about the dipole configuration of the geomagnetic field throughout Paleozoic. The comparison of the given data with the paleomagnetic definitions of the African, Arabian plates, Europe and Siberian platform leads to the conclusion that Minor Caucasus existed separately from the present general lithospheric blocks of Major Caucasus and Europe.

1.1-15p **PLANETARY DYNAMO SCALING AND CORE-MANTLE EVOLUTION OF THE EARTH**

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For fast rotating planet/moon, we derive hydrodynamic and electromagnetic scaling laws in the limit of negligible molecular diffusivity, viscosity and magnetic diffusivity effects. In the Earth, ancient Mars and Moon magnetic energy dominate over kinetic one and typical magnetic field is proportional to the third root of the buoyancy flux power driving the convection as it was obtained recently via numerical simulations. Besides, here we present new scaling laws for estimation of the long-time magnetic consequences due to different evolution scenarios of core-mantle system.

The currently accepted scenario with the inner solid core of the Earth crystallizing from the liquid core provides us with too small value of geomagnetic field during more than 3 billions years after formation of the liquid core. Since this is inconsistent with the available paleomagnetic records we are suggesting another scenario with a solid protocore which occupied almost all the core of just formatted Earth. This protocore is slowly melted under the surface influence of the overheated liquid core. It grows up to its modern size when the solid core is small relic of the protocore. Such protocore concept resolves the problem of the energy source for geodynamo and for plume activity in the mantle. In case of validity of this concept the mantle should be supplemented by silicate material from the protocore with primitive isotope composition of the lead but which can't be the result of the liquid core crystallization. Additional argument to the validity of this concept could be the primitive isotope composition of lead in combination with the primary helium enriched by isotope ^3He . This work was partly supported by Russian Funds of Basic Researches grant No. 13-05-00893-a and 12-05-00523-a.

1.1-16p **DYNAMO IN A SPHERICAL SHELL, DRIVEN POINCARÉ EIGENMODES**

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In the study of the mechanisms of planetary dynamo, various options for the problem of conducting fluid convection in a rotating spherical shell appear. Application of spectral methods for the solution of these problems raises the question on the choice of the basis to present the fields of velocity, temperature and magnetic field. The paper suggests to apply Poincaré operator eigenmode approximations as the basis for velocity. The geometrical structure of these modes corresponds to free oscillations of ideal rotating fluid and seems to be the most natural from all the considered problems.

In this work the large-scale approximations of Poincaré modes and low-mode models of convection in conducting rotating shells are proposed. The models present velocity as an approximation of one of Poincaré modes by spherical harmonics, the temperature field and magnetic field are specified by spherical harmonics structurally consistent with the velocity. It is shown that dipole magnetic field is generated in this type of modes.

It is shown, that inhomogeneities in the Earth's liquid core density may topology correspond to one of Poincaré modes, according to the splitting-functions of its free oscillations.

1.1-17p CONSISTENCY BETWEEN GEOMAGNETIC SECULAR VARIATION DATA AND A STABLY STRATIFIED LAYER AT THE CORE-MANTLE BOUNDARY**Whaler, K.A.; Wardinsky I.; Lesur, V.**

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Recent calculations (Pozzo *et al.*, 2012) of outer core thermal and electrical conductivity from first principles have raised their values by a factor of three. This has significant implications for geodynamo operation, in particular, forcing the development of a stably stratified layer at the core-mantle boundary (CMB). The lack of convection in this layer means there should be no large-scale upwelling and downwelling of core fluid at the CMB. In principle, this can be tested against geomagnetic secular variation (GSV) data, by examining whether a purely toroidal core flow (consistent with no upwelling and downwelling) can fit them. When this was first attempted (Whaler, 1986), with an imposed main field, it was found and that there is very little difference in the GSV data fit achieved by a purely toroidal flow compared to a less restrictive one allowing upwelling and downwelling. Therefore, adherence to the underlying assumptions and careful examination of the error budget is necessary to address the question. A new inversion method that solves for the time-dependent main field consistent with frozen-flux alongside the CMB flow (Wardinski and Lesur, 2012) allows us to re-examine the issue. We do this using a data set including large quantities of recent high quality satellite data that provides the most detailed constraints on the core field and its evolution, and advective flows that can explain the GSV. However, co-estimating the field invalidates the statistical test used by Whaler (1986), and we therefore look for other ways to assess whether a purely toroidal flow is acceptable.

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Whaler, K A, 1986. Geomagnetic evidence for fluid upwelling at the core-mantle boundary, *Geophys. J. R. astr. Soc.*, 86, 563-588

1.1-18p THE STRENGTH OF GRAVITATIONAL CORE-MANTLE COUPLING**Davies, Chris**

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Gravitational coupling between Earth's core and mantle has been proposed as an explanation for a 6-year variation in the length-of-day (ΔLOD) signal. This coupling mechanism also plays a key role in the proposed super-rotation of the inner core. Explaining the observations requires that the strength of the coupling, Γ , falls within fairly restrictive bounds; however, the value of Γ is highly uncertain because it depends on the distribution of mass anomalies in the mantle. We estimate Γ using a model of viscous mantle flow with density anomalies inferred from models of seismic tomography, varying four input parameters: the seismic tomography model, depth-dependent scaling factor between shear-wave velocity and density, depth-dependent mantle viscosity profile, and surface boundary condition. We conduct over 100 models and find that $10^{19} \leq \Gamma \leq 10^{22}$ N m. Requiring models to give a $> 70\%$ correlation to the surface geoid and to match the dynamic core-mantle boundary ellipticity inferred from Earth's nutations reduces the range to $3 \times 10^{19} < \Gamma < 9 \times 10^{19}$ N m, which is too small to explain the 6-year ΔLOD signal.

SESSION 1.3 ELECTROMAGNETIC IMAGING OF CRUSTAL STRUCTURES AND PROCESSES**1.3-1 EM IMAGING ALONG THE INTRAPLATE COLLISIONAL SUTURE ZONE AND ITS GEODYNAMIC AND SEISMICITY IMPLICATION****Stanica, Dumitru; Stanica, Dragos Armand**

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The magnetotelluric profiles crossing the Eastern Carpathians, the Moesian, Scythian and East-European Platforms supplied information regarding the conductivity structure of the crust along both the intraplate collisional suture zone and Peceneaga-Camena deep fault, regardless of the thickness of the thrust belt and sedimentary formations which cover them. Some models, derived from the 2D inversion and forward modeling of the magnetotelluric (MT) data, are presented in order to identify the structural particularities of the above-mentioned tectonic elements, by means of the geoelectrical conductivity anomaly induced by them in lithosphere. On this way, it is possible that from a large scale of data to use those characterizing the presence of various types of crust and their main rheological features, as well as the relation between Carpathian electrical conductivity anomaly and these important tectonic elements. Thus, a remarkable electrical anomaly, characterized by a very strong gradient and low resistivity, has been detected along the Carpathians and the western limit of the East European Platform.

As a sequence of the high structural complexity in the Carpathian Arc area, we had to add new information in order to detect the extension of this very important intraplate collisional suture zone known as Trans-European Suture Zone (TESZ). Therefore, we have appealed to a previous N-S trending MT profile (North Dobrogea), as well as to a recent structural map at the lower crust level which permitted us to confirm the TESZ placement along to Peceneaga-Camena fault separating Precambrian Moesian crust to the South-West and Cimmerian crust towards North-East. In connection with this suture, other relevant geophysical and geological information have been used to emphasize its crustal and subcrustal features, without neglecting certain aspects concerning the nature of the deposits which are comprised in the subduction process.

1.3-2 **IRETHERM: GEOTHERMAL ENERGY POTENTIAL OF HYDROTHERMAL AQUIFER, RADIO-THERMAL GRANITE AND WARM SPRING TARGETS IN IRELAND**

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IRETHERM (www.iretherm.ie) is an academic-government-industry, collaborative research project, funded by Science Foundation Ireland, with the overarching aim of developing a holistic understanding of Ireland's low-enthalpy geothermal energy potential through integrated modelling of new and existing geophysical and geological data. IRETHERM's objectives over a four-year period are to:

(i) Develop multi-parameter geophysical modelling and interpretation software tools that will enhance our ability to explore for and assess deep aquifers and granitic intrusions

(ii) Model and understand temperature variations in the upper-crust. Firstly, by building a 3-D model of crustal heat-production based on geochemical analysis of surface, borehole and mid- to lower-crustal xenolith samples. Secondly, by modelling, using a fully self-consistent 3-D approach, observed surface heat-flow variation as a function of variation in the structure and thermal properties of the crust and lithosphere, additionally constrained by surface elevation, geoid, gravity, seismic and magnetotelluric (MT) data.

(iii) Test a strategic set of eight type geothermal targets with a systematic program of electromagnetic surveys (MT, CSEM) across ten target areas.

During 2012, IRETHERM collected over 220 MT/AMT sites in the investigation of a range of different geothermal target types. Here we present preliminary electrical resistivity modelling results for each target investigated and discuss the implications of the models for geothermal energy potential.

1.3-3 **GEOELECTRICAL STRUCTURES AND THEIR GEOMETRIES IN CENTRAL TIBETAN PLATEAU FROM INDEPTH MAGNETOTELLURIC DATA**

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Magnetotelluric (MT) data collected on N-S profiles crossing the Banggong-Nujiang Suture, which separates the Qiangtang and Lhasa Terranes in central Tibet, as a part of InterNational DEep Profiling of Tibet and the Himalaya project (INDEPTH) are modeled by 2D and 3D inversion codes. The 2D deep MT model of line 500 confirms previous observations concluding that the region is characterized to first-order by a resistive upper crust and a conductive, partially melted, middle to lower crust that extends from the Lhasa Terrane to the Qiangtang Terrane with varying depth.

The same conductive structure setting, but in shallower depths is also present on the eastern 400 line. From deep electromagnetic sounding, supported by independent 1D integrated petro-physical investigation, we can estimate the next upper-mantle conductive layer at depths from 200 km to 250 km below the Lhasa Terrane and less resistive Tibetan lithosphere below the Qiangtang Terrane with conductive upper-mantle in depths about 120 km.

The anisotropic 2D modeling reveals lower crustal anisotropy in Lhasa Terrane, which can be interpreted as crustal channel flow. The 3D inversion models of all MT data from central Tibet show dominant 2D regional strike of mid and lower crustal structures equal N110E. This strike orientation is parallel to Shuanghu suture, BengCo Jiali strike-slip fault system and perpendicular to convergence direction. The lower crust conductor in central Lhasa Terrane can be interpreted more likely as 3D lower Indian crust structure, located to the east from line 500, than geoelectrical anisotropic crustal flow.

1.3-4 CHARACTERIZATION OF A CRUSTAL TRANSITION ZONE IN NORTHERN TIBET USING MAGNETOTELLURIC MODELLING

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The overall objective of the final phase of the INDEPTH (International Deep Profiling of Tibet and Himalaya) project has been to develop a better understanding of the structure and evolution of the northern margins of the Tibetan plateau, namely the Kunlun and Altyn Tagh faults. For the Kunlun Fault, both INDEPTH Phase III and new Phase IV magnetotelluric (MT) data were investigated using 2D isotropic and anisotropic modelling, as well as 3D modelling. The resulting resistivity models characterize a northwards penetrative extension of the partially molten Tibetan middle crust, crossing the subvertical Kunlun Fault. Furthermore, the anisotropic observations highlighted by the INDEPTH MT modelling define progressive finger-like melt intrusion beneath the Kunlun Shan. However, this intrusion may not be homogeneous along the whole of the northern Tibetan border along the Kunlun Fault, as its depth and horizontal extension are likely to vary. The partial melt associated with the anisotropic anomaly observed on the INDEPTH resistivity models may have been triggered by strain heating associated with heat production during ductile deformation in a mid-crustal shear zone located beneath the Kunlun fault in the southern Kunlun ranges. This shear zone might be characterized by different levels of strain along the whole of the northern Tibetan border and may have developed into separated channels where the Songpan-Ganzi partially molten crust flows to the north, mechanically weakening the Kunlun crust. Melt penetration across the Kunlun Fault through intrusive channels likely accommodates crustal shortening in northern Tibet, but may also characterize a transition zone between the weak partially molten crust of the plateau and the more rigid Qaidam lithosphere, associated with the growth of the plateau to the north.

1.3-5 MT AND CSAMT METHODS FOR HYDROCARBON EXPLORATION AT NILE DELTA,

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The Nile Delta Basin, Egypt is known as a significant source of gas and oil. The study area is located in the Middle Eastern part of the Nile Delta near to Mansoura city. Magnetotelluric method (MT) is the most promising tool for oil and gas exploration compare to any other electromagnetic technique. Hydrocarbon reservoirs are usually typically exhibited by higher electric resistivity than their surroundings. MT method has been used to investigate the resistivity subsurface structure that related to hydrocarbon exploration and then has been integrated with seismic data conducted in the same area. MT-??? survey has been performed in two frequency ranges: high (10 Hz to 100 kHz) and low (0.1 Hz to 1 kHz). At first natural MT-AMT survey has been fulfilled, and measurements have been then repeated using a controlled source for CSAMT realization. A good coherence between the electromagnetic and seismic profiles has been found. The results show that hydrocarbons is appeared in the Abu-Madi and Qawasim channels which represent the main gas containing layers in the Nile delta. The depth and extension of these layers were estimated and imaged. The maximum thickness is 4000 m at the profile 1 in the north-western part of the study area.

1.3-6 ELECTROMAGNETIC IMAGING OF CRUSTAL GEOTHERMAL SYSTEMS WITHIN THE NORTHERN ANDES

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This study analyzes crustal geothermal systems within the Central Cordillera of the Northern Andes, especially those associated with fluid movement and displacement, using various electromagnetic data. The investigation has been divided into two stages: the first stage employed existing and open source near-surface data from the World Digital Magnetic Anomaly Map with satellite data both at 100 and 400 km in altitude (CHAMP satellite data). The technique, referred to as spectral-spatial analysis (SPAN) detects weakly magnetic heterogeneities within the crust at considerable depth. As in this study, SPAN often culminates with one or more geomagnetic section along the selected profile. The purpose of the SPAN was to inexpensively and rapidly determine and prioritize blind survey target areas which might be appropriate for detailed study by more costly ground-based electromagnetic methods. SPAN did in fact clearly detect rheological weak layers connected with the geothermal activity. These layers appear to be elements of geothermal fluid systems. At least one of several SPAN target and perspective areas appear to confirm near-surface reservoirs that are traceable to drillable depths of 1 to 3km. These appear connected to a base of the upper crust (depth of approximately 8km) by conductive channels. The second stage of this study involved the application of a ground based low-frequency magnetotelluric survey over one of the perspective target areas. The second stage, involving extensive and costly ground survey work, confirmed preliminary SPAN results in greater resolution. Detailed information about the methods and results will be presented.

1.3-7 **AERO-ELECTROMAGNETIC MAPPING OF THE HIDDEN GROUND WATER CONDUIT SYSTEMS BENEATH THE TULUM KARST PLAINS**

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Karst aquifers, as typical for the Yucatan Peninsula, represent an important but vulnerable source for the water supply to a significant part of the Earth's population. To support sustainable use of these resources, integrated management tools based upon specific numerical groundwater models are proposed as mean of choice. The development of such a model by application of innovative data acquisition and modelling methods is main goal of the research presented herein. In principle, karst aquifers are characterized by the presence of two distinct flow domains: the limestone matrix and the karst conduits. Up to a certain distance to the coast, the aquifer is further subdivided into a fresh water top layer and the denser saltwater body beneath. A flow model of karst aquifers requires detailed, spatially and temporally distributed information on characteristic parameters governing state and dynamics of the ground water regime. Methods determining the distribution of the electrical resistivity within the subsurface could provide such information. Airborne electromagnetic (AEM) mapping has been chosen to be a promising method due to its potential of gathering a large amount of data over wide and difficult accessible areas in short time. To test the capability of the method for providing crucial input information to improved ground water modelling of karst aquifers, the international scientific research cooperation XPLORE was initiated in 2008. The project was carried out around the Sian Kaan Biosphere Reserve, a coastal wetland of internationally recognized importance, located south of Tulum, Quintana Roo. Airborne surveys were performed in 2007 and 2008. The results showed that the signature of the cave system can be clearly detected by AEM mapping. Additionally, for better coverage of ground truth and calibration of the hydrological model, three extended ground geophysical campaigns have been conducted in 2009-2011 comprising geoelectrics, GPS-water level measurements, GPR, and borehole geophysics. The airborne and ground survey data, as well as corresponding cave mapping information, where available, then was used to generate a first numerical ground water model of the karst system. However, the complexity of the subject raised numerous new questions. So, to continue and deepen the successful approach of XPLORE, in 2012 the follow up project XIBALBA, a joint research initiative of the Geological Survey of Austria and the University of Neuchatel was launched. In XIBALBA the work concentrates on comprehensive acquisition of crucial data concerning the conduit system, i.e. caves geometry, water flow, water heads monitoring, all together serving as an extended input for refining and advancing the hydrological model developed in the XPLORE project. This is conducted by a mix of traditional methods (e.g. tracer tests, piezometry monitoring) and new high tech methods in development stage for capturing laser scans of the cave geometry or inductive flux measurement in the submerged caves. Moreover, reprocessing of existing data based upon new processing concepts shall give deeper insight into the vast and complex network of the underwater cave systems beneath the coastal plains around Tulum. Politically, the scientific results already form an important impact into the discussions concerning the ongoing socio-economic development process in and around Tulum. The awareness of the complex structure, dynamics, and sensitivity of the large fresh water resource beneath Tulum by decision makers and stake holders is growing from almost zero and will have to be further developed on the basis of solid scientific results and dissemination initiatives of the local partner Amigos de Sian Kaan.

The research is funded by the Austrian Science Fund, the Swiss National Science Fund and the Austrian Academy of Sciences. All this work is enabled only through the great support of Amigos de Sian Kaan, Cancun, Xibalba Dive Center and Bil Philipps, Tulum, and Simon Richards, Akumal, to mention only the most contributing ones.

1.3-8 **GEOELECTRICAL CHARACTERIZATION OF THE PYRENEAN LITHOSPHERE USING MAGNETO-TELLURIC DATA. MAIN GEOELECTRICAL STRUCTURES AND ITS EVOLUTION ALONG THE STRIKE**

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The Pyrenean range resulted from the continental collision between the Iberian and European plates from Late Cretaceous to Early Miocene. The significant amount of available geophysical data and the well-constrained geological evolution corroborate the subduction of the Iberian lower crust, as a main geological result, and determine the physical and chemical processes of the Pyrenean subsurface. However, although the large amount of data acquired in the Pyrenees, in the Eastern Pyrenees, close to the Mediterranean Sea, only few lithospheric-scale studies have been carried out, being this region less characterized. Thirteen BBMT/LMT sites have been acquired in this area imaging the electrical resistivity values of the lithosphere. Preliminary results have been obtained using apparent resistivity, phases, induction arrows and horizontal magnetic tensor values. Results have been compared with three recently published MT profiles in the Central, the West-Central and the Western Pyrenees, constraining the evolution of the main geological structures at a lithospheric scale and the associated physical processes. Major results have been related to low electrical resistivity values associated with the presence of partial melting in the Iberian Subducted

Lower Crust (IBSLC), caused by dehydration of Muscovite and Biotite, and with the asthenosphere, suggesting an European plate thicker than the Iberian plate close to the collision zone. Moreover, major crustal structures associated with the presence of fluids, sediments and graphite have been also characterized.

1.3-9 DIFFERENCES AND COINCIDENCES OF SUBDUCTION RESISTIVITY IMAGES FROM TWO MT TRAVERSES IN WESTERN MEXICO: IMPLICATIONS ON CONVERGENCE DYNAMICS

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We present magnetotelluric resistivity sections of two tectonically different areas across the convergent margin in western Mexico. One, at latitude of $\sim 19^\circ$ N that runs over the Jalisco Block (JB), a crustal fragment of the North American plate that converges at a rate of ~ 2 cm/yr against the Rivera micro-plate, a segmented portion of the Pacific plate. The other, located at latitude $\sim 16^\circ$ N in southwestern Mexico, where the Cocos plate is subducting at a larger convergence rate of ~ 6 cm/yr under older Paleozoic North American crust. Coincidences of the resistivity images include the existence of a sub-horizontal conductor at ~ 10 km depth, partly associated to low PT (0.2GPa, $\sim 250^\circ\text{C}$) dehydration reactions at the bending of the subducting slab, and a dipping conductor that define the top of the slab where most of the dehydrating metamorphic reactions are expected to occur. Also, in both resistivity images crustal uplift appear to take place, although in distinct tectonic conditions.

The more obvious difference between the Rivera and Cocos plate subduction slabs is in their dipping angle, being steeper ($\sim 50^\circ$) under the Jalisco Block and gentle ($\sim 15^\circ$) below the Oaxaca terrain. A consequence derived from dissimilar convergence regimes is the existence of a narrower anomalous conductor above the subducting Cocos plate implying adiabatic fluids release promoted by a sealed lower crust. The dehydration related broader anomalous conductor under the JB area in contrast, implies extensive mobility of mineralized fluids through an eroded younger continental crust. Uplift and faulting of the crust appear to occur in both regions as a result of upwards migrating buoyant mantle diapirs. However, crustal uplift in the Paleozoic-Mesozoic Oaxaca zone occurs around 250 km away from the trench whereas within the Jalisco Block younger terrain occurs at about 150 km from the trench. In the first case aqueous mineralized fluids have precipitated to form large mineralized provinces, while in the former case have produced volcanism, erosion, and an intense fracturing at the wedge of the convergent continental crust.

1.3-10 MAGNETOTELLURIC IMAGING OF THE PRECAMBRIAN SUPERIOR-GRENVILLE MARGIN IN CANADA

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The Archean Superior province shares a tectonic boundary with the Proterozoic Grenville province. The lithosphere beneath the Superior-Grenville margin, in southern Ontario, was investigated with a northwest-southeast oriented, 650 km long profile of magnetotelluric (MT) data. The profile consists of 40 broadband MT sites from Portable Observatories for Lithospheric Analysis and Research Investigating Seismicity (POLARIS) and the earlier LITHOPROBE Abitibi-Grenville transect. It crosses the Abitibi and Pontiac subprovinces of the Superior province and the Central Gneiss and Central Metasedimentary Belts of the Grenville province. The Grenville Front Tectonic Zone separates the Grenville province from the Superior province and the Central Metasedimentary Belt Boundary Zone separates the two belts in the Grenville province.

Geoelectric strike analysis results show that the strike azimuth varies both along the profile and with depth. Dominant strike azimuths of N45E and N85E were defined for the crust and the lithospheric mantle respectively. An azimuth of N68E determined for asthenospheric depths (200-400 km) is parallel to the hotspot reference model of absolute plate motion in the area. The 2-D inversion model for the crust shows that the 1000 Ma Grenville Front Tectonic Zone and the 1080 Ma Central Metasedimentary Belt Boundary Zone extend with a southeast dip throughout the crust. A resistive zone dipping into the lower crust beneath between these structures, corresponding to the Central Gneiss Belt, indicates that widespread conductive lower crust observed farther to the north must be at least 1000 Ma old. A 2-D inversion model for the whole lithosphere defines a deeper resistive zone dipping southeast from a location beneath the Central Gneiss Belt. The resistive zone extends beneath the Central Metasedimentary Belt where it lies between 100 km and 260 km depth. It is interpreted to be modified lithosphere formed by both emplacement of subducted Archean lithosphere and/or earlier mantle depletion. A deep conductor is observed extending across the northwest and central part of the profile. Beneath the southwest Superior province it is approximately horizontal and lies at a depth of about 160 km. The conductivity of the feature increases beneath the Pontiac subprovince, where it is overlain by a shallower mantle conductor. Further to the southeast, the feature dips downwards beneath the Grenville province, with its top reaching a depth of 300 km. The conductor is interpreted to be the lithosphere-asthenospheric boundary and the part with higher conductivity beneath the Pontiac subprovince as representing a refertilized mantle scar. The scar, which has survived a series of tectonic events, was left by an Archean thermomechanical event and was last refertilized by the Cretaceous Great Meteor hotspot plume.

1.3-11 GEO(ELECTRO)MAGNETIC IMAGING AND MAGNETIC PHASE TRANSITION IN THE CRUST: OPEN QUESTIONS

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In the paper by Kiss *et al.* (2005, DOI: 10.1029/2005GL024199) we studied some magnetotelluric and geomagnetic symptoms of the so-called second-order magnetic phase transition in the crust. We assumed that some geomagnetic anomalies of unknown origin could perhaps be explained by a huge enhancement of magnetic susceptibility in a very narrow interval just around the Curie (Néel) depth, instead of commonly magnetized, large-size rock bodies, somewhere between the surface and the critical depth. The hypothesis originated from solid state physics theory (where the so-called Hopkinson peak is infinitely large) and it is supported by experiments, carried out on artificial materials. At the same time, rock physics experiments rarely showed higher peak in the magnetic permeability than 3-4 times the ferromagnetic value.

The lack of high Hopkinson peak measured on real earth materials does not falsify the hypothesis. As we found, in laboratory it is impossible to reconstruct the in situ physical (temperature and pressure) conditions, either in terms of stability or homogeneity. If the in situ Hopkinson-peak is really higher than 100 times the normal ferro(i)magnetic permeability value, the effect becomes markedly observable in magnetotelluric sounding curves. Ignoring the high magnetic permeability, one-dimensional magnetotelluric inversions would result in very high-resistivity- and very thick pseudo-layers, and in two-dimensional case especially the H-polarization curves would cause misleading solution. Controlled-source electromagnetic soundings may provide more detailed picture than the magnetotellurics does, due to the higher numbers of measurable field parameters, as it is shown by the resolution matrices. There have been found such field anomalies, suspected to be of magnetic phase-transition origin.

It is remarkable that the magnetic phase transition of the magnetite takes place just at mid-crustal depths, and the magnetic phase transition is accompanied with an enhancement of the specific heat and of some elastic constants (and perhaps of the electrical conductivity itself).

In lack of rock laboratory facilities, it would be possible to verify the hypothesis by surface geophysical (geomagnetic) survey in active areas, repeated after a few decades. If the phenomenon of magnetic phase transition exists in the Earth's crust, it would certainly lead to a re-interpretation of some midcrustal structures and processes. The questions are still open.

1.3-12 MAGMA IMAGED MAGNETOTELLURICALLY BENEATH AN ACTIVE AND AN INACTIVE MAGMATIC SEGMENT IN THE AFAR REGION OF ETHIOPIA

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We present audio-frequency magnetotelluric data collected along profiles over two magmatic segments comprising part of the sub-aerial Red Sea arm of the Afar triple junction, which sample the resistivity of the top 40-50 km of the sub-surface. One of the segments has been active since a seismo-volcanic crisis began in late 2005, when at least 8 m of opening accompanied injection of a mega-dyke; the other is currently inactive. After robust processing and galvanic distortion analysis, we find that the data pass the criteria normally deemed acceptable for two-dimensional modelling of the sub-surface resistivity distribution. Profiles across the segments have well-defined geoelectrical strike directions parallel to the local rift axis directions. Data from a profile past one of the volcanoes at northern end of the active segment have a more ambiguous strike direction that is oblique to the profile direction, but the choice of direction does not have a severe impact on the two-dimensional model deduced from them. All three models display large zones of low resistivity in the lower crust and upper mantle, which we interpret as arising from magma and partial melt. We show that the Moho-straddling conductive body beneath the active cross-rift profile can be concentrated into bands reminiscent of sills. Petrological information from samples collected over two volcanoes, and erupted at the rift axis in association with recent dyke injection, has been used to constrain the resistivity of the parent melt, and hence to estimate melt fractions from the bulk resistivities in our models using formulae applicable to well-connected melt. We find evidence for substantial quantities of melt at high fractions both straddling the Moho to the west of the current rift axis of the active segment, and in the crust near the volcano at its northern end. Limiting calculations to regions where the melt volume is estimated to be 3% or more, the total amount of melt estimated beneath the profile crossing the active segment, ~500 km³, is approximately an order of magnitude greater than that beneath the profile crossing the currently inactive rift. This implies that magma availability is at least one factor affecting whether a segment is active.

1.3-13 HEAT OF THE EARTH IS THE LOVE OF LIFE?!**Alavipanah, Seyed Kazem**Faculty of Geography, University of Tehran, Tehran, Iran
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The balance of heat balance is very essential in life. If we think about life in Erath or even other plants, the optimization of surface or air temperature must be taken into account. This optimization might be true not only for DNA Molecules but also the Earth surface and its biosphere. So wherever we are looking for the heat balance of living organism, it is very vital to include temperature factor in our research in all disciplines and even geophysics. We believe that heat is an indicator of world consciousness. This belief is based on the fact that all substances at temperature above absolute zero temperature (-273.15 centigrade of Kelvin Zero) radiate electromagnetic waves from themselves. It means when in our real words we have matters, the matters have a temperature and due to that temperature, any reaction with matter might have a reaction in temperature. If it is true, we must focus more on the critical topics of Thermal Infrared Remote Sensing on the Earth. Because heat is an important factor in any physical, chemical and biological study that should be considered. It may be not an exaggeration to say that the heat factor in the form of love and social, moral and psychological processes is effective. Therefore, in this paper, we conduct the Erath studies into the importance of temperature and heat in it. We take the combination of science, art, literature, and technology, in addition, any things is related to heat such as ice melting, volcanology, soil formation, desertification, human impact, geo thermal, into consideration in this paper too. Therefore, we use different scientific, literary, art resources for making the role of heat in the Earth. We concluded that the key role of heat is so that we may define it as indicator of world consciousness.

Keywords: temperature, Mars, constraints, potential, thermal remote sensing geological features.

1.3-19p HIGH-RESOLUTION RESISTIVITY TOMOGRAPHY PROFILES AT THE EPICENTRAL AREA OF THE 2009 L'AQUILA EARTHQUAKE (ITALY)**D'AJello Caracciolo F., Nicolosi I., Carluccio R., Porreca M., Mochales-López T., Speranza F.**Istituto Nazionale di Geofisica e Vulcanologia
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This work was carried out in the frame of the FIRB ABRUZZO project (funded by MIUR, Italian Ministry for University and Research), aimed at the high-resolution seismotectonic study of the area where on April 6th 2009 a Mw 6.1 earthquake caused severe damage to both the population and the infrastructures, destroying most of the medieval city of L'Aquila (Abruzzi, Italy) and nearby villages.

The main objective of this project is to characterize the sedimentary sequence in the depocentral area of a continental basin formed in consequence of the late Pleistocene-Holocene earthquakes striking the L'Aquila plain. The aim is to reconstruct past seismic events by the observation of discontinuities in the sedimentary sequence. A deep well will be cored, and its best location has been selected using several geophysical methods, including some seismic tomographies and several electrical resistivity profiles.

This work is focused on the analysis and interpretation of two-dimensional electrical resistivity tomography profiles; each profile was acquired mainly using both Wenner-Schlumberger (WS) and dipole-dipole (DD) electrode arrays, in order to have accurate vertical and horizontal resolution. In some cases we acquired using pole-dipole (PD) array to have good sensitivities at higher depth compared to WS and DD. Induced Polarization (IP) data were also collected to better identify clayey component into sediments.

We carried out several profiles using an IRIS Syscal Pro resistivity meter applying different spacing of steel electrodes; the instrument was configured to inject a square waved signal for 250 ms, with the energizing electrodes generating a potential difference of 400 Volts. A mean resistivity contact value between adjacent electrodes was about 1kOhm*m.

The interpretative models are based on inverting a mixed dataset of apparent resistivity from the two or three different arrays (we used a profile configuration of 72 electrodes 5 and 10 meters apart, and 48 electrodes 5 meters apart).

In order to calibrate the method, we acquired stratigraphy data from a nearby water wells. The inversion models show two main groups of resistivity values. Low-medium values, ranging from 15 to less than 100 Ohm*m represent the geophysical signature of the fine-grained components of the sediments present in the L'Aquila plain. A second group, characterized by higher values, ranging from 200 up to 1000 Ohm*m, are typical of coarse sand to gravel sediments.

Two major geological discontinuities or facies variations, disturb the horizontal continuity of the recovered resistivity layers in the surveyed area. The identification of these two discontinuities allowed us to correctly locate the coring well, and to select areas where the sedimentation was more continuous and undisturbed.

This work shows how geoelectrical tomography is a useful tool in sedimentary basin exploration where good resistivity contrast are present, highlighting major discontinuities due to particle sized, lithological or tectonic variations.

1.3-20p GEOMAGNETIC DEEP SOUNDING INVESTIGATIONS AT THE TRANSITION BETWEEN THE TRANSANTARCTIC MOUNTAINS AND THE WILKES SUBGLACIAL BASIN, NORTHERN VICTORIA LAND

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North Victoria Land (NVL) features two major tectonic elements: the Transantarctic Mountains (TAM), forming the uplifted flank of the Mesozoic and Cenozoic West Antarctic Rift System, and the Wilkes Subglacial Basin (WSB). Structure of the TAM rift flank has been partially investigated with different geophysical approaches. To the West, the Wilkes Subglacial Basin is present, a broad depression over 400 km wide at the George V Coast and 1200 km long. Geology, lithospheric structure and tectonics of the Basin are only partially known because the Basin is buried beneath the East Antarctic Ice Sheet and is located in a remote region which makes geophysical exploration logistically challenging. Different authors have proposed contrasting hypothesis regarding the origin of the WSB: it could represent a region of rifted continental crust or it may have a flexural origin or might represent an "extended terrane".

Here we present inferences on the electrical conductivity structures at the transition between the TAM and the eastern margin of the WSB, based on Geomagnetic Depth Soundings (GDS) carried out during three different international Antarctic campaigns supported by the Italian Antarctic Project: the BACKTAM, WIBEM and WISE expeditions. All the data have been processed in the frame of the ISEE project, aimed at evaluate the bias effect of the Polar Electrojet on geomagnetic transfer functions at different high geomagnetic latitudes and to study processing algorithms for magnetotelluric impedance tensor and magnetovariational transfer function estimate with high geomagnetic latitudes data.

The qualitative analysis of the induction arrows, in the period range 20-170 s, reveals an approximately 2D regional electrical conductivity pattern with a clear differentiation between the three Terrains crossed by the GDS transect: the Robertson Bay, the Bowers and the Wilson Terrain. Bi-dimensional models suggest a differentiation of the investigated area in three crustal sectors separated by the Daniels Range and the Bowers Mts., in close relation with main known structural lineaments; to the West, a deep conductivity anomaly is associated with the transition to the Wilkes Subglacial Basin.

1.3-21p ELECTRICAL RESISTIVITY IMAGING OF THE NORTHWEST SUPERIOR CRATON

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Magnetotelluric (MT) data from two projects in northeastern Manitoba, the Lithoprobe Western Superior transect and the Geological Survey of Canada Knee Lake profile, were compiled to investigate the geoelectric structure of the Archean Superior Province and adjacent Paleoproterozoic Trans-Hudson Orogen. Analysis and modelling was completed with the objectives of (1) imaging the subsurface conductivity structure of the northwestern Superior craton and adjacent Trans-Hudson Orogen, and (2) investigation of North American tectonic processes.

The geoelectric structure of the study area was defined in terms of its dimensionality and strike and using 2-D inversion of the MT responses. The results indicate that some parts of the study area have regional 2-D structure but 3-D elements occur at large depth and at more shallow depth near the margin of the Northern Superior superterrane and Pikwitonei Granulite belt. Strong three-dimensional galvanic distortion of the MT responses occurs throughout the study area. Extended Groom-Bailey tensor decomposition, implemented in the STRIKE program was used to further define distortion and geoelectric strike. This method enables determination of the regional MT response as a function of specified frequency range or depth range. At crustal depths the geoelectric strike azimuth throughout the study area has a dominantly northwest-southeast direction. At lithospheric mantle depths the azimuth has a bimodal distribution with both a northwest-southeast component and an east-west component that is particularly prominent close to east-west terrane boundaries at the northern margin of the Superior craton. Two-dimensional inversion of the data was done using an overall geoelectric strike azimuth of 127°. The results show a generally-resistive heterogeneous crust overlying a more conductive mantle throughout the study region. The 2-D resistivity model includes a conductive body in the lower crust beneath the Fox River belt and Kiseynew domain. Mantle conductors include a well resolved conductor dipping to the northwest beneath the Island Lake-Munro lake subprovince, and less well resolved conductor beneath the Northern Superior superterrane. The results suggest significant refertilization of the mantle lithosphere of the northern Superior craton.

1.3-22p DEEP GEO-ELECTRIC STRUCTURE OF THE DHARWAR CRATON (INDIA) INFERRED FROM MAGNETOTELLURIC STUDIES

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The Dharwar Craton (DC) is an important region among the world's Archaean cratonic blocks especially within the Gondwana land. Towards east and south of the craton, the areas are characterized by metamorphic and igneous bodies and structures related to the Pan-African assembly of Gondwana. The interior of the craton largely escaped significant Pan-African overprinting, while the northern margin of the craton is masked by Proterozoic sedimentary rocks and Deccan traps, whereas the eastern side is overlain by the Meso-Neoproterozoic Cuddapah basin

Broadly the DC has been considered to consist of Western (WDC) and Eastern (EDC) parts, sutured along the eastern fringe of Chitradurga schist belt during late Archaean. Magnetotelluric (MT) investigations along SW-NE oriented Chikmagalur (west) to Anantapur (east) traverse (~300 km), which is transverse to the structural grain in that region, have been conducted as a part of geological and geophysical imaging. Broadband (0.001 - 1000 sec) MT data has been acquired at 50 locations with a station interval of 6-8 km, and long period MT (LMT: 50 - 15000 sec) data at 15 locations with spacing of 20-25 km. Continuous MT time-series measurements over a period of about 3 days were made at each MT sounding location, while 10-12 days continuous recording were made for each LMT measurement site.

Prior to modeling of the data set for meaningful conductivity structure along the profile, the MT data were analyzed to determine the dimensionality and appropriate geo-electric strike values. A value of -570 (N570W) estimated from multi-site, multi-frequency analysis is assumed as the regional geo-electric strike for the profile, which also corroborates with the surface geological trends in the area. The 2D electrical section shows that the high resistive (>10000 Ohm-m) top layer (up to 20 km) beneath the western part as compared to ~25 km thickness in the eastern Dharwar craton corroborates well with geological, deep seismic and other geophysical results.

The top layer in the geoelectric section appears as a block structure, while at deeper levels (> 80 km) the electrical structure under WDC & EDC are significantly different. At about 150-200 km under WDC and 100 km beneath the EDC, the result reveals a major vertical electrical discontinuity, which might be considered as base of the lithosphere following studies from other places in the world. The results are compared with electrical structural data under other cratonic regions like Kaapvaal & Zimbabwe (South Africa), Yilgarn (Australia), Slave (Canada) and North China.

In the global scenario, though the Dharwar craton of India and the Kaapvaal craton of South Africa belong to Archaean age & Gondwanaland, the geoelectric models of both regions indicate that the subcontinental Lithospheric mantle under DC is less resistive than the Kaapvaal craton. In view of the thermally thinned (Mesozoic-Cenozoic) North China craton, it may be interesting that- could the difference in the resistivity between two parts of Gondwana land be due to significant difference in their geodynamical history/evolution. Since Jurassic, the narrow strip of peninsular India has been carved out by two major continental breakups and also mantle plume activity (at ~120 & 65 Ma). The large thermal pulse of Laccadive-Maldives island chain is very close to WDC while the Kaapvaal craton has under influence of Karoo plume activity during Triassic.

1.3-23p ON CONSTRUCTION OF THE EARTH CRUST MODEL USING GEOELECTRICAL AND GRAVITATIONAL DATA

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The problem of constructing density models of the Earth crust is one of the most important at regional geophysical studies. The possibility of construction of the electro-gravitational models with use of EM data obtained in the east of the Urals, covered by sedimentary mantle of the West Siberian Platform (WSP) and gravity data is considered. For realization of the proposed approach a large amount of experimental research with artificial and natural sources of electromagnetic field in the wide frequency range (the methods IEMS-AMTS-MTS-DMTS) along profile with a total length of ~ 1000 km was carried out. The analysis and generalization of information on the electrical resistivity, density and porosity of the sedimentary cover and basement rocks of the Ural and western part of the WSP is executed. Also relationships between the physical properties are investigated. Geoelectric sections of the lithosphere in the range of depths from the first meters to 300 km are constructed. 2D interpretation of the Bouguer gravity anomaly is executed on the basis of geoelectric structure. The obtained results have been coordinated with features of a tectonic structure and compared with materials obtained by other independent methods: direct current geoelectric sounding, information about crystalline basement rock composition according to the deep wells and measurements of electrical resistivity, density and porosity of rock samples in the laboratory.

The main results are as follows: the stratification, electrical conductivity and density of the sedimentary cover and basement are established; the junction zone of the open Urals and WSP is studied; the composition of rocks in the upper parts of the crust to the depths of 30-40 km is determined.

The further research can be directed to application of proposed approach on development of complex geophysical model of the Earth crust and upper mantle.

1.3-24p MAGNETOTELLURIC STUDY IN THE NW BORBOREMA PROVINCE, NE BRAZIL: EVIDENCE FOR DUAL SUBDUCTION ZONES WITH OPPOSITE POLARITY

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The Borborema province is a complex orogenic system in the northeasternmost corner of the Brazilian shield which in pre-drift reconstructions lies adjacent to coeval Pan-African fold belts and cratonic terranes from western Africa. Geologic evidences indicate that some major shear zones, litho-structural and tectonic domains of the province find their counterpart in the African continent but different dynamic processes involved in its formation and evolution are still poorly understood. They include the identification of possible sutures related to ocean closure, crucial to understand the Neoproterozoic evolution of the province either as a collage of allochthonous terranes or as intraplate tectonism driven by far-field stresses reworking preexisting Archean-Paleoproterozoic crust. In this paper the results of two NW-SE magnetotelluric profiles across the main tectonic grain in the NW part of the Borborema are discussed. Tensor decomposition gives acceptable fits to the measured data at most sites and shows that strikes are generally oriented NE-SW, consistent with surface tectonic features, but induction arrows at the western side of the MT profiles show influences of coastal effects. A 3D modeling was performed in order to check the coastal effects on the data set and to define a period interval not influenced by the sea at each site. Decomposed MT data for each profile were inverted using the REBOCC algorithm and the models allow acceptable misfits between observations and model predictions. These models show that the broad range of tectonic and volcanic activity in the province, including periods of extension in the Paleoproterozoic, compressional deformation in the Neoproterozoic, and widespread emplacement of post-collisional granitoids from Neoproterozoic to Cambro-Ordovician, has contributed to the total expression of the conductivity signatures. In one of the profiles, potentially pre-existing Neoproterozoic structure formed during the collisional process has been virtually obscured by the pervasive post-collisional magmatism, whereas in the other profile the magmatism has not been so voluminous as to obliterate the geophysical signature of the collisional event. The most meaningful features of this last profile are the presence of two resistive structures dipping in opposite directions into the lower crust and merging each other in the upper mantle. They are interpreted as relict subduction zones associated with island arc-continent collision during the Neoproterozoic.

1.3-25p GEOELECTRICAL IMAGE OF AR-PT BOUNDARY AT THE BALTIC SHIELD: STUDIES OF THE LADOGA CONDUCTIVITY ANOMALY

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The strong elongated crustal conductors are the prominent features of the pre-Cambrian cratons. Often they stretch on the continental scale distances following the boundaries between different age blocks and imprinting the ancient collisional/extensional events.

Lake Ladoga anomaly at the Baltic Shield of the East European Craton (EEC) was originally discovered in 80th and traced on the magnetovariational data as the most intensive segment of Ladoga - Bothnian Bay conductive zone, which is associated with the Archaean-Proterozoic (Ar-Pt) border. Later, due to magnetotelluric observations of St.Petersburg University, the first deep conductivity cross-section of the Ladoga anomalous area was constructed in the frames of quasi-1D approach. New stage of the investigations has been initiated in 2013 to overcome limitations of the previous interpretation, reconstruct a detailed resistivity section and create a prognostic volume geoelectrical model of LA to constrain the existing hypotheses on ancient tectonic environment during its origin. New experiment implies the synchronous MTS/MVS profiling across the Karelian Isthmus and additional soundings at the SE termination of the anomaly.

We present the analyses of spatial-frequency behaviour of all available conditional MT\MV responses over the area under study, including assemblage of the induction vectors from different sources and hot data of this year field campaign. New 2D MT+MV inversion results are also on display for the segments of regional seismo-electromagnetic geotraverse 1EV, which cut the LA at SE where it probably merges under the thickening sedimentary cover of the EEC at Ladoga monocline.

The data of potential fields anomalies, characteristic for the LA region, are also attracted to help in the comparison of its actual geoelectrical image with the similar images of anomalously conductive Ar-Pt suture at Ukrainian Shield and Voronezh massive (Kirovograd anomaly) and in the understanding of their probable similar genetics.

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1.3-26p CREATION OF CRUSTAL CONDUCTIVITY ANOMALY MAP OF NORTH EURASIA**Golubtsova, Nina; Pushkarev, Pavel; Slepikh, Ksenia;**

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In 1985 specialists in magnetotelluric (MT) method, working in the USSR, united their efforts within a significant scientific project on generalization of all information about conductivity anomalies in the consolidated crust, collected in the country, and creation of anomaly map. The chairman of the editorial board of the map was prof. M.N. Berdichevsky, vice-chairs were prof. L.L. Vanyan and prof. M.S. Zhdanov. Leading specialists from 11 regions of the country supervised analysis of MT data obtained in the Baltic shield, the Voronezh antecline, the Ural Mountains, the Caspian depression, Ukraine, East Siberia, Kazakhstan, central part of Central Asia, Tian Shan, Kamchatka and Sakhalin. Unfortunately, due to difficult economic situation in the beginning of the 1990-ies, this work was reduced and many of the results were not published. However, very informative map of crustal conductivity anomalies, indicating their presumable nature, was made by prof. A.A. Zhamaletdinov.

We are trying to continue this work. First, we reviewed the information, collected within the abovementioned project. Second, we collected the new results, obtained within the last 20 years, when many regional profiles were created in remote regions of Russia, such as North Siberia and North-East of Russia, and where MT studies were not performed previously. Taking into account all these old and new results, we are creating a new map of crustal anomalies of North Eurasia. The map will be in the form of geographic information system, we construct it using Esri's ArcGIS software. A variety of other geological and geophysical maps of Northern Eurasia exist. Study of correlation of conductivity anomalies with geological structures and anomalies of other properties will help to discover the nature of many anomalies.

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1.3-27p INCREASED RESOLUTION OF SUBSURFACE PARAMETERS FROM MT 1D MODELING**Shireesha, Mothe, Harinarayana, Thirumalashetty**

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In electric and electromagnetic techniques, it is well known that principle of equivalence poses a problem in the interpretation of the subsurface layers. This means the inversion problem can provide the conductivity-thickness product more confidently than the individual parameters conductivity and thickness separately. The principle of equivalence corresponds to the middle layer in a three layered earth structure. In order to resolve this problem, we have touched upon the different formulae of apparent resistivity proposed by earlier workers considering the real and imaginary parts of the impedance tensor and designed a new formula to compute apparent resistivity for different models. We observed that the application of our new formula for apparent resistivity using the combination of real and imaginary parts of the impedance that has a better resolution as compared to earlier conventional formulae of apparent resistivity. The results have been demonstrated through both forward and inverse modeling schemes.

1.3-28p THREE-DIMENSIONAL MAGNETOTELLURIC STUDIES OF THE ALUTO-LANGANO GEOTHERMAL FIELD, ETHIOPIA**Samrock, Friedemann; Bakker, Jenneke; Fisseha, Shimeles; Jackson, Andrew; Kuvshinov, Alexey**

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The magnetotelluric (MT) method is a powerful tool of geothermal exploration aiming to identify geothermal reservoirs and to estimate their potential for renewable energy extraction. MT easily covers exploration depths down to a few kilometers and is especially sensitive to zones of high electrical conductivity, which, in geothermal environments, are typically related to high temperature hydrothermal or magmatic reservoirs.

We performed MT studies at Aluto-Langano geothermal field in the surrounding of the only operating geothermal power plant in Ethiopia. Aluto volcano is known for its remarkable feature of rapid deformation. In 2004 and 2008 two pulses of inflation (20 cm) separated by subsidence at an averaging rate of 3-5 cm/yr have been obtained using Interferometry Synthetic Aperture Radar (InSAR) satellite observations. One of the goals of the MT survey is to identify the source of the unrest and its implications for geothermal production. MT data were collected in 2012 at 50 sites in a period range from 0.001 to 100 s, and inside the deforming area which covers around 10km x 10km. When interpreting MT responses in the region it was necessary to estimate and correct for effects arising from the pronounced topography at Aluto volcano with elevations between 1600 and 2400 m. We present the results of 3-D modeling of the topographic effects and discuss first results of the 3-D inversion of the MT data. Our MT data analysis indicates the presence of two conductors under Aluto-Langano geothermal field: one shallow in depths around 1 - 2 km and a deep conductor in depths greater than 10 km.

1.3-29p **GEOELECTRICAL IMAGE OF INDIAN PLATE SUBDUCTION IN CORRESPONDENCE WITH SEISMIC TOMOGRAPHY RESULTS AND SEISMICITY DISTRIBUTION IN GARHWAL HIMALAYA**

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Garhwal Himalaya is the area of high seismicity, which is monitored by seismological networks. Independent data on the disjunctive tectonics and rheological regimes, supplied by magnetotelluric (MT) and magnetovariational (MV) soundings, are also valuable for seismic hazard assessment.

Goelectrical model of the Garhwal along Roorkee-Gangotri (RG) profile has been constructed by Israil *et al.* (2008). The profile was further extended and all Mertronix and Phoenix observations were reprocessed under Indo-Russian project in 2010-2012. We present the updated resistivity cross-section, discuss 2D approach resolution problems and focus on the interpretation of the delineated conductivity features in the context of regional tele- and local earthquake tomography results and geothermal models from adjacent segments of the Himalaya.

In the resulted resistivity distribution the following relevant features are recognized: sediments of IGP and Siwalik; descending top of the resistive Indian plate, Main Himalayan Thrust, and bright conductive anomaly within MHT ramp at mid-crustal depths under Main Central Thrust zone. The areas responsible for generation of significant seismicity of Garhwal corridor have been attributed: a resistive block in the upper crust above the mid-crustal conductor and one more cluster of hypocentres (deep and strong earthquakes) underlying this conductive anomaly.

Goelectric and seismotomography images of anomalous zone under MCT are in a good agreement and well consistent with MHT ramp geothermal model. They indicate the area of partial melt+dehydration fluids, heated and mechanically weak, in the crust of Garhwal corridor and contribute to the explanation of the bi-modal earthquake distribution at a depth.

RG MT/MV data have also revealed a strong elongated conductive feature at East flank of the profile, which most likely corresponds to the Trans-Himalayan conductor of (Arora and Mahashabde, 1987). This important feature still needs a proper resolution and probably is caused by minor, rotational, component of Indian plate movement activating ancient trans-Himalayan structures and preparing arc segmentation.

The reliable resolution of the main goelectric structures along RG profile approved by the comparison of two method results provides objective constraints on the regional seismogeneration pattern for Garhwal Himalaya as well as geodynamic models of the India-Eurasia collision.

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1.3-30p **A BROADBASED ASSESSMENT OF CRUSTAL CONDUCTANCE DISTRIBUTION IN T**

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Existing 2-D goelectric sections generated from Indian subcontinent have been collated, digitised and electrical conductances computed upto 50 km depth. Graphical and contouring techniques were employed to analyse the observed conductances in order to assess their spatial distribution within the crust and upper mantle depths. Abnormally high conductances (>1500S) that correlate poorly with coincident Bouguer gravity anomalies were observed in some parts of the Himalayan, West Coast, tectonically active mobile junctions like the Tatapani junction, parts of the Central Indian Tectonic Zone (CITZ) and eastern Dharwar Craton (EDC) regions. In the CITZ region, abnormally high conductances (>1500 S) that show fairly good correlation with coincident Bouguer gravity anomalies are dominant. Moderate-high conductances dominate the sutures zones while low conductances features dominate the southern granulite terrain (SGT), tectonically less active regions and depths below 30 km. Aqueous fluids and their associated partially molten substances which thermal buoyancy forces and density contrast have forced to flow upwards towards region with low pressure and temperatures (upper-mid crust); rocks that are naturally enriched with conductive minerals like ultramafic and other high grade metamorphic rocks like orthopyroxenites and websterites; conductive structures accommodated in sutures, fractures, etc and highly resistive (dehydrated) materials were suspected to be the dominant source of conductivity in the four groups. At upper mantle depths, poor conductance conditions that were attributed to dominance of dehydrated rocks were observed. Thus a combination of Bouguer gravity and electrical conductance anomalies are very useful tools for discriminating between alternative sources of conductivities.

1.3-31p **THREE-DIMENSIONAL MAGNETOTELLURIC IMAGING OF THE TAUPO VOLCANIC ZONE: AN EXAMPLE OF THE REPOROA / WAIOTAPU GEOTHERMAL SYSTEM, NEW ZEALAND**

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Over a period of 3 years more than 250 broadband magnetotelluric (MT) measurements were recorded in the Taupo Volcanic Zone (TVZ) of New Zealand with site spacing varying from 500 m to 2 km. A 3D inversion was carried out on the dataset to determine the deeper structures of the TVZ and to gain information for future deep geothermal exploration. The investigated area hosts several geothermal systems, and many of them are already utilized for geothermal power generation.

MT is a passive geophysical exploration tool that utilizes naturally occurring, time-varying electromagnetic (EM) fields recorded on the surface to determine spatial variations in subsurface electrical resistivity. Temperature, porosity and fluid content, as well as hydrothermal alteration processes, have significant effects on patterns of subsurface electrical resistivity. Therefore, MT is well suited to image the different parts of a geothermal system, and is accordingly the most utilized geophysical imaging technique in geothermal research.

This paper will focus mainly on the results for the Reporoa / Waiotapu area. The Reporoa geothermal area is located in a caldera on the eastern side of the TVZ. For the last 40 years scientists have argued whether Reporoa is an independent geothermal system or just an outflow structure of the Waiotapu geothermal system to the north. Due to its location and possible connection to the Waiotapu geothermal system, which is a protected system and a big tourist attraction, the Reporoa system needs to be well characterized before commercial exploitation can be considered.

The first results show a thin hydrothermally altered layer at shallow depth, a more extensive hydrothermally altered layer at 1-3km depth as well as a plume-like structure on the northern boundary of the caldera located between the Reporoa and Waiotapu system.

SESSION 1.4

NEAR SURFACE APPLICATION OF ELECTROMAGNETIC INDUCTION

1.4-1 **IMAGING OF 3D ELECTROMAGNETIC DATA AT LOW-INDUCTION NUMBERS**

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We expressed electromagnetic measurements at low induction numbers as spatial averages of the subsurface electrical conductivity distribution and developed an algorithm for the recovery of the latter. The basis of our approach is an integral equation whose averaging kernel is independent of the conductivity distribution. That is, the recovery of conductivity from the measurements leads to a linear inverse problem. Previous work in one and two dimensions demonstrated that using a kernel independent of conductivity leads to reasonably good results in quantitative interpretations. This study extended the approach to 3D models and to data taken along several profiles over a given area. The algorithm handles vertical and horizontal magnetic dipoles with multiple separations for appropriate depth discrimination. The approximation also handles issues like negative apparent conductivities, which commonly appear when crossing near surface conductors. This happens particularly when using vertical magnetic dipoles; whose averaging kernel has significant negative weights in the space between the dipoles, something that does not happen for the horizontal dipoles. In general, the more complex the kernel, the more complicated the signature of any given anomaly. This makes qualitative interpretations of pseudo-sections somewhat difficult when dealing with more than one conductive or resistive body. The algorithm was validated using synthetic data for imaging data from horizontal or vertical coils or from a combination of them. Imaging of field data from a mine tailings site recovered a shallow 3D conductive anomaly associated with the tailings. Since the publication of this paper at Geophysics in 2012, we have explored more the negative apparent conductivities even for horizontal magnetic dipoles array.

1.4-2 **ANOMALOUS TIPPER MAGNITUDE**

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Anomalous Tipper Magnitude: A Possible Indicator of Coal Mine Fire Front

Audio Magnetotellurics (AMT) is a passive electromagnetic imaging technique using the Earth's magnetic field to map geologic contacts and structure typically up to depths of 500 meters or more. With the lower Magnetotellurics (MT) frequencies, imaging can be extended deeper. The ability of identification of geologic features varies with depth and depends upon target size, resistivity contrasts and contact geometry. AMT is very effective method for a better understanding of the subsurface of the Earth in terms of shallow structural setup of a geologically complex

area, with variant electrical property.

Jharia coalfields is one of the most important coalfields in India, located in Dhanbad district, between Latitude $23^{\circ} 39'$ to $23^{\circ} 48'$ N and Longitude $86^{\circ} 11'$ to $86^{\circ} 27'$ E. The coal basin extends for about 38 km in an East-West direction and a maximum of 18 km in North-South direction, and covers an area of about 456 sq. km (Fox, 1930). This is the most exploited coalfields because of available metallurgical grade coal reserves. The coalfields is surrounded by metamorphic rocks made up of granites, mica etc. The Coalfield has 49 seams with 26 regional seams and rests are local seams (Sengupta, 1980). Lower Gondwana rocks are well developed in Jharia coalfield; the rocks exposed mainly sandstones of Talchir, Barakar, Barren measures and Raniganj measures. The Barakar and the Raniganj are coalbearing formations (CMPDIL, 1988).

The coalfield is well known for a coal field fire that has burned underground for nearly a century and hosts the maximum number of known coal fires among all coalfields in India. The first fire was detected in 1916 and more than 77 coalmine fires have been reported by Mishra *et al.*, (2011) and Michalski, (2004), in this region.

Duba (1977 and 1983) described the changes in electrical conductivity of coal samples and their pyrolysis products. The heating of water-saturated coal samples increased their conductivity from an initial value of 10-3 Siemens per meter (Sm-1) (resistivity= 1,000 Ohm-m) at 24 °C to 100 Sm-1 (0.01 Ohm-m) when recovered as char from pyrolysis at temperatures of 800°C. King (1987) performed electromagnetic measurements over burned coal seams in Australia and found significantly lower resistivities for the coal heated to 800 °C and more.

The objective of present geophysical survey was to detect and delineate coal fire areas through AMT surveys. The AMT survey served to reveal areas of high electrical conductivity over the coal fire zones. We carried out AMT sounding over part of Jharia Coal field. Out of various MT parameters here we analyse Tipper. The tipping of the H vector out of the horizontal plane, is called the tipper. In general, the tipper is a dimensionality indicator. A tipper value of 0-0.1 indicates 1D structure, the tipper value between 0.1-0.2 is an indicator of 2-D and if the value is more than 0.5 but less than 1.0 is an indicator of 3D structure. However, in anomalous conducting zones this tipper value may be more than 1.0.

We carried out 7 AMT soundings. Station A is a site very close to coal mine fire front. The smoke was oozing out from the region. The tipper value observed was about 7.5 at 150 Hz. Subsequently we carried out AMT soundings at stations B and C at about +500 m and -500m from station A. It was observed that the tipper value decreased to about 2.5. Then two more soundings were carried out at stations D and E at about +1.5 km and -1.5 km away from A. These stations did not have any surface manifestation of coal mine fire. The observed tipper values at these sites are again about 7.8. The tipper value of these two sites as compared to site A is same. This possibly indicates a concealed fire zone.

Keywords: Audio Magnetotellurics (AMT), Apparent Resistivity, Phase and Anomalous Tipper.

1.4-3 CONTROLLED SOURCE RADIOMAGNETOTELLURICS FOR FREQUENCY RANGE 1-1000 KHZ AND ITS NEAR SURFACE APPLICATION

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The radiomagnetotelluric (RMT) method, based on measurements of radio transmitter's electromagnetic fields, has been actively developed last years. The application of this method in urban areas is the most effective because of the possibility to measure signals from 20-30 radio transmitters in frequency range 10-1000 kHz. In remote areas there is a possibility to measure the VLF transmitter's signals only with the profiling survey realization. For these conditions a controlled source version of the RMT method (CSRMT) with a horizontal electric dipole has been developed.

The RMT-C equipment includes a transmitter (1 kW) of rectangular pulses and five-channel digital recorder for frequency range 1-1000 kHz. Signals on 3-4 main frequencies and their sub harmonics are measured at a sounding station. The received sounding curves have sufficient details (30-40 points) for frequency range 1-1000 kHz. Because the frequency limit is lowered from 10 to 1 kHz the investigation depth is increased in approximately three times up to 100-150 m. The far-field zone of the electric dipole begins on the distance 400-500 m from the source and the working area is extended with the used dipole length 300-500 m up to 4-5 km. At the distance of several hundreds meters - first kilometers a wave zone of the source is allocated, where the electromagnetic field structure depends on displacements currents in the air. Wave effects should be taken into account at CSRMT surveys.

Examples of application of the CSRMT method in remote regions of Russia (Chukotka, Yakutia, Arkhangelsk region) for the solution of near surface engineering and exploration tasks are presented. Advantages compare to the standard vertical electric sounding method (in 10 time faster survey, possibilities of measurements with ungrounded electric lines in winter time on the surface of snow and ice) are demonstrated.

1.4-4 ESTIMATION OF SUBSURFACE TEMPERATURES IN THE TATTAPANI GEOTHERMAL FIELD, CENTRAL INDIA FROM LIMITED VOLUME OF MAGNETOTELLURIC DATA AND BOREHOLE THERMOGRAMS USING A CONSTRUCTIVE BACK PROPAGATION NEURAL NETWORK

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A constructive back-propagation code which was designed to run as a single hidden layer feed forward neural network (SLFFNN) has been adapted and used to estimate subsurface temperature from a small volume of magnetotelluric (MT) derived electrical resistivity data and borehole thermograms. The code was adapted to use looping procedure in searching for better initialisation condition that can optimally solve nonlinear problems using the random weight initialisation approach. Available one dimensional (1-D) MT derived subsurface resistivity distribution and borehole temperature records from the Tattapani geothermal field in Central India were collated and digitised at 10 m interval and paired to form a set of input and output pairs. The data pairs were partitioned into three mutually exclusive and trained in a supervised manner. The network was experimentally trained using total training data volumes of 52 % and later 61 % and the performances were in each case rated using statistical techniques of coefficient of determination (R^2), relative error (?), absolute average deviation (AAD), root mean square error (RMSE) and regression analysis. Attempt was also made to solve the same problem using the conventional manual procedure and the ? technique was used to rate the performance. Worst case performance that was observed to be 0.965, 3.746, 4.09, 1.407, 1.176 and 1.076 respectively for R^2 , AAD, ?, RMSE, slope and intercept. Using the ? technique, the performance of the manually designed static network was observed to be 20.233, 23.00 and 21.554 respectively for TPMT30/BH11, TPMT7/BH10 and a combination of TPMT30/BH11 and TPMT7/BH10. Comparatively, the structurally flexible network is a better performing network especially when the data volume is small although it needs to be tested further.

1.4-5 EM STUDIES FOR EARTHQUAKE-INDUCED LANDSLIDES HAZARD ASSESSMENT

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The main objective of this paper is to present the near-surface electromagnetic (EM) monitoring system that may provide the landslide hazard level assessment induced by to the intermediate depth earthquakes occurred in the seismic active Vrancea zone (Romania). The activities which have been accomplished are: (i) experiment and continuous improvement of the EM system at the local geoelectrical conditions of the landslide area for pattern recognition; (ii) assessment of the short-term electromagnetic precursory parameters related to both the earthquakes and the landslides associated; (iii) managing the data-sets available to produce pre and post seismic 2D resistivity models and tomographic images. The specific methodology and software packages have been applied for to obtain, in near real-time, all the important EM parameters and to point out their anomalous behavior versus the specific pattern established in non geodynamic conditions. Consequently, by analyzing the data carried out at the Provita de Sus landslide (test site), placed in Subcarpathians area, at about 100km far away of epicentral zone, it was possible to assign the increase of the landslide activity due to the local active fault which has been reactivated by the earthquake of M6 triggered in the Vrancea zone, in 27 October 2004. In the end, we illustrate the stage of the monitoring system implementation and the results highlight the utility of merging the electromagnetic parameters (normalized function Bzn, anisotropy, skewness and strike) with different 2D tomographic images associated with pre and post-seismic landslide processes. Thus, for the Provita de Sus-test site, we provide a landslide hazard level model based on a combination of susceptibility (slope, lithology, electrical conductivity) and triggering (earthquake) factors.

1.4-6 APPLICATION OF SHALLOW SEISMIC REFRACTION AND DC RESISTIVITY IMAGES

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The Giza necropolis plateau and its valuable pyramid, the one of the seven world miracles, are considered as the most characteristic examples of the ancient Egyptian civilization. They are attractive for tourists and for different scientific and archeological project. Therefore, it is interesting to carry out geophysical survey including seismic refraction and multi-electrode direct current resistivity imaging methods for mapping different rock units of the pyramids area and studying any groundwater infiltration that might have a negative impact on the archeological remains.

The results have indicated the presence of a geoseismic layer of high velocity corresponding to the dolomitized limestone that constitutes the main lithologic unit of the pyramid plateau. It is overlain at some localities by moderate and/or low velocity layers. The low velocity one is interpreted as the surface layer consisting of friable sand and fragments of limestone. The moderate velocity layer is referred to the fractured- marly limestone that might be affected by the percolation of the groundwater from rainfall and drainage systems giving relatively low resistivities as inferred from 2D resistivity imaging results. The archeological remains such as caves, mysterious, tombs, and / or secret rooms may be present as indicated by localized anomalous sensitivities.

1.4-7 3D MODELING OF DEMINING SCENARIOS USING METAL DETECTORS**Vargas, John; Everett, Mark; Bustamante, Roberto**

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Landmines are still considered a threat of major importance in some countries around the world such as Afghanistan, Colombia, and Pakistan, among others. Although new devices for landmine detection such as GPR have been implemented, the entities in charge of demining in the above mentioned countries continue to use electromagnetic induction metal detectors as their main tool.

Metal detectors started to be used for landmine detection since the World War II time frame. However; it is considered that its potential has not been used to the fullest due, in part, to the lack of rigorous tridimensional modeling tools supporting the design of this type of systems.

Since the 80's, some rigorous models to obtain electromagnetic induction response of a 3D conductively arbitrary scenario with homogeneous permeability have been solved using the node based Finite Element Method.

Nevertheless, it was until 2010 when Texas A&M University presented a model that included the option to configure the permeability of each element using the Edge Based Finite Element Method. This is a great advance in modeling and simulation for this kind of systems; however, as the author mentions in his dissertation, this simulation software has some restrictions.

This work aims to improve the software presented by Texas A&M. The objective is to extend its application capabilities so that scenarios that include landmines can be simulated. In this case, there is a double challenge for the Finite Element Solution; the buried objects are small and there is a high contrast between the electromagnetic properties of the elements. To support this work, we have the GSSI EMP400 Profiler; this equipment will allow us to make an experimental validation of the model and its FEM solution.

1.4-16p NEAR-SURFACE UTILITIES FEATURES MAPPING USING GPR**Adepelumi, A.A.; Akindulureni, J.O.**

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Until recently, Ground Penetrating Radar (GPR) technique has not been applied for utilities and subsurface feature mapping in Southwestern Nigeria. However, this method has proven to be indispensable for shallow subsurface structural and stratigraphic investigations. The efficacy of the technique was tested along Road 1 at the Obafemi Awolowo University, Ile-Ife campus with the aim of mapping the buried utilities and geologic structures that characterize this area. Accurate account of the exact location of these features is hitherto unknown.

GPR data was acquired along three pre-determined traverses, each approximately 600 m long and parallel to one another with a traverse-traverse separation of 10 m. The GPR equipment used was the GSSI SIR® System-2000 in common offset mode. The monostatic GPR antenna was shielded with center frequency of 200 MHz. The data collection mode was continuous with data window of 300 ns. The acquired data was subject to processing tools as dewow filtering, time zero correction and gain functions.

The results obtained from the study revealed that utilities, culverts and fractures (joints) and distinct lithologic boundaries of rocks beneath the surveyed area exist at depths varying between 0.5 m and 9 m. These utilities range from buried cables of varying widths, to underground water and sewage pipes. The fractures mapped have varying angles of dip between 22° and 30° and occur parallel to one another.

These results show a successful application of the GPR method, an evolving remote sensing technique to near surface investigations in a Basement Complex environment of Nigeria.

1.4-17p PRELIMINARY STUDY OF A SMALL PORTION OF THE MEXICO BASIN AQUIFER (CIUDAD UNIVERSITARIA CAMPUS, MEXICO CITY) USING TDEM**Arango-Galván, Claudia; Sagahón-López, Edgar Jesús; Macías-González, Héctor Luis**

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The increase in water supply demand due to population growth in Mexico City as well as the subsidence phenomena related to overexploitation of the aquifer has led to implement some measures to preserve and protect groundwater supplies. Water regulation entities have recommended conservative policies including development of local and regional studies to get a better insight of the dynamics of aquifers. These strategies will contribute to optimize water management and decrease subsidence rates of the subsoil. In the framework of a project to study a portion of the aquifer in the Mexico Basin, we implemented a TDEM study at Ciudad Universitaria (UNAM main campus) (southern Mexico City) with the main goals of characterizing the geometry of the aquifer in the area and identifying the geological units where the aquifer is confined. The TDEM soundings were acquired on the sports area (soccer and baseball fields) along an EW profile. The geoelectric section shows a shallow high electrical resistivity horizon, probably related with the basaltic layer from recent volcanic activity in the Chichinautzin range. Underlying this resistive horizon, there is a sequence of conductive layers that can be associated with Tarango Formation units

(i.e. sandy tuffs, volcanic breccias, clayish tuffs), which constitute the aquifer. This preliminary geoelectrical section shows consistency with the available geological information as well as data from a pumping test conducted in one of the supply wells at the university campus.

1.4-18p STUDYING THE EFFECT OF SEA WATER INTRUSION ON THE GROUND WATER POTENTIALITY USING 1-D AND 2-D INVERSION OF DC RESISTIVITY DATA: CASE STUDY AT RASHID AREA, EGYPT

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Since the past century, a decline in climate changes rate has been observed, especially along the coastal plains. These changes caused sea water rising which affected on the coastal zone. The increase of sea water level is causing increment in sea water intrusion, water-logged and salt-affected areas. As a strategic affected area, Rashid area was our target for this research, which is located about 75 Km East to Alexandria. As most of coastal areas its groundwater aquifer is highly affected by salt water intrusion from the Mediterranean Sea. This means that fresh groundwater may have a dramatic variation in distribution all over the area, which makes it hard to estimate water depth and type (fresh, brackish or saline) at any region.

The current research focuses on monitoring the shallow groundwater aquifers and examines the effect of sea water on these aquifers and the validity of the usage of these aquifers using geophysical data. For this purpose, we carried out 1-D and 2-D inversions based on the least squares method with smoothness constraints for a Schlumberger Vertical Electric Sounding (VES) data to identify the types of groundwater aquifer, distribution, freshwater depth and thickness and estimating subsurface lithology.

Seventeen VES stations were measured with current electrode separation ($AB/2$) ranges from 1.5 m to 100 m, then interpreted using 1-D and 2-D inversion scheme of DC resistivity data inversion.

The inverted resistivity distribution at relatively shallow depth shows an important low resistivity zone that probably reflects salt water alteration zone (northern parts). Depth to the freshwater bearing layer reaches its maximum at the south and decrease towards the north. From quantitative interpretation, Invasion of salt water started at depth about 10 m, Thickness of freshwater bearing layer ranging from 15 to 25 m, while at depth of about 120 m all the layers are saturated with salt water.

1.4-19p THE ROLE OF THE IMPEDIVITY IN THE MAGNETOTELLURIC RESPONSE OF 2D STRUCTURES
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In this work we study the influence of the resistivity dispersion on the magnetotelluric response. The dispersion consists in a variation of the resistivity according to the frequency of the telluric currents. Geothermal and hydro-carbon research are application fields where MT can be affected by this phenomenon. The complex physical and chemical fluid-metal-rock interactions may produce induced polarization effects, which are related to the dispersion in rocks. This is manifested on the MT response either in recognizable or in subtle forms, in both cases creating a distortion on the experimental curves. Disregarding the distortion effect may lead to misleading interpretation of the surveyed structures. We performed MT synthetic responses adopting 1D, 2D and 3D models in order to illustrate the dispersion effect on different kinds of geometrical structures typical of a volcano-geothermal environment. We also analyze experimental MT soundings in the Campi Flegrei volcano-geothermal area (Southern Italy), where dispersion effects have been recognized, in order to reconstruct the ideal (undistorted) behavior of the curves.

1.4-20p INTEGRATED GEOPHYSICAL ANALYSIS OF SINKHOLE CHARACTERISTICS BY MEANS OF EM, GPR, MAGNETOMETRY AND MICROGRAVIMETRIC SURVEYS

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The application of geophysical methods to characterize complex geological structures in the subsoil, especially in karstic terrains, requires a feed-back analysis between different geophysical techniques and their interpretation for well constrained geological-geophysical models. In the case of mantled karst, combined solution and sedimentation can result in complex contacts between units sedimented or deformed under different conditions, time and sedimentary environments. In the case of surficial sinkholes related to solution of evaporites below the quaternary deposits, filling coeval to subsidence or collapse generated complex geological structures and geophysical signatures. The persistence of cavities below the surface, and poorly compacted materials at surface, contrasting geological characteristics of the filling of collapsed zones with respect to the host rock and the intrinsic and state characteristics allow to define anomalies in map view, resulting from different sensitivity to underground changes. Geophysical

techniques indicate changes related to type of sediment, sedimentary architecture, internal characteristics and also indirect changes related to higher water content, for example between clay-rich deposits filling sinkholes and the more permeable and dry sedimentary gravel deposits surrounding them. The presented analysis is carried out from the integration of EM multifrequency induction, magnetometry, microgravimetry and gpr (50, 100, 250 and 500 MHz antennas) through a dense grid and systematic survey. The proposed methodology consists in the integrated analysis of geomagnetic data (total field and vertical gradient), EM induction data (apparent susceptibility and conductivity), Bouguer anomaly from microgravimetry (density), and imprint in the gpr record for different antennas by qualitative and semiquantitative analysis with EM and subsoil state characteristics.

1.4-21p GEOPHYSICAL INVESTIGATIONS (EM INDUCTION, MAGNETOMETRY AND GROUND PENETRATING RADAR) IN THE TUSCULUM ARCHEOLOGICAL SITE (LATIUM, ITALY).

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An integrated geophysical survey was carried in a surface of nearly 6,000 m² within the Tusculum roman city (Latium, Italy). The survey consisted in detailed data collection along a rectangular 80x50 grid with a spacing of 1 m between profiles, with N-S direction. Three techniques were applied: (i) EM induction profiles with a GEM-02 device (Geophex) for three measurement frequencies (65 to 5 KHz), (ii) magnetometry (GSM-19 Overhauser magnetometer as rover, PGM-1 as base) survey, including measurement of the total magnetic field and the vertical gradient, with two different survey configurations at 0.5 m and 1 m from the surface for the lower sensor and (iii) ground penetrating radar (RAMAC CUI-2 and shielded antennas of 250 MHz) with a denser grid and profile separation of 0.5 m. The survey was complemented with the measurement of magnetic susceptibility in construction blocks of rocks (mainly lavas and tuffs of volcanic origin) and different types of soils in the surrounding of the survey zone by means of a portable susceptometer (Terraplus). The integrated analysis of geophysical techniques is used to define the correlations between geophysical changes in the subsoil and to identify the sensitivity of different techniques, or measured properties for the archaeological characterization of the structure of non natural structures. The map of anomalies can be used to identify changes related to isolated buried elements in the subsoil and orthogonal patterns related to polygonal archaeological structures in the subsoil.

1.4-22p MAPPING FLOW STAGES IN RAJMAHAL TRAP REGION, INDIA USING AMT DATA

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Magnetotelluric (MT) is a passive exploration technique that utilizes a broad spectrum of naturally occurring geomagnetic variations as a power source for electromagnetic induction in the earth.

It appears that around 117 Ma ago the Earth opened along the palaeo-continental margin of the eastern India and a huge amount of molten rock poured on to the land blanking an area of about 4100km². The Rajmahal Traps evolved through decompressional melting of mantle material along the then eastern continental margin of India following rifting of Gondwanaland.

Rajmahal Volcanics or Rajmahal Traps exposed in the Rajmahal Hills of Jharkhand, India. About 600m thick flood basalts constitute this hilly terrain. The rocks are represented by basalt and dolerites. There are couple of flows constituting the Rajmahal Traps.

10 Audio Magnetotelluric (AMT) sounding data were acquired over a part of Rajmahal Traps, India in a frequency range of 104 Hz-100 Hz. The data analysis showed that the tipper value is around 0.1 for majority of frequencies and thus 1-D inversion of the acquired data was carried out.

1D inversion of all data showed a maximum depth of 300m. There are two flows observed from the inversion of the data. The first flow has a thickness of 100-200m with resistivity of around 3000 ohm-m followed by the second flow of thickness of 30-50m and resistivity of around 300 ohm-m at a depth of 10m. The sediments of thickness 10-30m with resistivity of 10 ohm-m are trapped between these two layers. The interpreted data matches fairly well with the lithology.

SESSION 1.5**ADVANCES IN ELECTROMAGNETIC MODELLING AND INVERSION****1.5-1 NOISE SENSITIVITY OF A VHF BROADBAND INTERFEROMETER****Wen, Chih-Fong; Collier, Andrew B.**

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A VHF interferometer can be used to measure the three-dimensional source of radiation emitted by lightning discharges. This is achieved by analysing the phase delay between the signals recorded at each of the three antennas. Using a numerical model of an interferometer coded in R we simulated a simple interferometer, including the source, antennas and a data processing unit. First, a monochromatic and isotropic point source was simulated in order to validate the structure of the model. The model was then expanded to include multiple monochromatic signals and finally a truly broadband signal. Using the model we were able to simulate the effects of noise on the resolving power of the interferometer and determine under what conditions the observations become unreliable.

1.5-2 FORWARD MODELING OF INDUCTION LOG RESPONSES FOR NATURAL AND HYDRAULIC FRACTURES**Elliott, Marcus; Everett, M.E.; Heidari, Zoya**

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Reliable evaluation of fractured reservoirs can significantly enhance production plans. The objective of this paper is to quantify the effects of natural and hydraulic fractures on simulated induction logs. Induction logging is a controlled-source electromagnetic method commonly used for formation evaluation. It is normally applied during wireline or Logging While Drilling (LWD) operations in conjunction with other logging tools, such as gamma ray, acoustic, density, and neutron porosity. Induction logs assist in characterizing a reservoir by inducing magnetic fields and measuring the associated physical response of the formation. In this paper, we numerically simulate the response of borehole induction logs in multi-layer fractured formations.

The software used for numerical simulation of induction logs, known as Seatem, is based on the finite element method. Seatem solves the governing diffusive Maxwell equations, formulated in terms of secondary Coulomb-gauged electromagnetic potentials, for the response of three-dimensional (3-D) heterogeneous electrical conductivity distributions on a cylindrical mesh. Our numerical simulations are capable of generating induction logs for a multi-layered earth model by defining formation conductivities of each geologic section. A roughness parameter α is also applied to simulate natural fractures within these layers.

Idealized linear hydraulic fractures are then explicitly placed within the geologic layers. We first identify a relationship between the roughening parameter and hydraulic fracturing. Then we analyze the impact of natural and hydraulic fractures on induction logs, after including various fluid compositions and density distributions into the model. Numerical simulations show a measurable impact of fracturing pore fluids on formation conductivity measured by induction logs. The results are promising, when combined with other borehole geophysical measurements, for the successful application of induction logs for reservoir characterization of fractured formations.

1.5-3 DIFFERENTIAL PROCESSING BASED MT DATA INVERSION**Maurya, V.P.; Srivastav, Prateek; Kumar Sahadev; Shalivahan**

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Magnetotellurics (MT) means a joint measurement of the natural Electric (E) and Magnetic (H) field variations on the surface of the earth subsequently deriving the information of shallower as well as deeper parts in the form of resistivity. Second derivative has much better resolving ability particularly in case when a thin conductive layer is sandwiched in between highly resistive interfaces (Xiang Lee, 1997). In this paper we are implementing the concept of second derivative on inversion of MT data for two cases, one belongs to detection of intertrapean sediments among different flows of shallower volcanic activity and in other we are able to map the sediments below the decan trap with varying thickness (1-5km). We can detect thin layers of sediments (Intertrapean Sediments) more precisely by implementing the concept of second derivative on inversion of MT data.

Key words: Magnetotellurics (MT), Second Derivative, Inversion and Intertrapean Sediments.

1.5-4 AGALVANIC DISTORTED COPROD2S2 MAGNETOTELLURIC DATASET AND ITS INTERPRETATION**Muñiz, Yunuhen; Esparza, Francisco J.; Gómez-Treviño, Enrique**

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The COPROD2S2 is a 2D synthetic magnetotelluric data set whose model is undisclosed. It consists of 33 soundings along a 50 km profile, with 8 periods per sounding ranging from 1 to 3,000 seconds. The theoretical responses of

the model were contaminated by the author with random noise, static shifts and also with some outliers. The objective was to challenge interpreters to propose models and learn from the application of different inverse approaches. We interpreted the data set as made available in internet, and decided to go a little further by adding galvanic distortions using the Groom-Bailey factorization. That is, we added twist, shear and also strike direction distortions to make a more realistic data set. We then proceeded to remove, sequentially, the effects of strike direction, twist and shear, using a simple formula and a visual minimization process for one of the variables. The remaining distortions, the static shifts, are determined using a 2D inverse routine that fits as much as possible part of the data set. The process mimics the EMAP method by providing data that originates solely from electromagnetic induction effects. A 2D model is proposed based on 1D depth averages of electrical conductivity.

1.5-5 **DEVELOPMENT OF MAGNETOTELLURIC DATA INTERPRETATION METHODOLOGY FOR GEOTHERMAL RESOURCES EVALUATION**

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We constructed a number of 3D resistivity models, typical to geothermal zones and reservoirs. Synthetic magnetotelluric (MT) data sets were obtained and used to evaluate the possibilities of different MT data inversion methods.

First, we considered a resistivity model of a typical geothermal zone, including near-surface and deep elongated conductive bodies. The upper conductor can be connected with mineral alteration, and the lower one with melting, besides, thermal water may contribute to the conductances of both. If the ratio of length and width of the conductive bodies is 3:1, then 1D inversion provides distorted image of the lower conductor, but 2D inversion gives very good results.

Second, we studied two three-layered models, one with local conductive zones, and the second with an extensive twisting zone in the resistive second layer. Synthetic data from only one MT profile was used for 3D inversion. For both models the inversion gave poor results when homogeneous half-space was used as a starting model. However, when three-layered starting model was used, the inversion provided correct structures beneath the profile and even in the surrounding area.

Finally, we constructed a series of models of artificial conductive geothermal reservoirs, created in a resistive crystalline basement of a platform. Exploitation of deep geothermal resources in platform regions may become efficient in the near future, and MT method could help to image and monitor artificial reservoirs. However, our modeling showed that the excitation of a reservoir, created in a resistive basement, is very small, and clear anomalies of MT data are observed only if reservoir depth is about 1-2 km, where temperatures are still low.

Nevertheless, MT method can help in prognosis of deep geothermal resources in platform regions. It allows revealing conductivity anomalies in the consolidated crust. They include graphitized and/or water saturated zones of increased permeability and heat-and-mass transfer. Moreover, some of these anomalies may be connected with modern tectonic activation, heating, partial melting and dehydration. Therefore, crustal anomalies may correspond to zones with relatively more heated interiors.

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1.5-44p **SURLARI OBSERVATORY, READY FOR PRESENT AND FUTURE, IN THE THIRD MILLENIUM**

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Since March 2009, in the frame of an international cooperation agreement with GFZ-Helmholtz Centre Potsdam, the Surlari observatory has continuously respond to national and international requirements for geomagnetic data, in terms of quality and rapid availability. The very first aim of the observatory is to preserve its present INTERMAGNET standards. A highest accuracy for all magnetic measurements is the main goal and an absolute accuracy less than 1 nT is foreseen. As for all modern ground observations, Surlari uses comparable instrumentation to produce similar data products. A Bartington fluxgate-theodolite (DI-Flux) and an Overhauser proton magnetometer for scalar measurements are the magnetic reference instruments for a FGE variometer, which is subject to instrumental drift. Surlari observatory has also plenty considered the new worldwide needs for new and better products, like quasi-definitive data or 1-second data, relevant for some specific scientific topics and for real-time applications. Since January 2012, Surlari quasi-definitive data have been published within 30 days after recording, their accuracy being very similar to that of the definitive data. This is due to the large recent efforts in a continuous scrutiny of the quasi-definitive data: visual inspection of the quasi-definitive baseline, checking of the continuity between the current quasi-definitive and previous year definitive data, checking of the scalar residuals (ΔF), and visual review of all components at different time-scales. Additionally, an algorithm to remove spikes and jumps, and to replace the missing FGE one-minute values from a back-up system has been developed. These new developments in the actual standard of the Surlari observatory are presented, together with some specific examples of the use of data.

1.5-45p REMOVABLE OF GALVANIC DISTORTION ON 3-D MT INVERSION

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Recent years, 3-D MT inversions are widely used for geophysical investigations of geothermal and volcanic area. The 3-D MT inversion can give us more realistic results than the 2-D inversion, especially to complex geological structures, such as geothermal or volcanic area. In the practice of 3-D MT inversions that have been applied to field data, some fundamental issues are not so well considered. For example, the effect of galvanic distortion in 3-D MT inversion is the one of major problems. This research confirms the effect of galvanic distortion in 3-D MT inversion result and proposes a method to improve the results from 3-D MT inversion. The galvanic distortion is caused by local resistivity anomalies near the surface and generates artificial false images in the inverted result model. Originally these effects of galvanic distortion should be reproduced as local anomaly at the surface layer model. But, because of the smoothness constraint, the galvanic distortion on MT response is reproduced as gradual resistivity changes at deeper area in the order of several kilometers that are close to the target depth of earth resources exploration. As in the 2-D inversion, false anomalies could be created in inverted model when ignoring the galvanic distortion. Therefore, the galvanic distortion has to be removed. In our research, we first confirm the effects of galvanic distortion would generate false resistivity anomalies in the inverted model in particular in deeper part because of smoothness constraint. This problem should not be ignored to know realistic resistivity structure of the subsurface. The result of modified model covariance matrix is more reliable than that from the original model covariance matrix. Since the thin surface layer could be analogues of the galvanic distortion, we could deal with the galvanic distortions by a thin layer at each of the observation locations.

SESSION 1.6 MARINE ELECTROMAGNETIC STUDIES**1.6-1 THE ROLE OF CSEM METHODS IN THE EXPLORATION STRATEGY OF PEMEX IN THE GULF OF MEXICO**

Vázquez, Marco

Pemex Exploración

The start model is very important for any inverse modeling as the final result strongly depends on it. Commonly, the start model is built based on stratigraphic criterion, assigning a resistivity value for each formation. However, this approach does not take into account the dependence of resistivity on porosity, compaction, depth, and temperature, which has been observed especially for young sediments; to include this information, empirical relationships between the local velocity and resistivity trends have been used. A case study using full-azimuth 3D CSEM for salt imaging in the deep water Gulf of Mexico is presented. Two start models were evaluated: 1) Based on structural framework from seismic; 2) Based on velocity model. Anisotropy regularization in the anisotropic inversion was used for both exercises (Morten *et al.*, 2013). Both inversions are compared based on their misfits (both initial and final), convergence speed and resulting resistivity models. The results indicate that is important to account for the compaction effects when dealing with young sediments. All results show alternative salt distributions than the one suggested by the seismic. This information could be used to improve the velocity model and thus enhance the seismic imaging.

1.6-2 3D MULTI MEASUREMENT IMAGING USING SEISMIC AND ELECTROMAGNETIC METHODS IN COMPLEX GEOLOGICAL ENVIRONMENTS

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Seismic imaging in basalt and salt provinces is well known to be extremely challenging. As recent publications have shown (De Stefano *et al.* 2011, Medina *et al.* 2012), to achieve a good quality seismic image, the complementary use of non-seismic methods is one of the recommended solutions. Electromagnetic methods, such as magnetotellurics (MT) and controlled source electromagnetics (CSEM), are sensitive to the presence of massive salt or basalt structures due to their high resistivity contrast with respect to surrounding sedimentary units.

In this study we show marine case studies as well as synthetic analyses of cooperative and simultaneous inversion of seismic and EM measurements, in 3D modelling workflow, to improve the seismic image in geological settings with presence of salt bodies and basalt. The 3D simultaneous joint inversion (SJI) workflow, indeed, enhances the contribution of EM data, particularly in complex salt provinces, where this method can leverage the differences between salt/basalt and sediment in both resistivity and velocity.

1.6-3 DIRECT IDENTIFICATION OF HYDROCARBON FILLED LAYERS USING CSEM**Adepelumi, A.A.; Akindulureni, J.O.**

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Recently, there has been tremendous interest in the controlled-source electromagnetic (CSEM) method as a direct hydrocarbon mapping tool because of its ability to map thin resistive layers sometimes associated with hydrocarbons. Remote characterization of reservoirs using CSEM is of economic importance to the hydrocarbon industry because of its cost-effectiveness. This is due to the fact that discriminating between the presence of water or hydrocarbons from traps mapped from seismic imaging technique has remained a challenge. Therefore, to ascertain the usefulness of CSEM as a direct hydrocarbon identification tool in offshore Niger Delta Nigeria, we have carried out one-dimensional CSEM modeling.

The model used is a 1-D layered half-space consisting of homogeneous and transversely isotropic layers, the model parameters are thus the layer resistivities and the thicknesses. The modeling problem was solved using the new finite element algorithm developed at Scripps Institute of Oceanography. Modeling of the CSEM response was carried out for simple geologic scenario with the seawater having a resistivity of 0.33 Ω m; homogenous half-space resistivity was varied from 1 to 2.5 Ω -m, while the resistivity of the hydrocarbon layer was varied from 50 to 100 Ω -m. The water depth was fixed at 1 km, while the potential pay zone is assumed to be buried at about 2 km depth. The thickness of the reservoir was varied from 50 to 200 m. The data set thus consists of inline electric and transverse magnetic field amplitude for the in-tow (Tx going toward the receiver) and out-tow (Tx going away from receiver) soundings for the receivers at the frequency 0.1, 0.5, 2.5 and 10 Hz, and its first two odd harmonics. The outcomes and analysis of the CSEM modeling produce a more robust and in-depth understanding of the prospect. Also, it shows the importance of incorporating a priori geologic information in modeling exercise. The result also provides an irrefutable evidence for direct hydrocarbon detection using the novel controlled source electromagnetic method (CSEM).

We have thus demonstrated that CSEM method can effectively detect the presence of thin hydrocarbon-bearing layers at certain source-receiver configurations, and in certain source-frequency ranges. In-addition, the so-called split effect that is diagnostic of buried resistive layers is verified by the one-dimensional modeling. Conclusively, this study illustrates predictive power of CSEM data in a favorable deepwater setting. The results are particularly significant, as the risk of residual gas cannot be effectively reduced by seismic technology and geologic consideration only.

1.6-4 SENSITIVITY ANALYSIS OF MARINE CSEM MEASUREMENTS**Calderón-Moctezuma, A.; Gallardo-Delgado, L.A. and Gómez-Treviño, E.**

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We develop analytical solutions for the Fréchet derivatives of electric and magnetic fields with respect to a 1D vertical resistivity function, when the source is a horizontal electric dipole. As for the fields themselves, the Derivatives still require a numerical Hankel transform. Cross sections of the sensitivity provide visual pictures of how the measurements are affected by the resistivity distribution, in the interplay of source-receiver separation and frequency. Of particular interest is the capacity of some configurations to focus the sensitivity at depth. For some components of the fields it can be visualized the optimal distances and frequencies for reaching a given depth.

Also, the difference between detecting resistive and conductive layers at depth can be visualized. The results confirm that the components of the magnetic field are more sensitive to the resistivity of conductive layers, and that the components of the electric field are more sensitive to the resistivity of resistive layers. However, both magnetic and electric fields are sensitive to the thickness of resistive layers. In general, the sensitivity analysis complements what we already know about marine CSEM measurements, by offering a visual synthesis of what the different components of the fields have to offer in the detection of particular targets.

1.6-5 INTEGRATED WELL LOG, SEISMIC, AND CSEM INTERPRETATION OF HYDRATES IN THE DEEP-WATER GULF OF MEXICO**Baltar, Daniel**

EMGS Trondheim, Norway

Gas hydrates are generated at high pressure and low temperature conditions available in the first hundreds meters of sediments of the deep-water sedimentary areas. Their existence has been detected in different places within the Gulf of Mexico. Detection of gas hydrates is important for the oil industry as they pose a drilling hazard and their potential for becoming producible resources in the future. Seismically gas hydrate presence is detected through an almost parallel to the seabed seismic reflection, usually known as bottom simulating reflector (BSR). The BSR results from the seismic property contrast that exists between the high impedance hydrated sediment on top and the low impedance gas filled sediment below. Seismic hydrate detection and characterization is often hard, as hydrate can exist without a BSR being present, and the hydrate thickness and saturation estimations might suffer from high uncertainties. Inclusion of CSEM derived resistivity in the interpretation allows an easy detection of the hydrate layers

even in the absence of a BSR, and a better definition of the hydrate thickness and saturation when combined with seismic data. A workflow for 3D CSEM, seismic data, and well log data integration is proposed in order to generate a common interpretation of the lateral variations of lateral thickness and saturation. An example of the workflow using real data is provided, the input data is oil industry standard well log, 3D seismic, and CSEM data. The application of this workflow allows for the detection of areas with high hydrate saturation and thickness and the distinction from other areas with minor hydrate presence. These lateral variations are quite important as they significantly improve the seismic hydrate interpretation uncertainty, yielding a more informed estimate of the hydrate thickness and saturation.

1.6-6 **A DEEP-TOWED CSEM SOURCE AND RECEIVER SYSTEM FOR MAPPING SHALLOW MARINE GEOLOGY**

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Marine controlled-source electromagnetic sounding (marine CSEM) using deployed ocean-bottom EM (OBEM) recorders and a deep-towed electric field transmitter has been used for several decades to study the oceanic crust and uppermost mantle, with source-receiver offsets of up to 100 km achievable. More recently, marine CSEM has been used as a tool for hydrocarbon exploration, identifying resistive targets at depths of a few kilometers in the more conductive sedimentary basins of the continental shelves. However, study of geological targets such as marine gas hydrate, groundwater, hydrothermal circulation systems, and metal sulfides/oxides requires imaging of the uppermost few hundred meters of seafloor. The use of deployed receivers in this case becomes less efficient because of the small spacings required to resolve structure. To address this problem we have developed a 3-axis electric field receiver towed behind an EM transmitter to collect continuous constant-offset data, either as a stand-alone surveying technique or as a supplement to an OBEM-based survey. By towing a neutrally buoyant receiver behind a transmitter deep-towed 50 to 100 m above the seafloor, we can operate in areas of rugged volcanic bathymetry or installed seafloor infrastructure, as well as avoid noise associated with towing electrodes in contact with seafloor. By using a rigid body we can avoid noise associated with lateral motion of cables in Earth's magnetic field as well as measure vertical and cross-line components of electric field. The vertical field in particular is strongly coupled to resistive structure both galvanically and inductively. Initial applications used a single receiver towed 200-400 m behind the transmitter, but by including real-time depth monitoring we have extended this to four receivers towed up to 1100 m behind the transmitter. We will present data from various experiments, including surveys in the Gulf of Mexico and offshore California that target marine gas hydrate.

1.6-7 **INVERSION TO VERTICAL AND HORIZONTAL RESISTIVITIES OF TOWED STREAMER ELECTROMAGNETIC DATA**

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The Alvheim Boa field is a medium sized producing oil and gas field located in the Norwegian sector of the North Sea. Two lines were acquired with our towed streamer electromagnetic acquisition system over the reservoir traversing close to the depo-center as mapped from the 3D seismic data. The source bipole was towed at 10 m and the user selectable source signal runs at 1,500 A. The source sequence is 120 seconds long with the last 20 seconds used for noise analysis, followed by noise attenuation processing. The streamer has effectively 26 offsets ranging from 0 – 7,700 m and it is towed at a nominal depth of 100 m. Maximum water depth is 400 m but larger depths are acceptable if the target is very large, shallow below mudline, or has a very high transverse resistance. The acquisition speed is 4 – 5 knots and the system is combinable with simultaneous acquisition of 2D seismic. The medium sized reservoir is located 2,100 m below mudline making it a challenging target to detect. The inversion was done as a series of common mid-point (cmp) 1D inversions posted along the acquisition lines to create 2D images. The background model consisted of the water layer followed by two layers representing the overburden and seven thin layers representing the reservoir, and ending with a half-space at the bottom of the layered model. Only the water layer thickness was adjusted for each cmp and only the constant bed thicknesses were used as constraints in the inversions. The inverted data closest to the depo-center shows the reservoir is quite strongly anisotropic, with a vertical to horizontal resistivity ratio of 5, arising as effective anisotropy in the depositional sequence of hydrocarbon charged sands inter-bedded with shales. With the resistivity of the shales known from log data, together with the inverted vertical and horizontal resistivities allows the vertical and horizontal resistivities of the sands to be estimated also together with an estimate of net-to-gross.

1.6-46p PROPERTIES OF THE TSUNAMI DYNAMO EFFECT REVEALED BY 2-D SIMULATIONS USING THE FINITE ELEMENT METHOD**Minami, Takuto; Toh, Hiroaki; Hamano Yozo**

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Conductive sea water moving in the geomagnetic main field generates dynamo effects in the ocean. This phenomenon has been studied mainly for long-period oceanic motions with negligible self-induction (Sanford, 1971). However, seafloor magnetic observations succeeded recently in observing electromagnetic (EM) signals associated with tsunamis, whose periods are normally less than 1 hour (Manoj et al., 2011; Suetsugu et al., 2011; Toh et al., 2011). Our research group also obtained a magnetic tsunami signal, whose peak is as large as 3 nT in the vertical and horizontal magnetic components at the seafloor EM observation site in the North-West Pacific (NWP) at the time of the 2011 Tohoku tsunami. It is important to understand how tsunamis generate EM signals, because the EM tsunami signals may lead to better understanding of tsunamis by using seafloor EM observations and improving the existing global tsunami early warning systems.

Tyler (2005) derived simple relationship between sea level changes and tsunami-induced magnetic fields in the frequency domain, taking into account the self-induction, which is important in short-period phenomena. Although Tyler's formulation is powerful, the frequency-domain formulation cannot appreciate some realistic factors, such as effects of solitary waves, conductivity structures beneath the seafloor, and realistic bathymetry.

In this study, we developed a time-domain 2-D tsunami dynamo simulation code, using the finite element method (FEM), in order to reproduce the magnetic tsunami signals observed at our NWP site. With the help of FEM, our tsunami dynamo simulations can include realistic bathymetry and arbitrary conductivity structures beneath the seafloor. In our simulations, tsunami flows are initially calculated hydro-dynamically, and the induction equation in terms of the magnetic vertical component is solved numerically, using obtained tsunami flows in the same numerical grid.

As a result, our tsunami dynamo simulation has reproduced magnetic tsunami signals observed at NWP and sea level changes observed at the DART21401 and 21419, which are DART system observation sites nearest to NWP, simultaneously. It is also found that an initial rise as large as 1 nT in the magnetic horizontal component parallel to the tsunami propagation direction was also induced by the tsunami passage. The initial rise in the horizontal component is approximately 5 minutes preceding the arrival of the first wave of the tsunami. Considering the period of the tsunami, T , is approximately 20 min, the initial rise appears to be $T/4$ ahead of the tsunami arrival, which is implicitly inferred by Tyler's frequency-domain formulation. Detailed analysis of the initial rise, therefore, may enable us to know tsunami heights and propagation directions before the arrival of actual tsunami peaks.

In the presentation, we will report tsunami signals obtained at Site NWP and results of our tsunami dynamo simulations. In addition, we will discuss whether the initial rises in the horizontal magnetic component can be applied to the existing tsunami early warning systems.

1.6-47p START MODEL BUILDING FOR CSEM INVERSION**Sánchez-Pérez, Luis Alberto**

EMGS

The start model is very important for any inverse modeling as the final result strongly depends on it. Commonly, the start model is built based on stratigraphic criterion, assigning a resistivity value for each formation. However, this approach does not take into account the dependence of resistivity on porosity, compaction, depth, and temperature, which has been observed especially for young sediments; to include this information, empirical relationships between the local velocity and resistivity trends have been used. A case study using full-azimuth 3D CSEM for salt imaging in the deep water Gulf of Mexico is presented. Two start models were evaluated: 1) Based on structural framework from seismic; 2) Based on velocity model. Anisotropy regularization in the anisotropic inversion was used for both exercises (Morten et al, 2013). Both inversions are compared based on their misfits (both initial and final), convergence speed and resulting resistivity models. The results indicate that is important to account for the compaction effects when dealing with young sediments. All results show alternative salt distributions than the one suggested by the seismic. This information could be used to improve the velocity model and thus enhance the seismic imaging.

1.6-48p ORIENTATION OF SEABED MT STATIONS WITH LAND MAGNETIC OBSERVATORY DATA**Miquelutti, L.G.; Ulugergerli, E.U.; Meju, M.S.; Fontes, L.; Nascimento, D.**

Observatório Nacional; Petronas; Petrobrás

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A marine magnetotelluric survey was conducted in Santos basin (Brazil) with seabed sensors which lack electronic compass, resulting in acquired data with unknown direction. This work aims to orientate these sensors with data from a land magnetic observatory by inspecting parameters as coherence or magnetic transfer function between horizontal magnetic components of a mmt station and the observatory.

SESSION 1.7**TIME VARIABILITY OF THE GEOMAGNETIC FIELD: SUPERCHRONS, REVERSALS, SECULAR VARIATION, JERKS****1.7-1 RECONSTRUCTING HOLOCENE GEOMAGNETIC FIELD VARIATION: NEW METHODS, MODELS AND IMPLICATIONS****Nilsson, Andreas; Holme, Richard; Korte, Monika; Hill, Mimi**

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The Holocene palaeomagnetic database consists of data from two main sources: (i) archaeological artefacts/lavas and (ii) lake/marine sediments. Data from the latter group are generally associated with larger uncertainties both with respect to dating control and magnetic information. However, in order to obtain a relatively global data distribution for geomagnetic field modelling and to extend models beyond the last three millennia it is necessary to consider both datasets. Here we present a new family of continuous spherical harmonic models of the geomagnetic field for the last 9000 years. We have used a similar initial dataset and modelling approach used for *cals10k.1b* (Korte et al., 2011) but made adjustments to the sedimentary data and how the different datasets are weighted in the inversion process. We explore the physical implications of these new results with a focus on millennial scale variations associated with, or on similar time scales as, previously reported periodicities in the variation of the equatorial dipole (Korte et al., 2011; Nilsson et al., 2011). We also discuss implications for the stability and longevity of high-latitude flux lobes at the core mantle boundary.

1.7-2 ON THE DIRECTORAL BEHAVIOR OF THE GILSA EXCURSION RECORDED ON THE**Herrero-Bervera, Emilio; Valet, Jean Pierre**

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Previous published work on Lanai indicated that the volcano was formed mainly during the Matuyama Chron (Herrero-Bervera et al., 2000). In order to constrain further the timing of the active phases of the Lanai volcano, we conducted a paleomagnetic and rock magnetic study involving a 250-m thick sequence of lava flows that were erupted between 0.76 \pm 0.06 Ma and 1.6 \pm 0.08 Ma according to previous K/Ar and ⁴⁰Ar/³⁹Ar dating (Leonhardt et al., 2009). Low-field susceptibility versus temperature (k-T) and SIRM experiments performed on a dozen flows indicate that magnetite dominates the remanent magnetization (575 degrees C). In a few cases, a low-temperature mineral phase (300-400 degrees C) could reflect the presence of titanomagnetite with low Ti content, but the presence of maghemite or pyrrhotite cannot be completely excluded. Additional investigations are in progress on this matter. All specimens were step-wise demagnetized by alternating fields from 5 to 100 mT. Companion specimens from the same samples were demagnetized at 15 temperature steps. The demagnetization diagrams obtained with each technique showed a stable direction of remanence. In all cases, the characteristic (ChRM) component was clearly defined from at least seven successive directions isolated during step-wise demagnetization. The succession of the mean directions calculated for each lava flow reveals the existence of three polarity intervals. Based on radiometric dates, they were assigned to the Gilsa, Gardar and Bjorn "excursions". Thus, the present results, along with the radiometric ages of the lavas, indicate that the tholeiitic flows that formed the Lanai volcano were erupted over a short time period, and only during the Matuyama Chron (0.780-2.58 Ma). No eruption occurred during the Brunhes Chron (0.78 Ma) as previously reported for the K-Ar dated lavas in the Maunalei Gulch. The excursions VGP from the onset of the Gilsa excursion recorded on Lanai are situated near the vicinity of the west coast of South America and lingering to the west part off Australia. These transitional/excursion directions are well correlated to other subchrons such as the Cobb Subchron, the Punaru, the Kamikatsura excursions and the Matuyama/Brunhes precursor suggesting a dipolar dominance during the onset of these excursions indicating perhaps an influence of lower mantle heterogeneities.

1.7-3 PALEOINTENSITY OBTAINED FROM LATE CRETACEOUS AND EARLIEST PALEOGENE BASALTS DRILLED FROM LOUISVILLE SEAMOUNT TRAIL DURING IODP EXPEDITION 330**Yamazaki, Toshitsugu; Yamamoto, Yuhji**

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IODP Expedition 330 occupied six sites on 5 seamounts along the northwestern part of the Louisville hotspot track. The age of the seamounts ranges between 50 and 74 Ma. Fresh basalts were recovered by drilling despite the old ages. From onboard examination of the rocks, it is considered that part of basalts erupted in subaerial or shallow submarine conditions and probably suffered high-temperature oxidation, in particular at Sites U1372 and U1373, suggesting that they may be suitable for absolute paleointensity estimation.

We conducted paleointensity measurements using the Tsunakawa-Shaw method with low-temperature demagnetization (LTD) and double heating (DHT). First, thermomagnetic curves were measured for all samples with a Curie

balance at the Center for Advanced Marine Core Research, Kochi University. Samples that showed evidence for being suffered low-temperature oxidation were excluded. Then, samples from which characteristic magnetization component was isolated by stepwise alternating-field demagnetization were subjected to the paleointensity experiments; samples with MAD of larger than 10 deg. were excluded.

Paleointensity of 22.1 ± 8.4 micro T was obtained at Site U1372 on the Canopus Seamount, the oldest seamount drilled (~74 Ma), as the mean of 18 lithological units (lava flows) that passed the selection criteria of Yamamoto and Tsunakawa (2005). Sites U1373 and U1374 on the Rigil Seamount (~70 Ma) yielded paleointensity of 21.7 ± 9.0 micro T ($n=22$), and Site U1376 on the Burton Seamount (~64 Ma) resulted 21.9 ± 6.8 micro T ($n=12$). The mean paleointensities are converted to virtual axial dipole moment (VADM) of approximately 3.5×10^{22} Am² based on a paleolatitude of 47 deg. S of the Louisville hotspot between 50 and 74 Ma from onboard paleomagnetic results. The results of this study suggests that paleointensity of latest Cretaceous to earliest Paleogene was about a half of the present field intensity and similar to the mean of the last 5 Ma by Yamamoto and Tsunakawa (2005).

1.7-4 STATISTICAL PROPERTIES OF REVERSALS AND CHRONS IN NUMERICAL DYNAMOS AND IMPLICATIONS FOR THE GEODYNAMO

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We analyse a series of very long runs (equivalent to up to 50 Myrs) produced by chemically-driven dynamos. All runs assume homogeneous boundary conditions, an electrically conducting inner-core (except for one run) and only differ by the choice of the Rayleigh number Ra . Introducing dynamo-based definitions of reversals, chrons and related concepts, such as "failed reversals" and "segments" (bounded by reversals or failed reversals), we investigate the distributions of chron and segment lengths, those of reversal and failed reversal durations, the way dipole field behaves through reversals and failed reversals, and the possible links between the axial dipole intensity and chron or segment lengths. We show that chron and segment lengths are very well described in terms of a Poisson process (with no occurrence of superchrons), while distributions of reversal and failed reversal durations are better fitted by log-normal distributions. We found that reversal rates generally increase in proportion to $Rm - Rm_c$, Rm being the magnetic Reynolds number and Rm_c a critical value. In contrast, reversal and failed reversal durations appear to be mainly controlled by the core's magnetic diffusion timescale. More generally, we show that much of the reversing behaviour of these dynamos can be understood by examining their signature in a (g_1^0, g_1^1, h_1^1) phase-space plot. This reveals that the run with an insulating inner-core is very different and has only two distinct modes of opposite polarity, which we argue is the reason it displays less reversals and failed reversals, and has a clear tendency to produce an intensity "overshoot" and some systematic pattern in the dipole pole behaviour through reversals and failed reversals. This contrasts with conducting inner-core runs, which display an additional central unstable mode, the importance of which increases with Rm , and which is responsible for the more complex reversing behaviour of these dynamos. Available paleomagnetic data suggest that the current geodynamo could have such a (small) central mode, which would thus imply a strong sensitivity of the frequency and complexity of reversals and of the likelihood of failed reversals, to changes in the geodynamo's driving parameters through geological times.

1.7-10p HISTORICAL SOURCES OF THE GEOMAGNETIC FIELD IN AUSTRIA

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Historical sources play an important role in expanding our knowledge of geomagnetic field evolution back to the late Middle Ages. In this context, church orientations, historical maps, sundials and globes with attached compasses and magnetic measurements performed during field expeditions, at monasteries and astronomical observatories or by the navy are evaluated for the Austrian and surrounding areas.

In our work, from above mentioned sources, the possible use of magnetic compasses for the orientation of buildings was investigated first. Although "Easting" of churches actually refers to the alignment towards the azimuth of sunrise at the church patronal festival, deviation of nave alignment from the geographic East direction is often assumed to be caused by the use of magnetic compasses. Church orientations in Lower Austria and northern Germany have been determined from georeferenced satellite images. Metadata like the construction year, possible reconstructions and the church patron are essential to determine the date, when current church direction was appointed, and to clarify the issue of "Easting". However, in both regions a significant correlation between deviations from geographic East direction and magnetic declination at the construction date or sunrise azimuth is not found.

On historical maps the value of declination is occasionally indicated on compass roses or written down. Up to now, about 100 maps with declination values for different regions in the world have been collected; including 16 for the Austro-Hungarian Monarchy area. Declination information from these maps dates back to the 16th century, although most maps are from the 17th and 18th century.

Other sources, like for example early measurements of declination and inclination in monasteries are currently investigated and first results will also be presented.

1.7-11p **BRUNHES AND MATUYAMA CHRON PALEOSECULAR VARIATION STUDY FROM DAT**

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Sixteen oriented sites of basaltic lava flows from the West Maui Volcano series (island of Maui, Hawaii) were selected to improve the determination of the Brunhes and Matuyama time-averaged geomagnetic field between >0.6 and 1.8 to 2.6 Ma respectively. We sampled five flows from the Wailuku Volcanics (ca. 1.97±/−0.96-1.58±/−0.13 Ma), five flows from the Honolua Volcanics (ca. 1.50±/−0.13 Ma) and six flows were drilled from the rejuvenated-stage Lahaina Volcanics (ca. <0.610±/−0.012 Ma). Identical Characteristic Remanent Magnetization (ChRM) directions with reverse polarity carried by magnetite were isolated by stepwise alternating-field and thermal demagnetization in 12-15 specimens from each site. The final mean direction points south while the inclination is ~7 degrees lower than the inclination of the geocentric axial dipole (GAD). This offset is reduced after correcting the site latitude for the Pacific plate motion, which has been neglected so far in most studies. The mean corrected direction is almost perfectly antipodal to the Brunhes mean direction derived from the Lahaina Volcanics in the same island of Maui and for the Honolulu Volcanic series (HVS) which are part of the Koolau Volcano on the island of Oahu. After applying the tectonic correction, the inclination remains several degrees larger than the inclination of the axial dipole and cannot be accounted for by a small axial quadrupole which would reverse with the dipole. The mean inclinations of other Hawaiian records (mostly younger than 1 Ma) involving long sequences of lava flows exhibit similar deviations from the GAD which are too large to be accounted for by a small axial quadrupole. Tilting of all sections is difficult to defend for so many localities and persistent secondary components have not been detected. Thus, these inclination anomalies would reflect the presence of a long-term standing component under Hawaii but crustal magnetization linked to the volcanic edifice cannot be completely ruled out.

1.7-12P **CONSTRAINING THE BEHAVIOUR OF THE EARTH'S MAGNETIC FIELD IN MESOAMERICA FOR THE LAST 47KA USING VOLCANIC DATA.**

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In this work, we propose a first palaeosecular variation curve for the Mesoamerican region covering the last 47ka by using volcanic lava flows. The present Mexican volcanic database has been completed with a new set of volcanic data which are also given in this work. A total of 30 directional (declination and inclination) and 24 intensity data have been used to define the behaviour of the full vector for the last 47ka for this region, showing the large long-term time variations of the geomagnetic field. For each geomagnetic field elements, we developed a continuous palaeosecular variation curve by using the penalized cubic B-splines with knot points every 200 yr. A bootstrap algorithm was applied in order to obtain the curve's error (at 65% of level of confidence) which takes into account the age and measurement uncertainties of the lava flow data. The directional curves present values between [−20°, 10°] and [20°, 65°] for the declination and inclination respectively. The intensity curve is not well constrained for different time intervals due to the lack of data and reaches values from 20 microT to 55 microT over the entire time interval. We also compare the obtained curves with the lava flow data from other regions, as the case of the volcanic database of Hawaii, in order to analyse the differences in the geomagnetic field elements which could be explained by the non-dipolar behaviour of the geomagnetic field.

SESSION 1.8

PALEOMAGNETISM AND DATING

1.8-1 **CONSTRAINING ERUPTIVE HISTORIES BY SEQUENTIAL CORRELATION OF PALAEOMAGNETIC DIRECTIONS**

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The origin of large igneous provinces and their environmental impact remain controversial topics. The eruption rate, if well-constrained, could be crucial in resolving many of the issues involved, and magnetostratigraphy has been used extensively to provide mean rates of extrusion through sequences. A particular challenge is to quantify changes in the eruption rate within individual polarity chrons. The recorded secular variation may provide some information but as the magnitude of secular variation changes over geological timescales, this approach must be used cautiously. Here we present a method for constraining the eruption rate through a lava pile based on the degree of

next-neighbour correlation of palaeomagnetic directions through the sequence. The next-neighbour correlation is described by a single additional parameter which can be evaluated by constructing a suitable co-variance matrix. We calibrate the measure using archaeomagnetic field models and theoretical arguments, and test the robustness of our estimates with synthetic data. Applying the method to palaeomagnetic data from the North Atlantic igneous province and Kerguelen, it is found to be a useful proxy for the rate of eruption of lavas. Significant next-neighbour correlation is revealed even in the absence of grouping of directions, giving a method of detecting changing eruption rates when there are no magnetostratigraphic markers.

1.8-2 NEW PALEO- AND ROCKMAGNETIC RESULTS FROM THE JURASSIC KIRKPATRICK BASALTS, MESA RANGE, NORTHERN VICTORIA LAND, ANTARCTICA: EVIDENCE FOR SHORT BUT INTENSIVE VOLCANISM

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The Jurassic continental flood basalts (Kirkpatrick) and sills (Ferrar) of the Transantarctic Mountains are linked to early break-up of Pangea. Published ages all cluster around 183 Ma suggesting an emplacement interval of less than 1ma. Paleomagnetic studies, in the 80s and 90s of the last century, yield two well defined but significantly different groups of paleopole positions (A and B). Whereas A plots at 57°S and 221°E, B plots at 79°S; 181°E close to the Cretaceous segment of the Apparent Polar Wander Path for Antarctica. The significance of this distribution has been discussed at length (see Lanza and Zanella, 1993), and general agreement has been reached that A is representative for the geomagnetic field during Jurassic times. The interpretation of cluster B is less clear and several lines of thought have been brought forward including complete remagnetization during a Cretaceous thermal event. Here we report new data from the Kirkpatrick basalts, where about 220 oriented paleomagnetic samples were taken, covering about 800 meters in stratigraphy and 23 volcanic flows. Unblocking temperatures do not exceed 580°C, coercivities rarely 60mT. After removal of a steep magnetic overprint with low coercivities and low unblocking temperatures (~150°C), linear segments with steep upward pointing inclinations, trending toward the origin of projection are identified in almost all samples. The resulting mean pole plots at 69°S; 222°E (?95 of 7°, N= 19 site mean directions), very close to cluster B. Reflecting light microscopy shows a magnetic inventory dominated by magnetite with irregularly curved shrinking cracks and broad ilmenite lamellae, the latter being diagnostic for high temperature oxidation of titanomagnetite. Shrinking cracks are well known for low temperature oxidation of ocean floor basalts which still carry the primary directional information. Additional material from coeval volcanic rocks from Antarctica, originally believed to have been remagnetized during a Cretaceous thermal event, show similar characteristics. Based on these results, both clusters A and B are interpreted to reflect primary magnetizations and that the Kirkpatrick basalts might have recorded secular variation. If this is valid we conclude that the >800m of Kirkpatrick basalts have been deposited during a time span of not more than a couple of thousands of years.

1.8-3 PALEOMAGNETIC DATING OF CEBORUCO VOLCANO LAVA FLOWS, MEXICO

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Ceboruco and its neighboring volcanoes (western central Mexico) are considered to be one of the most active volcanic regions in Mexico, with numerous eruptive events during the Holocene. Ceboruco's last activity was 1870 with the emplacement of a voluminous lava flow. A big Plinian eruption took place between about 990 and 1020 AD, and between these two events several lava flows were emplaced whose absolute age is not known, because no suitable charcoal material could be found for C-14 dating. We will present paleomagnetic mean directions from several of these flows and show that sampling of multiple sites per flow is highly recommended to obtain a precise mean direction. The use of a sun compass is important to take into account the small scale variability of the regional geomagnetic field, leading to differences of the magnetic declination between different sites of the same lava flow. Finally we will use the flow mean directions to carry out a paleomagnetic dating.

1.8-4 ARCHEOMAGNETIC DATING OF THE EROPTION OF XITLE VOLCANO (MÉXICO) FROM A REAPPRAISAL OF THE PALEOINTENSITY WITH THE MSP-DSC PROTOCOL

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The Xitle volcano, located south of Mexico City, is a monogenic volcano that has provided seven lava flows in a time interval of a few years. The age of these eruptions, estimated by means of radiocarbon dates on charcoal from beneath the flows, range from 4765+ -90 BC to 520+-200 AD (see Siebe, JVGR, 2000 for a review). This lava field was emplaced over the archaeological city of Cuicuilco. The latest radiocarbon dating by Siebe (2000), sets the age of the eruption to 280 + -35 AD. Because this new age has direct implications on the history of the movements of

ancient populations in the Central Valley of Mexico, we propose in the present study to check this estimate by archaeomagnetic dating. By using the Thellier method the values of paleointensity scatter between 40 and 90 mT in a single flow (Alva, 2005). We propose here to estimate the paleointensity by means of the MSP-DSC protocol (Fabian and Leonhardt, 2010) with the new ultra-fast heating furnace FURemAG developed in Montpellier (France). The sampling was performed along four profiles, one vertical through the entire thickness of the flow and three horizontal (at the top, middle and the bottom of the flow). Our preliminary results show that there is no difference between the values found in the different profiles, all providing a value around 62 mT. The comparison of our results (Dec = 358.4°, Inc = 32.8°, F=62.8±1.1 mT) with the model CALS3K.4 for secular variation provided an Archaeomagnetic age between 176 BC and 58 BC at 95% significance value. This age is consistent with the hypothesis of archaeological destruction and the abandonment of Cuicuilco during the eruption of the Xitle volcano. A review of the paleointensity value is in progress because it still is overvalued for this period of time.

1.8-5 PALEOSECULAR VARIATION, ROCK MAGNETIC PROPERTIES AND MAGNETOSTRATIGRAPHY OF THE SAN BORJA AND JARAGUAY MONOGENETIC VOLCANISM, BAJA CALIFORNIA NORTE, MÉXICO.

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We report results of 230 cores from 27 sites, taken from magnesium andesitic lava flows, all with radiometric ages previously determined. These rocks belong to San Borja and Jaraguay volcanic fields, Baja California Norte, which include monogenetic, composite and ignimbrite volcanism distributed between 30° and 28° north latitude, as a result of the stages of tectono-magmatic activity of the last 23 Ma.

Results of rock magnetic experiments such as susceptibility vs. low and high temperature, hysteresis, FORC, and directional analysis, suggest in most of the cases 80% contribution of TM0 to TM20. This represents a unique mineralogical phase (reversibility) with slight changes, SD + MD non-linear magnetic domain with small contributions of SP, and a single component of magnetization. The temporal distribution of all sites was divided in two main periods: 2.6 – 6.3 Ma (18 sites) and 8.12 – 14.64 Ma (9 sites). We determine the paleosecular variation of the first group and compare with the GPTS to observe the degree of correlation. The mean direction of the first group (Dec = 357.5°; Inc = 39.5°; Kappa = 11; A95 = 11.2°) overlaps the geocentric axial dipole (GAD) in normal polarity, while reverse polarity is consistent with a GAD plus a 5% of quadrupole component. The virtual geomagnetic pole scatter of this first group (13.9°, with lower and upper 95% confidence limits of 11.4° and 17.8°) is relatively consistent with both, the expected value from Model G and model TK04.

1.8-6 PRELIMINARY PALEOMAGNETIC RESULTS FROM CENOZOIC BASALT IN SINAI PENINSULA, EGYPT.

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Different phases of igneous activity took place in Egypt during the Mesozoic and the Cenozoic but very few paleomagnetic results have ever been published from these rocks for the period 0–200 Ma. In order to fidelity of Egyptian paleomagnetic data base, Palaeomagnetic samples from 9 sites of basalts at Wadi Nukhul, Wadi Matulla and Wadi Tayiba in west Central Sinai peninsula were collected and subjected to rock magnetic and palaeomagnetic investigations. The rock magnetic properties such as K-T point to Magnetite and Titano-Magnetite, as the main carrier of the remanent magnetization. Primary characteristic remanent directions were identified by alternating field treatment of 93 samples. Three sites from Wadi Nukhul basalt (24.8 ± 1.6 Ma) give a mean direction of D= 168.1°, I= -62.6°, K= 78, $\alpha_{95}=6.4^\circ$, which transfers to virtual geomagnetic pole positions at 71.7° N, 20° E. The mean direction for Wadi Matulla basalt (23.7±1.4 Ma) is D=175.5°, I=-67.9°, K=64, $\alpha_{95}=6^\circ$, with virtual geomagnetic pole positions at 67.9° N, 25.5° E. The direction of the Wadi Tayiba basalt (22.8 ± 1.4 Ma) yields a mean direction of D=184.9°, I=-66.9°, K=31, $\alpha_{95}=4.7^\circ$ and virtual geomagnetic pole positions at 69.1° N, 42° E. Sinai's VGPs are significantly different from the 25 Ma Master Pole. Therefore, Sinai sub plate was not part of the African plate during Oligo-Miocene period.

Key words: Paleomagnetism, Oligo–Miocene, Jurassic, basalt, Sinai, Egypt.

1.8-13p MAGNETOSTRATIGRAPHY AND CYCLOSTRATIGRAPHY OF THE PERMO-CARBONIFEROUS ITARARÉ GROUP, IN THE SANTA CATARINA STATE, SOUTHERN BRAZIL: AGE CONSTRAINTS AND TECTONICS

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The Upper Carboniferous- Lower Permian glaciogenic deposits of the Itararé Group (Paraná Basin) cover an extensive area in southern Brazil, although the outcrops are confined into a narrow band towards the eastern margin. In Santa Catarina State the Group is subdivided into the Rio do Sul, Mafra and Campo do Tenente formations, from younger to older. The first two show varve-like rhythmites forming several meters thick packages counting some hundreds of couplets. The rhythmites show a regular repetition of couplets of light coloured, dm-scale sandstone/siltstone layers and thinner, mm-scale dark lamina of siltstone/claystone. Paleomagnetism on continuous sequences of rhythmic layers identified only characteristic remanent magnetization (ChRM) of reversed polarity for both Mafra and Rio do Sul formations, placing them within the Permo-Carboniferous Reversed Superchron (PCRS; ~318-264Ma). However, the subjacent Campo do Tenente Formation showed normal polarity which may be related to the base of the PCRS or to a short normal polarity zone that occur within the PCRS.

Above the Itararé Group, the coal-bearing Rio Bonito Formation cropping out in Rio Grande do Sul State (latitude difference of nearly 4° from the studied outcrops) gave absolute ages of ~281 Ma, and an age of around 311Ma was inferred for the base of the Itararé Group based on the integrated absolute dating and palynological data. If these ages are also applicable to the outcrops in the Santa Catarina State, then they represent very good constraints for the ages of the rhythmites.

Spectral analysis of the ChRM parameters, bulk susceptibility (Kz), and thickness variation along the rhythmite sections allowed the recognition of Milankovitch periodicities imprinted in the investigated sections. The astronomical calibration provided sedimentation rate estimates. Such evaluations, along with the magnetostratigraphic control allow a refinement in the positioning of the two formations of the Itararé Group in the Geological Time Scale, as well as inferences for the whole sedimentation. This is a contribution from NAP/GeoSEdex/USP

1.8-14p PRELIMINARY MAGNETOSTRATIGRAPHIC RESULTS FROM A LOWER MIDDLE MIOCENE SEDIMENTARY SEQUENCE IN CENTRAL JAPAN: A SHORT NORMAL-POLARITY REVERSAL EXCURSION IN CHRON C5BR?

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A lower Middle Miocene (ca 15.8–15.7 Ma) sequence of diatomaceous siltstone in the Mizunami sedimentary basin in central Japan is dominantly reversely magnetized, but it has a normally magnetized section in its upper part. Paleomagnetic samples were collected from more than 40 stratigraphic horizons on the ca 90 m sequence of the Oidawara Formation, and remanent magnetization was measured with a pass-through cryogenic magnetometer, with careful stepwise thermal or a.f. demagnetization on all the samples measured. Four horizons approx. 25–30 m below the top of the sequence have characteristic remanent magnetization of normal polarity. No difference is found in lithology between the sediments of the four horizons and the sediments of the other reversely magnetized horizons. Depositional age and high sedimentation rate have been documented from a high-resolution diatom biostratigraphic study. This preliminary magnetostratigraphic investigation suggests that there was a short normal-polarity reversal excursion at ca 15.7 Ma in Chron C5Br.

1.8-15p TAKING THE PULSE OF THE PARANA - ETENDEKÁ LARGE IGNEOUS PROVINCE

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It is becoming increasingly accepted that large igneous provinces were erupted by means of a series of high frequency, high volume flows, which lasted an overall duration of only a few million years. The Parana – Etendeká large igneous province was emplaced during the Early Cretaceous, a time when the Earth's magnetic field was reversing polarity at a relatively rapid rate, on average every 325 kyrs. This high frequency reversal rate during trap emplacement makes the Parana – Etendeká an ideal candidate for testing the short timescale theory using magnetostratigraphic constraints i.e. by constraining individual flow volumes to certain magnetic chrons.

To this end a detailed magnetostratigraphic section through the upper part of the Etendeka lava pile, Namibia, is presented. This section records a series of magnetic reversals that went unrecorded in previous, less detailed, magnetostratigraphic sections through the province stratigraphy. The implication of this is that the duration of the Parana – Etendeká extrusive volcanism may in fact be longer than the million year timescale estimated for this province in previous studies and often accepted as the characteristic timescale for these large scale flood basalt events.

1.8-16p AN ASSESSMENT OF PALAEOMAGNETIC LOCK-IN DELAY IN ORGANIC RICH VARVED LAKE SEDIMENTS USING RADIOCARBON WIGGLE MATCHING

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Varved lake sediments in central and northern Sweden have proved to be excellent recorders of palaeomagnetic

secular variation (PSV). In an effort to extend the regional data set to southern Sweden we discovered an organic rich varved lake sediment sequence in Gyltigesjön, Halland. In contrast to the sites further to the north, however, the Gyltigesjön varves are dominated by detritus (strictly organic material) and the laminated structure reflects seasonal changes in the flux of biogenic components and chemical precipitates. Rock magnetic studies, including FORC diagrams and the TEM analysis of magnetic concentrates, indicate that the stable natural remanent magnetization (NRM) is carried by single-domain magnetite, which is probably magnetosomal. To estimate the lock-in delay associated with these organic gels we obtained alternative time-depth relationships based on radiocarbon dating of bulk sediments, terrestrial macrofossils and wiggle-matching of a floating varve chronology that spans the period between 3000 and 2000 cal BP. This period is characterized by distinct geomagnetic field changes and abrupt increases in atmospheric radiocarbon concentration. Our radiocarbon wiggle-match approach enables us to (i) secure the floating varve chronology to the IntCal09 radiocarbon calibration curve and (ii) quantify the ^{14}C reservoir age for Gyltigesjön during the investigated period to c. 260 years. Statistical comparison between the wiggle-matched ages of the PSV variations and ages based on the FENNOSTACK regional PSV curves indicates a minimum lock-in-delay of approximately 250 years, which equates to a consolidated sediment thickness of approximately 0.4 m. Attempts to recover the uppermost 1-2 m of sediment to empirically measure the lock-in-depth as the sediment becomes consolidated were hindered by the extremely high water content (90%), but we did establish that the NRM intensity has stabilized at a depth of about 0.75 m. Established models of depositional remanent magnetization acquisition that include bioturbation are not applicable to these non-bioturbated sediments, in which magnetosomal magnetite appears to be the dominant ferrimagnetic component.

SESSION 1.9

PALEOMAGNETIC REFERENCE MODELS (GPTS, APWP, ETC)

1.9-1 PRELIMINARY PALEOMAGNETIC STUDY ON LATE PALEOZOIC TO EARLY MESOZOIC ROCKS IN SIBUMASU AND INDOCHINA AND ITS CLUE TO THE EVOLUTION OF EASTERN PALEO-TETHYS

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The reconstructions of the paleo-position of Eastern Asia in Pangea supercontinent are notably inconsistent among most of those models proposed by different authors, and the lack of reliable and quantitative paleomagnetic constraint is the main reason that leads to the uncertainty of Eastern Asia reconstruction models. Paleomagnetic study on the Late Paleozoic to Early Mesozoic sediments in the Sibumasu and Indochina blocks can provide a quantitative constraint on the evolution of Eastern Paleo-Tethys, during which process Asia continent converged from a complex collage of terranes/blocks, volcanic arcs, and suture zones. Only a few paleomagnetic data have been reported from these two blocks, yet of which the reliability remains suspectable. To better resolve this problem, we have collected paleomagnetic samples of 61 sites from 20 sections in Baoshan block in West Yunnan of China, 47 sites from 9 sections in Shan state of Myanmar and 41 sites from 16 sections in Indochina block in West Yunnan. Preliminary rock magnetic results and the demagnetization of represent samples provide a glimpse of that these samples may well keep original paleomagnetic records. Systematic rock magnetism and paleomagnetism experiments are still ongoing and detailed data will be got soon. We hope that these latest paleomagnetic data will provide a clue to accurately determine the paleo-positions of Sibumasu and Indochina blocks in Late Paleozoic to Early Mesozoic and make it clearer how and when the Eastern Paleo-Tethys closed and provide more information for Eastern Asia reconstruction.

1.9-2 PALEOMAGNETIC EVIDENCE FOR PERMIAN INTRA-PANGAEA BLOCK ROTATIONS

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Paleogeographic reconstructions for the Early Permian based on paleomagnetic data show a significant continental overlap between Laurasia and Gondwana. If this overlap is real and not an artefact due to inclination shallowing, contributions of non-dipolar fields or ambiguities in magnetization acquisition age assignments, it can be overcome by positioning the northwestern margin of South America next to the North American East coast (Pangea B configuration). However, this is still a rather controversial issue since it requires a westward translation of Gondwana by about 3000km prior to the opening of the Atlantic in Jurassic times, presumably during a 20Ma time window during the Middle Permian. The main objection against this scenario is the supposed lack of geological evidence for such a large shear zone accommodating thousands of kilometres of plate movement at fairly high rates of 10-15 cm/yr.

Here we present high-quality paleomagnetic data from Permo-Triassic sediments and volcanic rocks from the western Mediterranean (Toulon Basin, Sardinia) documenting the existence of an intra-Pangea belt of tectonic blocks straddling from the Massif Central to southern France and Corsica-Sardinia and characterized by complex clockwise

and counterclockwise block rotations of up to $\sim 34^\circ$ that we constrained to be of pre-Jurassic age. New paleomagnetic results from sedimentary and volcanic rocks from the Pyrenees and the Catalan Ranges will further constrain the deformation pattern within the region and potentially provide the long missing geological evidence for an intra-Pangea transform fault during the Permian.

1.9-3 NEW PALEOMAGNETIC RESULT OF THE MIDDLE-LATE JURASSIC ROCKS FROM NORTHERN QIANGTANG BLOCK, WEST CHINA

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A paleomagnetic study was carried out on the Middle to Late Jurassic sediments of the northern Qiangtang block in Qinghai-Tibet Plateau, west China. 11 sites (118 samples) of limestone and 10 sites (99 samples) of sandstone oriented drill-core samples from YanShiPing section (33.6°N , 92.1°E) were collected. Detailed stepwise thermal demagnetization allows us to isolate two components, the low-temperature component (LTC) isolated from most of samples fail the fold test and has been identified as a viscous remanent magnetization. The high-temperature component (HTC) could be divided into two groups: (1) HTC of the limestones from SuoWa formation (J3s) and BuQv formation (J2b) is carried by magnetite, all with normal polarity, and pass the fold test at 99% confidence level. (2) While HTC of the sandstones from XueShan formation (J2x) and QueMoCuo formation (J2q) is carried by a combination of magnetite and/or hematite, displays dual polarities, pass the reversal test at 95% confidence level and fold test at 99% confidence level. Positive fold and reversal tests indicate that both the two HTC groups could be primary magnetization acquired in the Middle-Late Jurassic period. The overall mean direction of the first group (in limestones) is $D_s=355.7^\circ$, $I_s=42.1^\circ$, $k=58.2$, $\alpha_{95}=6^\circ$ after tilt-correction. The overall mean direction of the second group (in sandstones) is $D_s=3.3^\circ$, $I_s=28.9^\circ$, $k=30.7$, $\alpha_{95}=8.9^\circ$ after tilt-correction. By comparison with the mean dip angle of the first group from limestones, the contemporary mean dip angle of the second group from sandstones is about 13° shallower, this anomalously shallow inclinations could be explained by inclination flattening during compaction. The paleomagnetic north pole calculated from 11 limestone sites is: $80.0\text{N}, 295.2\text{E}$ with $dp/dm=7.4/4.5$. Previous paleomagnetic results indicate that the north Qiangtang region wandering at mid-low southern latitude regions in the late Carboniferous to late Permian periods, and displaced northward in the late Permian to early Triassic periods. The rapid velocity of the northward displacement was taken place in the early Mesozoic period (about 4100km). The north Qiangtang region arrived at 24.3°N in the middle to late Jurassic, and up to 900km of latitudinal motion from current location was taken place subsequently.

1.9-4 PALEOMAGNETISM OF LATE CRETACEOUS ROCKS FROM THE WESTERN EDGE OF THE LHASA BLOCK AND FURTHER INSIGHT INTO THE INDIA-ASIA COLLISION

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“When and where did India and Asia collide?” is an old question but still remains unresolved. Paleomagnetism plays an important role on the determination of paleolatitudes of the blocks at both sides of the Indo-Yarlung Tsampo Suture zone, and thus can provide important constraints on the timing and position for initial contact of the India-Asia collision. Based on an updated dataset from a new round of paleomagnetic studies, several important models argue for an initial collision time of ~ 65 -60 Ma at $\sim 10^\circ \text{N}$ or ~ 50 Ma at relatively higher latitude of ~ 20 - 24°N . However, paleomagnetic constraints are still weak especially in the western sector of the suture zone and it is obviously unfavored for further understanding of the timing and paleoposition of the India-Asia collision. In this study, two late Cretaceous paleomagnetic poles are reported from the Yare and Shiquanhe basins in the western Lhasa Block. Three new $^{40}\text{Ar}/^{39}\text{Ar}$ ages of 90.28 ± 2.45 Ma, 91.85 ± 2.24 Ma and 75.57 ± 1.67 Ma determined from fresh matrix of lava flows suggest a Late Cretaceous age of the investigated units. The AMS observations suggest the sampled rocks suffered from no or very weak latter deformation. The ChRM component isolated from 10 individual lava flows and 2 intercalated sandstones in 15 sites from the Yare Basin passes a fold test suggesting a pre-folding origin and yields a paleomagnetic pole at 68.4°N , 299.8°E with $A_{95}=2.9^\circ$; whilst the ChRM directions isolated from the Shiquanhe basin have both positive reversal and conglomerate test results indicative also of a primary origin and 10 valid sites yield a paleomagnetic pole at 65.5°N , 211.1°E with $A_{95}=11.2^\circ$. The two paleopoles from Yare and Shiquanhe yield compatible paleolatitudes of $12.7^\circ \text{N} \pm 2.9^\circ$ and $14.1^\circ \text{N} \pm 11.2^\circ$ respectively at reference site of 31.5°N , 80°E during ~ 90 -75 Ma. A comprehensive analysis of the paleomagnetic data obtained from the western and middle parts of the Lhasa Block indicates the southern margin of Asia was located at ~ 10 to 15°N prior to the India-Asia collision, which is compatible with that estimated from the Linzhou Basin in the eastern Lhasa Block. Reconstruction of southern margin of Asia and Greater India prior to the collision supports the initial collision model of ~ 60 Ma at ~ 10 to 15°N .

SESSION 1.10**PALEOMAGNETISM AND MAGNETIC FABRICS APPLIED TO TECTONIC PROCESSES****1.10-1 TECTONIC SIGNIFICANCE OF THE ANISOTROPY OF MAGNETIC SUSCEPTIBILITY****Cañón-Tapia, E.; Mendoza-Borunda, R.; Suárez-Vidal, F.; Ortega**

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The western part of Mexico records the occurrence of two major tectonic events during the last 150-200 m.y.: (1) the convergent tectonism of the middle Mesozoic-early Cenozoic related with the subduction of the Farallon plate under the western margin of North America, and (2) the inception and evolution of the San Andreas transform system, starting to take place when the Pacific and North America plates first made contact ca. 28 Ma, and subsequently giving rise, between 6 and 4 Ma, to what we currently know as the San Andreas-Gulf of California fault system. Along the present day of the Gulf of California region, the type of volcanism during the stage of rifting (i.e., in the last ~14-12 my) has been of bimodal character (rhyolitic-basaltic), and has been dominated by a huge volume of pyroclastic flows. Due to the age spectrum covered by those units, and to their wide spatial distribution not only in northeastern Baja California, but extending to include some of the islands in the Gulf of California and the state of Sonora, some of those units have been used as a structural markers in regional tectonic reconstructions. Nevertheless, and despite the progress made in the last two decades in terms of the characterization of those rocks, there still remain some issues that need to be addressed in relation with the validity of the use of those units as true regional stratigraphic markers. Among the several aspects that need to be revised, it is possible to mention: (1) the discrimination of each of the pyroclastic flows, and the determination of their real distribution in the Gulf Extensional Province (GEP), (2) the vent location of all the rhyolitic volcanism (effusive and explosive), focusing on those key ignimbrites that are extensively distributed across the GEP, and (3) the need to evaluate whether the widespread ignimbrites were erupted from a single vent as a form of a mega-eruption or as the result of activity taking place from multiple vents. In this paper, we report the first results of a study of the anisotropy of magnetic susceptibility (AMS) of a bimodal volcanic succession of late Mioce age, found along one of the largest volcanic provinces in northeastern Baja California (The Sierra Juárez-Las Pintas Volcanic Province). These rocks have been poorly studied until now despite their wide-distribution (over more than 1000 km²) and large volume estimates (100-150 km³). Consequently, use of their AMS signature to infer flow direction should provide relevant information concerning the tectonic evolution of the northern part of the GEP.

1.10-2 NON PARALLEL STRAIN RECORD AT AMS MAGNETIC FABRICS DUE TO OVERLA**Pueyo-Anchuela, Óscar; Pocoví, Juan Andrés; Gil Imaz, Andrés**

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The Pyrenees (collision belt between Iberia and European plates) represent a relative non complex fold and thrust belt where detailed analysis about strain evolution can be developed and where comparison of different approaches can be performed below a constrained geological, tectonic and diagenetic setting. The analysis of magnetic fabrics, especially Anisotropy of Magnetic Susceptibility (AMS) in sedimentary rocks at low strained conditions, exhibits a high sensibility related to the record of a lonely horizontal tectonic shortening process. This sensibility is identified both at the definition of the confidence zones of AMS axes and the anisotropy of the particular ellipsoid at sample scale and depending upon local tectonic structures. However, at the orogen scale, the AMS pattern exhibits punctuated progressions producing, on contrary to the expected strain increase at outcrop scale, a non parallel or even an inverse trend respect the identified strain increase. Lithology, deposit age and the magnetic mineralogical assemblages are analyzed in order to identify their imprint in the AMS magnetic fabrics. However, besides the previously described factors, the competence of different magnetic fabrics and subfabrics related to different tectonic processes are revealed as the main factor modifying the non parallel AMS correlation respect strain. The competence between bedding related fabrics, horizontal shortening related to LPS processes, folding mechanisms and cleavage development produce that, depending upon the local structure, the different strain processes affect to sampling points at coaxial or non coaxial manners. This apparent change of strain orientation affecting to the studied sites, produces composite magnetic fabrics biasing the expected progressive strain accumulative record at the AMS. These composite magnetic fabrics are identified by the isolation of different subfabrics at the same sites, the development of intersection lineation magnetic fabrics and subtle data girdles affecting the confidence zones of the AMS at the stereographic projection.

1.10-3 SEPARATION OF FIELD-INDEPENDENT AND FIELD-DEPENDENT SUSCEPTIBILITY TENSORS USING A SEQUENCE OF FULLY AUTOMATED AMS MEASUREMENTS**Chadima, Martin; Hrouda, Frantisek; Studynka, Jan; Suza, Petr**Institute of Geology, AV CR, v.v.i., Charles University; Agico, Inc;
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Low-field magnetic susceptibility of diamagnetic and paramagnetic minerals as well as that of pure magnetite and all single-domain ferromagnetic (s.l.) minerals is field-independent. In contrast, magnetic susceptibility of multi-domain pyrrhotite, hematite and titanomagnetite may significantly depend on the field intensity. Hence, the AMS data acquired in various fields have a great potential to separate the magnetic fabric carried by the latter group of minerals from the whole-rock fabric. The determination of the field variation of AMS consist of separate measurements of each sample in several fields within the Rayleigh Law range and subsequent processing in which the field-independent and field-dependent susceptibility tensors are calculated. The disadvantage of this technique is that each sample must be measured several times in various positions, which is relatively laborious and time consuming.

Recently, a new 3D rotator was developed for the MFK1 Kappabridges which rotates the sample simultaneously about two axes with different velocities. The measurement is fully automated in such a way that, once the sample is mounted into the rotator, it requires no additional positioning to measure the full AMS tensor. The important advantage of the 3D rotator is that it enables to measure AMS in a sequence of pre-set field intensities without any operator manipulation. Whole procedure is computer-controlled and, once a sequence of measurements is finished, the acquired data are immediately processed and visualized. Examples of natural rocks demonstrating various types of field dependence of AMS are given.

1.10-4 APPARENT UNDISTURBED POSITION OF PLUTONS OF THE SOUTHERN PENINSULAR RANGES BATHOLITH, BAJA CALIFORNIA, MEXICO (28.3-28.8 °N) FROM PALEOMAGNETIC AND STRUCTURAL DATA**Torres-Carrillo, Xóchitl; Delgado-Argote, Luis A.; Böhnell, Harald; Molina-Garza, Roberto; Weber, Bodo; Peña-Alonso, Tomás**

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We report structural and paleomagnetic data for five mid-Cretaceous plutons along the southwestern margin of the Peninsular Ranges batholith (PRb). With the exception of the Punta Prieta pluton area in the Pacific coast, where Aptian Alisitos Fm. is well identified, the plutons of the studied region intruded arc related Jurassic-Early Cretaceous volcanic and clastic rocks. The intrusive bodies of this study are included in a 4,000 km² area divided in three zones based on the relative concentration of Fe-Ti oxides (SEM analyses) of 14 plutons and aeromagnetic interpretations as well. The Western Zone (WZ) is comprised of magnetite (Mag) and titanomagnetite (Tmt) with exsolved ilmenite (Ilm) bearing gabbroic to tonalitic plutons (magnetic intensities vary between 1,400 and -1,400 nT); the Central Zone (CZ) is comprised of Mag and titanite (Ttn) rich quartz dioritic to granodioritic plutons and is characterized by a N55°W trending negative magnetic contours paralleling the tectonic grain; and the Eastern Zone is characterized by Ilm-rich tonalitic plutons. In the limits of the CZ and EZ, the rutile bearing Compostela pluton was emplaced in the border between a Jurassic arc-back arc crust in the west, and a mostly Paleozoic continental-like crust in the east. The Jurassic sequence typically shows a steep eastward monocline geometry that favored the emplacement of the Early Cretaceous Alisitos related plutons. Magmatic foliations almost parallel the mode of deformation of the enclosing rocks, and kinematic analyses in the intrusive and enclosing rocks also indicates simultaneous dextral transpression and simultaneous magma emplacement during the Cretaceous.

The three plutons from the WZ, and two from the CZ, are included in a 50 km wide zone perpendicular to the structural grain, which can be compared with the well known section between San Telmo and San Pedro Mártir plutons located northward (30° N transect). The paleopoles of the five plutons yielded a mean value of 345/47 (a95= 12.7) that is concordant with the North America reference pole, and overlaps the confidence interval (CI) of the plutons of the western sector of the 30°N transect after closure of the Gulf of California. The plutons of the CZ (Rinconada and Compostela) can be compared with the clockwise rotated El Potrero and San José plutons (30°N) because they lie in a zone deformed by compression; however, no rotation is evident in the plutons of the southern PRb region.

We interpret that Early Cretaceous plutons of the southern part of the PRb were emplaced into Late Jurassic, mostly volcanic arc remnant units, and psammitic rocks deposited in transform spreading centers deformed sometime before 132 Ma, which is the approximate age of the almost undeformed psammites cropping out near the WZ-CZ border.

1.10-5 PALAEOMAGNETISM OF THE MIOCENE JANTETELCO GRANODIORITES AND TEPEXCO VOLCANIC GROUP AND INFERENCES FOR CRUSTAL BLOCK ROTATIONS IN CENTRAL MEXICO: A REEVALUATION

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A study by Urrutia-Fucugauchi (Tectonophysics, 76, 149-168, 1981) of Miocene rocks in a total of 9 sites located ~100 km south of Mexico City revealed discordant paleomagnetic directions. These were interpreted in terms of a ~50° counterclockwise rotation about a vertical axis of the sampling area, possibly related to a regional lateral shear zone. We have re-examined the rocks from this area and report results from 32 sites, covering mainly the same formations and time span as the previous work. The overall mean direction determined is indistinguishable from the Miocene reference direction for the North America plate, suggesting that no tectonic movement of the sampling area has occurred at all since that time.

1.10-6 PALEOMAGNETISM AND AMS OF THE EASTERN CORDILLERA (COLOMBIA)

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We report on the paleomagnetic and anisotropy of magnetic susceptibility (AMS) investigation of 58 sites from Cretaceous to Miocene marine and continental strata gathered in the Eastern Cordillera (EC) and the Cucuta zone, at the junction between the Santander Massif and the Merida Andes of Colombia. The EC, widely investigated in the past for hydrocarbon exploration, is a NNE-trending double vergent intra-continental thick-skinned range inverting a Triassic-early Cretaceous rift zone. Twenty-three sites reveal no rotation (on average) of the EC range with respect to stable South America. Our data show that the EC inverted a NNE-oriented rift zone, and that the locations of the Mesozoic rift and the mountain chain roughly correspond. Surprisingly, magnetic lineations from AMS analysis do not trend parallel to the chain, but are oblique to the main orogenic trend. By also considering GPS evidence of a ~1 cm/yr ENE displacement of central-western Colombia accommodated by the EC, we suggest that this belt arises from ENE oblique convergence reactivating a NNE rift zone. Oblique shortening was likely partitioned in pure dip-slip shear characterizing thick-skinned frontal thrust sheets (well-known along both chain fronts), and by range-parallel right-lateral strike-slip fault(s), which have not been identified yet and likely occur in the axial part of the. Finally, the 35°±9° clockwise rotation observed in four post-Miocene magnetically overprinted sites from the Cucuta zone reflects late Cenozoic and ongoing right-lateral strike-slip displacement occurring along buried faults parallel to the Boconó fault system, possibly connected with the right-lateral faults inferred along the EC.

1.10-7 ROCK MAGNETIC CYCLOSTRATIGRAPHY: EXAMPLES THROUGH GEOLOGIC TIME

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Rock magnetic cyclostratigraphy is a new application of rock magnetism in which rock magnetic parameters can be used to identify orbitally-forced global climate cycles in sedimentary rock sequences. The technique does not rely on facies interpretations of lithologic variations in sedimentary sequences to observe global climate cycles, and like all rock magnetic measurements, is non-destructive and fairly fast and inexpensive. The identification of rock magnetically encoded Milankovitch cycles in sedimentary rocks allows assignment of high-resolution time to sedimentary sections for geologic and tectonic studies. Our work has been able to push the successful application of the technique back in geologic time to the Neoproterozoic with nominally <20 kyr resolution at nearly 600 Ma. Examples of studies in which the rock magnetic parameters record orbitally-forced global cycles from rocks Plio-Pleistocene to Neoproterozoic in age will be given. These studies include: Plio-Pleistocene marine marls from the Stirone River section in the Po valley of northern Italy in which susceptibility variations record obliquity and precession, Eocene marine marls from the Spanish Pyrenees in which ARM captures precession and eccentricity variations, Triassic carbonates from Latemar-equivalent rocks in the Italian Dolomites where susceptibility variations see long and short eccentricity, and Ediacaran carbonates from the Johnnie Formation in Death Valley, CA in which ARM, susceptibility, and IRM capture what appears to be eccentricity and precession. New work on the Mississippian Mauch Chunk fluvial red beds and the Neoproterozoic Kingston Peak Formation glacial diamictites showing that IRM variations can possibly record eccentricity and precession will also be presented.

- 1.10-8 KINEMATIC CONSTRAINTS ON THE DEXTRAL STRIKE-SLIP EL TIGRE FAULT, ARGENTINE PRECORDILLERA, ON THE BASIS OF PALEOMAGNETIC AND MAGNETIC FABRIC STUDIES**
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The El Tigre Fault, in the Western Precordillera of Argentina, is a 120 km long dextral strike-slip fault of Quaternary age. It is very well exposed and it is characterized by geomorphic markers of horizontal displacement as well as a conspicuous fault scarp in its central section that indicates a component of vertical movement. Several controversies with respect to the geometry and kinematics of the fault have not yet been solved. We present the results of a combined paleomagnetic and magnetic fabric study on Miocene to Quaternary sediments exposed very close to the fault trace. The paleomagnetic study was performed on 442 samples collected at 31 sites on Middle Miocene-Early Pliocene, Middle Pleistocene and Late Pleistocene sediments. The results show variable values of rotations around vertical axes, both clockwise and counterclockwise, that suggest that this section of the fault is segmented into several blocks. They can be modelled as forming a domino general pattern of rotations with strong drag both along the main as well as secondary faults. Magnitudes of rotation are related to the age of the studied sediments, reaching largest values in some sites of Miocene strata. The magnetic fabric study was carried out by means of anisotropy of magnetic susceptibility (AMS) on 19 sites. Most sites showed magnetic fabric with tectonic overprint, despite the fact that they were generally collected from subhorizontal strata of poorly consolidated sediments with no macroscopic evidence of internal deformation. A change in the main regional shortening direction from WSW-ENE to W-E between the Middle and Late Pleistocene is suggested by the AMS data.

- 1.10-9 STRESS ANALYSIS AND TECTONIC TRENDS OF THE CENTRAL EASTERN DESERT OF EGYPT, USING ANISOTROPY OF MAGNETIC SUSCEPTIBILITY CONSTRAINS AND POTENTIAL FIELD DATA ANALYSIS.**
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The aim of the present work is to evaluate the stress direction and the tectonic trends of the study area using magnetic anisotropy and potential field data interpretations (Bouguer and aeromagnetic). The specific objective of the gravity and aeromagnetic interpretation is to establish the trend and depth of the structural configuration of the basement rocks. Horizontal gradient techniques could delineate directions of deep sources and enabled tracing several faults, lineaments and tectonic boundaries of basement rocks. The trend analysis shows NNW-SSE, N-S and NE-SW. However, Euler Deconvolution technique was applied using the aeromagnetic data to provide reliable information about penetrated source depth (100 m and 10.0 km) and trends of the subsurface sources (principally in NW and NE directions). Moreover, representative 236 oriented rock samples have been collected from 42 sites in the study area. The rock magnetic properties and magnetic anisotropy analysis have been determined for all the studied samples. The interpretation clearly defined magnetic lineation at all sites and anisotropy of magnetic susceptibility (AMS) parameters. The stress direction of the studied area has been evaluated using magnetic anisotropy and geophysical analysis. Generally the estimated geophysical data analysis (Bouguer and aeromagnetic) are well consistent with the AMS interpretations of this study. The results indicated that the directions of predominant faults and foliations are NNW-SSE (related to the Red Sea rifting) which indicate that the main stress and tectonic trend is ENE-WSW, which is more predominant in Eastern desert of Egypt region. Moreover, it is clear that, the studied area was affected also by less predominant sources trended in E-W and NW-SE directions. Finally, our results are extremely coincided with the previous stress directions derived from geological, seismological and tectonic analysis in northern Red Sea rift and Eastern desert of Egypt.

- 1.10-10 MAGNETOSTRATIGRAPHY OF AN UPPER CRETACEOUS SUCCESSION OF JAMES R**
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A magnetostratigraphic study was carried out in three sections of the Upper Cretaceous sedimentary succession exposed in James Ross and Snow Hill islands, Antarctic Peninsula. These sections are a) HN (200m, Lower Campanian), located to the North of Hamilton Point (64°19' S; 57°23' W). It comprises the informal members I and II of the Rabot Formation; b) Re (324m), exposed at Redonda Point (64°22' S; 57°26' W) and partly stratigraphically equivalent to HN and c) SC (250m, Upper Campanian), located in a nunatak in Snow Hill Island (64° 26' 29.6" S, 57° 12' 9.6" W), which corresponds to the Sanctuary Cliffs Member of the Snow Hill Island Formation and is stratigraphically younger than the other two. Anisotropy of magnetic susceptibility studies were carried out in all collected samples. The magnetic fabric parameters obtained from these rocks indicate a likely depositional origin (characterized by low anisotropy degrees, oblate ellipsoids and vertical K3 axes. From the information obtained from hysteresis loops and Lowrie-Fuller tests, Ti-poor PSD magnetite is interpreted as the characteristic remanence carrier.

After combined AF+thermal demagnetization a characteristic remanence was isolated in most samples which allowed us to build preliminary local magnetostratigraphic columns that will contribute to a better chronostratigraphy of the succession. Comparison with the GPTS suggests that chronos C33R, C33N, C32R? and C32N are represented in the studied sequences and allows further chronological constraints on the biostratigraphy of the study units. Mean paleomagnetic directions obtained from these Cretaceous units in the James Ross Basin suggest lack of meaningful tectonic rotations in the area since 80 Ma ago.

1.10-11 ANISOTROPY OF MAGNETIC SUSCEPTIBILITY OF THE XIAGANCHAIGOU FORMATION AND XIAYOUSHASHAN FORMATION SEDIMENTS FROM THE Q Aidam BASIN, NORTHWEST CHINA: A CLUE FOR THE SEDIMENTARY CENTER MIGRATION

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Anisotropy of magnetic susceptibility (AMS) results are reported from 877 samples of Xiaganchaigou Formation and Xiayoushashan Formation sediments at eight locations (Xichagou, Gansen, Eboliang, Heishiqiu, Luluohe, Kushuiquan, Hong Shan and Gahai) within the Qaidam Basin, Northwest China. Rock magnetic measurement indicates that these AMS samples are dominated by magnetite?except some samples from Gahai which are dominated by hematite. 16 lower hemisphere, equal area after bedding correction projections of the AMS data presents four sedimentary magnetic fabric projections, and 12 embryonic deformation magnetic fabric projections. Based on the AMS results, the Qaidam basin experienced an N-S compression no later than the Oligocene, which is much more intense in northern Qaidam basin than that in western Qaidam basin. The late NE compression which dominates the NW-trending folds in the modern Qaidam basin, is mainly recorded by AMS results in western Qaidam basin, indicating that this epoch of tectonic is more intense in western Qaidam basin than that in northern Qaidam basin. The stress strength transition gives a reasonable explanation of the eastwards migration of the deposition center during the Cenozoic. Diagrams of F-L, Pj-T and lower hemisphere, equal area after bedding correction projections of the AMS data all suggest that Kushuiquan is the site which experienced the strongest early N-S compression, and lineation degree and metamorphic degree decreases from Kushuiquan to both east and west sides.

1.10-12 RIGID BLOCK MODEL VERSUS CONTINUOUS DEFORMATION WITHIN CONTINENTS - GPS AND PALEOMAGNETIC DATA FROM KYRGYZSTAN, CENTRAL ASIA

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The exact deformational response of continental crust to stress is still a matter of debate. Mainly two end members are discussed, concerning the geodynamic and tectonic behavior especially at plate boundaries. One approach delineates complex deformation response to global plate tectonics by a finite number of microblocks, which are rigid. All deformation is localized at the boundaries of these blocks. The other concept favors a more continuous deformation, which can occur also inside larger microblocks.

A prominent example of intra plate deformation is the Central Asian Orogenic Belt (CAOB). Since the collision of Baltica with Siberia in the Late Paleozoic, the area has been exposed to almost continuous compressional deformation. A large number of strike slip fault systems formed there throughout the Mesozoic until very recent times. The most prominent example is the Talas-Ferghana Fault (TFF), which is interpreted to be a reactivated Paleozoic fault structure.

Late Paleozoic and Mesozoic paleomagnetic data indicate large counter-clockwise vertical axis rotations, which show large spatial variations, in the South-western segment of the CAOB. These rotational patterns cannot satisfactorily be explained by a simple oroclinal bending model.

Large amounts of shortening caused by the India-Eurasia collision is taken up in the Tianshan Mountains (up to ~20 mm/yr in the Kyrgyz Tianshan). Recent studies have proposed a small number of microblocks within Kyrgyzstan, which show relative rotations.

To constrain the paleotectonic history of this accretionary orogen, we undertook a comparison between GPS and paleomagnetic data of the last ~20 Myrs. The dense velocity field allowed the derivation of a horizontal strain rate tensor field. Furthermore, analysis of the anti-symmetrical part of the deformation tensor provided an estimation of current rotational rates. There is a general agreement between present day rotation rates and rates in the recent geologic past. Results from the vicinity of the TFF indicate, however, a continuous deformational response as much as 20 km around the fault.

We therefore interpret the area as a deformation zone, which can be mainly described by small microblocks,

which rotate, and where the deformation is concentrated on the boundaries. Additionally, faults, which are probably not all preserved, led to more continuous deformation in their vicinity.

1.10-32p REMAGNETIZATIONS APPLIED TO UNRAVEL LARGE-SCALE FOLD KINEMATICS IN THE CAMEROS BASIN (NORTH SPAIN)

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The utility of paleomagnetism in tectonic studies has been demonstrated during the last decades, as it is a useful tool to detect tectonic deformations yielding variations in paleomagnetic directions. Particularly, remagnetizations have been applied in studies for geometric reconstruction of inverted basins (Villalaín *et al.*, 2003, Casas *et al.*, 2009, Soto *et al.*, 2008, Soto *et al.*, 2011).

When remagnetization occurs between the extensional and compressional stages in inverted basins, the restoring of the paleomagnetic vectors can be used as a tool to determine the geometry of the beds at the end of the extensional stage (Villalaín *et al.* (2003). This study was focused in the Early Cretaceous Cameros basin (Iberian Range, NE Spain), where former studies proposed a generalized remagnetization of syn-rift units, and bracketed its age after deposition of the main sequences and before the compressional stage.

The multidisciplinary work by Casas *et al.* (2009) in the same basin (including paleomagnetic analysis of the previously described remagnetization) defines its extensional geometry as a large-scale syncline developed over the major basement fault and roll-over anticlines at the contact between the pre-rift series against the normal fault limiting the basin. According to the inversion model, during the Tertiary compression, the main syncline at the basin centre moved northwards, undergoing a hinge migration process and becoming a monocline. However, the detailed unfolding of this central syncline is still a matter of debate, since both the geometry and mechanisms of unfolding are not clear. In this work, we try to disentangle the kinematics of basin inversion by a detailed paleomagnetic study in the central sector of the Cameros basin. The present work provides new data from 12 sites of the Cameros basin, in order to check the basin and inversion geometry proposed by Casas *et al.* (2009), as well as to verify the reliability of paleomagnetic techniques applied to studies of sedimentary basin development. Sites are located in red beds, grey marls, claystones and marly limestones from the Oncala and Urbion Groups of the Cretaceous basin (units older than those investigated in previous works).

1.10-33p MAGNETIC ANISOTROPY AND PALEOMAGNETIC STUDY OF DIKES EMPLACED IN THE WAIANAEO VOLCANO, OAHU, HAWAII, USA

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The Waianae Volcano is the older of two shield volcanoes that make up the island of Oahu. Previous age determinations suggest that the subaerial portion of the edifice erupted between approximately 3.7 and 2.7 Ma. The eroded Waianae Volcano had a well-developed caldera centered near the back of its two most prominent valleys and two major rift zones: a prominent north-west rift zone, well-defined by a complex of sub-parallel dikes trending approximately N52W, and a more diffuse south rift zone trending between S20W to due South. In order to investigate the volcanic evolution, the plumbing and the triggering mechanisms of the catastrophic mass wasting that had occurred in the volcano, we have undertaken a paleomagnetic and AMS study of 7 dikes from the volcano. We drilled the dikes paying special attention to the chilled margins and recovered a minimum of 8 and up to 23 samples per margin. The width of the dikes ranged between 0.5 to 4 m. In terms of the paleomagnetic results, at least 20 samples per intrusive were step-wise demagnetized by a.f. from 5 to 100 mT. Companion specimens from the same core were demagnetized at 15 temperature steps. In both cases, demagnetization diagrams obtained with each technique showed a stable characteristic direction of remanence (ChRM) determined with no ambiguity. The ChRM was calculated using principal component analysis for the demagnetization diagrams, with a well-fined component trending to the origin. In addition, low-field susceptibility versus temperature (k-T) and SIRM experiments were able to identify magnetite at 575 degrees C and a low-temperature mineral phase at about 250-300 degrees C, which probably reflects the presence of titanomagnetite. The determined directions of the intrusives resulted in normal and reversed polarities, indicating that such dikes were emplaced at different periods of time covering a time gap of 350 kyrs. Magnetic fabric studies of the dikes along a NW-SE section across the present southwestern part of the Waianae volcano have been conducted. The flow direction was studied using the imbrication angle between the dike walls and the magnetic foliation (e.g. Geoffroy *et al.*, 2002). At the dike scale, the magnetic zone axis, which underlines the intersection of the magnetic foliation from the two borders of the dike (i.e. a direction perpendicular to the flow), has yielded a precise orientation in three of the sites studied. The flow direction has been obtained in the seven studied dikes. For the majority of the cases, the maximum axis, K1, appears to be perpendicular to the flow direction, and in some cases, with a permutation with respect to the intermediate axis, K2, or even with respect to the minimum axis, K3. In addition, in one of the sites studied, the minimum axis, K3, is very close to the flow direction. In all cases, the magma

flowed along a direction with a moderate plunge. For six of the dikes, the interpreted flow was from the internal part of the volcano towards the volcano border, and corresponds probably to the inflation phase of the volcano. In two cases (dikes located on the northwestern side of the volcano), the flow is slightly downwards, possibly related to the distal extension due to inflation of the central part of the volcano. The seventh dike is located closer to the center of the volcano and is characterized by a slightly different orientation with respect to the other six dikes. It also revealed a downward flow that could correspond to another magma pulse that resulted from a flow-back during distension due to the collapsing of the Waianae volcano.

1.10-34p CRETACEOUS BY THE PALEOMAGNETIC DATA OF ARMENIA

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Cretaceous by the paleomagnetic data of Armenia

In the Cretaceous sediments of Armenia allocated two complexes of large foraminifera. The first complex characterizes Campanian stage and is presented by two types - *Arnaudiella grossouvrei* Douville and *Pseudosiderolites vidali*. The second complex rich for types and sorts is also characteristic for Maastrichtian. With orbitoides a lot of large foraminifera and primitive nummulitida are also found. The studied period is characterized also by the values Ka/Ar definitions: 88-93m.y. (Turonian - Coniacian), 135-137m.y. (Late Jurassic- Early Cretaceous), 158 m.y. (Oxfordian). The composition of ferromagnetic fraction defined by spectral x-ray structure and thermo magnetic analysis methods. The main carriers of magnetization are magnetite, titanomagnetite, maghemite. In sections of late Jurassic normally and reversely magnetized zones are identified that testifies the alternating mode of Earth magnetic field of this period. In early Cretaceous sediments reverse magnetized zones are identified that are compared with the normally polarity of C34 chron base. The studied late Cretaceous sections are characterized exceptionally by normally polarity that is correlated with CNS (Cretaceous Normal Superchron) Superchron. By Tellie method on volcanogenic rocks of Jurassic and Cretaceous the values of intensity of Earth magnetic field are defined. Obtained the following preliminary data:

Lat Jurassic (NR polarity) - $H/H_0 = 0,99$

Lat Jurassic early Cretaceous (NR polarity) - $H/H_0 = 0,62$

Early Cretaceous (R polarity) - $H/H_0 = 1,04$

Late Cretaceous (NR polarity) - $H/H_0 = 0,96$

1.10-35p MULTIPLE EMPLACEMENT MECHANISMS FOR THE LATE MIOCENE MONTE CAPANNE PLUTON (ELBA ISLAND, NORTHERN TYRRHENIAN SEA, ITALY)

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The Elba Island represents a key area to observe the host-rocks deformation joined to the dynamics of pluton emplacement at shallow crustal levels. The younger M. Capanne intrusion and its well cropping out thermo-metamorphic aureole offer the possibility to understand the interplay of different mechanisms during pluton emplacement and the relationship between the intrusion of this acid plutonic body and post-orogenic extension in the inner sector of the Apenninic chain during the Late Miocene.

Many papers suggest pluton emplacement model getting insights from intrusive rocks (internal fabric analysis, petrographic composition). Otherwise In this paper, an integrated structural and magnetic fabric analysis in the metamorphic aureole was carried out in order to provide constraints about the pluton emplacement. Interpretation of wall rock deformation and igneous fabric together provides a more reliable picture of the multi-stage process of emplacement and assembly history, in which different mechanisms have interacted.

1.10-36p RECONSTRUCTION OF THE EMPLACEMENT CONDITIONS OF LAVA FLOWS AND PYROCLASTIC DEPOSITS BY MEANS OF GEOMETRICAL ANALYSIS OF AMS DATA. DECEPTION ISLAND (ANTARCTIC PENINSULA, SOUTH SHETLAND ISLANDS).

Pueyo-Anchuela, Óscar; Gil, Andrés; Gil, Inmaculada; Galindo, Jesús; Rey, Jorge; Maestro, Adolfo; Soto, Ruth; Oliva, Belén; López, Jerónimo

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The analysis of recent volcanic systems can have handicaps in their analysis when the most recent eruptions hide part of the geological history the geomorphological signals does not have univocal interpretations and when the abrupt topography linked to recent volcanic systems restricts the available places to perform detailed analyses. The study of Anisotropy of Magnetic Susceptibility (AMS) has been used to unravel the emplacement characteristics and flow direction distributions at recent and ancient volcanic systems. The sampling along the available and accessible outcrops around the island has permitted the unraveling of some of the geological processes involved in the evolution of the volcanic island. It has been identified a clear correlation between the anisotropy of the magnetic susceptibility ellipsoid, the pattern of the magnetic susceptibility axes distribution at the site scale, the type of magnetic fabrics and

the imbrication angle between the magnetic foliation and the emplacement surface. All these aspects are independent from the dip of the emplacement surface supporting the presence of a post-emplacement tilting of the studied volcanic deposits. In some of the sites, the shear plane (plane containing the K_{max} and K_{min} magnetic susceptibility axes and the flow direction) is incompatible from a kinematic point of view respect the dip of the emplacement surface, supporting their tilting at post-emplacement moments. The AMS results permit to constrain the recent evolution of the volcanic system through three stages involving a radial distribution of volcanic flows, a coaxial tilting of the analyzed deposits respect the main caldera during their collapse and the tectonic fracturation responsible of the tilting of the previous volcanic radial system and responsible of the nowadays distribution of the volcanic deposits. This study supports the potential application of AMS technique in order to unravel the recent evolution of complex volcanic systems of little accessible regions.

1.10-37p **MAGNETIC FABRICS AND PALEOMAGNETISM OF THE ALKALINE DIKE WARM FR**

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At least three dike swarms with different chemical composition (tholeiitic, lamprophyre and alkaline) crop out in the Ilhabela island. Dikes from these swarms crosscut Proterozoic polymetamorphosed rocks of the Costeiro Complex and alkaline stocks, and they crop out side by side in the beaches and falls. They range from a few centimeters up to 5 m wide, and their trend is predominately N40o-50oE with vertical dips. All swarms are related to the processes of separation between South America and Africa and, consequently, with the opening of Atlantic Ocean. The alkaline swarm is thought to be the youngest in age, and is related to the last stages of the Atlantic Ocean opening.

Magnetic fabrics were determined by applying both anisotropy of low-field magnetic susceptibility (AMS) and anisotropy of anhysteretic remanent magnetization (AARM). Rock magnetism properties indicate that pseudo-single-domain grains of almost pure magnetite carry the magnetic fabrics. Normal AMS fabric acquired during magma flow is dominant in the swarms, and its K_{max} - K_{int} plane is parallel to the dike plane whereas the magnetic foliation pole (K_{min}) is perpendicular to it. The analysis of the K_{max} inclination permitted to infer that the dikes were fed by horizontal ($K_{max} < 30^\circ$), inclined ($30^\circ < K_{max} < 60^\circ$) and vertical ($K_{max} > 60^\circ$) flows suggesting either distinct magmatic chambers or a small displacement of the South American plate during the dike emplacement. The AARM fabric is either coaxial or better defined than AMS fabric. Paleomagnetic studies show that the dikes registered both normal and reverse polarity of geomagnetic field indicating that the dikes were emplaced in two different episodes.

1.10-38p **MAGNETIC ANISOTROPIES OF THE SEDIMENTARY ROCKS (AQUIDAUANA FORMATION), MATO GROSSO DO SUL STATE, BRAZIL: PRELIMINARY RESULTS.**

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The glaciogenic sedimentation (Carboniferous-Permian) in the Mato Grosso do Sul (Paraná Basin) is represented by reddish-brown strata of the Aquidauana Formation. Subsurface data suggest that this Formation is equivalent to the Itararé Group, which contains the most extensive lithological record of Gondwana glaciation in the world. This Formation is composed of a variety of types of sandstones, siltites, and mudstones. The magnetic studies were performed on sites of undeformed reddish-brown sandstones, siltites, and mudstones. Magnetic fabrics were determined on oriented cylindrical specimens (2.54 cm x 2.2 cm) using anisotropy of low-field magnetic susceptibility (AMS). Rock-magnetic analyses reveal that both magnetite and hematite are the main magnetic minerals in the majority of the analyzed sites. Regarding the eigenvector orientations, the sites usually gave good results. The analysis at the individual-site scale defines two AMS fabric types. The first type shows K_{min} perpendicular to the bedding plane, while K_{max} and K_{int} are scattered within the bedding plane itself. This fabric is usually interpreted as primary (sedimentary-compactional), typical of undeformed sediments and is dominant among the sites. The second type shows good clustering of the AMS principal axes with K_{min} still either perpendicular or sub-perpendicular to the bedding plane. This fabric type could be interpreted as a combination of sedimentary-compactional and tectonic contributions if some strain markers or evidence for tectonic deformation had been found in the studied area. On the other hand, the tight K_{max} grouping in this fabric type could be explained by the action of currents since they cause K_{max} to be aligned sub-parallel to the paleocurrent direction.

SESSION 1.11**OPEN SESSION ON PALEOMAGNETISM AND ROCK MAGNETISM****1.11-1 A SUPERCOOLED THERMAL DEMAGNETIZER AND IT APPLICATION****Shaw, John; Hodgeson, Emma**

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Thermal Demagnetizers are used to analyse samples in palaeomagnetic and palaeointensity experiments often using many temperature steps that involve heating, holding at temperature and cooling back to room temperature. Of the 3 stages in the thermal cycle the longest is the cooling time which follows Newton's cooling curve and so the rate of cooling decreases exponentially towards room temperature. Using room temperature forced air cooling can reduce the cooling time but the curve is still exponential and getting down to room temperature can take hours.

We have developed a new Thermal Demagnetizer (MMTDSC, Magnetic Measurements Thermal Demagnetizer Super Cooled) that can heat samples very quickly (500oC in 10 minutes) with a temperature resolution of 0.1oC and uses cryocooled air to quickly cool the samples (500oC to 30oC in 15 minutes). A typical palaeomagnetic thermal cycle takes only 40 to 45 minutes and the repeatability of the temperature control is 0.2oC. The fast cycle greatly reduces experimental time and the high temperature resolution allows very small temperature steps to be used.

Examples of palaeomagnetic experiments using the new MMTDSC will be discussed.

1.11-2 ON THE STATISTICAL CHARACTERISTICS OF INTENSITY OF VDM FOR THE LAST 100 MA**Shcherbakov, Valerii; Sycheva, Natlia**

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Statistical analysis of the intensity of the geomagnetic dipole carried out for the time interval (5-100) Ma confirms the hypothesis of existence of a negative correlation between the mean VDM and reversal frequency f_{but} with the statistical confidence level 60-70% only. An attempt to analyze statistical characteristics of distribution function $g(\text{VDM})$ on intervals of constant polarity in the Cenozoic and Mesozoic was undertaken. To be included in the statistics, at least three Thellier-type determinations with pTRM checks are required for an interval. No correlation was found between the mean VDM and the length of the corresponding interval of constant polarity for the interval 5-30 Ma, where the reversal frequency did not change much. We suggest that if the VDM-f correlation is real, it exists only on a larger time scale when the reversal frequency (geodynamo regime) considerably changes. A positive correlation between the mean and variance of the VDM calculated inside intervals of constant polarity was found with the confidence level 99%. The relevant $g(\text{VDM})$ can be approximated by the gamma or log-normal distribution functions. In contrast, $g(\text{VDM})$ for the Brunhes epoch is better described by the normal distribution. It is uncertain whether this difference is an artifact originated from systematic errors in empirical data, or it reflects the real geomagnetic field behavior. A similarity of these results to those of predicted by published yet geodynamo numerical modeling is discussed.

1.11-3 NEW INSIGHTS INTO THE MAGNETIC PROPERTIES OF SERPENTINIZED PERIDOTITES**Carlut, Julie; Bonnemains, Diane; Malvoisin, Benjamin; Escartin, Javier**

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In this study we focus on the production of magnetite during serpentinization reactions. The amount of magnetite produced during such reactions depends on reaction progress but also on reaction temperature and other factors as water/rock ratio and silica activity. A method using the magnetic properties was developed to monitor experimental serpentinization and investigate different parameters. The saturation remanent magnetization signal (J_{rs}) was measured during the course of experiments and show contrasted results depending on the experimental parameters in particular the temperature. In addition the magnetic properties of samples from serpentinized massif from contrasted contexts: the Atlantic ridge at 23°N (samples drilled during odp leg 153), the South West Indian ridge at 28°S (samples dredged during the Smooth Seafloor cruise) and the Pindos Ophiolite (outcrops from Northern Greece) were investigated.

1.11-4 A MULTIPROXY STUDY OF LAKE ANONIMA, VEGA ISLAND, ANTARCTICA**Chaparro, Marcos A.E.; Córdoba, Francisco; Lecomte, Karina L.; Gargiulo, José D.; Manograsso Czalbowski, Nadia T.; Lirio, Juan M.; Chaparro, Mauro A.E.**

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The Lake Anonima is a small closed hydrological basin, which is located over moraine deposits in a periglacial ice free area from Vega Island (NE Antarctic Peninsula, 63.8°S; 57.3°W). In this contribution, sedimentary and hydrochemical processes in the lake and surroundings were investigated, focussing on magnetic proxies for

environmental processes, and their relation with the depositional dynamic (geology and geomorphology on modern depositional processes, lake currents, tributaries).

After a detailed bathymetry, lake sediments were collected from a grid of 61 sites, sub-sampled and studied using rock-magnetic (magnetic susceptibility, anhysteretic and isothermal remanent magnetisation), geochemical (TOC, TIC), sedimentological (grain size) and multivariate statistical techniques. In addition, some physicochemical characteristics of snow, river and lake water samples (pH, electrical conductivity, temperature, alkalinity, total dissolved solids and dissolved oxygen) were measured in situ and laboratory. The system shows high hydrological and hydrochemical dynamic behaviour during summer (e.g. changes in size and level). Physicochemical data and field observations indicate dominant evaporation processes over infiltration ones, as well as water input is mostly supplied by snow/ice meltwater rather than by streams. The multiproxy analysis suggests that tributaries around the lake basin contribute to the spatial sediment variations; e.g.: mass-specific magnetic susceptibility values ($63.4\text{-}166.7 \times 10^{-8} \text{ m}^3 \text{ kg}^{-1}$) show the influence of a stream that develops a delta in the SW coast. In particular, magnetic proxies reveal differences between clay-silt, fine and medium sand fractions; as well as between depositional areas as consequence of bottom morphology and the influence of episodic inflow into this lake.

This multi parameter analysis not only contributes to understand the present day sedimentary processes, but also it can help to understand environmental and magnetic changes in the past.

1.11-5 SPATIALLY INHOMOGENEOUS MAGNETIZATION IN CHINESE LOESS; ARTEFACT OR NATURAL?

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Recent in situ and laboratory experiments with material from Chinese loess unit 1 (L1) show that partial re-magnetization is imposed by the ambient seasonal temperature variation (during 17 months), or repeated thermal cycling between 5° to 30°C in the laboratory. Experiments were performed with blocks (~10 dm³) and slabs (~0.4 dm³) of loess that were subsequently cut into standard ~8 cm³ cubes. It was found that ca 50% of the sub-samples from the in situ blocks had not acquired any secondary magnetization and that thermal demagnetization did not resolve the components in the partially re-magnetized samples. However, alternating field (af) demagnetization decomposed the primary (i.e NRM) and secondary imposed magnetic directions in loess that had been thermally cycled under controlled conditions in the laboratory. In order to assess the spatial scale of this inhomogeneous magnetization, cubic samples (~8 cm³) were cut into 12 tiny bits (~6 mm³). Af demagnetization revealed spatially large variations of bits partially and completely re-magnetized. A further experiment was performed by gradually shaving off thin layers of loess from cubic samples, thus reducing the volume. These experiments showed that pristine loess carried a small spurious magnetization component that was removed after a weight reduction of some 30%, succeeded by a single component magnetization. Thermally cycled samples, however, carried a complex magnetization with partly overlapping volume-spectra.

NRM of pristine loess is evidently spatially homogeneously distributed inside samples, and the complex magnetization in thermally cycled loess may thus either be an artefact caused by the removal of loess from its natural surroundings (unloading the overburden) or reflect a process that actually happens under natural conditions too, but that has reached an equilibrium state.

1.11-6 MAGNETIC CHARACTERISTICS OF INDUSTRIAL DUSTS FROM DIFFERENT SOURCES OF POLLUTION

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We will report on measurements and analysis of magnetic parameters of various industrial dusts in order to distinguish dusts coming from different sources of emissions. The tested samples came from 4 branches of industry: power industry, cement, coke, ceramic industries as well as from biomass combustion. The following magnetic parameters were measured: mass-specific magnetic susceptibility (?), coercive force (Hc), coercivity of remanence (Hcr), saturation remanent magnetization (Mrs), saturation induced magnetization (Ms) and Curie temperature (Tc). Moreover, S parameter was determined from the DC remagnetization of saturation remanence. The measured parameters were used to characterize the analyzed dusts in terms of composition, concentration and grain-size distribution of magnetic grains. In fly ashes from the combustion of hard coal, magnetite is the dominant magnetic phase, and in the case of lignite-combustion ashes maghemite and/or hematite has significant contribution. Ceramic dusts and ashes from biomass combustion are characterized by paramagnetic properties. The ashes from the combustion of wood have higher ? values than those from the combustion of straw. Coke dust revealed different values of S parameter from the other groups of industrial dusts, indicating more complex mineral composition of the magnetic phases, probably including also the contribution of iron sulphides. In cement dusts the leading magnetic mineral was magnetite or ferrimagnetic calcium ferrite. Magnetic properties of soil samples collected in the area of coking plant prove that they are determined by the properties of coke dusts accumulated in the organic horizon. The research proved that

industrial dusts from various industrial emissions have slightly different magnetic properties. Diagrams depicting the dependence of saturation remanence versus χ values and S parameter versus M_{rs}/χ are an effective way to distinguish groups of dusts coming from the combustion of hard coal, as well as coke dusts, ceramic dusts and the dusts from the combustion of biomass.

1.11-7 MAGNETIC CHARACTERISTICS OF INDUSTRIAL DUSTS FROM DIFFERENT SOURCES OF POLLUTION

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We will report on measurements and analysis of magnetic parameters of various industrial dusts in order to distinguish dusts coming from different sources of emissions. The tested samples came from 4 branches of industry: power industry, cement, coke, ceramic industries as well as from biomass combustion. The following magnetic parameters were measured: mass-specific magnetic susceptibility (χ), coercive force (H_c), coercivity of remanence (H_{cr}), saturation remanent magnetization (M_{rs}), saturation induced magnetization (M_s) and Curie temperature (T_c). Moreover, S parameter was determined from the DC remagnetization of saturation remanence. The measured parameters were used to characterize the analyzed dusts in terms of composition, concentration and grain-size distribution of magnetic grains. In fly ashes from the combustion of hard coal, magnetite is the dominant magnetic phase, and in the case of lignite-combustion ashes maghemite and/or hematite has significant contribution. Ceramic dusts and ashes from biomass combustion are characterized by paramagnetic properties. The ashes from the combustion of wood have higher χ values than those from the combustion of straw. Coke dust revealed different values of S parameter from the other groups of industrial dusts, indicating more complex mineral composition of the magnetic phases, probably including also the contribution of iron sulphides. In cement dusts the leading magnetic mineral was magnetite or ferrimagnetic calcium ferrite. Magnetic properties of soil samples collected in the area of coking plant prove that they are determined by the properties of coke dusts accumulated in the organic horizon. The research proved that industrial dusts from various industrial emissions have slightly different magnetic properties. Diagrams depicting the dependence of saturation remanence versus χ values and S parameter versus M_{rs}/χ are an effective way to distinguish groups of dusts coming from the combustion of hard coal, as well as coke dusts, ceramic dusts and the dusts from the combustion of biomass.

1.11-8 MAGNETIC BIOMONITORING USING TILLANDSIA RECURVATA L. IN AN URBAN AREA FROM MEXICO

Castañeda-Miranda, Ana Gabriela; Chaparro, Marcos A.E.; Chaparro, Mauro A.E., Böhnel, Harald N.

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Passive natural collectors of contaminants have become important for monitoring urban and industrial pollution; in this contribution, the species *Tillandsia recurvata* L. was studied, specially, using magnetic measurements. This plant is able to absorb water, dusts and nutrients directly from the air; for this reason and because of its availability, the species was selected as a monitor of air pollution in the metropolitan area of Santiago de Querétaro, Mexico. Individuals were collected in sites that are subjected to different pollution degrees and sources.

Elements of interest were detected (including: Fe, O, Si, As, Sb, S, Cr, Mo, V, Zn, Ba, Pt, Cu) by ICP and particle morphologies by SEM-EDS analysis. Magnetic measurements include: hysteresis cycles, magnetic susceptibility (χ), anhysteretic and isothermal remanent magnetization (ARM and IRM) and thermomagnetic studies. In industrial and heavy traffic sites, the highest values of magnetic concentration dependent parameters were observed (e.g.: $\chi \sim 186 \times 10^{-8} \text{ m}^3 \text{ kg}^{-1}$, ARM $\sim 387 \times 10^{-6} \text{ A m}^2 \text{ kg}^{-1}$ and SIRM $\sim 32 \times 10^{-3} \text{ A m}^2 \text{ kg}^{-1}$), in contrast, sites with low vehicular traffic reached low values (e.g.: $\chi \sim 1.1 \times 10^{-8} \text{ m}^3 \text{ kg}^{-1}$, ARM $\sim 11.1 \times 10^{-6} \text{ A m}^2 \text{ kg}^{-1}$ and SIRM $\sim 0.5 \times 10^{-3} \text{ A m}^2 \text{ kg}^{-1}$). Furthermore, the integrated magnetic analysis (King's and Day's plots, remanent parameters and thermomagnetic measurements) revealed the presence of ferromagnetic minerals, magnetite-like with fine grain sizes (0.1-5 microns). In order to analyze the pool of data, descriptive statistics like population indicators (mean, variance, etc) and correlation Pearson index were calculated. The relationship between magnetic and chemical variables was analyzed using fuzzy c-means clustering analysis.

These results demonstrate the usefulness of the species *Tillandsia recurvata* L. as a passive pollution monitor, with an affordable and immediate application.

1.11-9 PALAEOMAGNETIC STUDY OF EL PINACATE VOLCANIC FIELD, SONORA, MEXICO

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The Pinacate Volcanic Field (PVF) was created by two eruptive events. The first one, the Pre-Pinacate, occurred during the middle Miocene, with reported ages between 15 Ma to 11 Ma (Vidal-Solano, 1998) and is formed by

calc-alkaline rocks, dominated by basalts and andesite-basalts. The second event, occurred during the Quaternary, the event Pinacate, with ages between 1.5 Ma to 10 Ka (Lynch, 1980), consisting of a mixture of monogenetic and polygenetic volcanism, centered on a volcanic shield that covers an approximated area of 1500 km². During that eruptive episode, several volcanic structures were formed (at least 400), between cinder and scoria cones, maars and many lava flows. This work reports the analysis of 235 core specimens, belonging to 21 sites. Besides the paleodirectional data, we performed magnetic experiments such as susceptibility vs. low and high temperature, hysteresis loop and FORC analysis. Based on these results we selected samples to perform paleointensity experiments (92 core specimens belonging to 11 sites), which were processed in the paleointensity oven by Thellier-Coe method. The results obtained were at least 25% successful, and the mean palaeointensity is to $28.31 \pm 2.44 \mu\text{T}$.

1.11-10 **MAGNETIC MINERALOGY OF THE K/Pg BOUNDARY WITHIN CHICXULUB IMPACT CRATER: HYDROTHERMAL SIGNATURE?**

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Paleomagnetic analyses of core samples from the Chicxulub impact crater, yielded a rather homogeneous composition, titanomagnetites, within the impact breccias and the limestones that constitute the K/Pg boundary. The homogeneous magnetic mineralogy contrasts with the heterogeneity of the magnetic inclination within the impactites sequence. While we expected a polarity consistent with the magnetochron 29R, all along the sequence, we found both polarities, reverse and normal, within a sequence generally accepted deposited within minutes, probably seconds. Therefore, we conclude that the magnetic fabric and, therefore, the magnetic field recorded within the sequence, is the result of a hydrothermal system emplaced after deposition. It is still not clear when and for how long this system was active.

1.11-11 **MAGNETIC ANOMALIES ON IO AND THEIR RELATIONSHIP TO THE SPATIAL DISTRIBUTION OF VOLCANIC CENTERS**

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The analysis of terrestrial magnetic anomalies has long proved useful for constraining crustal structure and dynamics. For example, satellite determination of the crustal magnetism of our planetary neighbor Mars suggests an early stage of plate tectonics, as evidenced by the presence of magnetic lineations and apparent transform faults. Here, we use Jupiter's moon, Io, to apply this approach to a currently active body. We conduct forward modeling of the putative crustal magnetic anomaly distribution on Io, one of the moons of Jupiter. Io is the most volcanic body in the solar system due to tidal heating from its Laplace resonance with Europa and Ganymede, causing extensive sulfur and silicate volcanism. As non-magnetic sulfur volcanism occurs at cool temperatures, beneath the Curie point, it should not greatly affect the planetary magnetism and consequently is ignored in this paper. However, this extensive volcanism does result in a resurfacing rate that obscures surface features in 1 to 10 million years.

Our first step is the development of a cylindrically symmetric model of the thermal evolution of an isolated volcanic center to obtain the distribution of the thickness of the magnetizable layer. The crustal rocks are presumed to be mafic or ultramafic in composition, based on their spectral signatures, the temperature of the silicate volcanic eruptions, and their rheology inferred from flow structures. Analysis of the 1997 Pillan eruption suggests a composition similar to lunar mare basalt or komatiite. The magnetic and thermal properties of lunar mare basalt have been well studied since the Apollo missions. Unaltered terrestrial ultramafics have been studied sufficiently to constrain their properties.

A global model of the depth to the Curie isotherm based on the spatial distribution of volcanic centers and hotspots on Io can be inferred from our thermal volcanic eruption model to determine the portions of the crust that are likely to be magnetized by the ambient Jovian field, thereby enabling a prediction of the magnetic anomalies that should be observed at flyby or orbiting-satellite altitudes.

1.11-12 **PALEOINTENSITY OF SUBAERIAL OBSIDIANS OF PLEISTOCENE AGE FROM ARMENIA**

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High quality paleointensity data is essential to investigate the variation of the Earth's magnetic field and its consequences. Subaerial rhyolitic volcanic glass, i.e. obsidian, as found in Armenia has been suggested to be an ideal recording material for such information earlier, particularly in geologically young environments. Alteration processes like hydration, however, could be identified recently which falsify the stored paleointensity information

and are difficult to detect. In order to investigate any time dependency in such processes and, ideally, to recover high quality records of the past magnetic field obsidians were sampled in Armenia which cover a long geological history and different geological environments. Here we present paleointensity data from 60 subareial obsidian samples taken from nine volcanic structures of Armenia covering age intervals of 0.5 to 0.65 up to ~6Ma, Thermal and alternating demagnetization experiments reveal the single component character of magnetization of almost all samples with linear directional components trending directly toward the origin of projection. The predominant part of the collection is characterized by magnetization directions of normal polarity with the exception of 1.75 and ~6 myr old obsidians carrying inverse magnetizations. Detailed rock magnetic studies show that the magnetization of the material is controlled by titanomagnetite with varying titanium content. Thermomagnetic experiments reveal the presence of two Curie temperatures at 190 to 270°C and 530° to 570°C, respectively. Almost all samples show reversible thermomagnetic curves underlining the thermal stability of the material. Paleointensities were determined using the standard Thellier algorithm with pTRM checks and standard quality tests were applied. The difference ratio (DRAT, Selkin and Tauxe, 2000) is generally below 3.5% suggesting no or only minor alteration. The resulting virtual axial dipole moments are $4.6 \cdot 10^{22}$ Am² (0.5Ma), $8.6 \cdot 10^{22}$ Am² (0.65Ma), $9.4 \cdot 10^{22}$ Am² (1.5Ma), $6.9 \cdot 10^{22}$ Am² and $7.3 \cdot 10^{22}$ Am² (~6 Ma). The VADMs obtained so far for the obsidians of Pleistocene age agree rather well with published reference data (Channell *et al.* 2009). This underlines the suitability of subareial obsidians for detailed studies of the Earth magnetic field but also shows the potential of identifying the source area of prehistoric obsidian tools.

1.11-13 MINERALOGICAL AND MAGNETIC CHARACTERIZATION OF OLMEC ILMENITE ARTIFACTS: TOOLS TO CREATE SCULPTURES?

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San Lorenzo Tenochtitlán is located at the southeastern part of the Veracruz state, Mexico. From 1800 to 950 BC, it was the major center of the called mother pre-Hispanic Olmec culture in Mesoamerica, that flourishing between 1400 and 950 BC. Olmec people designed and created monumental structures of earthen and rock. San Lorenzo was home of governors dominant whom colossal stone portraits (heads) are actually the most recognized Olmec objects.

One of the most important findings in San Lorenzo was a place of production (workshop) supported by the elite that contained six tons of ilmenite artifacts, which is an imported material to this site; the source of this mineral should be found at the distant Pre-Cambrian Terrane called Oaxaquia, specifically in Huitzo village, Oaxaca. These pieces were found in this factory, as well as filling large subsurface holes.

The aim of this work is to characterize since the mineralogical and rock magnetic point of view the artifacts that seem to have been used as tools to create the Olmec sculptures and with these determine their probable provenience.

We did observations at distinct level of magnification (hand-sample, optical microscopy and scan electron microscopy) and made micro-geochemical analysis, using varied instruments. Rock magnetic analyses were: magnetic susceptibility as a function of low and high temperature, hysteresis parameters, isothermal remanent magnetization acquisition, backfield demagnetization curves and FORC analyses. Correlation between microscope and rock magnetic studies are very good, and comparison with the anorthosite massif samples, supposedly the rock source from Huitzo area, to verify their provenience is in progress.

1.11-14 MINERALOGICAL AND MAGNETIC CHARACTERIZATION OF OLMEC ILMENITE ARTIFACTS: TOOLS TO CREATE SCULPTURES?

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1.11-15 **ARCHAEOMAGNETIC AND THERMOLUMINESCENCE DATING OF HISTORICAL KILNS FROM N. GREECE**

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Archaeomagnetism has continuously developed, especially the last two decades, in Greece. Several archaeomagnetic studies have been performed spanning the last 8 millennia and the variation of the three elements of the geomagnetic field has been recorded resulting in the construction of the Greek Secular Variation Curves. The SVCs exhibit still several gaps in specific archaeological periods but can be considered as an alternative new dating tool for the archaeological sites. In this study we present archaeomagnetic and thermoluminescence datings from a historical archaeological site found in the city of Thessaloniki (N.Greece). The site consists of four kilns and is considered as ceramic workshop. An archaeomagnetic study has been performed in three of the above kilns in order to define the direction of the geomagnetic field during the last firing, accompanied with rock magnetic analysis of the studied material such as IRM curves, and variation of magnetic susceptibility with temperature. The dating of the site has been accomplished using both methods. The calculated ages and their standard deviation indicate the limits of the methods and the necessity of a multidisciplinary approach in order to define more accurately the last use of the fired structures. Finally the different age determinations using both techniques are discussed.

1.11-16 **TURKISH AND CYPRIOT ARCHAEOINTENSITY DATA AND THEIR IMPACT ON ARCHAEOMAGNETIC JERK THEORY**

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Globally distributed archaeointensity data are required to understand geomagnetic behaviour on decadal to millennial timescales, to produce reliable field models, and to test hypotheses of geomagnetic-climate coupling during the Holocene. Here, we will present new high quality data spanning the age range 2400 BC to 700 BC from Turkey and Cyprus. The new intensity results and associated rock magnetic data were obtained from samples from Tell Atchana, Kilise Tepe (Bronze Age archaeological sites in Southern Turkey) and Marki Alonia (a Bronze Age site in central Cyprus). These high quality archaeointensity results were gathered from 147 discrete samples from 16 different occupation levels of Tell Atchana, as well as 8 discrete samples from 4 different occupation levels of Kilise Tepe and 34 samples from 4 different archaeological time periods in Cyprus. The intensity values calculated range from $31\mu\text{T}$ to $57\mu\text{T}$. The samples are mostly unoriented potsherds collected from different occupation levels but also include oriented pavement cores from a palace rebuilding phase in Tell Atchana. The palaeointensity measurements were made using microwave and thermal techniques applying both the Coe and IZZI Thellier-type protocols.

The time period that the samples span and the location they were sourced from allows a direct comparison with the archaeointensity results of Gallet *et al.* (2006) obtained from Syrian and Iranian brick fragments. That study postulated the presence of archaeomagnetic jerks (sharp increases in field intensity) correlated with periods of cooling in the North Atlantic and major cultural crises in the Middle East. The implications of our new dataset for these intriguing potential links will be presented and discussed.

1.11-23p **HOLOCENE SEDIMENTARY RECORDS OF THE KATARRAKTES CAVE SYSTEM (N. GREECE): AN ENVIRONMENTAL MAGNETISM APPROACH**

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The Katarraktes cave system is located in northern Greece and is a complex of a rockshelter and a cave formed on the south river bank of Krousovitis River canyon (Serres, Macedonia region). The archaeological site area located in the rockshelter is well known as one of the most important archaeological sites in SE Europe since it hosts numerous archaeological findings dating back to the Early Bronze Age. Detailed sampling was performed along three archaeological sections (in the rockshelter) and along a sedimentary sequence found inside the cave. Magnetic susceptibility

obtained in high and low frequency as well as remanence parameters, such as NRM, saturation isothermal remanent magnetization (SIRM) and S-ratio, were measured in all samples collected from the archaeological sections and inside the cave. Results indicate a significant variability in the magnetic signal stored in the sedimentary record of Kataraktes cave system distinguishing between natural and anthropogenic sequences. The results derived from the magnetic properties of the sediments in combination with the stratigraphic analysis give some first evidences for the palaeoenvironmental conditions dominating in the region during Holocene.

1.11-24p WELL TO WELL CORRELATION BASED ON THE DSA OF IRM CURVES

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A well to well correlation at two Venezuelan oil fields has been performed based solely on the decomposition of the IRM curves of the studied samples. Thus, we have determined and quantified the main magnetic phases present in well samples applying a Direct Signal Analysis (DSA) of the IRM curves. The samples were taken at shallow depth levels (first 1500 m) from wells that belong to two fields in Western and Eastern Venezuela. At some of these levels, magnetic susceptibility (MS) anomalies were observed and they have been related to hydrocarbon migration. Applying the DSA, we obtained bar plots showing the vertical relative variation of the amounts of the main magnetic minerals along the studied stratigraphic levels. The results suggest different diagenetic processes along the whole sedimentary column of the wells. The relative amounts of magnetite, pyrrhotite, hematite and goethite quantified along the studied profiles, reveals the dominant presence of magnetite in the sediments characterized by the anomaly of relatively high magnetic susceptibility associated with hydrocarbon migration. Nevertheless, the relative mineral proportions vary from well to well and even distinct minerals are observed at these anomalous levels. These bar plots, as well as those obtained after the relative normalization of the areas along the wells, were compared trying to test if this kind of quantification could serve as an additional stratigraphic marker. These plots showed a clear variability that also allowed, at each field, to carry out a lateral correlation between strata with the same magnetic composition and the same relative proportion. In some cases, it seems to be a partial relationship between lithology and magnetic mineral assemblages. Nevertheless, in most cases the differences in the magnetic composition between these wells indicate different authigenesis related to hydrocarbon migration. Hence, this analysis correlates depth levels where authigenesis could take place and that are related with hydrocarbon migration. The results of the western field were also compared with a relatively close well located at the Colombian Llanos foreland basin. In that Colombian well it was found a level, with only hematite and goethite according with the DSA results, which has been associated with a thoroughly documented global regression.

1.11-25p IDENTIFICATION OF TSUNAMI DEPOSITS USING MAGNETIC METHODS OFF-SHORE SW IBERIA

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Identification of tsunami deposits is a key point to assess tsunami hazard. Most studies on tsunami deposits focus on onshore deposits settle during tsunami inundation or in turbidite deposits recover in deeper waters, thus not subjected to hydraulic action of coastal waves. In this work, we analyze 5 meter long cores, and perform detailed environmental magnetic analyses supported chemical and Rare Earth Elements analyses on a five meters core collected at a depth of approximately 100 m and 15 km away from the southern Portuguese coast. This location was selected for the several reasons: i) sediments of shelf domains typically result from high sedimentation rate, what enables a high temporal resolution; ii) avoid the reworking of sediments by coastal waves; and iii) enables a detailed characterization for the last 6 ka (period with stable water column height). Our results clearly shows a sedimentary horizon with a thickness of 4 cm that shows an abrupt change of several magnetic parameters that are accompanied by drop of iron content, by a significant increase of heavy rare earth elements and increase of the finer sedimentary fraction. According to the age model, this interval is contemporaneous of one of the major earthquakes and subsequent tsunami ever documented, the 01.11.1755 earthquake. In spite of the fact, that temporal and spaa better temporal and spatial coverage are always desired, our results claim that sediments of the continental shelf (outside coastal waves influence), are potential natural records of tsunamigenic deposits.

This work was funded by: POPEI project (PDCT/MAR/55618/2004), and Estudo de avaliação do risco de tsunami e periodosidade sísmica no Concelho de Cascais.

1.11-26p ASSESSMENT OF ANTHROPOGENIC POLLUTION IN MARAMBIO STATION (ANTARCTICA) USING MAGNETIC AND GEOSTATISTICAL METHODS

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Results of mass-specific magnetic susceptibility (?) measurement in soils from Marambio Station (Antarctica) and nearby areas are presented. Environmental magnetic studies have successfully carried out in a great number of

pollution studies, proving to be a very effective, fast and low cost method. However, it is mainly used for preliminary studies before applying conventional techniques.

Antarctic soils are interesting to evaluate new techniques because the low number of pollutions sources allows a direct link between source pollution type and measurement in receptors. Here, continuing previous works, the spatial distribution of χ was studied with the aim of describing the magnitude and extent of the anthropogenic impact in this area. A number of 278 topsoil samples were collected from 2004 in three Summer Antarctic Campaigns (SAC) 2003/2004, 2004/2005 and 2005-2006. In the laboratory, the samples were prepared and different magnetic parameters were measured.

The study area was divided in zones for posterior statistical and geostatistical analysis, they were: Pristine Area (i.e. without or very low anthropogenic influence), whole Marambio Station and both Power Plant and Solid Waste Disposal inside the station. A statistic significant difference was found in χ parameter, between the Pristine Area ($\chi = 14.1 \times 10^{-8} \text{ m}^3/\text{kg}$, max $19.7 \times 10^{-8} \text{ m}^3/\text{kg}$) and whole Marambio Station ($\chi = 31.7 \times 10^{-8} \text{ m}^3/\text{kg}$, max $615.9 \times 10^{-8} \text{ m}^3/\text{kg}$). Two geostatistical data description tools were used: the Moran Index, and variograms for the same four zones. Each of these was fitted following an exponential variograms model and three fitting parameters were found: Sill, Range and Nugget effect. Hence, Kriging maps were obtained to assess the spatial distribution of magnetic carriers reflecting different pollutant sources.

1.11-27p **THE IMPORTANCE OF REMANENT MAGNETIZATION IN MAGNETIC QUANTITATIVE MODELING OF IRON ORE DEPOSITS: A STUDY OF ACALPICAN, LA CRUZ AND EL VENADO ANOMALIES, IN LAS TRUCHAS MINING DISTRICT, MICHOACAN, MEXICO.**

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Magnetic survey interpreters generally consider that an anomaly is due only to the induced magnetization. However, when dealing with lithology of high magnetic mineral content, problems with interpretation may arise in case of significant remanence. In these cases, the study of magnetic properties (magnetic susceptibility and remanence) is a useful tool for a correct interpretation of the anomalies, providing constraints for the model and thus obtaining better approximations of ore body distribution. Additionally, they provide information to understand the genesis and tectonics of the area.

The mining district of Las Truchas is located within the iron metallogenic province in the Michoacan state, west of Mexico, and is one of the largest and most productive deposits of the country. The aim of this work is focused on obtaining the iron-ore distribution pattern from magnetic data for Acalpican, La Cruz and El Venado anomalies, taking into account the values of susceptibility and remanent magnetization obtained previously from the sites (Alva-Valdivia and Urrutia-Fucugauchi, 1998). Aeromagnetic data were provided by Arcelor-Mittal mining company.

In order to estimate geometry and depth of the magnetic sources, we performed the qualitative analysis of magnetic data, as: reduction to the pole, analytic signal and Euler deconvolution. Finally, we propose the quantitative models considering all together: geological units, magnetic properties and qualitative analysis results.

1.11-28p **SPOT READING OF THE ABSOLUTE PALEOINTENSITY GEOMAGNETIC FIELD OF POTSHERDS (AGE CA. 1500 AD) IN TEOTIHUACAN, MEXICO**

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Archeointensity data have been obtained successfully using the Thellier-Coe protocol from thirteen potsherds recovered from the vicinity of the Piramide del Sol, Teotihuacan, Mexico. In order to understand the magnetic behavior of the samples we have conducted low-field versus temperature (k-T) experiments to determine the magnetic carriers of the artefacts, such as saturation Isothermal Remanent Magnetization (SIRM), as well as hysteresis loops and back-fields. The Curie temperatures indicate the presence of at least three magnetic mineral phases (i.e. 238-276oC, 569-592oC, and 609-624oC). The Curie temperatures for these samples are typical of magnetite. The presence of cation deficient (CD) magnetite was identified for some samples with Curie temperatures distributed in the range of 609-630oC. It is interpreted that the apparent absence of hematite (Curie temperature 675oC) may simply reflect its relative weak saturation magnetization, which is about two orders of magnitude less than that of magnetite. Therefore, when a significant portion of magnetite is present, the signal from hematite is swamped. The results of the magnetic grain size analyses indicate that if the magnetic mineral in a sample is only magnetite, the distribution on the Day *et al.*, diagram yields specimens in the Single (SD), Pseudo (PSD) and Multidomain (MD) ranges. The thirteen successful absolute paleointensity determinations using the Thellier-Coe protocol have yielded an average paleointensity of 39.76 μ -Tesla (s.d. +/-2.28). Thus, our results correlate well with the recently published CALS3K.4 curve and therefore the age of the artefacts correspond to the Late Postclassic-Historic Teotihuacan cultural period.

1.11-29p A MAGNETIC SOLUTION TO THE MUPE BAY MYSTERY**Emmerton, Stacey; Muxworthy, Adrian; Sephton, Mark**Imperial College London; Imperial College London; Imperial College London; Universidad Simón Bolívar; Corporación Geológica Ares; University of Edinburgh
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An outcrop of Wealden beds at Mupe Bay (UK) is associated with a key piece of evidence for the timing of hydrocarbon migration in the Wessex Basin. A conglomeratic bed contains oil-stained clasts and matrix that appear different upon superficial observation. Conventional interpretations assign differences to the erosion and transport of oil-cemented clasts by Wealden rivers before their incorporation into a later stained conglomeratic bed. This scenario constrains the onset of oil migration in the basin to the Early Cretaceous, however, arguments have been put forward for single phase staining.

Magnetic information may provide new ways to examine the Mupe Bay record of oil migration. Migrating fluids such as hydrocarbons have been shown to cause chemical conditions suitable for the alteration or formation of authigenic magnetite resulting in associated chemical remanent magnetization (CRM). Magnetic characterization reveals both the matrix and clasts contain multi-domain magnetite but abundant hematite only exists within the clasts. Hysteresis parameters show the matrix has more multi-domain and likely larger magnetic grains than the clasts.

Magnetic directions are different in the clasts and matrix supporting a two-phase oil-staining event. Moreover, paleomagnetic directions for the clasts after tilt correction are consistent with biodegradation processes in the Early Cretaceous. Consistent directions in separate clasts imply the biodegradation and magnetite formation took place following transportation and incorporation of the oil-cemented clasts into the conglomerate bed. Magnetic directions reveal that the Mupe Bay matrix has a viscous remanent magnetization (VRM) corresponding to today's magnetic field, confirming the matrix represents an active oil seep.

This study represents an unprecedented use of magnetic data to date the onset of oil migration in a basin. The classic two-stage oil-staining scenario which constrains the onset in the Wessex Basin to the Early Cretaceous is supported by our data.

1.11-30p BIODEGRADATION REDUCES MAGNETIZATION IN OIL BEARING ROCKS: MAGNETIZATION RESULTS OF A COMBINED CHEMICAL AND MAGNETIC STUDY**Emmerton, Stacey; Muxworthy, Adrian; Sephton, Mark; Aldana, Milagrosa; Costanzo-Álvarez, Vincenzo; Bayona, German; Williams, Wyn**Imperial London; Imperial College London; Imperial College London; Universidad Simón Bolívar; Corporación Geológica Ares; University of Edinburgh
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Relationships between magnetization and hydrocarbons have been alluded to in the past; here we report a study that identifies a definitive connection between magnetic mineralogy and biodegradation within oil-bearing rocks. Samples from Colombia, Canada Indonesia and the UK were collected and magnetically characterized. A distinct decrease in magnetic susceptibility was correlated to decreasing oil quality (loss of aliphatic hydrocarbons). Further magnetic characterization revealed that the high quality, low biodegradation oils from Colombia have a higher magnetic susceptibility (10^{-3} - 10^{-4} m³kg⁻¹) and are dominated by pseudo-single domain grains of magnetite. The lower quality oils i.e., the UK, Canadian and Indonesian samples, displayed decreased magnetic susceptibility (10^{-5} - 10^{-6} m³kg⁻¹) and pseudo-single domain to multidomain grains of magnetite and hematite. Magnetite and pyrrhotite framboidal material were found in all but the Canadian samples. Therefore, with decreasing oil quality there is a progressive dominance of multidomain magnetite as well as the appearance of hematite. The presence of hematite only within heavily biodegraded samples suggests a later stage of biodegradation at the surface due to oxidation of magnetite. We have identified a relationship between magnetization and the relative abundance of aliphatic organic compounds in oil. Biodegradation appears to remove both aliphatic hydrocarbons and magnetic susceptibility owing to influence of bacterial metabolic activity that uses ferric iron minerals as electron acceptors. These findings reinforce the importance of bacteria within petroleum systems as well as providing a platform for the use of magnetization as a hydrocarbon migration proxy and as an inexpensive and simple method to determine oil quality.

1.11-31p MINERALOGICAL FERROMAGNETIC AND PARAMAGNETIC ANALYSIS AS A QUALITY CONTROL OF BRICK PRODUCTION**Pueyo-Anchuela, Óscar; Somovilla Ion Ander; Gil Imaz Andrés; Gisbert Aguilar Josep**Departamento de Ciencias de la Tierra, Universidad de Zaragoza
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Brick production requires detailed control of the source materials and the production conditions in order to obtain high quality products both for strength and appearance. In some cases, their color depends on the characteristics of the raw materials and the manufacturing process (temperature and oxidation conditions during burning), stability of temperatures during the different production stages and their subsequent cooling conditions. In this work an analysis, based on magnetic properties, is carried out in order to analyze the origin of color changes in groups of

bricks undergoing the same production processes. These bricks exhibit changes from the expected white color, with red stains or pink colors are obtained. The presented study considers the analysis of the original composition of the raw materials, the production and material mixture processes, and the mineralogical composition of materials giving bricks with different colors at bricks located at the same production piles. The mineralogical analysis was carried out by means of XRD analysis and thermomagnetic susceptibility curves. Obtained results show uniform parageneses in the raw materials, with independence of the sedimentary characteristics (clays and marls), and a uniform mineralogical composition in bricks, with independence of their external color. In all cases, the cooling curves from thermomagnetic treatments are similar, although the heating curves show distinctive characteristics between the raw materials and bricks. In the case of the analyzed bricks, similar heating curves are identified between white (reversible) and pink-red bricks (non reversible) but original susceptibility of white and pink bricks is different (higher for the pink ones and a more paramagnetic susceptibility for white ones). This can be interpreted as the result of higher free-iron content in the pink bricks with respect to the white ones, where (i) bricks that remains stable at the highest temperature permit the formation of silicates (mainly augite) that consume free-iron thus giving a white color, while (ii) bricks in which the temperature increasing is not uniform, high temperature silicates do not consume all the free-iron from the samples, producing a remaining free-iron content that gives the reddish brick aspect during cooling.

1.11-32p THERMOMAGNETIC ANALYSES OF OCEANIC BASALTS - TESTING A NEW APPROACH TO DIFFERENTIATE OXIDATION DEGREE FROM THE PRIMITIVE COMPOSITION OF TITANOMAGNETITES
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Low-field magnetic susceptibility as a function of temperature $\chi(T)$ is one of the most powerful techniques to assess the main magnetic mineralogy of rocks from distinct geological settings. For the specific case of titanomagnetite solid solution, the dependence of Curie temperature from their composition and oxidation degree, imposes limits to the application of thermomagnetic methods as a tool to assess independently one of the variables, i.e., the pristine composition and/or quantification of the oxidation degree. In order to overcome this ambiguity several authors resorted to independent methods, like microprobe, scanning electron microscopy (SEM) and transmission electron microscopy (TEM) analyses. The study here presented seeks to establish a new approach able to correlate the oxidation degree with T_c variations of partially oxidized submarine basalts, only supported by the thermomagnetic analyses conducted between -190°C and 650°C . 40 thermomagnetic signatures were evaluated along cross-section profiles of four pillow-lavas, sampled from the Mid-Atlantic Ridge and from the Terceira Rift (Azores plateau). For each one was collected a lamellae with a thickness of 2 to 3 mm, along each centimeter of the profile. Our thermomagnetic curves of partially oxidized oceanic basalts are characterized by a peak of susceptibility between $300\text{-}350^\circ\text{C}$ and $520\text{-}550^\circ\text{C}$, which mostly results from the inversion of the thermally metastable titanomaghemite into a complex multi-phase intergrowth. From our experiments, we were able to obtain a good linear correlation between the amplitude of this peak and the Curie temperature for each profile. With this correlation becomes viable a more accurate determination of the main pristine composition of basalts Fe-Ti oxides and permits a qualitative inference of oxidation degree. This work is a contribution to research project REGENA (PTDC/GEO-FIQ/3648/2012) funded by FCT (Portugal)

1.11-33p HEAVY METAL POLLUTION IN FARMLAND IRRIGATED WITH RIVER WATER NEAR A STEEL PLANT - MAGNETIC AND GEOCHEMICAL SIGNATURE

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The presence of heavy metals (HMs) in the environment is a major threat for humans. Magnetic proxies provide a rapid method for assessing the degree of HM pollution in environment. We have studied farmland soil irrigated with polluted river water in the vicinity of a steel plant in Loudi city (Hunan Province, China) in order to test the efficiency of magnetic methods for detecting the degree of HM pollution. Both magnetic and non-magnetic (microscopic, chemical and statistical) methods were used to characterize these farmland soils. Enhanced magnetic concentration values were found in the upper arable soil horizon (0-20 cm), which is related to the presence of spherical ~ 10 to 30 μm sized magnetite particles. The spatial distribution of magnetic concentration and HM contents in the farmland soils matches with the spatial pattern of these parameters in river sediments. These findings provide evidence that heavy metal pollution of the farmland soil is mainly caused by irrigation with wastewater. HMs Zn, Pb, Cu, Cd, Co, Ni, V are well correlate with magnetic susceptibility (χ). The Pollution Load Index (PLI) of all nine anthropogenic

HMs (including also Cr and Mo) and $\log_{10}(x)$ are significantly correlated. Using the resulting linear PLI- $\log_{10}(x)$ function, values of ? can serve as a convenient tool for semi-quantifying the degree of HM pollution in the uppermost ~20 cm of the studied farmland soils. These findings suggest that magnetic methods can generally serve as a convenient tool for detecting and mapping HM pollution in farmland soil irrigated with wastewater from sites nearby heavy industrial activities.

SESSION 1.12

APPLIED ROCK MAGNETISM: TOWARD A BETTER UNDERSTANDING OF CONTROLLING FACTORS OF ENVIRONMENTAL MAGNETIC PROXIES

1.12-1 MAGNETOSOMAL GREIGITE IDENTIFIED IN BALTIC SEA SEDIMENTS AND ITS ENVIRONMENTAL MAGNETIC SIGNIFICANCE

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We have conducted a detailed rock magnetic study of Baltic Sea sapropels that provides new and important information about the magnetic properties of greigite magnetofossils. TEM-EDS analysis of magnetic concentrates confirms that stable single-domain magnetosomal greigite (Fe₃S₄) is responsible for the magnetic enhancement of laminated sapropels, which formed in the Baltic Sea during periods of anoxia. The magnetic enhancement is significant and causes rock magnetic concentration parameters to be two orders of magnitude higher than non-laminated sediments. The concentration of clastic magnetic minerals is negligible and we do not detect magnetosomal magnetite (Fe₃O₄).

The laminated sediments have a room temperature coercive force of 10-15 mT and FORC diagrams display a narrow central ridge that is characteristic of non-interacting single domain grains. In contrast, well characterized samples of considerably larger authigenic greigite that formed through inorganic processes have a coercive force between 40-60 mT and FORC diagrams that are consistent with magnetic interaction and/or anisotropy. The coercive force of the magnetite magnetofossils is approximately 30 mT, which is considerably more than our values for Baltic Sea greigite magnetofossils. The values of interparametric ratios considered to be diagnostic of magnetite magnetofossils, such as relatively high X_{arm}/SIRM, X_{arm}/arm and SIRM/X, appear to be common to our greigite magnetofossils. Thus, these values may imply a biogenic origin of the magnetic material, but they do not discriminate between magnetosomes made of greigite or magnetite, which probably form in very different geochemical environments. For example, the concentration of greigite magnetosomes in the Baltic Sea sediments is positively correlated to organic matter content and occurrences of hypoxia and anoxia, which are traditionally associated with magnetite dissolution caused by sulphate reduction. Further research needs to establish the type of bacteria that produced them, where they lived and at what depth the magnetofossils contribute to the natural remanent magnetization.

1.12-2 CHARACTERIZING MAGNETIC MINERALS IN SURFACE SEDIMENTS FROM MAJOR ASIAN DUST SOURCES AND IMPLICATIONS FOR TRACING AEOLIAN MATERIAL

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The wind-borne mineral aerosol (dust) is an important component of the Earth's climate system. To better decipher the dust signal preserved in archives, the prerequisite is to determine the dust origin and characterize the dust from the source region. On the basis of the satellite data, the major dust source region is located at the Northern Hemisphere, and the Eastern Asia is one of the most important region to generate dust. Previous studies suggested that the potential dust source regions at the Eastern inland Asia covers a wide range of region including the Gobi and deserts, the Qaidam Basin, the Tibetan Plateau and its eastern areas, the Gansu Corridor. In this study, we systematically investigated surface samples from the potential dust regions in western China using environmental magnetic methods to better characterize and quantify the iron oxides in material from the dust source areas. The major objective of this study is to characterize and quantify the magnetic minerals in material from the dust source regions, and further test whether the magnetic properties are sensitive to changes in the local environments, and then be used to distinguish the dust sources. Results show that there exist three kinds of hematites in samples from the source regions and from the Chinese Loess Plateau in terms of the diffuse reflectance spectroscopy (DRS) band positions at 560, 545, and 535 nm (named P650, P545, and P535). The group P535 is present dominantly in paleosols, and is interpreted as the hematite pigments formed via pedogenesis, and the Al content is relatively higher than the other two groups. The P560 component is present only in some samples from the source regions. This group is more pure and should correspond to the lithogenic hematites coming from the physical disintegration of the surrounding bedrock.

The group P545 is an intermediate phase, which is present both in the surface samples from the source region and in the loess with little alteration by pedogenesis. Compared to the group P535, the group P545 is relatively larger in size and less Al-substituted than the group P535, but definitely has higher Al substitution than the group P560. Results further show that the coarser-fraction of magnetic particles have been preferentially sorted out during the transportation processes and thus the average grain size of magnetic particles at the CLP is narrower and finer than the counterparts from the source region. By integrating the DRS pattern and concentration of hematite (indicated by the hard isothermal remanent magnetization, HIRM), dusts from the major sources region can be confidently distinguished. Therefore, this study provides great constraints on interpreting the dust signals.

1.12-3 **MAGNETIC CHARACTERISTIC OF CURRENT ROADSIDE POLLUTION FROM EXPERIMENTAL MONITORING PLOTS LOCATED IN DIFFERENT COUNTRIES.**

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The aim of the study is a qualitative recognition of current roadside pollutants deposited on topsoils in areas located in close vicinity to roads with high traffic volume. So far, the determination of pollutant contents in soil samples has shown the amount of contaminants that have accumulated over long time periods, but at the same time it became clear that distinguishing roadside pollution from other industrial sources is difficult. In order to avoid this issue and recognize current threats originating from road traffic, monitoring plots had been installed in Poland, Germany, Finland, Tajikistan, Greece and China. For installation of monitoring plots ca. 7 cm of topsoil had been removed and replaced by boxes filled with clean quartz sand with known chemical composition and diamagnetic properties. This sand was considered as a neutral matrix for the accumulation of traffic pollution. Measurements of magnetic susceptibility and other magnetic parameters were conducted in the soil layer removed from the monitoring places and in the sand matrix after 12 and 24 months of exposure.

Highest values of magnetic susceptibility of removed soils were revealed in the plots from Poland, Germany and China. After 24 months of exposition magnetic susceptibility of the sand matrix were very diverse. Highest values were observed in Finland and China, however in most of monitoring plots magnetic susceptibility values were lower after 24 months than after 12 months of exposure.

Thermomagnetic analyses (χ T curves) of both the removed soil samples and the sand matrix after 12 and 24 months of exposure showed that the main magnetic mineral is magnetite. Additionally, in almost all investigated samples an increase in χ values was observed in the heating curve shortly before reaching the Curie temperature of magnetite. We interpret this as a Hopkinson peak which is characteristic for magnetite grains occurring in a relatively homogeneous fraction.

1.12-4 **MAGNETIC BIOMONITORING OF AIR POLLUTION IN A MIDDLE-SIZED CITY FROM ARGENTINA**

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This study assesses the environmental pollution in an urban area (Tandil city) using lichens as biomonitors. Several lichen species -living on tree bark- are available in Tandil, where the main pollution source is the vehicular traffic, but there is also influence of metallurgical industries situated inside the urban area.

From different available species, the specie *Parmotrema Pilosum* was tested for being one of the most common in the study area. A two-way stratified sampling design was performed using density of trees as weight. A number of 410 sites from the central urban area were selected, from these sites, a total of 130 lichen samples were collected and studied. The vegetation material was measured in laboratories from Argentina (IFAS, UNCPBA) and México (CGEO, UNAM). The magnetic properties were determined using rock-magnetic measurements: magnetic susceptibility, magnetic hysteresis loops, anhysteretic and isothermal remanent magnetization and thermomagnetic measurements.

The results show that magnetite-like minerals are the main magnetic carriers. The Day's plot shows that the samples are located in PSD (pseudo-single domain) area and it suggests magnetite as the main magnetic fraction. Magnetic grain size estimations indicate clear differences between sample sites: presence of fine particles in sites with low vehicular traffic or park areas, while sites affected by pollution (high vehicular traffic or metallurgical industry influence) are characterized by coarser magnetic grain sizes.

Magnetic grain size and concentration dependent parameters were computed in 2-D contour maps, and it was possible to discriminate polluted and non-polluted areas. The distribution of magnetic values evidences areas with high vehicular influx and zones influenced by metallurgical industry.

1.12-5 MECHANISM OF TRAFFIC DERIVED POLLUTION ALONG ROADSIDES**Ojha, Gobinda; Appel, Erwin; Magiera, Tadeusz; Wawer, Malgosia**

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In our present study we focus on typical traffic pollutants (heavy metals HM, platinum group elements, polycyclic hydrocarbons PAH) and investigate the use of magnetic parameters, in particular to discriminate the importance for the distribution of contaminants by surface runoff, splash-water and airborne transport. For monitoring we installed pillars at 1 m and 2 m distances to the roadside with samplers in different heights (ground-based, 0.5 m, 2 m) as well as 4 m long u-channels (surface and 2.5cm above ground) perpendicular to the road. Clean quartz sand was used as collector material. Significant differences of mass-specific susceptibility (?) were noticed in pillars and u-channels within one year of monitoring. Similar enhancement in ground-based and elevated samplers (0.5 m for pillars; 2.5 cm for u-channels) suggests that surface runoff is of secondary importance. Magnetic results revealed that magnetite-like phases are responsible for the enhancement of magnetic concentration. The concentration of pollutants (HM, PAH) also show a significant increase with time. A good correlation between ? and semi-volatile and particle-bound PAH phases suggests that ? can be used as a proxy for traffic derived PAHs pollution. SEM observations and energy dispersive X-ray analyses identified a dominance of angular and aggregates-shaped particles with composition of Fe-Cr-Ni-W derived from traffic-specific activities (abrasion of tyres, exhausts and brake linings). The results from our monitoring studies will be utilized to develop new innovative roadside pollution monitoring concepts.

1.12-6 MAGNETIC PROPERTIES OF SEDIMENTS FROM THE YANGTZE DELTA AND ENVIRONMENTAL IMPLICATIONS**Zhang, Weiguo; Dong, Yan; Dong, Chenyin, Yu, Lizhong**

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Magnetic properties of modern and Holocene sediments from the Yangtze Delta were explored and their implications for environmental processes studied. Magnetic properties of modern sediments are strongly influenced by sediment particle size, which can be used to indicate hydrodynamic variations. After burial, diagenesis altered magnetic signatures, and sedimentation rate influence the diagenesis zone of sediments. Generally, oxidative diagenesis in tidal flat sediments lead to production of high-coercivity minerals, while reductive diagenesis occurs at deeper layer where sedimentation rate is higher. In the Holocene sediments, greigite is found widely at the transition zone of terrestrial and marine facies, and therefore a potential good marker of sea level. The vertical variations of magnetic properties provide a tool for stratigraphic correlation. Overall, magnetic properties in combination with other sediment characterization methods, such as geochemical and mineralogical analyses, can provide valuable information in the study of environmental processes and paleoenvironmental reconstruction.

1.12-7 OUT-OF-PHASE SUSCEPTIBILITY AND TIME-DEPENDENT ACQUISITION OF VISCOUS MAGNETIZATION: TWO INTERCORRELATING MAGNETIC PROXIES IN MAGNETIC GRANULOMETRY OF SEDIMENTS AND SOILS**Chadima, Martin; Hroudá, Frantisek; Kadlec, Jaroslav**

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The presence of the ultrafine superparamagnetic (SP) magnetic particles in rocks, soils and environmental materials is traditionally investigated using the frequency-dependent (in-phase) magnetic susceptibility. In addition to that, modern instruments for measuring magnetic susceptibility in weak alternating fields are able to resolve the measured susceptibility into components which are in-phase and out-of-phase with respect to the applied field. Since there is a direct relationship between the frequency-dependent in-phase susceptibility and the out-of-phase susceptibility (provided that the latter is due to the viscous phenomena), the out-of-phase susceptibility alone may be used as a proxy parameter for magnetic granulometry. The advantage of the out-of-phase susceptibility compared to the frequency-dependent susceptibility is that it does not require measurements at two or more frequencies. A combined use of the frequency-dependent and out-of-phase susceptibilities is demonstrated on loess/paleosol sequences located in the territory of the Czech Republic which belongs to the European loess belt. Increased concentration of the SP particles in the sections is supposed to indicate the pedogenic processes controlled by Pleistocene climatic oscillations. The variations in both frequency-dependent and out-of-phase susceptibilities correlate with the alternation of loess and paleosol horizons in the sections. The obtained trends are verified independently through investigation of the time-dependent acquisition of viscous remanent magnetization. In addition, a simple test is proposed for checking that the out-of-phase susceptibility is solely due to the viscous phenomena and not due to electrical eddy currents or weak field hysteresis.

1.12-8 MINERAL MAGNETIC PROPERTIES OF SEDIMENTS FROM THE NORTHERN SLOPE OF SOUTH CHINA SEA AND THEIR ENVIRONMENTAL SIGNIFICANCE

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As the largest marginal sea in the western Pacific realm, South China Sea (SCS) is often considered a key region that hosts abundant sedimentary archives for deciphering the coupling processes between terrestrial and marine systems. We carried out a detailed mineral magnetic study of a ~ 5.8 m long sediment core that was collected from the northern continental slope of SCS to investigate the environmental change history of the study area. The chronology is constrained with 10 AMS radiocarbon dates and the record of the core spans over the past 20 kyrs. Downcore variations in various magnetic parameters that characterize the abundance, type, and particle sizes of magnetic minerals show marked shifts that appear to be coeval with major climatic intervals such as the last glacial maximum (LGM), Bolling-Allerod warming (B/A), and the Younger Dryas (YD) events as recorded in both terrestrial and marine proxy records. Although the magnitude of variations of magnetic parameters during the Holocene is relatively subdued, the overall pattern seems in concert with that of the Asian monsoon proxy records from South China, suggesting that terrigenous inputs dominate the Holocene magnetic records of sediments from the northern slope of SCS. Examining the mechanistic link between variations in magnetic properties and major climatic events could potentially shed new light on the coupling processes between the terrestrial and marine systems.

1.12-9 THE ENVIRONMENTAL MAGNETIC RECORD ACROSS THE 12.9 KA YOUNGER DRYAS BOUNDARY: EVIDENCE FOR IMPACT?

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The cause/s of the onset of the Younger Dryas (YD) climactic event at 12.9 ka and the corresponding extinction of Pleistocene megafauna and changes in human subsistence patterns in the Americas remain a geologic mystery. Firestone *et al.* (2007) proposed a bolide impact on the Laurentide ice sheet to explain these dramatic environmental changes, citing an increase in the concentration of magnetic spherules (M_{Sp}) and magnetic grains, among several other parameters. Here we present complete rock magnetic analyses across the YD at two well-dated archaeological sites (Friedkin Site, TX and Topper Site, SC). These measurements were conducted on bulk, unprocessed soil samples collected continuously across the YD boundary. Rock magnetic techniques are one of the most sensitive means for detecting subtle changes in sediment source, grain size variation, and pedogenic development. Our goal was to test whether there are any changes in sedimentation or pedogenesis at these sites consistent with a large bolide impact or airburst. There is no evidence at either site of any magnetic change coincident with the YD boundary.

1.12-17p ENVIRONMENTAL MAGNETIC PROXIES: PALAEOCLIMATIC IMPLICATIONS FOR LAGUNA POTROK AIKE

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This study was carried out on three piston cores collected from Laguna Potrok Aike (51°57'S, 70°24'W), a deep maar lake in southern South America. Magnetic measurements (magnetic susceptibility at low and high frequency, anhysteretic remanent magnetisation, saturated isothermal remanent magnetisation, remanent coercivity) were performed on sub-samples from about 15,500 cal. BP to the present and associated parameters like soft-IRM, S-ratio, ARM/??SIRM/? and ARM/ SIRM were also calculated.

A simple model based on concentration of magnetic parameters, magnetic grain size and magnetic mineralogy is proposed in order to infer lake level and wind changes. Under consideration of similar magnetic mineralogy, when allochthonous sediment dominated, variations of magnetic concentration and grain size indicate lake level fluctuations. High/low values of both parameters were found for high/low lake levels. Magnetic susceptibility shows the best fit with hydrological changes. In addition, during dry periods a low percentage of greigite is observed indicating lake stratification. Geochemical data and coarse magnetic grain size suggest an eolian sediment source for these periods. According to this study, Laguna Potrok Aike was stratified at least four times during the studied time interval, probably due to the weakening of the Southern Hemispheric Westerlies. More studies are needed in order to characterize the greigite that was identified in the sediment record and to establish the associated environmental characteristics.

Relationships between magnetic parameters, total organic carbon, total inorganic carbon, different elements, gastropods, pollen and diatoms were analysed to support our model.

1.12-18p MAGNETIC PROPERTIES OF THE ANLLÓNS RIVERBED SEDIMENTS (NW SPAIN)**Costanzo, Vincenzo; López, Diego; Devesa, Rosa; Barral, María T.**Universidad Simón Bolívar (USB) Venezuela; Universidad Complutense de Madrid; Centro Universitario de la Defensa, Escuela Naval Militar, Universidad de Vigo, Marín (Pontevedra); Universidad de Santiago de Compostela vcosta@usb.ve

We analyzed thermomagnetic curves and hysteresis loops of 13 samples from the Anllóns riverbed (northwestern Spain) and the association of rock magnetic properties to heavy metal contamination. Thermomagnetic curves show a phase transition at 250–350 °C that may indicate the inversion of maghemite to hematite. They also show a transition at 450–550 °C that is likely due to the transformation of hematite to a strong magnetic phase revealed by the highly irreversible cooling curve. In a Day plot, the tightly grouped Mrs/Ms and Hcr/Hc data for the Anllóns River lie in the middle range of the synthetic MD+SD mixing curves [1]. The Anllóns data also overlaps the clay fractions (<2µm) of the Luochuan paleosols with a dominant maghemite fraction [2]. Bulk magnetic susceptibility was previously used in [3] as an indicator of pollution in these samples, showing a linear correlation with some heavy metals produced by mining and industrial activities. However, the present study proves that there is not such a linear relationship between these metals and the Mrs/Ms ratios that increase as the grain sizes of magnetite decrease. The widely observed association between heavy metals and magnetic parameters may be due to the incorporation of contaminants into the crystalline structure of magnetite and/or hematite-rich fly ashes (1µm) produced by anthropogenic sources. Therefore, the pollutant load released into the atmosphere and accumulated in soils, may sometimes be related to a fraction of fine-grained magnetic minerals. In these cases a link between heavy metals and magnetite grain size would be expected. Conversely, this association may be also due to a later incorporation, via adsorption, of heavy metals on the surface of the magnetic carriers already present in the soils. This mechanism could be the one that applies to this study since maghemite is usually a byproduct of weathering or low-temperature oxidation of detrital, pedogenic and/or anthropogenic magnetite. Thus, the pollutant load would be rather linked to the bulk magnetic susceptibility, a first order measure of the amount of ferrimagnetic minerals in soils and sediments. Ref. [1] Dunlop (2002) *J Geophys Res*, 107 (B3): EPM5-1-15; [2] Hao *et al.* (2012) *Geophys J Int*, 191: 64-77; [3] Devesa *et al.* (2006) *MAGIBER IV Libro de Resúmenes*, 39-42.

1.12-19p MAGNETIC AND DIFFUSE REFLECTANCE SPECTROGRAPHIC CHARACTERIZATION OF HEMATITE AND GOETHITE IN TIDAL FLAT SEQUENCE IN COASTAL PLAIN OF JIANGSU PROVINCE, CHINA**Dong, Yan; Zhang, Weiguo; Dong, Chenyin; Ge, Can; Yu, Lizhong**State Key Lab. of Estuarine and Coastal Research, East China Normal University, Shanghai 200062, China ldyz@ntu.edu.cn

In this paper we present the results of research on a coastal lowland Holocene tidal flat sequence in order to explore the variations in magnetic mineralogy during the process of tidal flat sedimentation and subsequent land formation. Three cores (~6 m in length) were collected from the coastal plain in Jiangsu Province, China, and investigated with magnetic measurements, diffuse reflectance spectrograph (DRS) and free iron oxide (Fed) analyses. The tidal flat sequence shows a fining-upward trend, and the top ~2 m of each core with redoximorphic feature was interpreted to be a salt marsh facies in origin. Unmixing of isothermal remanent magnetization acquisition curves identify magnetite and maghemite as well as high-coercivity hematite and goethite, with the latter iron oxides confirmed by DRS analysis. Enrichment of goethite, hematite and maghemite occurs in the salt marsh deposits in comparison to the lower intertidal and subtidal deposits, with goethite being the dominant iron oxide. The changes in hard isothermal remanent magnetization acquired in field above 100 mT field (HIRM100) and the S-100 ratio largely reflect the presence of medium-coercivity maghemite in absolute content and relative proportions, respectively. The approach used for iron oxide characterization may offer an efficient diagnostic tool for recognizing sediments or soils subjected to redox condition oscillation elsewhere and contribute to studies of iron cycling in (paleo-)environmental researches.

1.12-20p PRELIMINARY PALEOCLIMATIC DATA FROM SEDIMENTS OF LAGUNA CHATTEL**Irurzun, M. Alicia; Gogorza, Claudia; Sinito, Ana; Fey, Michael;**Universidad Nacional del Centro de la Provincia de Buenos Aires (UNCPBA)-CONICET; Universidad Nacional del Centro de la Provincia de Buenos Aires (UNCPBA)-CONICET; Universidad Nacional del Centro de la Provincia de Buenos Aires (UNCPBA)-CONICET; GEOPOLAR airurzun@exa.unicen.edu.ar

Sequences of lake sediments are excellent paleoclimatic archives because they provide continuous records of magnetic parameters and detailed multiproxy information on paleoclimatic changes. This study was carried out on sediments collected with a gravity corer from Laguna Chaltel, an almost circular crater lake located in Patagonia, Argentina (49.9° S 71° W).

Magnetic mineralogy, concentration and magnetic grain size measurements were made to all the samples. On selected samples, hysteresis curves were measured and HCR/HC and MRS/MS were calculated. The main magnetic carrier is magnetite in the pseudo-single domain range with noticeable variations on concentration and mineralogy

particularly from 4700 to 2900 cal. BP.

A model using magnetic grain size, concentration and mineralogy, previously applied to Laguna Potrok Aike to infer lake level changes, was used for Laguna Chaltel. The results indicate an increasing trend in the water lake level from 3950 to 500 cal. BP with few pulses of relative higher lake level between 3900 and 3000 cal. BP. A high concentration of low coercivity minerals with coarse magnetic grain size is observed at 4000 cal. BP, suggesting that this is the time of the driest event with the lowest lake level during the last 4700 years in this area.

1.12-21p MILLENNIAL-SCALE ROCK MAGNETIC VARIATIONS INDICATING INSTABILITY OF NORTH ATLANTIC ENVIRONMENTS DURING INTENSIFICATION OF NORTHERN HEMISPHERE GLACIATION

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We have investigated millennial-scale environmental changes in the subpolar North Atlantic after the intensification of Northern Hemisphere glaciation through multi-proxy analyses of a sediment core drilled at IODP Site U1314 (southern part of the Gardar Drift; 2820 m water depth). In this study, we have performed Ice-rafted detritus (IRD) counts, XRD measurement, rock-magnetic analysis of the sediments at every 100~200 years (at every 2cm intervals) from 2.55 to 2.50 Ma, including the period of marine isotope stage (MIS) 100.

During MIS 100, eight IRD events occurred with a periodicity of three- to five-thousand years. The analysis of XRD data indicates that quartz is the most dominant component of the IRD. The rock-magnetic analysis demonstrates that quick decrease associated with IRD events and succeeding gradual recover was observed in Mr/Ms (saturation remanence/ saturation magnetization) and Hc (coercive force). These results indicate that magnetic grain size increased associated with IRD arrivals and subsequently decreased gradually. It is highly possible that the observed variation in magnetic grain size reflects the variation in bottom current with little affection by IRD input, because Mr of IRD layers is so low that the magnetization of IRD material may be negligible. The sediments in Icelandic source have finer magnetic grain size than any other sediments that may contribute as the source of sediments in the Gardar drift. Therefore, the coarser magnetic grain size associated with IRD events probably indicates relatively low intensity of sediment transport by ISOW (Iceland-Scotland overflow water) that transport sediments with fine magnetic grain size from Icelandic sources to the Gardar drift variation in bottom current with little affection by IRD input, because Mr of IRD layers is so low that the magnetization of IRD material may be negligible. The coarser magnetic grain size associated with IRD events is interpreted to be relatively low intensity of sediment transport by ISOW (Iceland-Scotland overflow water) that transport sediments with fine magnetic grain size from Icelandic sources to the Gardar drift, because the sediments in Icelandic source has finer magnetic grain size than any other sediments that may contribute as the source of sediments in the Gardar drift.

1.12-22p ENVIRONMENTAL MAGNETISM IN CULTIVATED SOILS FROM PAMPEAN PLAIN, ARGENTINA

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Results of a comparison of magnetic parameters measured in samples collected in native vegetation and cultivated soil profiles from Pampean plain are presented. Both these soils are found within the same geomorphological region, with the same climate and have similar topographic attitude and drainage. A correlation is found between agricultural activity and the magnetic properties. Natural uncultivated soils showed a slight enrichment of magnetic particles. In agreement with the hypothesis of the generation of the magnetic signature used in this contribution, it is suggested that this increase is related to the generation of magnetite and the preservation of detritic titanomagnetite.

One of the cultivated soils showed enrichment in magnetic particles whilst another a slightly impoverished. This could be due to different factors linked to agricultural practices. One hypothesis suggests that the disparity could be a consequence of the state of growth of the crop, and/or the time under no-till farming. Another hypothesis suggests that the use of different fertilizers in the studied areas could be the cause of the different magnetic signature.

1.12-23p ASSESSMENT OF HEAVY METAL CONTAMINATION OF DUSTFALL IN NORTHERN CHINA FROM INTEGRATED CHEMICAL AND MAGNETIC INVESTIGATION

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Magnetic phases are a common component of dustfall samples and mineral magnetic studies have been increasingly exploited for air quality studies in recent years to assess the source and spatial-temporal distribution of anthropogenic magnetic particulates and associated heavy metals. Here we report a comparative study of magnetic

and chemical properties of atmospheric particulate deposits from rural areas of Inner Mongolia and urban regions of Hebei and Beijing. The sample sets were collected at 13 monitoring stations by the gravimetric method between April 2009 and March 2010. At the rural sites paramagnetic clays, complemented by hematite and goethite recognized by Isothermal Remanent Magnetism (IRM) and Diffuse Reflectance Spectra (DRS) investigations, accompany fine grained magnetite as an important fraction. Although present as a residual phase in samples from the urban regions, coarse-grained magnetite of anthropogenic origin dominates the magnetic signatures in these latter environments. Systematic variations with local anthropogenic activity including traffic, the mining of ores and a range of industrial emissions are identified, together with a seasonal signature in the Beijing area. We use correlations between magnetic concentration-related parameters, notably magnetic susceptibility, and the Pollution Load Index to demonstrate how magnetic parameters can be used as a practical tool for mapping degrees of heavy metal pollution and tracing the sources of pollutants in dustfall samples.

SESSION 1.13

THEORETICAL AND EXPERIMENTAL ROCK MAGNETISM

1.13-1 CAN PSD GRAINS ACCURATELY RECORD THE ANCIENT FIELD

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Pseudo-single domain (PSD) behavior is ubiquitous in nature, yet quantifying the magnetic behaviour of PSD grains is particularly difficult due to the problems in synthesizing samples with controlled grain size distributions and controlled grain separation: most synthesis methods produce distributions of grain sizes that span the single domain through to the multidomain grain size range, with no or little control over inter-grain spacing. However, using the technique of electron beam lithography (EBL), we have synthesized thin-films of arrays of near-identical magnetite particles with controlled inter-grain spacings. Such samples are ideal for testing PSD responses. In this paper we report the response of a suite of EBL-produced PSD samples to a synthetic Thellier-Thellier-Coe palaeointensity experiment.

1.13-2 ATOMIC AND MAGNETIC ORDER IN NANOSIZED GOETHITE OBTAINED BY CO-P

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Among iron oxy hydroxides goethite (γ -FeOOH) is the most stable one occurring in nature and plays a significant role in science and technology. It is a common weathering product in rocks and a major inorganic component in terrestrial soils, sediments and ore deposits so that it happens to give them its characteristic yellowish-to-reddish brown to deep brown colour. The compound has long been known as pigment in the industry and as one of the major corrosion products that make up rust layers on atmospherically exposed steels. Its strong uptake capacity for toxic metals and radioactive cations has attracted recent interest for use as a sorbent of high potential for environmental protection. Due to the mostly acicular shape synthetic goethite particles are best known as the most frequently used precursor among the various starting substances for preparation of acicular particles (e.g. γ -Fe, maghemite γ -Fe₂O₃) for use in magnetic particulate recording media and ultra-high density data storage devices. In this last respect appropriate methods have been developed for synthesis of high quality nanoparticle material so that nowadays acicular goethite nanoparticles can be produced with optimised aspect ratio and narrow size distributions.

On the route to understand natural nanomaterials and the effects arising on the nanometer scale of particle size, the aim of the present work was to characterise thermal treatment effects on the short and long range atomic and magnetic order of goethite material of different origin. Natural samples, containing well-defined natural goethite from five localities (chemical composition, crystallite size and grain size are known), and fine particle acicular goethite with high axial ratio 8:1 prepared by co-precipitation route were studied using x-ray and neutron diffraction, electron microscopy, Mössbauer spectroscopy and magnetisation measurements. Full profile analysis of diffraction patterns was performed. The results are discussed in the light of previous structural investigations of synthetic and natural goethites reporting on the transitions of goethite to iron oxides.

1.13-3 TSUNAKAWA-SHAW PALEOINTENSITY EXPERIMENTS ON BAKED CLAY SAMPLES TAKEN FROM THE RECONSTRUCTED ANCIENT KILN

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In 1960-1970s systematic oriented-sample collections were made from baked clay at many archeological sites in Japan. Paleomagnetic directions had been intensively measured from these samples. As a next step, we plan

paleointensity measurements from these samples. To test how reliable paleointensity results we can obtain, we have conducted paleointensity experiments on baked clay samples taken from the reconstructed ancient kiln, which was completely imitated to that of an excavated kiln of the 7th century (Nakajima *et al.*, 1974).

The reconstruction experiment was conducted on January 1972 (Nakajima *et al.*, 1974). After the experiment, baked clay was taken from (1) the floor surface and (2) the level 20 cm below the floor, with orientation using plaster. Nakajima *et al.* (1974) conducted partial alternating field (AF) demagnetization up to 20-40 mT on the baked clay samples and reported that mean paleomagnetic directions are generally consistent with the in-situ geomagnetic field measured prior to the reconstruction.

Tsunakawa-Shaw (LTD-DHT Shaw) paleointensity method (Shaw 1974; Rolph and Shaw 1985; Tsunakawa and Shaw, 1994; Yamamoto *et al.*, 2003) mainly utilizes AF demagnetization and it can be applicable to partially AF demagnetized samples in previous. Mini specimens (about 1.7cm cube) cut from 12 baked clay samples were subjected to the Tsunakawa-Shaw paleointensity experiment. Nine results passed selection criteria and they give mean paleointensity and its standard deviation as 45.9 +/- 7.4 micro-T.

Mini specimens giving the nine successful results consist of seven red-colored ones taken from (1) and two gray-colored ones taken from (2). If we exclude results from the two gray-colored specimens, mean paleointensity and its standard deviation results in 46.1 +/- 3.5 micro-T (N=7). The standard deviation becomes smaller. Considering the in-situ geomagnetic field measured prior to the reconstruction (46.4 micro-T), it can be concluded that archeointensity can be estimated by the accuracy within 10 per cent of the mean using red-colored baked clay specimens taken from a kiln floor, with the application of the Tsunakawa-Shaw method.

1.13-4 THE STUDY OF THE DOMAIN STRUCTURE OF NATURAL FERRIMAGNETS HOUGHT THE INSTRUMENTALITY OF MAGNETOACOUSTIC EMISSION.

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The Institute of Geophysics, Ural Branch of the Russian Academy of Sciences was constructed a special equipment complex, which for several years conducted research on the effect magnetoacoustic emission of natural ferrimagnets. When the magnetic samples place in an variable magnetic field, there is a rearrangement of the domain structure at different induction level, which is accompanied by electromagnetic radiation (the Barkhausen noise) and acoustic emission (magnetoacoustic emission). Barkhausen noise quickly fades away in depth because of the electromagnetic type. Unlike the Barkhausen noise, which permits studying only the surface of the sample, acoustic radiation can take information about rearrangement of the domain structure for the entire volume remagnetized. The most clearly difference in the domain structures manifested magnetoacoustic emission of pyrrhotite. Samples are magnetized at a frequency of 0.1 Hz. This frequency was chosen to avoid the echo-impulses. Reception frequency of acoustic signals are from 10 kHz to 150 kHz. Magnetizing field value is changed from - 150kA / m to + 150kA / m. In order to study the anisotropy of the samples were prepared in the form of cubes 24x24x24 mm. Samples of ores magnetite and pyrrhotite of various origins were subjected study. Studies have revealed a definite patterns in the modification of the domain structure associated with the conditions for the formation of different type of rocks and ores. Various conditions the formation of ferrimagnetic minerals affect the shape and amplitude of signals magnetoacoustic emission. The presence in the sample of several generations of natural ferromagnets leads to additional peaks on the curve signal of the magnetoacoustic emission from the magnetizing field. We research the influence of heat up and applied pressure by the magnetoacoustic emission effect.

In addition, has been studied the frequency spectrum of the emitted acoustic signal model, which also provides information on the domain structure. The anisotropy on rock samples gives the information of the magnetic texture of the samples. The presence of the magnetic texture indicates on physical-chemical processes applied to the sample after it is formed. The study of magnetostriction on the same samples allowed to associate the signal amplitude magnetoacoustic emission with magnetostriction.

1.13-5 A PREISACH APPROACH TO COOLING RATE CORRECTIONS: A CASE STUDY THE LATE-ARCHAEOAN MODIPE GABBRO, BOTSWANA

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A Preisach approach to cooling rate corrections: A case study from the late-Archaeoan Modipe Gabbro, Botswana.

During most palaeointensity experiments, the thermoremanence acquisition process is replicated in the laboratory in a known field. The cooling rate of thermoremanence acquisition is known to influence the resultant thermoremanence intensity, and as such it is important to quantify how differences in cooling rate may affect palaeointensity estimations. This is particularly important for intrusive rocks like gabbro, which may have cooling times as long as one million years. Current estimates for cooling rate corrections are based on non-interacting single domain theory for thermoremanence acquisition.

In this paper, we present a Preisach approach to estimating the cooling rate correction, which includes inter-grain interactions. The Preisach distribution is determined through measurement of first-order reversal curve (FORC) data. The new Preisach approach is used to determine the cooling rate correction for each partial thermoremanence during a Thellier-Thellier-Coe palaeointensity estimation: the cooling rate correction is applied before Arai plot analysis, not post as has been the case up until now.

The new approach is applied to a collection of new samples from the 2.78 Ga Modipe Gabbro of Botswana. The magnetic properties of these samples are very favourable, leading to an unusually high success rate and a well-constrained result of 36-40 μT (95% confidence interval). Whereas pure single-domain (SD) corrections often lead to quite large decreases in paleointensity estimates (sometimes exceeding 50%), we find a modest increase of about 10%.

1.13-6 TCRM AND PALEOINTENSITY DETERMINATIONS

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Basaltic samples containing TM with T_c around 300 $^{\circ}\text{C}$ were heated in air in fields (50-100) μT at temperatures T_h between 400 and 500 $^{\circ}\text{C}$ for times as long as 200 hrs with the purpose to impart the TCRM. Products of the oxidation were monitored by thermomagnetic and hysteresis properties measurements completed with the analysis of X-ray spectra obtained on different stages of the reaction. For short runs gradual oxidation of TM to titanomaghemite results in increase of T_c to (450-550) $^{\circ}\text{C}$ and widening spinel X-ray spectral lines. For runs about a few hrs duration near-magnetite SPM grains appear leading to increase of M_s . For longer runs hexagonal phase in X-ray spectra emerges. Pure TCRM and TCRM+pTRM(T_h , T_{room}) acquired under various conditions were subjected to Thellier-type experiments with help of a fully automated vibrating and/or rotating sample thermomagnetometers. The resulting Arai CRM-TRM and TCRM-TRM plots crucially depend on the stage to which the oxidation proceeded. For short runs the Arai plots are mostly nonlinear and show obvious marks of ongoing chemical alterations (single- and/or hetero-phase oxidations). If the hexagonal component is present (exsolution develops), the plots become quite linear over the majority of the TRM blocking temperature range. However, pTRM checks in this case are not perfect when the high T_b are considered and this observation can be used for the detection of possible TCRM presence in practice. An apparent strength of the acquisition field of TCRM inferred from these diagrams is usually underestimated.

1.13-7 TESTING THE SIMPLIFIED CORE-SHELL MODEL IN ASSESSING THE SIZE OF SUPERPARAMAGNETIC MAGHEMITE/MAGNETITE PARTICLES

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Superparamagnetic magnetite/maghemite grains play important role in the studies of various environmental samples. Estimation of their size is of great importance for the interpretation of their origin and fate, as well as environmental conditions at which they evolved. Although scanning electron microscopy gives a good estimate of total grain sizes, its application is rather limited and, for example, does not provide information on relative volume portion of ferrimagnetic particles on total sample volume. Therefore, other physical approaches are desirable. In our contribution, we test a simplified core-shell model based on the assumption of spherical particles composed of superparamagnetic core with induced magnetization determined by Langevin function and para/diamagnetic shell of constant and/or relative thickness. We examined four different samples of synthetic superparamagnetic maghemite, one of them being pure, other two coated by silica, and the last one representing maghemite precipitated within the pores of poly(styrene-co-divinylbenzene) microspheres of narrow grain-size distribution. The model was adjusted to curves of measured induced magnetization by the least-square approach using Excel Data Solver. Our preliminary results suggest that the core-shell model fits well the experimental curves of induced magnetization. Even the limit case of uniquely sized particles can provide a reasonable estimate of the grain size, as compared to that determined using the SEM observations.

1.13-8 HOW DO SPELEOTHEMS BECOME MAGNETIZED? AN ELECTRON MICROSCOPIC AND ROCK MAGNETIC STUDY OF THE MAGNETIC MINERAL ASSEMBLAGE IN SPELEOTHEMS

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Speleothems are an attractive alternative to traditional geomagnetic recorders, due to their continuous deposition, sub-annual resolution, and resistance to alteration. Calcite speleothems, especially stalagmites, have been the subject of paleomagnetic research since the 1970s, demonstrating their ability to record geomagnetic variations at multiple timescales. However, in spite of recent advances in magnetometer technology and a resurgence of interest

in speleothem magnetism, the mechanisms of magnetic recording in stalagmites are still poorly characterized. To address this oversight, we conduct a tandem magnetic and microscopic study of five stalagmites from four caves across the United States, integrating rock magnetic techniques with SEM and TEM analysis of magnetic extracts. Preliminary results show a variety of magnetic mineral assemblages heavily dominated by detrital material, with little (if any) evidence for the precipitation of magnetic grains in situ. The magnetism of samples with flood layers is typically dominated by magnetite and other low-coercivity minerals, while those without flood layers show more significant contributions from goethite. The grain size of magnetic material in speleothems is also controlled by flooding; speleothems with flood layers include magnetic grains ranging from submicron to tens of microns in diameter, whereas those without are typically limited to submicron grains. Microscopic analysis of speleothems both with and without flood layers reveals the presence of titanomagnetites, some with etched exsolution textures, providing evidence for the allochthonous sourcing of magnetic material in cave formations.

1.13-9 ATOMIC SCALE STUDY OF MAGNETIC PHASE TRANSITIONS IN (CO,TI;SC) S

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BaFe₁₂O₁₉ and related isostructural (M-type) hexaferrites derived by single or double cation substitution for Fe³⁺ with preservation of the formal valence are a recognized group of oxides for their remarkable properties. The magnetic interactions may be tuned by suitable substitutions resulting in notable magnetic properties utilized extensively for permanent magnets, microwave devices and perpendicular recording media.

We report on the magnetic structure evolution accompanying the magnetic anisotropy change, from a combined magnetic (SQUID), x-ray and neutron diffraction, and magnetic field dependent ⁵⁷Fe Mössbauer study on BaFe₁₂O₁₉ at selected cation substitutions. The short and long range atomic and magnetic order in powder samples of nanosize particles prepared by soft chemistry routes were studied and compared with own and literature data for the parent BaFe₁₂O₁₉ compound prepared by solid state reaction.

Refinements based on diffraction data show that the magnetic structures of BaFe_{12-x}XxO₁₉ (X=Co,Ti; Sc) hexaferrites are largely temperature and substitution dependent. Between 200 and 300K the (Co,Ti)-hexaferrites (x=0.4, 0.7, 0.8, 0.85) display ferrimagnetic structures where the canting of the magnetic moments depends on the substitution rate. When lowering the temperature the magnetic structure for x=0.45 remains ferrimagnetic down to 10 K, while for x=0.7 and x=0.8 a complex conical magnetic structures is finally established. For x=0.85 significant distortions in the local oxygen surrounding of ferric cation sites were established, while the grain-size effect on the structural parameters was considerably smaller. The thermal expansion coefficient exhibits a strong anisotropy. The refined magnetic moments are considerably lower than the theoretical spin only moments, especially for the 4e and 12k sites, indicating a local noncollinearity with short-range ordering.

The five-cation sublattice collinear ferrimagnetic structure of uniaxial type known as Gorter type for BaFe₁₂O₁₉ remains effective also for BaFe_{10.4}Sc_{1.6}O₁₉ at room temperature and below it down to about 190 K. Below 190 K it gradually transforms into a complex canted structure with spins pointing out of the axial direction so that at 10 K the complex arrangement of magnetic moments could be described in terms of an incommensurate complex block-type conical structure.

1.13-10 THE EFFECTS OF ANISOTROPIC AND NON-LINEAR TRMS ON THELLIER-TYPE PALEOINTENSITY DATA

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A recently developed stochastic model of single domain (SD) paleointensity behaviour is expanded to investigate the effects that anisotropic and non-linear thermoremanent magnetizations (TRMs) have on the paleointensity results and the parameters used to select data. The model results indicate that before applying any form of correction these non-ideal factors can produce results that are self-consistent, but highly inaccurate. The methods that are currently used to correct for anisotropic and non-linear TRMs are effective and greatly increase the likelihood of obtaining accurate results. The corrections, however, do not restore the results to those of ideal SD samples measured with the same laboratory-to-ancient field ratio, but the data are restored to those of ideal SD samples with the equivalent laboratory-to-ancient magnetization ratios (MLab/MAnc). The simulations indicate that non-linear and anisotropic TRM have no or only a weak influence on the parameters commonly used to select paleointensity data, which means that these non-ideal factors are effectively undetectable. Given the high self-consistency and highly inaccurate results that anisotropic and non-linear TRM can yield, it is essential to test for such effects and all Thellier-type paleointensity studies must include tests for anisotropic and non-linear TRM to assert the reliability of the data obtained.

1.13-11 HYDROSTATIC PRESSURE EFFECT ON MAGNETIC HYSTERESIS PARAMETERS OF MULTIDOMAIN MAGNETITE: IMPLICATION FOR CRUSTAL MAGNETIZATION

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To investigate the source of magnetic anomalies observed on the Earth and planets, it is necessary to understand the magnetic properties of deep crustal rocks. Magnetic hysteresis parameters (saturation magnetization, M_s ; saturation remanence, M_{rs} ; coercivity, B_c ; coercivity of remanence, B_{cr}) provide the fundamental information concerning magnetic behaviors. Especially, these parameters are related to the relaxation time of remanent magnetization, which is poorly understood with respect to the deep crustal rocks. Since pressure and temperature increase with depth, it is crucial to evaluate their effects on the hysteresis parameters. However, there have been few studies conducting the in-situ hysteresis measurement under hydrostatic pressure because of the difficulty in experimental techniques. In the present study, using a high-pressure cell specially designed for a Magnetic Property Measurement System (MPMS), we have conducted the in-situ magnetic hysteresis measurements on multidomain (MD) magnetite under high pressure up to 1 GPa. With special attention to hydrostatic condition and sample preparation, pressure dependences of its magnetic hysteresis parameters are revealed as follows: (1) B_c monotonically increases with pressure at a rate of +91 %/GPa, (2) M_s is constant under high pressure up to 1 GPa, and (3) the changes in ratios M_{rs}/M_s and B_{cr}/B_c correlate with each other, resulting in systematic movement of data point in the Day plot. Taking into account new results of the pressure dependences, we quantitatively estimate change in the relaxation time of magnetic remanence with depth for MD magnetite. Our estimate suggests that the relaxation time monotonously decreases with depth in the continental crust, and a preexisting remanence must be overwritten by a viscous remanent magnetization acquiring over the Brunhes epoch. In the continental areas, it is suggested that MD magnetite in deep crustal rocks can contribute to a source of magnetic anomaly mainly in viscous and induced magnetization, which is parallel to the present ambient geomagnetic field direction.

1.13-12 MAGNETIC CHARACTERIZATION OF SYNTHETIC TITANOMAGNETITES

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We report the characterization of synthetic igneous rock analogues, to assess their ability to record the geomagnetic field. The titanomagnetite-rich samples were synthesized using the glass-ceramic method, under carefully selected conditions so that they are abundant in pseudo-single domain material, very much like those found within igneous rocks. Various methods have been used to characterise the samples including: in situ XRD, the TEM technique of off-axis electron holography, various high- and low- temperature magnetic techniques including first-order reversal curve (FORC) analysis. Their response to synthetic Thellier-Thellier-Coe palaeointensity investigation is also reported.

SESSION 2.1

EQUATORIAL SPREAD-F AND F3-LAYER STUDIES DURING GEOMAGNETIC QUIET AND DISTURBED PERIODS

2.1-1 RECENT DEVELOPMENTS IN THE UNDERSTANDING OF F3 LAYER

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A brief review of the physical mechanisms and observations of an additional stratification of the daytime equatorial F region, called the F3 layer, under magnetically quiet and active conditions is presented. Following this, the paper reports the first simultaneous observations of the F3 layer and vertical ExB drift velocity made in an Indian station Gadanki (6.50 mag. lat) during the low solar activity period 2008-2009, and SUPIM. The observations confirm the frequent occurrence of the F3 layer in summer months compared to winter months; the layer is also clear and distinct in summer though such layer occurs occasionally in winter also. In addition to a threshold ExB velocity, its time integrated value is found to be important in the formation of the F3 layer. The model results qualitatively reproduce the observations; and show that irrespective of season the formation of the F3 layer is centered on that side of the equator where equatorward neutral wind reduces the downward field-aligned flow of plasma, and the latitude band of the layer can extend to the opposite hemisphere, especially when the upward ExB velocity is large.

2.1-2 IS THE EQUATORIAL PLASMA BUBBLE MORE STRUCTURED AT THE TOP THAN NEAR THE EQUATORIAL F LAYER PEAK

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Observation of significant L-band scintillations near the crest of the equatorial ionization anomaly (EIA) region, when L-band scintillations are absent in the dip equatorial region, although strong scintillations on a VHF signal are recorded there, has been attributed to the higher ambient plasma density near the EIA crest. This was demonstrated theoretically by considering intensity scintillations produced by Gaussian irregularities, and it was concluded that the coherence time scale computed from VHF scintillation data could be used to represent the strength of the irregularities when scintillations were saturated ($S_4 \approx 1$). However, consideration of irregularities with a power-law spectrum shows that the coherence scale of the ground scintillation pattern of intensity for saturated scintillations is strongly dependent on the irregularity spectrum. Recorded scintillations are an integrated effect of all the irregularities in the path of the signal, with maximum contribution from the F layer peak. Here it is explored whether the evolution of the irregularity spectrum in the magnetic east-west direction, near the equatorial F layer peak plays a role in the absence of L-band scintillations in the dip equatorial region. The coherence scale and also the random velocity, which is a measure of the decorrelation of spaced receiver signals, are computed from equatorial spaced receiver measurements of intensity scintillations on a VHF signal transmitted from a geostationary satellite, to study the evolution of intermediate scale (~100 m to few km) structure in equatorial plasma bubbles (EPBs) near the F peak region, under different ambient conditions. Results show that for saturated scintillations on the VHF signal, the intermediate scale irregularity power-law spectrum attains its shallowest form after 22 LT, when the spaced receiver signals are generally well correlated on magnetically quiet days. A possible explanation for the observation of fairly strong L-band scintillations near the EIA crest before 22 LT, could be that the equatorial irregularities that map down to the EIA crest region are present near the top of the EPBs, where ion-neutral collisions are infrequent and inertial effects dominate, resulting in an irregularity spectrum, which is shallower than that near the equatorial F layer peak.

2.1-3 SPORADIC E-LAYER AND EQUATORIAL SPREAD-F: ARE THEY CONNECTED?

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The equatorial spread-F is a manifestation of the plasma irregularities that occur in the equatorial F region. The spread-F development is strongly connected to the post sunset rise of the F-layer due to the eastward electric field enhancement from F-region dynamo and to the strong gradients in conductivity that are set at the sunset terminator. The sporadic E-layers at low-latitudes are formed mainly due to the action of electric fields and winds. The winds and electric fields present around sunset can affect the sporadic E-layers development, which, in turns, can modify the ambient conductivity. The possible connection between sporadic E-layers and equatorial spread-F has been addressed in some works in the literature and sometimes they are controversial. Some of these works will be reviewed and model results will be used in order to try to explain the observational results and to better understand the physics involved in the process.

2.1-4 ESF OCCURRENCE OVER TIRUNELVELI AT LOW SOLAR ACTIVITY IN 2007-09

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Equatorial spread F (ESF) shows large variation in day-to-day, seasonal, solar cycle and magnetic activity dependent occurrence. The current study presents the occurrence characteristics of ESF over the Indian equatorial station Tirunelveli (8.7°N, 77.8°E, dip latitude 0.6° N) using CADI ionogram data for the extremely prolonged solar minimum period during 2007-2009. The ionograms used are recorded at 15 minute interval. Preliminary investigation of the data reveals anomalous peaks in the monthly percentage occurrence of ESF during winter months. In addition to this, some of the usual equinoctial month peaks are found to be missing. Comparison of h_pF variation on ESF and non-ESF nights doesn't show any regular pattern. The study looks at the possible reasons of this anomaly.

2.1-5 ON THE ROLE OF LSWs AND PSSR IN TRIGGERING OF ESF - A STATISTICAL STUDY BASED ON DIP EQUATORIAL OBSERVATIONS FROM INDIA

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Cause of day-to-day variability in the occurrence of equatorial spread-F (ESF) continues to be a challenging and interesting low latitude aeronomy problem. Among the factors contributing to the triggering of ESF, Post sunset rise (PSSR) of bottom side F-region due to pre-reversal enhancement of electric fields is long believed to be very

important. Recently, the role of large scale wave-like structures (LSWS) in triggering of the equatorial spread F is gaining wider attention. In this study we examine the importance of both LSWS and PSSR in triggering of ESF based on ionosonde observations made from dip equatorial site Tirunelveli (8.7°N; 77.8°E; 1.1° dip latitude). Ionospheric soundings were carried out at 5 minute cadence between March 2008 and February 2009. We utilize this data to study the presence of ESF, strength of PSSR and precedence of LSWS before ESF onset. LSWS is identified with the help of satellite traces in ionograms. The study shows that PSSR is not a controlling factor in the formation of ESF, at least during solar minimum conditions. In addition, the study reveals that the LSWS do not trigger ESF whenever it is present. There are several occasions in which LSWS signatures are observed without subsequent formation of ESF. This implies that the onset of ESF is a complex phenomenon whose prediction requires information on parameters other than PSSR and LSWS.

2.1-6 LONGITUDINAL STATISTICS OF THE TOPSIDE IONOSPHERE PLASMA BUBBLES: POSSIBLE EFFECT OF THE SOLAR THERMAL TIDES

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He⁺ density depletions, considered as originating from equatorial plasma bubbles, are involved in this study. They are usually detected in the topside ionosphere (~1000 km) deeply inside the plasmasphere ($L \sim 1.3-3$) [Sidorova, ASR, 2004, 2007].

(a) He⁺ density depletions were considered in connection with equatorial F-region irregularities (EFI), equatorial F-spread (ESF) and equatorial plasma bubbles (EPB). Their longitudinal statistics, calculated for all seasons and both hemispheres (20°S-90°N), were compared with EFI statistics taken from AE-E [McClure *et al.*, JGR, 1998], OGO-6 [Basu *et al.*, RS, 1976], ROCSAT [Su *et al.*, JGR, 2006] observations. ESF, EPB statistics taken from [Maruyama, Matuura, JGR, 1984; Watanabe, Oya, JGG, 1986] based on ISS-b and Hinotori data were also used for comparison. It was revealed that the main statistical maxima of the equatorial F-region irregularities are well enough reflected in the statistical plots of the He⁺ density depletions (PHe⁺) of the both hemispheres. The best conformity was obtained for equinoxes, the worst one - for solstices, when the most dramatic insolation differences take place in the different hemispheres. It was validated once again that He⁺ density depletions may be considered as an indicator of topside plasma bubble presence or as fossil bubble signatures [Sidorova and Filippov, JASTP, 2012].

(b) The most of the PHe⁺ plots have wave-like structure with well-defining four peaks. The peaks are the most pronounced in the NH during March equinox/December solstice and in the SH during March equinox/June solstice. Similar wave number 4 longitudinal structure has recently been found in the low-latitude ionosphere density distribution [*e.g.*, Immel *et al.*, GRL, 2006; England *et al.*, GRL, 2006; Jin *et al.*, JGR, 2008; Fang *et al.*, JGR, 2009]. It is assumed that the longitudinal plasma density variations appear due to the modulated vertical \times drift. It is supposed that solar thermal tides excited in the troposphere induce zonal perturbation electric fields, which are added to the background F-region dynamo field, modulating the ionosphere fountain process. According to [Immel *et al.*, GRL, 2006, Kil *et al.*, JGR, 2008] the 4-peaked density structure is also observed in the topside ionosphere during the day and at night some seasons. If the hypothesis about an equatorial origin of He⁺ density depletions is true, we can suppose that such 4-peaked structure projected to the topside ionosphere are reflected in the longitudinal statistics of the topside ionosphere plasma bubbles seen as He⁺ density depletions. Perhaps this idea can be very useful for explanation of the obtained results.

2.1-6 ON THE CHARACTERISTICS OF METER-SCALE F-REGION IRREGULARITIES OBSERVED BY THE SAO LUIS RADAR DURING LOW SOLAR FLUX CONDITIONS

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The 30 MHz coherent backscatter radar installed in the equatorial observatory of Sao Luis, Brazil (2.59 deg. S, 44.21 deg. W, -2.35 deg. dip lat) has been in operation since December 2000. The radar has allowed observations of 5-meter scale size equatorial E- and F-region irregularities in the Eastern American Sector. Recently, in August 2010, we made a few small but significant changes in the data acquisition system used to collect the observations made by the Sao Luis radar. These changes allowed more continuous observations than previously possible. For instance, full 24-hour continuous soundings were made for the first time by the Sao Luis system. The changes also allowed a more efficient/quicker analysis of the measurements. In this presentation we will describe results of our analysis of the measurements of F-region irregularities made by the Sao Luis radar between August 2010 and February 2012, a period of relatively low solar activity conditions. We will describe the seasonal variability in the generation, vertical development, and lifetime of the quiet-time irregularities observed by the Sao Luis radar. Our analysis of the variability is aided by measurements of ionospheric vertical plasma drifts near the Sao Luis site made by the IVM (ion velocity meter) instrument onboard the C/NOFS satellite.

2.1-8 STRATIFICATION OF THE LOW-LATITUDE AND NEAR-EQUATORIAL F2 LAYER:**Klimenko, M.; Karpachev, A.; Klimenko, V.; Zhao, B.; Nosikov, I.**WD Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radiowave Propagation (IZMIRAN); IZMIRAN;
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A large number of researches have been devoted to the occurrence of additional layers in the F region of the equatorial ionosphere. The occurrence of such layer was originally named as stratification of equatorial F2 layer. The additional layer above regular F2 layer later was renamed as the F3 layer. The physical mechanism of the F3 layer formation is clearly formulated for the morning-noon period in the near-equatorial region. The theoretical researches have shown that in this case the F3 layer is formed by $E \times B$ vertical plasma drift with assistance of meridional component of thermospheric wind and field-aligned plasma diffusion. However, as has been shown in the recent publications, the stratifications of the F2 layer is also observed at other local times. This report presents a brief review of the additional layer researches, and describes the current progress of these researches. The characteristics of the F2 layer stratification and its dynamics have been greatly clarified by recent observations and model studies, but there are still several remaining questions. One such big question regards the seasonal, latitudinal, and longitudinal dependence of the F3 layer. The second problem needing to be clarified is the relationship between the topside ledge and ground-based F3 and F1.5 layers. One of the interesting issue is the occurrence of the multilayer pattern in vertical profiles of electron density. Another important question concerns the formation mechanisms of the F2 layer stratification in quiet and storm-time period at different local times. In addition we need to clarify the relationship between the every process in the lower atmosphere and the occurrence probability of the F2 layer stratification and its development. We would briefly consider all these issues in our report.

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2.1-9 FORMATION PATTERN OF THE F3 LAYER AT CHINA'S SOUTHERNMOST STATION SANYA**Zhao, Biqiang; Wan, Weixin; Ning, Baiqi**

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In southernmost of China Sanya (dip latitude 12.6°N), inside the equatorial ionospheric anomaly (EIA) region, A DPS-4D digisonde has been equipped and operated since April 2011. Here we report some new features regarding the low latitude F2 layer stratification based on the 2-year Sanya data. First, the well-known F3 layer mechanism at low latitude near the magnetic equator proposed by Balan *et al.* [1995], is due to combination of zonal electric field and summer-to-winter meridional wind. While at Sanya, quite considerable cases of the F2 layer stratification was due to the upward gravity waves (GWs) propagation which was also observed at EIA region by Fagundes *et al.* [2007] in Brazil. Thus both the electric field and GWs should be considered in producing the F2 layer stratification at Sanya. Second, the distribution of two formation patterns (pattern A and pattern B are defined with increasing F3 peak density and with nearly constant or decreasing F3 peak density respectively as the peak moving upward around the onset of the F3 layer's occurrence) of the F3 layer is investigated based on statistics of formation patterns of the F3 layer in Sanya and Kwajalein (3.8°N) in 2011. The ideal equinoctial distribution (without the summer-to-winter neutral wind) of those patterns is symmetrical about magnetic equator with pattern A in magnetic low-latitude region and pattern B near magnetic equator. When taking the summer-to-winter neutral wind which helps plasma resist (enhance) diffusion to higher latitude in the windward (leeward) into consideration in a solstice, pattern A could be observed near magnetic equator in summer hemisphere and pattern B in magnetic low-latitude region in winter hemisphere compared with the ideal distribution in the equinox.

2.1-10 VHF RADAR OBSERVATIONS OF THE F-REGION FIELD-ALIGNED IRREGULARITIES OVER INDONESIA**Otsuka, Y.; Shiokawa, K.; Nishioka, M.; Effendy**

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A VHF backscatter radar with operating frequency 30.8 MHz has been operated at Kototabang (0.20°S, 100.32°E; dip latitude 10.4°S), Indonesia, since February 2006. We analyzed F-region field-aligned irregularities (FAIs) observed by this radar from February 2006 to December 2012, and found that FAIs appeared frequently at the post-midnight sector between May and August during a solar minimum period. Five-beam measurements by the radar revealed zonal propagation of the F-region FAIs. The present paper reports statistics of the zonal propagation velocity of the post-midnight FAIs. Between May and August, 46% (14%) of the post-midnight FAIs propagated westward (eastward), and zonal propagation was not discernible for 40% of the post-midnight FAIs. Average velocity was approximately 50 m/s westward. The post-midnight FAIs were likely associated with either plasma bubbles or medium-scale traveling ionospheric disturbances (MSTIDs).

2.1-11 SAMI3/ESF MODEL STUDIES USING THREE APPROACHES FOR ELECTROSTATICS**Aveiro, H.C.; Huba, J.D.**U.S. Naval Research Laboratory
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We present a study of the evolution of equatorial F region irregularities using the NRL SAMI3 model. Three different solutions for the ionospheric electrostatic potential are used: (a) one based on the equipotential magnetic field line approach, (b) a 3-D solution with no forcing along the magnetic field, and (c) a full 3-D solution. The results show that the generalized Rayleigh-Taylor instability, which has maximum growth rate near the F peak, is not affected by the choice of approach for the potential solution. However, differences are observed in the plasma flows at the bottomside of F region, where the collisional-shear instability plays a major role, pointing out that 3-D effects are important during the first stages of evolution of equatorial F region plasma irregularities.

2.1-12 F3-LAYER FORMATION DUE TO DOWNWARD MOVEMENT OF F LAYER PLASMA**Nayak, C.K.; Bhattacharyya, A.; Kakad, B.; Sripathi, S.; Emperumal K.**

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In the paper we present the observations of ionospheric F3 layer occurrence over equatorial station Tirunelveli (77.8 E, 8.7 N, dip lat. 0.7 N) under extremely prolonged low solar activity period during 2007-2009. The diurnal and seasonal dependence of the F3 layer has been investigated along with the solar activity dependence. As suggested by Balan *et al.* (1998), the F3 layer mainly occurs in the pre-noon period due to the combined effect of vertically upward $E \times B$ drift and the equatorward neutral wind. In this paper we report the behavior of F3 layer occurrence with respect to the equatorial electrojet (EEJ). It is found that the layer occurs preferably during the time when the EEJ attains the peak value of the day. This can be explained on the basis that the EEJ can be used as a proxy for the eastward electric field. So when EEJ attains its maximum value, the eastward electric field is in increasing phase and so is the vertically upward $E \times B$ drift. So this creates a favorable condition for the formation of the F3 layer. But this may not be entirely true during the afternoon period. During the afternoon periods, the F3 layer has been observed to occur in the presence of counter electrojet (CEEJ) which corresponds to westward electric field and hence downward $E \times B$ drift. At the same time the height of the F3 layer is found to move downwards. So this points towards the possibility that the F3 layer is formed due to the vertically downward movement of the plasma instead of the usual upward movement. This is a first report of F3 layer formation due to the downward movement of plasma. But such a behavior is observed only during afternoon period and not in the morning period. This may be due to the fact that the afternoon ionosphere is relatively broader as compared to the prenoon ionosphere. A more detailed study is presented in the paper.

2.1-13 EQUATORIAL AND LOW LATITUDE SPREAD-F IN THE BRAZILIAN SECTOR.**Fagundes, P.R.; de Abreu, A.J.; de Jesús R.**

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Spread-F at equatorial and low latitude is usually related with large-scale equatorial irregularities. These large-scale equatorial irregularities are generated in the bottom side of the equatorial F-region just after sunset and are nearly aligned along the Earth's magnetic field lines. As soon as irregularities reach higher altitudes in the equatorial region, they grow poleward, due to the high conductivity along the Earth's magnetic field. Then, after sometime, these irregularities can be observed at low latitude. In this work we show the importance of taking into account the planetary wave effects on the modulation of the F-region postsunset height rise during the electric field pre-reversal enhancement (PRE) and consequently on the generation and evolution of large scale ionospheric irregularities.

2.1-24p ZONAL IONOSPHERIC PLASMA DRIFTS IN BRAZILIAN SECTOR DURING THE LAST EXTREME LOW SOLAR ACTIVITY**Coelho, Flavia Elaine; Abalde, José Ricardo; Fagundes, Paulo Roberto; de Jesús Rodolfo; Sahai, Yogeshwar; Pillat, Valdir**

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Transequatorial F region plasma bubbles are large-scale ionospheric depleted regions that develop in the bottomside of equatorial F region due to plasma instability processes. All-sky imaging observations of the OI 630.0 nm nightglow emissions were done at low-latitude region (Sao Jose dos Campos 23.21°S, 45.86°W; dip latitude 17.6°S - hereafter SJC) and near equatorial region (Palmas 10.28°S, 48.33°W; dip latitude 6.7°S - hereafter PAL), Brazil, during the years 2008 and 2010, a period of extremely low solar activity (LSA). Because the OI 630.0 nm emission results from excitation mechanisms by dissociative recombination of $O_2^+ + e^- \rightarrow O + O^*(1D)$ and afterwards $O^*(1D) \rightarrow O(3P) + h\nu(630.0 \text{ nm})$ this emission is closely related with electronic density and consequently with the ionospheric electrodynamic. In this work we present and discuss the nighttime F region zonal plasma drift velocities inferred

using OI 630.0 nm emissions imaging, during the occurrence of a plasma bubble. We investigated the nighttime zonal plasma drift variations using fixed emission peak altitudes at 280 km, used by earlier investigators, as well as emission peak altitudes based on simultaneous ionospheric sounding observations for both observatories. The nighttime pattern is similar to those observed during high solar activity (HSA). However, the maximum and minimum zonal plasma drift are lower than those observed during HSA. In addition, the zonal plasma drift was calculated using two different methodologies, fixed height (280 km) and variable height (based on ionosonde data measurements). The maximum and minimum average zonal plasma drift velocities using fixed emission peak altitudes for SJC are 119 ± 6 m/s and 58 ± 10 m/s and for PAL are 111 ± 5 m/s and 85 ± 10 m/s. The peak emission height based on simultaneous ionospheric observations for SJC are 116 ± 7 and 57 ± 15 m/s and for PAL are 119 ± 6 and 58 ± 10 m/s, respectively.

2.1-25p INVESTIGATION OF IONOSPHERIC RESPONSE TO TWO MODERATE GEOMAGNETIC STORMS USING GPS-TEC MEASUREMENTS IN THE SOUTH AMERICAN AND AFRICAN SECTORS DURING THE ASCENDING PHASE OF SOLAR CYCLE 24

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In this paper, responses of the ionospheric top-side parameter during two moderate geomagnetic storms have been investigated. The first moderate geomagnetic storm around 1500 UT on 02 May, 2010 has a Dst index value of -64 nT and on 29 May, 2010, the second moderate geomagnetic storm Dst index at 1400 UT was -85 nT. One of the moderate storms that occurred on 28 May, 2010 was later characterized by a smaller intensity of geomagnetic storm during ascending phase of the solar cycle 24. The responses of vertical total electron content (VTEC) and phase fluctuations (in TECU/min) from Global Positioning System (GPS) observations due to these disturbances (geomagnetic storms), covering from the equatorial to mid-latitude regions in the South American and African sectors were investigated. The results obtained during these two moderate geomagnetic storms from both sectors show an expressive positive phase at the equatorial, low- and mid-latitude regions. The wind extreme movement towards the equator and the electric field strength were strong indicating mechanisms responsible for these expressive positive phases at these regions. The traveling ionospheric disturbances (TIDs) were also observed to contribute similar mechanical effects as the wind moves toward the equator. A pre-storm event was observed at African sector from low- to the mid-latitude regions on 01 May, 2010. Our results reveal that geomagnetic storm from 02 to 04 May, 2010 suppresses equatorial ionospheric irregularities.

2.1-26p A COMPUTATIONAL TOOL FOR IONOSONDE CADI'S IONOGRAM ANALYSIS

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The purpose of this work is to present a new computational tool for ionogram generated with a Canadian Advanced Digital Ionosonde (CADI). This new tool uses the fuzzy relation paradigm to identify the F trace and from this form extract the parameters foF2, h0F, and hpF2. The tool was very extensively tested with ionosondes that operate at low latitudes and near the equatorial region. The ionograms used in this work were recorded at São José dos Campos (23.21 S, 45.91 W; dip latitude 17.61 S) and Palmas (10.21 S, 48.21 W; dip latitude 5.51 S). These automatically extracted ionospheric parameters were compared with those obtained manually and a good agreement was found. The developed tool will greatly expedite and standardize ionogram processing. Therefore, this new tool will facilitate exchange of information among many groups that operate ionosondes of the CADI type, and will be very helpful for space weather purposes.

2.1-27p EFFECTS OBSERVED IN THE EQUATORIAL, LOW-, MID- AND HIGH-LATITUDE F REGION IN THE AMERICAN SECTOR DURING THE INTENSE GEOMAGNETIC STORM ON 26 AND MODERATE GEOMAGNETIC STORM ON 27-28 SEPTEMBER 2011 AND COMPARISON WITH THE GSM TIP MODEL RESULTS

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We present studies on geomagnetic disturbance effects and the corresponding responses of the ionospheric F-region at the American sector, during the intense storm event occurred on 26 September, 2011, which was followed by another moderate geomagnetic storm on 27-28 September 2011. In this work, we have used F-region ionospheric parameters such as the critical frequency (foF2) and the minimum virtual height (h'F) from ionograms

registered at São José dos Campos station (SJC, 23.2° S, 45.9° W; dip latitude 19.1° S; a low-latitude station located under the Southern crest of the Equatorial Ionization Anomaly), Brazil, and Estação Antártica Comandante Ferraz (EACF, 62.1° S, 58.4° W; dip latitude 37.8° S; a high-latitude station), Antarctica. We also present data from ionosonde stations at Jicamarca (JIC; 12.0° S, 76.8° W, dip latitude 0.13° S; equatorial station), Peru, and Port Stanley (PST; 51.6°S, 57.9°W, dip latitude 31.5°S; mid-latitude station), UK. The GPS observations from 16 receiver stations spread over the American sector were used to obtain the measurements of the Vertical Total Electron Content (VTEC) and phase fluctuation (rate of TEC). In addition, these data sets are also compared with simulations obtained with the Global Self-Consistent Model of the Thermosphere, Ionosphere and Protonosphere (GSM TIP). The using of GSM TIP model allowed us to investigate the role of different formation mechanism of ionospheric response on geomagnetic storms. Salient features from these observations will be presented and discussed.

SESSION 2.2

DIV II/ICMA ELECTRODYNAMICS AND ENERGETICS OF THE MIDDLE ATMOSPHERE AND LOWER THERMOSPHERE: THE LOCAL AND GLOBAL PICTURE

2.2-1 TIDAL SIGNATURES IN MIDDLE ATMOSPHERE TEMPERATURE DATA OBTAINED BY LIDAR

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Tidal waves play an important role in coupling of the lower and upper atmosphere. At the mid-latitude station of Kühlungsborn/Germany (54°N, 12°E) we combine a new RMR lidar for continuous, day and night, temperature soundings in the mesosphere with a K lidar for temperature soundings in the mesopause region. By this, temperature tidal amplitudes and phases can be measured in the altitude range of 40-100 km. Soundings are performed on a routine basis since March 2011 with some additional data in summer 2010. For tidal analysis about 100 h (~4 days) of temperature data are required for suppression of gravity wave effects and retrieval of tidal parameters. Case studies during clear sky periods allow examination of short-term tidal variability. During less favourable weather conditions a composite of all observations within a particular two or four week period is formed to derive the average tidal wave structure. During most of the year we found a dominating diurnal variation in the lower mesosphere (~1–2 K), while in the mid-mesosphere (65–70 km) diurnal, semi- and terdiurnal variation all have amplitudes of ~1–2 K. Around 90 km altitude again the diurnal variation is typically dominating with amplitudes of ~6 K in the monthly average. Short-term amplitudes in the whole mesosphere are partly much higher, especially for the terdiurnal variation.

We will show some examples of lidar temperature soundings during day and night. A first seasonal variation of diurnal, semi- and terdiurnal wave amplitudes and phases in the mesosphere will be presented. The observations are compared with results of the MERRA re-analysis dataset. Furthermore we will discuss the effect of temperature variation on the diurnal and semidiurnal variation of noctilucent cloud (NLC) occurrence rates observed simultaneously at our mid-latitude site.

2.2-2 FIRST RESULTS OF POTASSIUM DENSITY AND TEMPERATURE PROFILES BY A RESONANCE SCATTERING LIDAR FOR ANTARCTIC OBSERVATION

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The National Institute of Polar Research (NIPR) is leading a six year prioritized project of the Antarctic research observations since 2010. One of the sub-project is entitled "the global environmental change revealed through the Antarctic middle and upper atmosphere". Profiling dynamical parameters such as temperature and wind, as well as minor constituents is the key component of observations in this project, together with a long term observations using existent various instruments in Syowa, the Antarctic (39E, 69S). As one of instruments in this project, we are developing a new resonance scattering lidar system with multiple wavelengths and plan to install and operate it at Syowa (69S), Antarctica. The lidar transmitter is based on injection-seeded, pulsed alexandrite laser for 768-788 nm (fundamental wavelength) and a second-harmonic generation (SHG) unit for 384-394 nm (second harmonic wavelength). The laser wavelengths are tuned in to the resonance wavelengths by a wavemeter that is well calibrated using a wavelength-stabilized laser. The lidar will measure temperature profiles using resonance scatter of atomic potassium (K, 770 nm) and density variations of minor constituents such as atomic iron (Fe, 386 nm) and K, calcium ion (Ca⁺, 393 nm), and aurorally excited nitrogen ion (N₂⁺, 390-391 nm). Currently, the laser pulses are transmitted with approximately 120 mJ/pulse at 25 Hz and the backscattered signal is received with a 35 cm diameter telescope. We got the first light from the K layer on January 28, 2013 and have started test operation to measure K density and temperature profiles at NIPR in Japan. We will show the primary observation results and discuss nightly variations of K density and temperature profiles.

2.2-3 STEP-LIKE AND LONG RECOVERY EARLY VLF PERTURBATIONS CAUSED BY**Haldoupis, Christos**

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Sub-ionospheric VLF (very low frequency) recordings are investigated in relation with intense cloud to ground (CG) lightning data. The study identified a new early-type VLF signature that is due to long-lasting ionization changes in the uppermost D region ionosphere caused by powerful \pm CG lightning electromagnetic pulses (EMP), which are also known to generate elves. The perturbations appear in narrowband VLF signal amplitudes as abrupt jumps which usually show no imminent recovery thus offsetting the signal level for long times (often > 30 min), while in other cases they can gradually recover back to pre-onset levels within times ranging from several to many minutes. These events are seen when VLF transmissions in the Earth-Ionosphere waveguide pass in the vicinity of thunderstorms that produce lightning strokes carrying very intense peak-currents. The perturbations are triggered instantly (early) by either a positive or negative polarity discharge of a large CG peak current (usually > 250 kA) when the discharge is located within ~ 250 km from the great circle path (GCP) of a VLF transmitter-receiver link. The probability of occurrence increases with lightning stroke intensity, and approaches unity for (rare) discharges with peak currents higher than ~ 300 kA. These phenomena occur during nighttime, when ionospheric conductivity is low and thus VLF reflection occurs in the uppermost D region, and preferentially during winter when strong \pm CG discharges are more frequent and more intense. This new signature is the VLF fingerprint of elves, apparently because powerful EMPs emitted by \pm CG discharges can energize free electrons to impact on neutrals and produce both airglow emissions (elves) and ionization changes in the upper D and lower E region ionosphere.

2.2-4 REANALYSIS OF ROCKET-BORNE TURBULENCE MEASUREMENTS USING 100 M RESOLUTION SPECTRAL MODEL TECHNIQUE.**Szewczyk, Artur; Strelnikov, Boris; Luebken, Franz-Josef; Rapp, Markus**

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In the last decades a series of sounding rockets was launched at high northern latitudes to investigate the mesosphere and lower thermosphere (MLT) region. Among other things the payloads were equipped with the TOTAL (the name emphasizes that total number densities are measured) or CONE (COMbined measurements of Neutrals and Electrons) instruments to measure neutral air density with very high precision and spatial resolution. The CONE measurements allow us to analyze tiny relative density fluctuations of ~ 0.05 % magnitude at very small spatial scales of a few centimeters. Spectral analysis of those small-scale density fluctuations allows us to derive turbulent energy dissipation rates based on a spectral model technique. Results of in-situ turbulence measurements up to the years 1997 and 2001 were published by Luebken 1997 and Luebken et al. 2002 for winter and summer seasons, respectively. All those data were analyzed using a spectral model technique based on Fourier spectral analysis which yielded energy dissipation rates with an altitude resolution of 1 to 5 km.

In recent years, a new spectral analysis tool, the wavelet analysis, has increasingly been applied to get insight into the temporal and spectral evolution of geophysical phenomena. An advanced spectral model technique based on the wavelet analysis of the measured density fluctuations yields energy dissipation rates with an altitude resolution of ~ 100 m. We have performed a reanalysis of the old density fluctuations data using the new technique and increased the turbulence measurements database by adding results of 12 new rocket soundings.

In this paper we show the new results of turbulence measurements in the MLT region and discuss new geophysical implications. Some of the findings include: turbulence is highly intermittent, most of the turbulence layers are much thinner than 1 km, turbulent energy dissipation rates are highly variable both in winter and summer. Also, localized values of the dissipation rates of thin turbulence layers can exceed those derived by the conventional technique by several orders of magnitude.

2.2-5 PROPERTIES OF TRAINS OF PRELIMINARY BREAKDOWN PULSES OCCURRING PRIOR TO THE FIRST STROKE OF NEGATIVE CLOUD-TO-GROUND LIGHTNING**Kolmasova, Ivana; Santolik, Ondrej; Uhlir, Ludek; Lan, Radek**

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We study the characteristics of the trains of preliminary breakdown pulses (PBP) occurring prior to the first return strokes of negative cloud-to-ground lightning discharges. These trains are believed to be connected with initial breakdown processes, but it is not understood yet how these pulses are generated. Several conductive channels are probably formed inside the cloud during the preliminary breakdown. One of the channels evolves in the stepped leader. The train of PBP could then identify the beginning of the stepped leader development. The detailed analysis of the train properties can therefore contribute to our understanding of the lightning initiation. We measure

waveforms of the magnetic-field derivative using a newly developed broad-band analyzer with a sampling interval of 12.5 ns. The analyzed frequency band goes from 5 kHz to 37 MHz. We use numerically integrated waveform records for the analysis of the properties of the trains. Our dataset consists of 17 trains of magnetic-field preliminary breakdown pulses measured during one single thunderstorm, which occurred close to Rustrel, France in October 2012 and lasted about three hours. Observed trains of PBP were followed by return strokes. The lightning detection network METEORAGE identified these return strokes as negative cloud-to-ground discharges located at a distance of 14-57 km from the receiving station. We estimate the duration, the number of pulses and the inter-pulse intervals for each individual train. We calculate the ratio between the amplitude of the largest pulse in the train and the peak of the following return stroke. We estimate also the time distance between the last pulse in the train and the peak of the following return stroke. We study the variability in the pulse shapes and the occurrence of different types of pulses in different parts of the train.

2.2-6 TLE OBSERVATIONS IN BRAZIL AND THE DEVELOPMENT OF THE LEONA NETWORK IN SOUTH AMERICA

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South America's combination of intense thunderstorm activity and geomagnetic characteristics creates a unique natural laboratory for investigating a variety of atmospheric phenomena and their possible coupling. Its large latitudinal extent, from ~12° N to ~55° S, encompass equatorial, tropical and subtropical regions with meteorological conditions that makes South America the second most active thunderstorm and lightning, and consequently one of the most active Transient Luminous Events (TLEs) region of the globe. TLEs are optical emissions from transient plasma discharges excited in the upper atmosphere by the electromagnetic field of underlying lightning flashes from thunderstorms. Since 2002, five different campaigns have been performed in Brazil to make TLE observations, more than 700 events, mainly sprites, have been recorded over South American thunderstorms during Brazilian campaigns so far. During the first campaign, in 2002/2003, 18 sprites were recorded above Minas Gerais State in two different nights; 11 sprites from 3 different storms above Goiás and Mato Grosso States was the total recorded on a single night of the second campaign, in 2005. The third campaign, in 2006, had the impressive record of more than 600 TLEs from two thunderstorms, over Argentina and Paraguay, in different nights. In 2007 we recorded 27 sprites from a single system above Uruguay, and in 2008, 13 TLEs were registered above one convective system over Rio Grande do Sul State. This paper will review the main results of these observations. It will also introduce the Transient Luminous Event and Thunderstorm High Energy Emission Collaborative Network in Latin America – LEONA. The network has two prototype observation camera system already installed in Brazil and will be developed to cover the whole South America.

2.2-7 ANALYSIS OF RADIO OBSERVATIONS OF LIGHTNING PROCESSES ASSOCIATED WITH TERRESTRIAL GAMMA-RAY FLASHES

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The discovery of terrestrial gamma-ray flashes (TGFs) and modeling of gamma-ray generation that followed have shown with near certainty that the basic process of relativistic runaway breakdown is driven by thunderstorms and lightning on Earth. Determining what processes are responsible for creating the potential drop of tens of megavolts and also seeding the breakdown with high-energy electrons, and understanding the conditions under which those processes occur, have proven much more challenging. Radio emissions are among the only observables that provide a view into the electrodynamics of the region of gamma-ray production. It is generally agreed that most and perhaps all TGFs are produced during the early, upward leader stage of normal polarity IC lightning flashes. Recent observations have indicated that at least some TGFs are simultaneous with a distinct low frequency pulse that is likely produced by the electron acceleration process that also generates the TGF itself. We will describe recent coordinated observations of lightning and terrestrial gamma-ray flashes that provide new insight into the detailed processes that generate this thunderstorm-driven high-energy radiation. Our goals are to confirm the presence of this distinct TGF radio signature in a larger number of events, and to quantify the current and charge motion before, during, and after the TGF on a range of time scales from several microseconds to several milliseconds. This effort employs TGF measurements from the GBM instrument on the Fermi satellite and multiple magnetic field sensors deployed at locations across the US.

2.2-17p INVESTIGATION OF GLOBAL LIGHTNING AND THE IONOSPHERE USING SCHUMANN RESONANCES AS MEASURED BY HIGH FREQUENCY INDUCTION COIL MAGNETOMETERS IN THE UK

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In June 2012, the British Geological Survey Geomagnetism team installed two high frequency (100 Hz) induction coil magnetometers at the Eskdalemuir Observatory, in the Scottish Borders of the United Kingdom. The induction coils permit us to measure very rapid changes of the magnetic field.

The Eskdalemuir Observatory is one of the longest running geophysical sites in the UK (beginning operation in 1904) and is located in a rural valley with a quiet magnetic environment. The data output from the induction coils are digitized and logged onsite before being collected once per hour and sent to the Edinburgh office via the Internet. We intend to run the coils as a long term experiment.

We present initial results from the first year of data. Analysis of spectrograms and power spectral density plots in the frequency band of 3-40 Hz from the coils show diffuse bands of peak power around 7.8 Hz, 14.3 Hz, 20.8 Hz, 27 Hz, 34 Hz and 39Hz related to the global Schumann resonances. We also detect a strong narrow peak at 25 Hz, which is a sub-harmonic of the UK electrical power system.

We investigate the diurnal and seasonal variation of the Schumann resonances and comparisons with other atmospheric phenomenon such as the Madden-Julian Oscillation. We also examine pulsation and low frequency activity during recent geomagnetic storms.

2.2-18p SIMULTANEOUS MEASUREMENTS OF RAINFALL INTENSITY, THERMAL NEUTRONS AND GAMMA RADIATION IN SÃO JOSÉ DOS CAMPOS, SP, BRAZIL

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ABSTRACT:

The project aims to study the correlation between the presence and intensity of rainfall and X- and gamma radiation and low thermal neutrons at one specific location to determine cause-effect relationships between changes in the intensities of the different types of radiation and meteorological phenomena.

INTRODUCTION:

Ionizing radiation is present near Earth's surface. This radiation is produced by the natural decay of radioactive isotopes that exist on the ground, water and atmosphere as well as the continuous bombardment of cosmic rays. This radiation is variable in latitude, and its maximum values are measured at the poles and minimum at the equator; in addition, its intensity varies with altitude, reaching a peak value between 13-17 km, and from this height up to 40 km the radiation intensity decreases almost linearly with altitude (Martin, I.M, 1970). Above this height, radiation originates outside Earth. The radiation from land/soil depends on the local geology and is comprised of alpha particles, X- and gamma radiation and neutrons. The gas radon (Rn-222) is a radioactive isotope that contributes significantly to the intensity of such radiation at ground level. Another possible source of X-radiation, gamma and thermal neutrons are atmospheric electrical discharges (Moore C. B. et al., 2001). Measurements of radiation produced by electrical discharges are very difficult to carry out because it is not possible to predict where such discharges might occur; moreover, detectors for measuring radiation produced by electrical discharges should have good radiation efficiency and operate with extremely short time resolution, in the order of milliseconds (Dwyer, J. R, 2003, 2004).

METHODS:

Rainfall was measured with a rain gauge placed on a pole 3 meters high and 3 meters away from the neutron and X-ray and gamma detectors. Measurements of gamma radiation were performed using a portable system based on a scintillator of sodium iodide doped with Thallium (NaI(Tl)). The scintillator crystal and photomultiplier are housed in an aluminum casing. A portable and compact electronic module (PMI, Aware Electronics, USA) was used for digital acquisition and high-voltage source. Measurement of thermal neutrons were carried out using by an He-3 gas tube (25311 tube, LND Inc., USA) with internal pressure of 6 atmospheres. Inside the tube, thermal neutrons collide with He-3 atoms of gas; proton and tritium resulting from such collisions produce electrical pulses, which are measured. The high-voltage source and digital acquisition system is the same as that of the NaI(Tl) scintillator. All instruments collected data continuously at 1-minute intervals. The collected data were stored in laptops for further analysis. The system was previously calibrated using standard laboratory radioactive sources. Measurements were performed in the Department of Physics of the ITA and in the tower of the Institute of Aeronautics and Space, São José dos Campos, SP, from 1 January 2013 until 30 March 2013.

RESULTS AND DISCUSSION:

In the period from early January to March 2013 rainfall was above average. The integrated intensity of X- and gamma radiation (0.030 to 10.0 MeV) was very sensitive to rainfall. However, measurements of thermal neutrons showed no correlation with measured local rainfall. Some events when radiation levels increased above the normal

background noise at the measurement location seem to be related to lightning discharges. Measurements of X- and gamma radiation show a periodic oscillation with a period of exactly 24 hours, with the maximum occurring around 11:00-13:00 hours. Thermal neutrons data also show an oscillation with a period of 24 hours, but with maxima occurring between 22:00-01:00 hours. During the rainy season, these periodicities were perturbed. The periodicities were analyzed taking into account the correlation with meteorological phenomena.

CONCLUSIONS:

The main results of this study were the observation of the correlation between rainfall intensity with the intensities of X- and gamma radiation at the study location, and the observed 24-hour periodicities in the intensities of X- and gamma radiation and thermal neutrons. However, the maximum count of neutrons occurs around local midnight, while the maximum in the intensity of X- and gamma radiations occurs around local noon. This is a new discovery and the object of much study to explain the cause of this reversal of patterns occurs. The solar modulation of cosmic rays shows a periodic oscillation whose maximum coincides with the maximum of neutron counts at around local noon). It also appears that during heavy or continuous rainfall these oscillations are perturbed. Measurements of these radiations during drier periods (less rainfall) will show more details about periodicities of X- and gamma radiation monitored continuously in the region.

Keywords: X-radiation, gamma and thermal neutron rains correlation.

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2.2-19p OBSERVATIONS OF ATMOSPHERIC ELECTRIC DISCHARGES AND THEIR CORRELATION WITH MEASUREMENTS OF X- AND GAMMA RADIATION AT GROUND LEVEL IN SÃO JOSÉ DOS CAMPOS, SP, BRAZIL.

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ABSTRACT:

The aim of this work was to determine qualitatively whether there is a correlation between measurements of X- and gamma radiation and the occurrence of atmospheric electric discharges in the region of São José dos Campos, SP, Brazil. First, we determined the intensity of the background noise of the X- and gamma radiation (30 keV to 10 MeV) at ground-level. With this "background" fully known, we determined the increase of counts of X- and gamma radiation during the occurrence of intense lightning over the region where the detector is located.

INTRODUCTION:

The intense electric field inside a storm cloud (of the order of 105 V/m) can accelerate electrons to relativistic velocities. The electron avalanche resulting from this process may start from a lightning discharge. However, this mechanism is still unknown with respect to the type of radiation created. Experiments with detectors placed on aircraft and stratospheric balloons registered an increase of gamma radiation during the production of lightning (EACK, 1996). Detectors located in high mountains recorded events in which gamma rays with energy above 1 MeV were produced during lightning (MOORE, 2001). Rocket-borne detectors also recorded increases in the intensity of X- and gamma radiations during lightning (DWYER, 2003, 2004). From observations made by satellites, Fishman (FISHMAN, 1994) found that gamma-ray emissions coincided with the position of storms. In 2007, a group of researchers measured gamma ray events with energies up to 10 MeV during storms and lightning (ENOTO, 2008).

MATERIAL AND METHODS:

In this study we analyzed data continuously collected between 02/19/2013 to 04/02/2013 (sampling interval of 1 minute) at the Atmospheric Phenomena Observation Tower of the Institute of Aeronautics and Space, in São José dos Campos, SP, Brazil. Measurements of X- and gamma radiation with energies from 30 keV to 10 MeV (counts / unit time) and atmospheric electric field were recorded simultaneously and compared with lightning strike records. For measurements of X- and gamma radiation, we used a scintillation crystal of sodium iodide activated with thallium NaI (TI) coupled to a photomultiplier, with energy resolution better than 15%. Records of lightning strikes were provided by the Brazilian Lightning Detection Service (BrasilDat) operated by Instituto Nacional de Pesquisas Espaciais, INPE).

Results and Discussion: During the study period, we observed that there was a strong temporal correlation between the increase in the magnitude of the atmospheric electric field due to the presence of storm clouds and increase in X- and gamma radiation counts. Variations in the electric field caused by the presence of electrified clouds over the study region coincided with an increase in radiation counts. Although it was not possible to quantify the contribution of lightning discharges, increases in gamma radiation counts were recorded during the occurrence of storms. To clarify this problem, it will be necessary to collect additional data on atmospheric electric field variations and

the spectra of gamma radiation resulting from the radioactive decay of radon gas before, during and after rainfall because radon is an important source of environmental radiation. Preliminary studies of the profiles of the peaks of gamma radiation as a function of time indicate that there is a difference between the profiles that were recorded during rainfall and the occurrence of lightning compared with periods when there is no rain. When there is rainfall and lightning, the profiles of the lines tend to have a symmetric Gaussian shape. During lightning storms the profiles of the peaks are describe by an asymmetric double sigmoid function. But, it was also observed that some of the peaks have shapes that can be fit by a Voigt function.

CONCLUSION:

In the study period, we observed that variations in the atmospheric electric field caused by the presence of electrified clouds over the study region, were correlated with increases in the X- and gamma ray counts. This result is in agreement with those previously reported in the literature. The correlation between variations in the X- and gamma rays counts and changes in the atmospheric electric field as well as changes in the profiles of gamma ray count peaks in the presence and absence of lightning activity associated with storms suggests that lightning probably play an important role in the production of X- and gamma radiation during of storms.

Keywords: atmospheric electric discharges X- and gamma radiation correlation

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2.2-20p **IMPACT OF THE EXTRAORDINARY SOLAR ACTIVITY OF OCTOBER/NOVEMBER 2003 ON THE UPPER BOUNDARY OF THE EARTH-IONOSPHERE CAVITY RESONATOR**

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The upper boundary of the Earth-ionosphere cavity is the ionospheric D-region. The upper part of this region is ionized by the solar UV, EUV, Lyman- α (121,6 nm) and Lyman- β (102,6 nm) as well as the soft (1-10 nm) and hard (<1 nm) X-ray in the sunlit site of the cavity. In the lower part of the D-region, the galactic cosmic rays are responsible for the ionization. A series of dramatic solar activity events occurred in October and November of 2003. The hard solar X-ray flux increased by more than two orders of magnitude already in October 18 and lasted until November 4 while the 10.7 cm radio flux indicating the 2-3 fold variations of EUV radiation maximized only in October 28. The time evolution of the disturbances of these two ionization sources was quite different. At the end of October and the beginning of November 2003 two active regions produced a series of extremely energetic solar eruptions. In connection with the flare on October 28, 2003, a coronal mass ejection was emitted at a high speed directly towards the Earth and caused a dramatic Forbush decrease. The effects of these events have been studied by Schumann resonance (SR) parameters measured at Nagycenk, Hungary and in Mitzpe Ramon in Israel. SR frequency increased simultaneously with the increase of the hard solar X-ray flux in October 18, 2003 and followed it in case of the 1st and 2nd Ez modes both at Nagycenk and in Mitzpe Ramon until November 4, 2003. Neither the increased EUV radiation with maximum at October 28, 2003 and nor the huge Forbush-decrease between October 28 and November 4, 2003 left any signature on SR frequencies. This result supports that the hard solar X-ray has an important role in conditioning the Earth-ionosphere cavity at the heights of ~ 90km -100 km as shown on the 11-year solar cycle and during short solar X-ray bursts (Satori et al., 2005).

2.2-21p **MONITORING OF IONIZING RADIATION FROM RADON GAS (Rn 222) IN THE SÃO JOSÉ DOS CAMPOS - BRAZIL REGION.**

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INTRODUCTION

Ionizing radiations are present in our daily lives, they are originated by nature or manmade. This job presents results of ionizing radiation dose from Radon gas (Rn 222). Radon is a natural gas that originates by the decay series

of Uranium and Thorium, it is in all locations of the earth's crust. The isotope Rn 222 is alpha and gamma emitter and a half-life of 3.82 days ($E_{\alpha}=5.49$ MeV), from its decay originate Po 218 and Po 214 which are responsible for around 50% of natural ionizing radiation on Earth. According to the American Journal of Epidemiology (2002), radon gas must cause lung cancer in humans, if exposure to large amounts of gas, experimentally proven with tests on animals. However, a study published in 2003 by the journal German Springer Verlag proves the therapeutic properties of Radon, in which patients are exposed to small amounts of gas in deactivated uranium mines to reverse cases of arthritis and skin diseases. These facts become relevant to observe the dynamics of this type of ionizing radiation, it can directly affect the structure of our DNA.

METHODS

Gamma radiation measurements was realized with a crystal scintillator of NaI(Tl) mounted in an aluminum cell and connected to a photomultiplier tube (Aware Electronics, USA). This detector was coupled to a PC for storing the data series. The scintillator, coupled to the photomultiplier and associated electronics, was previously calibrated only in energy range using standard radioactive in a laboratory. The background radiation measurement is collected each minute uninterruptedly during one day or until three months. The methods used to study the data sets are statistics and Fourier analysis.

RESULTS AND DISCUSSION

Measurements of gamma radiation were performed at the Physics Department of the ITA in São José dos Campos-Brazil, from January 1st to March 25th 2013 with a count interval of 1 in 1 minute throughout this period. From the monitoring of precipitation and radiation, noted a positive correlation between the rainfall intensity during this period and gamma radiation intensity (0.30 to 10.0 MeV) at the same location. Gamma radiation dose is highly sensitive to relative humidity, rainfall and dry weather. There are higher concentrations of radon gas when heavy rains occur mainly those resulting from the cold fronts. Furthermore, well-defined one cycle in 24 hours at a dose of radiation.

CONCLUSION

Due to the fact ionizing radiation directly affect the life of the whole planet, it is essential monitoring and analyze ionizing radiation concentration in the environment and correlation between natural phenomena and its dose. This branch of research is scarcely studied in Brazil, however with the sponsorship of the Institute of Technology Aeronautics (ITA) and National Counsel of Technological and Scientific Development (CNPq), it was possible to monitor the concentration of ionizing radiation on the Earth's surface using the equipment most suitable for this purpose.

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2.2-22p ON SODIUM ATOM LAYER VARIATION INDUCED BY AURORAL PARTICLE PRECIPITATION

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Sodium atom layer is generally distributed at 80-100 km. One of mysterious subjects on high-latitude sodium layers is relationship between auroral particle precipitation and sodium atom layer variation. A previous study suggested a sodium column density decrease during a geomagnetic active period due to that the particle precipitation accompanied by electron density enhancement could induce ionization of sodium atom through their ion-molecule chemistry. Another study pointed a possibility of sodium density increase. For this reason, it is suggested that auroral precipitating particle bombardment on meteoric smoke particles can sputter sodium atoms from the smoke particles. On the other hand, ionospheric electric field, which may become more significant near auroral precipitating regions, could induce ion motions (i.e. can generate sodium ion convergence and/or divergence), and then also could affect generation and/or loss processes of sodium atoms through their ion-molecule chemistry. Thus, for the examination of the causality, it is vitally important to distinguish the effects of auroral particle precipitation and ionospheric electric field. Using a sodium lidar (which was installed in early 2010) and European incoherent scatter (EISCAT) radar at Tromsø, Norway (69.6 deg N, 19.2 deg E), we have investigated, for the first time, that the actual effect of the particle precipitation to the sodium density variations without electric field injection. In the nighttime observation on 24-25 January 2012, we detected a significant decrease of sodium atom density coincided with electron density enhancements (implying strong particle precipitations) and low ion temperatures (implying no electric field injections). These results strongly suggested that auroral particle precipitations induced sodium atom density decrease. Furthermore we discuss observed time response in the sodium density decrease.

SESSION 2.3**DIV II/ICMA COUPLING PROCESSES IN THE ATMOSPHERE- IONOSPHERE SYSTEM****2.3-1 VERTICAL COUPLING OF THE ATMOSPHERE-IONOSPHERE SYSTEM OBTAINED BY THE GAIA MODEL SIMULATION****Miyoshi, Yasunobu; Jin, Hidekatsu; Fujiwara, Hitoshi; Shinagawa, Hiroyuki**

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Behaviors of gravity waves in the thermosphere/ionosphere are studied by using a general circulation model that includes the region from the ground surface to the upper thermosphere with high horizontal resolution (about 1 degree longitude by 1 degree latitude). The dominant period of the simulated gravity waves in the thermosphere becomes shorter at higher altitudes due to dissipation processes, such as molecular viscosity and ion drag force, indicating that gravity waves with a larger horizontal phase velocity (larger vertical wavelength) can penetrate into the thermosphere. We also investigate the longitudinal and seasonal variations of gravity wave activity in low latitudes and upward propagation of gravity waves from the lower atmosphere to the thermosphere/ionosphere. Our results clearly indicate that the longitudinal variation of the gravity wave activity in the mesosphere and thermosphere is closely related to the cumulus convective activity in the tropics, indicating vertical coupling between the lower and upper atmospheres. We are developing a higher horizontal resolution version (about 1 degree longitude by 1 degree latitude) of the atmosphere-ionosphere coupled model (GAIA). Using the high resolution version of the GAIA, we are planning to investigate upward propagation of gravity waves from the lower atmosphere to the thermosphere and its impact on the ionospheric variability.

2.3-2 ATMOSPHERIC DIURNAL TIDES FROM THE NUDGED EXTENDED CANADIAN MIDDLE ATMOSPHERE MODEL – CMAM20**Du, Jian; Ward, William; Beagley, Stephen**

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*jian.du@louisville.edu***2.3-3 EPP-INDUCED ATMOSPHERIC COMPOSITION CHANGES: COMPARISON BETWEEN MODEL SIMULATIONS AND OBSERVATIONS WITHIN HEPPA-MMI****Funke, B.**

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The High Energy Particle Precipitation in the Atmosphere model vs. measurement intercomparison initiative (HEPPA-MMI), as part of the SPARC SOLARIS-HEPPA activity, brings together scientists involved in atmospheric modeling using state-of-the art CCMs and CTMs on one hand and scientists involved in the analysis and generation of satellite data on the other hand. The objective of this community effort is (i) to assess the ability of state-of-the-art atmospheric models to reproduce composition changes induced by energetic particle precipitation (EPP), (ii) to identify and - if possible remedy model deficiencies related to chemistry, dynamics, and ionization schemes, and (iii) to serve as a platform for discussion between modelers and data producers. This is achieved by a quantitative comparison of observed and modeled species abundances during selected periods of pronounced particle forcing, as well as by inter-comparing the simulations performed by different models. The past HEPPA-I study has focused on the inter-comparison of MIPAS/Envisat data obtained in the aftermath of the Halloween SPE (26 October - 30 November 2003) with simulations performed by a large number of CCMs and CTMs, allowing for the evaluation of the overall ability of atmospheric models to reproduce observed atmospheric perturbations generated by SPEs, particularly with respect to NO_y, Cl_y, and ozone changes. The recently launched HEPPA-II intercomparison study focuses on the evaluation of EPP indirect effects (i.e., the descent of EPP-generated odd nitrogen from the MLT into the stratosphere) during the Arctic winter 2008/2009. This talk will give an overview of the results obtained and ongoing progress of these activities. exercise.

2.3-4 GEOMAGNETIC AND SOLAR ACTIVITY EFFECTS ON PRECIPITATION**Heredia, Teresita; Elias Ana G.**

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The long-term variability of precipitation in different regions is analyzed in order to detect possible geomagnetic and solar activity effects. Monthly time series of precipitation over the Northwestern region of Argentina, Sydney and some regions of India, together with Rz and aa index were used. A correlation analysis reveals different types of associations which could be understood as no association at all or as the presence of two or more interacting mechanisms which imply opposite effects. Adhering to this approach, we consider two mechanisms. The first one is through cosmic ray effects which are modulated directly by the solar wind. This mechanism supports a negative correlation between precipitation and solar/geomagnetic activity. The second mechanism consists of a link of processes

beginning in the upper atmosphere, which indirectly induce shifts in the atmospheric circulation patterns in the troposphere and would support a positive correlation.

2.3-5 **ELECTRODYNAMIC COUPLING OF THE ATMOSPHERE-IONOSPHERE SYSTEM DURING A GEOMAGNETICALLY QUIET TIME AND SSW CONDITIONS**

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Observations of the F-region ionosphere in the last 10 years have shown that the ionosphere is highly variable on different spatial and temporal scales, and that part of the F-region ionospheric variability is due the coupling of the ionosphere to the atmosphere below. One of the proposed coupling mechanisms is via the ionospheric electrodynamic which generates electric fields and ExB plasma drifts in response to tides and waves which propagate up from the atmosphere into the lower thermosphere. Observations support this claim by illustrating similar signals in vertical ExB plasma drifts and F-region plasma densities, especially during geomagnetically quiet periods when the influence of the lower atmosphere on the F-region ionosphere can be important.

In this presentation we focus on periods of Stratospheric Sudden Warmings (SSW) which are driven by major lower atmospheric dynamical disturbances. Tides that propagate through the middle atmosphere into the thermosphere can be strongly altered by a SSW and the associated changes in the background atmosphere. In this study we use the National Center for Atmospheric Research (NCAR) thermosphere-ionosphere-mesosphere-electrodynamics general circulation model (TIME-GCM) to simulate the SSW periods with realistic meteorological and geospace variability, and we address how variability in the different tidal and planetary-wave components is linked to the variability in the equatorial vertical plasma drift. We quantify SSW effects on the tides by comparing with a control simulation, and suggest mechanisms which might cause the tidal changes. We characterize and quantify the changes in the vertical drifts due to the SSW events. Through numerical experiments we evaluate the importance of the different wave and tidal components in generating the temporal variation in the vertical drift. Finally, we assess the SSW simulations of the vertical drift and the ionospheric signal in the context of the ionospheric observations.

2.3-6 **IONOSPHERIC RESPONSE TO A SUDDEN STRATOSPHERIC WARMING AT HIGH SOLAR ACTIVITY**

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The recent solar minimum has been an ideal opportunity to study the impact of lower atmosphere dynamics on the thermosphere and ionosphere. During January 2009, for instance, the response to a particularly large sudden stratospheric warming revealed large changes in the vertical plasma drift at the magnetic equator. The response in total electron content showed a 50% increase in the morning hours and a 50% decrease in the afternoon, compared to the typical diurnal variation. Modeling the period enable the physical processes to be unraveled. The change appeared to be in part due to a change in phase of the upward propagating semi-diurnal migrating tide. Numerical simulations have been performed to determine the likely response of the upper atmosphere if this particular stratospheric warming had occurred at higher solar activity. Theory might suggest the wind fields reaching the lower thermosphere dynamo region would be similar, so the changes in the electric fields would be more controlled by the plasma density and conductivity changes. The numerical simulation shed light on the likely response and whether the changes if plasma density would likely be discernable from other sources of solar and geomagnetic variability at high solar activity.

2.3-7 **COUPLING BETWEEN THE LOWER ATMOSPHERE AND THERMOSPHERE AS REVEALED IN GOCE ACCELEROMETER MEASUREMENTS**

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In recent years, accelerometer measurements from the CHAMP and GRACE satellites have revealed evidence for the penetration of non-migrating (longitude-dependent) solar tides into the 400-500 km region of the thermosphere. These tides are generated for the most part in the troposphere by solar radiation absorption and latent heating; they propagate vertically, grow exponentially with height, and undergo dissipation in the thermosphere. Accelerometer measurements from the GOCE satellite provide the opportunity to view the nature of these tides in middle thermosphere (ca. 250 km) densities and winds and with improved precision compared with, e.g., CHAMP. However, the Sun-synchronous orbit of GOCE presents a new challenge in terms of identifying and separating the different tidal components. On the other hand, the combination of both wind and density measurements adds additional information to the problem. In this paper we demonstrate how the GOCE data can be analyzed to extract waves of interest, validate the GOCE data against co-planar CHAMP measurements, and provide new science results from this methodology.

2.3-8 GLOBAL DISTRIBUTION OF THE TERDIURNAL TIDE SEEN IN GPS RADIO OCCULTATION SPORADIC E OCCURRENCE RATES.

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Global Positioning System (GPS) radio occultation (RO) measurements by the FORMOSA SATellite mission-3/ Constellation Observing System for Meteorology, Ionosphere and Climate (COSMIC) satellites were used to analyse the behaviour of the zonally averaged signature of the terdiurnal tide (TDT) in sporadic E (Es) layers. According to theory, the occurrence of Es is expected when the vertical zonal wind shear, which is mainly owing to solar tides, is negative. 4-year averages, based on 3-monthly mean zonal means from December 2006 - November 2010, were constructed for the terdiurnal oscillation in the occurrence frequency of Es. Comparison of the results at midlatitudes (43°N - 63°N) with VHF meteor radar wind observations of the TDT and the 8-hour oscillation in the vertical zonal wind shear at Collm, Germany (51.3°N, 13°E) shows a clear correspondence between the 8-hour signature in Es and wind shear. In particular zonal wind shear and Es phases agree well. Furthermore, the seasonal cycles of the 8-hour Es and 8-hour wind shear amplitudes closely correspond with each other. On a global scale, the seasonal and latitudinal distribution of the 8-hour occurrence rate amplitudes in Es shows good agreement with results of TDT analyses from numerical models and observations in the literature.

2.3-9 SMALL-SCALE GRAVITY WAVES IN THE THERMOSPHERE DURING A SUDDEN STRATOSPHERIC WARMING

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Small-scale gravity waves in the thermosphere during a sudden stratospheric warming

Lower atmospheric gravity waves (GWs) play an important role for the structure of the middle atmosphere. Their role for the thermosphere above the turbopause has been studied to a much lesser extent due to a series of limitations in models, gravity wave parameterizations, and observations. Yiit *et al.* (2008) developed for the first time a parameterization that can estimate the effects of subgrid-scale GWs in whole atmosphere models extending from the lower atmosphere to the upper thermosphere. This talk presents the first general circulation modeling results with the Yiit *et al.* (2008) scheme on the propagation and dissipation of lower atmospheric GWs in the thermosphere during a sudden stratospheric warming. The SSW occurrence modulates GW propagation and the resulting circulation feedbacks remarkably up to the upper thermosphere (Yiit and Medvedev, 2012). Gravity wave-induced root mean square increases by a factor of three above the turbopause during the warming. Compared to the non-warming period, GWs propagate to much higher altitudes during the SSW and produce large forcing. These results indicate that GW propagation from the lower atmosphere to the thermosphere during transient events plays an even greater role for the vertical coupling.

Yiit, E., A. D. Aylward, and A. S. Medvedev (2008), Parameterization of the effects of vertically propagating gravity waves for thermosphere general circulation models: Sensitivity study, *J. Geophys. Res.*, 113, D19106, doi:10.1029/2008JD010135.

Yiit, E., and A. S. Medvedev (2012), Gravity waves in the thermosphere during a sudden stratospheric warming, *Geophys. Res. Lett.*, 39, L21101, doi:10.1029/2012GL053812.

2.3-10 COMPARISON OF THE NEUTRAL DYNAMICS OF THE 2009 SSW SIMULATED BY DIFFERENT WHOLE ATMOSPHERE MODELS

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Different model simulations of the 2009 sudden stratosphere warming (SSW) are compared in order to gain insight into the global dynamical changes that occur throughout the middle and upper atmosphere in response to the SSW. The models considered are the Ground-to-topside model of Atmosphere and Ionosphere for Aeronomy (GAIA), the Whole Atmosphere Community Climate Model eXtended version (WACCM-X), and the Whole Atmosphere Model (WAM). Large differences are found in the changes in the zonal mean atmosphere, and these become particularly evident at higher altitudes where the models are no longer constrained by observations or reanalysis. These differences are primarily attributed to the use of different gravity wave schemes in the different models. The different treatment of gravity waves is shown to not only impact the model response to the SSW, but also the zonal mean climatology in the middle and upper atmosphere. The changes in the atmospheric tides during the SSW are also investigated. Comparison of the tides in the different models reveals some similarities in the tidal response to the SSW. However,

significant differences are also apparent in the magnitude and timing of the tidal variability. The comparison of the GAIA, WACCM-X, and WAM simulations clearly illustrates the similarities and differences in the modeled response to the 2009 SSW. The aspects that are similar in the model simulations are considered to be robust features of the dynamical changes that occur in the middle and upper atmosphere in response to the 2009 SSW. The differences serve to illustrate that there is also significant uncertainty in aspects of the modeled response to the 2009 SSW.

2.3-11 IONOSPHERIC DISTURBANCES INDUCED BY ACOUSTIC WAVE EXCITED BY MEGA-EARTHQUAKES

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After large earthquake, ionosphere disturbances are often observed because acoustic and gravity waves are excited by a vertical sudden displacement of the ground and sea surface caused by the earthquake and tsunami and then disturb ionospheric plasma. The M 9.0 Tohoku earthquake (Tohoku EQ) was a megathrust-type which occurred on March 11 of 2011 at 0546 UT in the western Pacific Ocean. After the Tohoku EQ, many types of ionospheric disturbances such as acoustic resonance and gravity wave were observed. Furthermore, large plasma depletion named tsunamigenic ionospheric hole was observed [Kakinami *et al.*, 2012]. Similar plasma deletions were also found in the 2010 M8.8 Chile and the 2004 M9.1 Sumatra earthquakes. This occurs because plasma is descending at the lower thermosphere where the recombination of ions and electrons is high through the meter-scale downwelling of sea surface at the tsunami source area, and is highly depleted due to the chemical processes.

Two types of coseismic ionospheric disturbance (CID) were also found after the Tohoku EQ [Kakinami *et al.*, 2013]. A faster CID propagated at ~3.0 km/s only in the west-southwest, while a slower CID propagated concentrically at 1.2 km/s or slower from the tsunami source area. The faster CID was associated with a Rayleigh wave but the slower CID was associated with an acoustic or gravity wave. The north-south asymmetry of the CID related to the Rayleigh wave suggests that the Rayleigh wave did not act as a point source of the acoustic wave because a point source propagating in all directions produces CID in all directions. Therefore, a superimposed wave front of acoustic waves excited by the Rayleigh wave produced the north-south asymmetry of the faster CID due to the magnetic inclination effect.

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2.3-12 VARIABILITY STUDY OF IONOSPHERIC AND NEUTRAL ATMOSPHERIC PARAMETERS

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The purpose of our study is to describe the temporal and spatial variability of the ionosphere together with the behavior of the neutral atmosphere in midlatitudes. We focus on atmospheric wave activity at different atmospheric heights. By mean of spectral analyses (especially wavelet transformation) we search for coherent wave bursts and further trace these coherent wave burts from lower atmospheric regions upwards. In our previous analysis we detected coherent wave-like burts within time series of stratospheric and ionospheric parameters. Such coherent wave bursts occurred on the planetary wave periods. Here, we present the extension of the study.

2.3-13 TIDAL AND PLANETARY WAVE COUPLING OF THE EQUATORIAL MESOSPHERE-LOWER THERMOSPHERE-IONOSPHERE REGION

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Planetary-scale atmospheric waves play an important role in the dynamics of the mesosphere-lower thermosphere (MLT) region. It has been hypothesized in the past that if a global-scale wave with large amplitude and fairly long vertical wavelength propagates into the ionosphere from below, it should drive an electric current system through the dynamo action with a period of the global-scale wave. This wave-like perturbation in current system causes perturbations in geomagnetic field that could be recorded on ground. Part of these variabilities during magnetically quiet times could very well be due to the variabilities of tides and other planetary-scale waves but what conditions exist in the MLT region that permit these large-scale waves to reach the dynamo heights and have an influence on the ionospheric variabilities there and higher above are not known. One of the ongoing studies carried out by us aims to delineate the role of atmospheric tides and planetary waves in driving the day-to-day variabilities of ionospheric current systems at low latitudes (Sq and EEJ).

In this work we make use of the long-term (two decades) observational data set from the tropical MLT radar site, Tirunelveli. Unusually larger tidal and planetary wave amplitudes during the deep solar minimum (2006-2009) have

indicated solar cycle influence. We focus on this period to investigate how tides and planetary waves drive the day-to-day variabilities of ionospheric current systems and contribute to the ground magnetic field variations.

2.3-14 COUPLING OF THE ATMOSPHERE-IONOSPHERE SYSTEM BY PLANETARY WAVES

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With the recent accumulation of the satellite ionospheric measurements the attention is now directed towards investigating the impact of wave forcing from the lower atmosphere. The periods of time when the level of solar and geomagnetic activity is very low are particularly appropriate for investigating the vertical coupling of the atmosphere-ionosphere system by atmospheric waves. In this study the signs of potential upward planetary wave coupling are examined by using the following global-scale observations: (i) in order to clarify the source region of the planetary waves (troposphere or stratosphere) the UK Met Office reanalysis fields are used; (ii) temperature measurements from the Sounding of the Atmosphere using Broadband Emission Radiometry (SABER) instrument on the Thermosphere-Ionosphere-Mesosphere-Energetics and Dynamics (TIMED) satellite have been analyzed to derive the global spatial structure and temporal variability of the main atmospheric waves from the lower stratosphere to the lower thermosphere (20-120 km) and at latitude range of $\pm 50^\circ$; (iii) total electron content (TEC) results from the GNSS derived global ionosphere maps define overall ionospheric variability at planetary wave time scales, and (iv) the six-satellite Constellation Observing System for Meteorology, Ionosphere and Climate (COSMIC) electron density measurements over the entire globe have been used for clarifying particularly the altitude structure of the ionospheric response to the planetary wave forcing from below for altitudes between 100 km and 800 km. Two case studies are considered in detail.

2.3-15 QUASI-TWO-DAY WAVES IN THE EQUATORIAL METEOR WINDS AND IONOSPHERIC DATA

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2.3-16 INVESTIGATION OF AFTER-STORM EFFECT ON ATMOSPHERIC ELECTRICITY AT HIGH LATITUDE

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One of the problems in the study of variations of atmospheric electric field is that of separating the sources of these variations on the external and internal. Variations in the atmospheric near-surface vertical electric field component (EZ) measured at the Indian Antarctic station Maitri ($70^\circ 45' 52''$ S, $11^\circ 44' 3''$ E, 117 m above mean sea level) in 2006 is analyzed in terms of finding the effect of before and after geomagnetic storm. To reinvestigate the latitudinal effect on EZ one more high latitude station Vostok ($78^\circ 5'$ S, 107° E) had been taken to discuss. Total of 12 events have been listed under this category in the solar near minimum year which show feeble solar activity helps to extract the solar dynamo contribution to the global electric circuit. The storm day is considered as a key day and followings days are counted as event days. All the above selected events, the key day holds the behaviours of geomagnetic storm and high/ sudden ionospheric absorption in D region of the ionosphere. The key day may not show any signature of storm rather the following event days, minimum 4 days & maximum 8 days, show the UT dependences of EZ variations irrespective of season. Maitri station is crossing dusk boundary at 23 UT - 5 UT which allows the particle from the terrestrial magnetotail, verified with GEOTAIL satellite data, to the auroral ionosphere in high latitudes. The same injection is also possible in Vostok station when it crosses over dusk at 08 UT- 16 UT. The measured EZ from these stations show the enhancement in event days as per dusk boundary crossing as a result of electrical coupling from ionosphere. The detailed mechanism will be discussed in this paper.

2.3-17 WHAT SCIENCE OF TLE CAN BE DONE WITH JEM-EUSO

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The main goal of the JEM EUSO experiment are studies of the extremely high energetic cosmic rays (1019-1021eV), but method which will be used (registration of the secondary light emissions induced by cosmic rays in the atmosphere) allows to study other luminous phenomena. Our paper will consist of four parts: review of the present knowledge on the TLE, presentation of the results of the simulations of the images of TLEs in JEM EUSO telescope, results of Russian experiments Tatiana 1 and Tatiana 2 and discussion of the possible progress of the science in this field with use JEM EUSO and possible cooperation with other space projects devoted to study of TLEs- TARANIS and ASIM. <ooo>Studies of the TLE became one of the main physical problems in the atmospheric physics. They

were discovered in 1989. In years 1992-1994 the registrations from space shuttle were done and recently from International Space Station. These events have short duration (milliseconds) and small scales (km to tens of km) and appear at altitudes 50 – 100km. Their nature is still not clear and each new experimental data can be useful for better understanding of these mysterious phenomena.

2.3-39p COUPLING BETWEEN SOLAR ROTATION AND LUNAR TIDE OSCILLATIONS IN THE EQUATORIAL ELECTROJET OVER HUANCAYO

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To first order the ground magnetic signature of the equatorial electrojet (EEJ) reflects the height integral of $J = \sigma E$ where σ is a conductivity and E represents some combination of the global dynamo-generated electric field and an electric field due to local winds. Day-to-day variations in the conductivity are strongly controlled by the solar flux, while E depends on solar and lunar tides, planetary waves, and the disturbance dynamo. In this study we seek a deeper understanding of how the residual noontime horizontal magnetic field (ΔH_n) varies from day to day, and in particular how the quasi-27-day variation in solar flux interacts with the 14.5-day lunar tide to produce complexity in the variability of ΔH_n , through interactions between these two waves and their sidebands. Towards this end, we analyze magnetometer data from the Huancayo observatory for the years 2002-2005 and 1989-1990 when solar rotation effects and the lunar tide are prominent. In addition, we employ EUV irradiances from TIMED/SEE in addition to the F10.7 radio flux to gain better insight into the solar flux effects on ΔH_n . We demonstrate how peaks in the ΔH_n spectrum arise through interaction between the ~ 27 -day and 14.5-day oscillations and their sidebands, and illustrate how these translate to differences between solar flux variability and ΔH_n in the time domain. As a result of this exercise, we gain a much better understanding of the origins of day-to-day variability of the equatorial-region ionosphere in the wider context.

2.3-40p LUNAR SEMIDIURNAL TIDE LONGITUDINAL VARIATION OBSERVED IN SABER TEMPERATURE DATA

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Lunar Tide theory suggests that the migrating components are much larger than the non-migrating ones. However, non-migrating modes are capable of introducing longitudinal variations. So, the non-migrating components must be important for the global distribution of this tide. The existence of non-migrating components might be due to ocean and solid Earth tidal forcing that propagate vertically or due to nonlinear interaction between stationary planetary waves and the migrating modes. In order to study the longitudinal variability of the atmospheric lunar semidiurnal tide ten years of temperature data collected by the TIMED/SABER satellite have been used. The amplitudes and phases have been calculated by performing least mean square fit in a dataset of about 60-day interval (combining ascending and descending data together) in latitude/longitude box. In this study a clear longitudinal variability was observed at three altitudes (81, 90 and 108 km) in March, June, September and December, but most pronounced at 90 and 108 km. The lunar semidiurnal tide amplitude at each latitude and longitude also presented a seasonal variability.

2.3-41p COMPETITION BETWEEN WINDS AND ELECTRIC FIELDS IN THE FORMATION OF BLANKETING SPORADIC E LAYERS

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This paper studies the competition between tidal winds and electric fields in the formation of blanketing sporadic E layers (Esb) over São Luís, Brazil (20° 31' S, 44° 16' W, dip = -2.3). The analysis is carried out using the maximum electronic density, which we estimate from the Esb layer top frequency (f_{TEs}) obtained by a digital ionosonde. The data selected for the present analysis covers the entire solar cycle 23 and extends up to 2012. To investigate the competition between winds and electric fields, we have used an ionospheric E-region model that includes the sporadic E layer (Carrasco *et al.*, JGR, 112, 2007), which allows to evaluate the influences of the electric field and the winds in the formation of Esb layers. The experimental and theoretical results are compared and discussed considering the influences of the aforementioned mechanisms: the electric fields and the tidal winds.

2.3-42p UPWARD ELECTRICAL COUPLING BETWEEN LOWER AND MIDDLE ATMOSPHERE AT EQUATORIAL LATITUDES BY MESOSCALE PHENOMENA - MODEL STUDY**Tonev, Peter; Velinov, Peter**

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Electrical sources in the lower troposphere, such as single thunderstorms, mesoscale convective systems and squall lines, typhoons, etc., can produce strong quasi-electrostatic fields in the middle atmosphere and lower ionosphere which can cause changes in these such as heating and changes of ionospheric characteristics. Similarly, earthquake related processes, can possibly cause a quasi-electrostatic coupling between the lower, middle and upper atmosphere. Therefore, it is useful to perform a model for investigation of the quasi-static electric fields and of their effects in the middle atmosphere and lower ionosphere above mesoscale structures of electrical sources in the lower atmosphere. The quasi-electrostatic fields generated in the lower ionosphere (60-100 km) by such underlying electrical sources of mesoscale horizontal dimensions (from tens to few hundred kilometers) located at equatorial latitudes are studied by modeling. The modeled electric fields are derived as a solution of the continuity equation for the Maxwell current. Our model takes into account self-consistently changes of ionospheric conductivity caused by the electric field. The solution is numerically obtained through a spatial approximation where a dramatic reduction of the complexity is achieved by simplified representation along north-south direction. It is shown by the model that mesoscale electric sources in the lower atmosphere by nighttime conditions can generate quasi-static electric fields in the lower ionosphere large enough to cause heating, and, in specific cases, to generate streamers. At equatorial latitudes a thin layer above ~85 km is formed where large horizontal currents and related strong vertical electric fields are generated. In the case of squall lines these electric fields are able to produce effects, such as heating and excitation of the atmospheric molecules, as well as vertically developing streamers. These last can cause one or a group of red sprites, which can be significantly horizontally shifted (in some cases, by tens of kilometers) from their causative lightning in the troposphere, according to actual observations.

2.3-43p GENERATION, INTENSIFICATION AND SELF-ORGANIZATION OF INTERNAL-GRAVITY WAVE STRUCTURES IN THE IONOSPHERE WITH SHEAR FLOW**Kharshiladze, Oleg; Chargazia, Khatuna**

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A study is made of the generation and subsequent linear and nonlinear evolution of internal-gravity wave (IGW) structures in the dissipative ionosphere in the presence of a nonuniform zonal wind (a sheared flow). The efficiency of the linear amplification of IGW structures in their interaction with a nonuniform zonal wind is analyzed. When there are sheared flows, the operators of linear problems are non-self-conjugate and the corresponding eigenfunctions are nonorthogonal, so the canonical modal approach is poorly suited for studying such motions and it is necessary to utilize the so-called nonmodal mathematical analysis. It is shown that, in the linear evolutionary stage, IGW efficiently extract energy from the sheared flow, thereby substantially increasing their amplitude and, accordingly, energy (by several orders). The criterion for instability of a sheared flow in an ionospheric medium is derived. As the shear instability develops and the perturbation amplitude grows, a nonlinear self-localization mechanism comes into play and the process ends with the self-organization of nonlinear, highly localized, solitary IG vortex structures. The system thus acquires a new degree of freedom, thereby providing a new way for the perturbation to evolve in a medium with a sheared flow. Depending on the shape of the sheared flow velocity profile, nonlinear structures can be either purely monopole vortices or vortex streets against the background of the zonal wind. The accumulation of such vortices can lead to a strongly turbulent state in an ionospheric medium.

SESSION 2.4**DIV II/ICMA AND CAUSES-II/SCOSTEP LONG- AND SHORT-TERM SOLAR INFLUENCES IN THE MIDDLE AND UPPER ATMOSPHERE****2.4-1 SOLAR EFFECTS ON THE UPPER ATMOSPHERE FROM SOLAR CYCLE TO SOLAR FLARE TIME SCALES**
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Solar irradiance is the primary energy input to the thermosphere/ionosphere system. The thermosphere absorbs solar irradiance in XUV (the soft X-ray ultra-violet, 1–30 nm), EUV (extreme ultra-violet, 30–120 nm), and FUV (far ultra-violet, 120–200 nm). The solar EUV ionizes, dissociates, and excites the thermospheric constituents, creates the ionosphere, and heats the thermosphere. In this presentation, we discuss solar irradiance variations from solar cycle to solar flare time scales, and their effects on the upper atmosphere, from the perspective of modeling and data results of thermosphere neutral density due to these variations in solar irradiance. We will discuss variations in

neutral density include solar-cycle variation, annual/semiannual variation, solar-rotational variation, diurnal variation, and abrupt changes with a time scale of minutes to hours due to solar flare. The neutral density data sets include neutral density observed by the accelerometers onboard the Challenging Mini-satellite Payload (CHAMP), neutral density at satellite perigees, and global-mean neutral density derived from thousands of orbiting objects. Modeling results are from the National Center for Atmospheric Research (NCAR) thermosphere-ionosphere-electrodynamics general circulation model (TIE-GCM), and from the NRLMSISE-00 empirical model.

2.4-2 ADVANCES IN SOLAR TRENDS IN MLT-REGION TEMPERARTURE

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As the newer data sets are becoming available on the temperature of MLT region, some new trends are emerging which are contrary to the earlier perceptions. It is also becoming increasingly clear that until the solar-related changes in the long term temperature series are well understood and quantified in the mesosphere, there is little hope of separating out changes due to longer-term secular variability caused due to human induced changes at the surface, much less gaining any insight into their causes. The discrepancy in the solar signal of temperature obtained by experimental data and the model results over the equatorial regions are still unresolved. The solar signal near the mesopause region is the most challenging task and we have relatively much better data coverage as compared to mesosphere. A diverse results from polar region to equator is observed for solar signal in the temperature which need to be understood properly. The instrumental uncertainty in most widely used measurement technique namely OH-airglow is now narrowing down with various groups. In this talk, an update of solar signal in temperature of the region from 50-100 km has been made based on available understanding.

2.4-3 SOLAR CYCLE DEPENDENCE OF MIDDLE ATMOSPHERE TEMPERATURES

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TIMED/SABER temperature measurements between 20 and 100 km during the declining phase of solar cycle 23 (2002-2007), through the deep minimum of 2008-2009, and the upswing of solar cycle 23 (2010-2012) are analyzed to extract the dependence on level of solar activity. Separate analyses are performed for the latitude range between $\pm 50^\circ$ latitude where the measurements are nearly continuous, and for higher latitudes ($\pm 50-80^\circ$) that are only visited during certain months in each hemisphere due to satellite yaw maneuvers. Most results are for 60-day-zonal-mean temperatures centered on the 15th of each month, in order for complete local time sampling to be accomplished; this removes most tidal and planetary wave contributions to the temperatures. The monthly means are then averaged to obtain a composite year, and monthly temperature residuals are computed by subtracting the composite year from each individual year. This step removes the average intra-annual variations, i.e., annual, semiannual and so forth. The residuals are then averaged in 10-km altitude bins and over latitude ranges $\pm 10^\circ$, $\pm 10-30^\circ$, and $\pm 30-50^\circ$, and annual-mean values are also calculated. The mean temperature residuals defined above are subjected to regression analysis to establish a linear relationship with the 81-day mean F10.7 solar radio flux. As some typical preliminary results, we find the change in annual-mean equatorial-region temperature per 1 s.f.u. in solar flux is .048 K at 90-100 km and .023 K at 60-70 km altitude, at the 95% confidence level. Values at higher latitudes are not too different, although the solar dependence appears to be more robust during some months.

2.4-5 THE INFLUENCE OF ENERGETIC PARTICLES ON THE ATMOSPHERIC CHEMISTRY AND CLIMATE.

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The solar magnetic activity variations influence the deposition of energy in the Earth's atmosphere modulating the energy spectrum and fluencies of different energetic particles. Precipitating magnetospheric electrons are able to produce substantial amount of nitrogen oxides (NO_x) in the lower thermosphere over the high latitudes. Due to relatively long life time in the absence of strong solar UV radiation NO_x can be transported down by diffusion and/or vertical advection into the stratosphere inside polar vortexes which is the most pronounced after the sudden stratospheric warming (SSW) events. The level of the reactive nitrogen and hydrogen oxides can be further enhanced after strong solar proton or radiation belt electron precipitation events leading to the ozone destruction in the upper stratosphere over the high latitudes. In the lower stratosphere and upper troposphere the ozone mixing ratio can be also modified by nitrogen and hydrogen oxides produced by galactic cosmic rays. The direct effects of these forcing consists of the alternation of the heating rates in the atmosphere leading to the changes of temperature distribution and circulation pattern in the stratosphere. The reconfiguration of the stratospheric wind pattern can penetrate further down influencing the wave properties and surface air temperature distribution. This chain of the physical processes

is characterized by downward propagation and can be detected either from the surface temperature field or from the depression of Brewer-Dobson circulation. Modeling of these processes requires application of sophisticated numerical models which include all relevant processes and their interaction. In this review talk I will discuss all involved mechanisms and their representation in the state-of-art models. Different features of the modeled atmospheric response to energetic particle precipitation will be presented and compared with the observation data. The implications of the potential weakening of the solar activity in the future will be also discussed.

2.4-6 **SHORT-TERM SOLAR INFLUENCES ON THE POLAR ATMOSPHERE**

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The Earth's atmosphere is a very complicated system affected by numerous internal and external factors. The role of solar variability as well as external space factors in atmospheric variability is an important topic for scientific and societal communities. Whilst the direct effects of the solar irradiance can be adequately modeled, other mechanisms of solar influence on the atmosphere remain poorly represented.

One potential external driver is related to energetic particles of solar and space origins. Such energetic particles are one of the main sources of the ionization of the whole atmosphere; however the importance of particles of different energies depends on altitude, as well as on latitude. By means of case studies of solar protons events with different energies of particles and their influence on various atmospheric parameters, it is possible to evaluate the effect of solar energetic particles (SEP) on polar microphysical processes. The case studies of the extreme SEP events show their possible applications for natural variations of the mesosphere and stratosphere parameters. However, the effect of the additional ambient air ionization on the microphysical processes is minor, in comparison with temperature effect, and can take place only in the cold polar atmospheric conditions.

The presented here results are obtained in the frame of the CAWSES-II Task 1 Project 1: What is the effect of transient solar events on the middle and lower atmosphere?

2.4-7 **HOW TO OVERCOME PERSISTENT BIASES IN THE COMPOSITE ANALYSES: AN EXAMPLE WITH COSMIC RAYS AND CLOUD COVER**

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The main purpose of superposed epoch (composite) analysis is to resolve significant signal to noise problems, identifying responses to particular events that may otherwise be obscured by unrelated variations at similar time scales. This technique has been frequently employed to examine a hypothesized link between solar activity and the Earth's climate following Forbush decrease events, during which strong reductions in the background cosmic ray flux occur. However, numerous studies using composites to test a link between cosmic rays and cloud properties arrived at a range of conflicting results. In this work, we argue that minor methodological differences in the manner in which composites have been both constructed and analyzed could provide an explanation for different results. Using extensive Monte Carlo simulation techniques and the two most widely used satellite cloud datasets (ISCCP, MODIS) we provide details on how a composite may be objectively constructed to maximize signal detection, to robustly identify statistical significance, and to quantify the lower-limit uncertainty related to hypothesis testing. Additionally, we also demonstrate how convincing false-positive results may be obtained from non-significant data, e.g. by using a small number of events in a composite, and by calculating anomalies against a base period, and/or by using traditional statistical tests (e.g. the Student's T-test) which are based on wrong assumptions in the case of cloud data.

2.4-8 **SOLAR CYCLE VARIATIONS OF MESOSPHERIC TEMPERATURE**

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Observations of the hydroxyl nightglow emission with a scanning spectrometer at Maimaga station, Yakutsk, Russia (63°N, 129°E), have been maintained since 2000. The current 13 year record allows tentative estimation of the atmospheric response in the mesopause region to solar cycle forcing and the underlying long-term linear temperature trend. Temperature generally has a positive response to changes in solar flux F10.7. A analysis mean hydroxyl temperatures yields a solar cycle coefficient of 6.1 ± 3.6 K/100 solar flux units (SFU) and a linear long-term cooling coefficient of 3.2 ± 2.1 K/decade. A distinct seasonal variation in trend coefficients is found in 30 day sliding window or monthly trend analyses. The largest solar activity response (7.8 K/100 SFU) is measured in autumn (September-October), and there is little or no solar response in spring (March-April).

2.4-9 DIFFERENCES IN HIGH-LATITUDE PLASMA DRIFTS AND NEUTRAL WINDS BETWEEN THE NORTHERN AND SOUTHERN HEMISPHERE: THE ROLE OF MAGNETIC FIELD ASYMMETRY

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The non-dipolar portions of Earth's main magnetic field constitute substantial differences between the geomagnetic field configurations of both hemispheres. They cause in particular different magnetic field flux densities in the opposite polar regions and different offsets of the invariant poles with respect to the rotation axis of the Earth. The offset is presently considerable larger (factor ~2) in the Southern Hemisphere compared to the Northern, which has substantial implications for the coupled magnetosphere-ionosphere-thermosphere system under the influence of external drivers.

Recent observations have shown that the ionospheric/thermospheric response to solar wind and IMF dependent processes in the magnetosphere can be very dissimilar in the Northern and Southern Hemisphere. We present statistical studies of both the high-latitude ionospheric convection and the upper thermospheric circulation patterns obtained from almost a decade of measurements starting in 2001 of the electron drift instrument (EDI) on board the Cluster satellites and an accelerometer on board the CHAMP spacecraft, respectively. Using the Coupled Magnetosphere-Ionosphere-Thermosphere (CMIT) model, on the other hand, we simulated a 20-day spring equinox interval of low solar activity with both symmetric dipole and realistic (IGRF) geomagnetic field configurations to prove the importance of the hemispheric differences for the plasma and neutral wind dynamics.

The survey of both the numerical simulation and the statistical observation results show some prominent asymmetries between the two hemispheres, which are likely due to the different geographic-geomagnetic offset, or even due to different patterns of geomagnetic flux densities. Plasma drift differences can partly be attributed to differing ionospheric conductivities. The forthcoming Swarm satellite mission will provide valuable observations for further detailed analyses of the North-South asymmetries of plasma convection and neutral wind dynamics.

2.4-10 INTERPRETING TIDAL VARIABILITY IN THE MESOPAUSE REGION: AN EXPLORATION USING THE EXTENDED CANADIAN MIDDLE ATMOSPHERE MODEL.

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Short term tidal variability has often been reported as typical of single site ground based observations. The cause of this variability, however, has not been clearly identified. Since ground based observations provide the amplitudes and phases of the superposition of migrating and non-migrating components of a particular period it seems plausible that this variability is associated with short term variations in these components. This variability could be in their amplitudes or phases. Implicit in the examination of this variability are assumptions about the time scale required to unambiguously identify the character of a particular tidal component. In this paper, tidal components diagnosed from a run of the extended Canadian Middle Atmosphere model are used to examine the nature of the tidal variability in the model. This variability is examined in terms of phasor summations. This analysis provides some insights into the nature and complexity of the variability and suggests that in many cases this variability must be characterized in a statistical manner rather than as a linear superposition of well-defined components.

2.4-11 INTERANNUAL VARIABILITY OF QUASI 16 DAY WAVE IN THE TROPICAL MES

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The zonal wave number 1 planetary wave with period of 12-20 days with westward propagating phase and it is robust feature in the tropical mesosphere and lower thermosphere region. This is global scale phenomenon of tropospheric origin and it becomes quit important in the equatorial latitude as they exhibit unique propagation characteristics. In the present work, the MLT wind observations from medium frequency (MF) radars at Pameungpeuk (7.6oS, 107.6o E), Tirunelveli (8.7oN, 77.8oE), Hawaii (19.5oN, 155.5oW) are used to investigate the interannual variability of 16 day wave during 1993-2012. It is observed that the 16 day wave amplitude maximize primarily in the equinox season and secondary maximum in summer season. Besides, the enhanced wave activity is associated with El-Nino Southern Oscillation events. It is suggested that the lower atmospheric large-scale convective systems originating over the western Pacific region in response to the El Nino Southern Oscillation (ENSO) amplifies the 16 day wave in the equatorial MLT region. The results of the present study along with earlier numerical studies suggests that the lower atmospheric large-scale convective systems originating over the western Pacific region in response to the ENSO could be a reason for the amplification the quasi-16-day wave in the tropical MLT region.

2.4-12 EUV MONITORING WITH SOLACES DURING HALF OF A SOLAR CYCLE**Jacobi, Christoph; Unglaub, Claudia; Nikutowski, Bernd; Brunner, Raimund; Erhardt, Christian; Schmidtke, Gerhard**University of Leipzig; University of Leipzig; IPM; IPM; IPM; IPM
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The continuous monitoring of the solar irradiance with highest possible accuracy is important for investigations of the impact of solar irradiance variability especially on the thermosphere/ionosphere system that are pursued in the TIGER program. Since the successful launch with the shuttle mission STS-122 on February 7th, 2008, SolACES as a part of the ESA mission SOLAR recorded the EUV irradiance. SolACES consists of three grazing incidence planar grating spectrometers and two three-signal ionisation chambers, each with exchangeable band-pass filters to determine the absolute EUV fluxes repeatedly. To enable in-flight calibration, the two double ionisation chambers of SolACES, can be re-filled with three different gases for each recording, allow the recalibration of the efficiencies of the three SolACES spectrometers from time to time. SolACES recorded the solar EUV variations during the extended solar activity minimum and during the period of increasing solar activity in the first part of solar cycle 24. We present EUV variations together with ionospheric TEC and thermospheric parameters during the SolACES mission as a contribution to solar-terrestrial coupling studies.

2.4-13 SOLAR FORCING ON THE WINTER PRECIPITATION IN THE WESTERN BALTIC REGION**Leal-Silva, Carmen**Posgrado Facultad de Ingeniería, Universidad Nacional Autónoma de México
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Changes in climate patterns in the Baltic region are leading to a general increase in annual precipitation and affecting the ice formation. The solar activity variations can contribute to natural climate variations. In the present work we study the variability of Winter Precipitation reconstructed time series in the Baltic Sea since the 15th century and its possible connection with solar activity, based in a method for finding and measuring amplitude-phase cross-frequency coupling in time series. The results suggest that the Winter Precipitation in the Baltic Sea is modulated by solar activity in several frequency bands. According to our model a strong coupling between the 11 yrs periodicity in the Winter Precipitation time series and the secular periodicity of solar activity is present. We found that the Winter Precipitation is strongly modulated by solar activity at the 11 yrs periodicity. We also found that the 180 year periodicity of the Barycentre Motion modulates the amplitudes of the 8 yrs periodicity of the Winter Precipitation. We also use the partial coherence transform in order to find the main contributor to the variance of precipitation time series. We found that solar activity is the main contributor to the variance in the climatic parameters.

2.4-14 METEOR HEIGHTS HAVE DECREASED DURING THE RECENT SOLAR MINIMUM**Jacobi, Christoph**University of Leipzig
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Average meteor heights has been observed using a SKiYMET VHF radar at Collm (51.3N, 13.0E) since late summer of 2004. Initially, the daily mean height was about 89.5 km. Since that time, average meteor heights have decreased. A linear fit gives a descent rate of -60 m/year. This is consistent with earlier results from the literature and from earlier results of low-frequency reflection height changes measured at Collm. During the recent solar minimum 2008/2009 the meteor heights further decreased, so that at that time they were 400m lower than 2004/2005. Assuming that meteor heights, on a long-term average, refer to a level of constant pressure, this decrease can be converted to a mean middle atmosphere temperature decrease of 1.6 K between 2005 and 2009.

2.4-15 THE CORRELATION OF PLANETARY WAVES IN THE STRATOSPHERE WITH SOLAR ACTIVITY**Guryanov, Vladimir**Kazan Federal University
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Studies of the relationship solar activity with planetary zonal and meridional wind wave amplitudes with wave numbers 1 and 2 according to the UK Met Office data for the period 1992-2012 were carry out. Because of limited sampling of correlation were calculated for calendar seasons.

Analysis of the correlation dependence of amplitudes of zonal wind with Wolf numbers showed that the correlation is strongly influenced by altitude, latitude, and season. In winter for the amplitude of the wave number 1 in the stratosphere of the Northern Hemisphere is dominated by positive correlations. Summer in the stratosphere of both hemispheres for the first harmonics have significant negative relationship. Temporal and spatial distribution of second harmonic pretty much has the opposite disposition. For it the greatest positive correlation observed in summer and in winter - the negative. Spring and autumn throughout the stratosphere cramped correlation for both the harmonics have lower values. The exception is the Equatorial latitudes in the upper stratosphere, where there is negative correlations -0.45.

A character correlation in the field of the meridional circulation is lower values compared to a zonal wind. For both of the meridional wind harmonic notes that a more extensive areas of negative correlation.

However, in all the seasons are opposite of dynamic parameter dependency of correlation with solar activity, as for the height and latitude. This reflects the presence of compensatory mechanisms for Sun-Earth's atmosphere. As a result over a long period of time is not a noticeable accumulation of quantitative changes of dynamic parameters of one sign, due to variations in solar activity.

2.4-48p **MESOSPHERIC AND LOW THERMOSPHERIC DYNAMICS OVER 22.7°S DURING SOLAR CYCLE 23**

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In this study we used wind observation data from mesosphere and lower thermosphere region (MLT), obtained from meteor radar measurements at Cachoeira Paulista (22.7° S, 45.0° W) from March 1999 to October 2008 to investigate the MLT dynamics during the solar cycle 23. From the spectral and harmonic analysis it was possible to identify presence of planetary-scale oscillations in the mean winds to study their transient character, which allowed to elaborate a climatology of planetary oscillation signatures. In this paper, we discussed the possible relationship between the signatures of solar and the planetary wave activities.

2.4-49p **CORRELATION PREVAILING WIND WITH SOLAR ACTIVITY IN THE RANGE OF 0-100 KM ALTITUDE**

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According to the UK Met Office data for the period 1992-2012 and radio meteor data sensing for the period 1986-2012 for region Kazan (56N, 49E) the analysis of the height-term structure of zonal and meridional circulation and the intensity of its wave disturbances in the range 0-100 km altitude were carry out. Correlations were calculated annual average values, amplitudes of annual and semi-annual oscillations of the zonal and meridional wind behind, as well as its intensity to solar activity for the period from 1986 to 2012.

Built high-altitude profiles calculated values of correlation of temporal variations of zonal and meridional wind to solar activity for altitudes 0-63 km and 80-100 km. A thin high-rise structure correlation values up to the change of character height. Also changes of angle dependency of correlation in the zonal and meridional winds at altitudes of the upper Mesosphere-lower Thermosphere are detected. Such a change in slope of the high-altitude profile for the zonal and meridional winds causes found to us to reduce solar effects in temporary variations of the average kinetic energy of the flow at these altitudes compared to kinetic energy of zonal and meridional circulation.

2.4-50p **SMALL PARAMETRIC MODEL OF THREE TYPHOON GENERATION WITH VARIATIONS OF WIND SPEED IN TROPICAL CYCLONES**

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SESSION 2.5

MIDDLE ATMOSPHERE SCIENCE

2.5-1 **TEMPERATURE TRENDS IN THE MESOSPHERE**

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Trend studies in the mesosphere in the period 1961-2009 have been performed applying the LIMA model (Leibniz-Institute Middle Atmosphere model) which is based on ECMWF below approximately 40 km and adapts temporal variations of CO₂ and O₃ according to observations. There is general agreement between LIMA and observations. Temperatures in the mesosphere/lower thermosphere vary non-uniformly with time, mainly due to the influence of ozone. We have therefore separated the influence of CO₂(t) and O₃(t) when determining trends. It is important to distinguish between trends on pressure altitudes, z_p , and geometric altitudes, z_{geo} , where the latter includes the effect of shrinking due to cooling at lower heights. Maximum total temperature trends reach approximately -1,3K/dec at $z_p \sim 60$ km and -1.8K/dec at $z_{geo} \sim 70$ km, respectively. Carbon dioxide is the main driver of these trends in the mesosphere, whereas ozone contributes approximately one third, both on geometric and pressure heights. Depending on the time period chosen, the ozone effect on trends can be significantly smaller or larger. Temperature trends on geometric and pressure altitudes can differ by as much as -0.9K/dec in the mesosphere. The altitudes of pressure

levels in the mesosphere decrease up to several hundred meters. The shift maximizes at mesopause levels where it accumulates to more than 1km. Most of the shrinking occurs in the mesosphere and a smaller fraction (~20%) in the stratosphere. For the first time, we have performed long term runs with LIMA applying the 20th Century Reanalysis from NCEP/NCAR dating back to 1871. Again, trends are non-uniform with time. Since the late 19th century temperatures in the mesosphere have dropped by approximately 5-7K on pressure altitudes, and up to 10-12K on geometric altitudes. This is much more than typical trends in the troposphere and stratosphere. It is therefore justified to summarize that the mesosphere (at least in summer and at middle latitudes) reacts substantially more sensitive to climate change compared to lower altitudes. As will be shown, the mesospheric temperature trends are consistent with long term variations of noctilucent clouds observed by satellites and lidars. We have extended our trend analysis starting from the late 19th century. As will be shown, carbon dioxide plays the major role in cooling the mesosphere.

2.5-2 **OBSERVATIONS OF TEMPERATURES AND DYNAMICS DURING THE SUMMER/FALL TRANSITION IN THE ARCTIC MESOPAUSE REGION**

Williams, Bifford P.; Fritts, David C.; Dunker, Tim; Hoppe, Ulf-Peter

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The sodium lidar at ALOMAR observatory (69N, 16E) measures temperature, winds, and sodium density from ~80-100 km altitude with day and night capability using large aperture (1.8m) telescopes. Recent improvements have yielded possibly the highest signal daytime Na lidar measurements to date, allowing the measurement of almost the full gravity wave spectrum during day and night when the sodium abundance starts increasing at the end of summer. We will present the temperatures, winds, and wave dynamics from measurements in August and September from 2010 to 2012. This includes 50 hours of data over 6 nights in Aug/Sep 2011 and a 40 hour continuous data set from August 13-15, 2012 showing a highly variable Na layer due to wave dynamics with 5 min to 24 hour periods, periodic sporadic Na layers repeating near midnight, and late-season noctilucent cloud formation during a temperature minimum.

2.5-3 **ON THE OVERSHOOT CHARACTERISTIC CURVE OF THE POLAR MESOSPHERE SUMMER ECHOES MEASUREMENTS DURING ARTIFICIAL HF HEATING**

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This work is a study of VHF radar observations of the artificially modified Polar Mesosphere Summer Echoes (PMSE) by HF radio waves. The data stem from high occurrence days between the years 2008 and 2012. From a total of around 45 days of experimental campaigns, we have not found the expected instantaneous overshoot effect at Bragg wavelengths of 2.67m (MORRO radar) and 0.67m (EISCAT VHF). Surprisingly, only in less than 10% of the observed days a weaker and delayed overshoot immediately after the heater on period was found. Even the PMSE weakening during the heater on-period sometimes was not present. The absence of the expected overshoot characteristic curve (OCC) of current VHF radar observations could most probably imply that the large heating effect in most cases occurred below the PMSE region. Due to the absence of PMSE echoes at Bragg wavelengths of 0.16m corresponding to the EISCAT UHF radar (930 MHz), incoherent scatter radar (ISR) signals at this radar frequency allow useful estimation of the plasma parameters at PMSE altitudes. We will evaluate the corresponding levels of electron temperature enhancement at PMSE altitude by fitting the UHF measured spectra to theoretical spectra with different collision frequency models. The typical low signal to noise ratio of current ISR measurements in the mesosphere and the important contribution of collisions between plasma particles and neutrals in this lower region, are the most challenging factors to be overcome in order to get reliable estimation of the plasma parameters.

2.5-4 **MULTI-SCALE GRAVITY WAVE DYNAMICS IN THE MESOSPHERE AND LOWER THERMOSPHERE**

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Multi-scale superpositions of gravity waves and mean or low-frequency wind and temperature structures are ubiquitous throughout the atmosphere. In the MLT, such multi-scale dynamics exhibit a variety of interactions and effects. High-resolution direct numerical simulations (DNS) are employed to explore these dynamics for various initial conditions. Results include strong wave-wave interactions and spectral energy transfers, induced and localized small- and larger-scale instabilities and turbulence, and evolution of sheet and layer structures in the temperature and wind fields at smaller scales. In several areas, DNS results agree very well with available observations.

2.5-5 SEASONAL VARIATIONS OF OZONE IN THE UPPER MESOSPHERE**Smith, Anne K.; Lopez-Puertas, Manuel; Funke, Bernd**

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We use observations from the SABER and MIPAS satellite instruments and simulations with the WACCM model to investigate the processes responsible for seasonal variations of ozone at the secondary maximum, about 90-95 km. Ozone is approximately in photochemical equilibrium during both day and night. Its distribution depends on the photolysis rate, the temperature, and the distributions of atomic hydrogen and oxygen. Interannual variability in high northern latitudes is associated with disturbances in the lower and middle atmosphere, particularly sudden stratospheric warmings. Seasonal variations in atomic hydrogen drive out of phase variations in nighttime ozone. There are large diurnal variations superimposed on the season cycle; as a result the apparent seasonal variation changes with local time.

2.5-6 NA LIDAR OBSERVATIONS COMPARED WITH WACCM SIMULATIONS AT 80 ~ 100 KM AND 69°N**Dunker, Tim; Hoppe, Ulf-Peter; Feng, Wuhu; Plane, John M. C.; Marsh, Dan R.**

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The ALOMAR Weber Na lidar is located on the Norwegian island Andøya (69°N, 16°E). We use Na column densities and temperature profiles 80 to 100 km altitude from 2004 until 2012. We will explain the principle of Na density and temperature measurements, with emphasis on possible systematic errors. Metal chemistry has recently been implemented into the Whole Atmosphere Community Climate Model (WACCM). We report on first results of a comparison between Na column density observed by ground-based lidar and WACCM output for high latitudes. For the comparison, we use two nudged WACCM runs, one with ECMWF ERA-Interim reanalyses, and one with output from the Goddard Earth Observing System model, version 5 (GEOS 5). The WACCM model was nudged up to an altitude of 60 km with temperature and air density values from ECMWF and GEOS 5 to approximate the actual values as best as we know them. Above 60 km, WACCM was free-running. The results from WACCM nudged with GEOS 5 agree better with the lidar observations than WACCM nudged with the ECMWF ERA interim reanalysis. The results show that, in general, WACCM models a larger Na density compared to the Na lidar by 20%, sometimes more. The best agreement is reached close to the equinoxes. The seasonal cycle of Na density is represented well by WACCM, with the minimum Na density during the summer months. The year 2009 is different from the other years in the time period: The lidar observes quite large Na column densities (about $3 \times 10^{13} \text{ m}^{-2}$) during summer. The ECMWF run shows a similar behaviour, but overestimates this deviation from the other years. The GEOS 5 run, on the other hand, shows 2009 very similar to the other years in the period. We investigate the centroid height of the Na layer, the layers' peak altitude and peak Na density, and neutral temperature.

2.5-7 ANNUAL INFLUX OF METEORIC NA AT 69° N ESTIMATED FROM LIDAR OBSERVATIONS**Hoppe, Ulf-Peter; Dunker, Tim; Williams, Bifford P.**

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Sodium (Na) lidars making use of resonance fluorescence by free Na atoms in the upper mesosphere and lower thermosphere have been operated since 1969. The source of Na in the 80 to 110 km height region is the ablation of meteors which contain Na among many other elements. We use data from the Weber Na Lidar that has been in operation at 69° N 16° E since August 2000. The Na layer is always present and displays seasonal, daily and faster variations down to scales of 15 s. Most of these variations are the consequence of chemical processes modifying the sources and sinks for atomic Na, dynamic processes that transport and compress or decompress air parcels containing Na, as well as presumably the variation of the average influx of Na with ablating meteors. We occasionally observe brief localized enhancements of Na density that are clearly too short and too localized to be classified as sporadic Na layers, also called sudden Na layers, which are often related to sporadic E layers. For instance, we observed two such events during 40 hours of lidar measurements in November and December 2010. We present the results from a systematic search for such events 2004 to 2012 and a careful analysis of the detection threshold, calibration and statistics of these observations. The result is a good estimate of the annual amount of Na entering the atmosphere with meteors at this location, and possibly information on the variation through the year and during a typical day. Based on assumptions published in literature about the global distribution of meteors, we can extrapolate to the probable annual global influx of Na with meteors. If we knew the average Na content in the meteors parent bodies, we could estimate the total flux of meteoric material entering the atmosphere.

2.5-8 INTERANNUAL VARIABILITY IN METEORIC SODIUM AND THE ROLE OF STRATOSPHERIC SUDDEN WARMINGS

Marsh, Daniel R.; Janches, Diego; Feng, Wuhu; Plane, John M.C.; Chu, Xinzhao; Huang, Wentao; Collins, Richard; Yuan, Tao

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Seasonality of sodium constituents near the mesopause that originate from the ablation of meteoroids is driven to a large extent by variations in transport via the mean meridional wind. In particular, the summer to winter hemisphere flow leads to the highest sodium species concentrations and loss rates occurring over the winter pole. It is known that stratospheric sudden warmings can dramatically affect the circulation of the mesosphere, and in some cases can lead to a short-term reversal of the meridional wind and mesospheric cooling over the winter pole. We use a global model of meteoric sodium to investigate the response of these constituents to SSWs and their role in their interannual variability. The model is forced with stratospheric and tropospheric winds from reanalysis and can reproduce the observed mesospheric circulation response. We simulate dramatic fluctuations in the atomic sodium abundances and compare these model predictions with recent ground-based sodium lidar measurements conducted in Colorado, Utah and Alaska.

2.5-9 MESOSPHERE-STRATOSPHERE COUPLING VIA ENERGETIC PARTICLE PRECIPITATION

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Polar winter descent of odd nitrogen produced by energetic particle precipitation (EPP-NO_y) represents an important vertical coupling mechanism transferring the solar signal from the mesosphere and lower thermosphere down to the polar stratosphere and possibly below. While production mechanisms of EPP-NO_y and dynamical processes affecting its downward transport are qualitatively well understood, uncertainties remain, however, with respect to their quantitative assessment. This talk summarizes recent progress in constraining these processes by observational data with particular emphasis on the analysis of the 10-years record of global NO_y obtained from MIPAS-Envisat during 2002-2012.

2.5-10 MAJOR SUDDEN STRATOSPHERIC WARMING EVENTS AND ENERGETIC PARTICLE PRECIPITATION EFFECTS

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The main source of stratospheric NO_x (NO+NO₂) is N₂O from the troposphere. Another source of stratospheric NO_x in the polar region is energetic particle precipitation (EPP). EPP produces NO in the mesosphere and lower thermosphere (MLT). During the polar night the EPP-produced NO_x (EPP-NO_x) can be transported to the stratosphere without being photochemically destroyed. The process whereby EPP-NO_x is transported to the stratosphere from the MLT is referred to as the EPP indirect effect (EPP IE). In the Southern Hemisphere the EPP IE is highly correlated with the level of EPP; however, in the Northern Hemisphere (NH) interannual variability in dynamics is an important factor controlling the EPP IE. In the most recent decade we have ample observational evidence of the importance of dynamics. January 2004, 2006 and 2009 had major sudden stratospheric warming (SSW) events followed by a reformation of the stratopause at an altitude characteristic of the mesosphere. This is known as an elevated stratopause (ES) event. Multiple satellite instruments have shown strong descent of NO_x into the stratosphere following the ES event in all three years even though the level of EPP was relatively low during the 2005-2006 and 2008-2009 NH winters. In the work presented here we investigate the effects of SSW and ES events on the magnitude of the NH EPP IE using the Whole Atmosphere Community Climate Model. We find a very strong relationship between the seasonal timing of major SSW and ES events and the strength of the EPP IE.

2.5-11 CORRELATIONS BETWEEN WIND AND AIRGLOW OBSERVATIONS IN THE POLAR MESOSPHERE AND LOWER THERMOSPHERE

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Observations of wind and airglow variations using a field widened Michelson interferometer (ERWIN II) and an all sky imager have taken place at the Polar Environment Atmospheric Research Laboratory (PEARL) at Eureka, Nunavut (80N, 86W) for the past four winter seasons. The all sky imager provides the means to follow disturbances across the full sky and ERWIN II provides wind and airglow observations in the four cardinal directions and zenith. The temporal cadence of these measurements is ~2 minutes. Variability in the wind and airglow observations at

temporal scales of the order of an hour up to 24 hours have been examined. Often the vertical wind is correlated with the airglow variations when variations associated with similar frequencies are examined. The phase difference is close to a quarter period as would be expected for vertical motion. Correlations between the wind and airglow variations in the cardinal directions are also correlated with the vertical observations but are more difficult to interpret in terms of linear gravity wave theory. In this paper, these wind and airglow observations are presented and the nature of the correlations between various directions discussed.

2.5-12 **MODELING AND OBSERVATIONS OF CO AND CO₂ IN THE MLT**

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We have used the Whole Atmosphere Community Climate Model (WACCM) to model the distribution and seasonal evolution of CO and CO₂ in the mesosphere and lower thermosphere, and we have compared the model results with recent observations of these species made by the MIPAS and ACE space-borne instruments from the stratopause to the lower mesosphere (~1 to 0.0001 hPa). WACCM includes the effects of molecular diffusion and diffusive separation, as well as CO₂ losses (and CO sources) due to extreme ultraviolet photolysis of CO₂ and reaction of CO₂ with O⁺. The model is able to reproduce the sharp fall-off of CO₂ above about 0.01 hPa (~80 km), as well as the rapid increase of CO in the lower thermosphere, and the calculated seasonal cycles of these species are in general agreement with observations. Model CO₂ mixing ratios above 0.001 hPa (~100 km) are, if anything, somewhat lower than observed by ACE, which suggests that vertical mixing due to parameterized gravity waves may be underestimated in the model. Modeled CO mixing ratios above 0.001 hPa are also systematically smaller than observed, by as much as 20% at all latitudes and in all seasons compared to both ACE and MIPAS. Possible reasons for the discrepancies between modeled and observed CO and CO₂ are examined.

2.5-13 **DIURNAL VARIATIONS OF MINOR CONSTITUENTS IN THE MIDDLE ATMOSPHERE AS REVEALED BY THE SUPERCONDUCTING SUBMILLIMETER-WAVE LIMB-EMISSION SOUNDER (SMILES)**

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The Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES) aboard the Japanese Experiment Module (JEM) of the International Space Station (ISS) made atmospheric measurements of minor species in the stratosphere and mesosphere for about six months from October 2009 to April 2010. High-sensitivity measurements of SMILES had been performed by a receiver using superconductor-insulator-superconductor (SIS) mixers, cooled to 4.5 K by a compact mechanical cryocooler. Thus global and vertical distributions of about ten atmospheric minor constituents related to the ozone chemistry are derived. Since the ISS took the non-sun-synchronous orbit, the SMILES measurements can be used to capture the diurnal variation of atmospheric minor constituents such as O₃, ClO, HO₂ and BrO. In this talk, we will introduce an overview of the SMILES measurements and show some observational results in association with middle atmospheric chemistry and dynamics. To support the SMILES observational results, we used outputs from nudged chemistry-climate models (MIROC3.2-CTM and SD-WACCM) in a complementary way. Particular attention is paid on the diurnal variations of several minor constituents such as O₃, ClO, HO₂ and BrO in the middle atmosphere. Through these comparisons we found that the SMILES observational data clearly showed the global pattern of diurnal variations of the minor constituents. These results demonstrate the SMILES high sensitivity measurements are expected to provide further insights into atmospheric chemistry.

2.5-14 **THE MID-LATITUDE MESOSPHERE'S RESPONSE TO SUDDEN STRATOSPHERIC WARMINGS AS DETERMINED FROM RAYLEIGH LIDAR TEMPERATURES**

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The original Rayleigh-scatter lidar that operated at the Atmospheric Lidar Observatory (ALO; 41.7°N, 111.8°W) in the Center for Atmospheric and Space Sciences (CASS) on the campus of Utah State University (USU), collected temperature data for 11 years, from 1993 through 2004. The temperatures derived from these data extended over the mesosphere, from 45 to 90 km. Recently, they were combined with other observations to examine the mid-latitude responses to Sudden Stratospheric Warmings (SSWs) in the polar regions. (The other observational instruments being an ionosonde, a meteor wind radar, a Na lidar, and a satellite.) Extensive Rayleigh lidar observations were made during a dozen SSW events. In order to look for effects of the SSWs, comparisons were made between the temperature profile on individual nights during an SSW event and the climatological temperature profile for that night of the year. An overall disturbance pattern was observed in the mesospheric temperatures during northern hemisphere SSWs. It included coolings (sometimes very significant) in the upper mesosphere and warmings in the lower mesosphere. Examples of the effects in the mesosphere from southern hemisphere SSWs are also given.

2.5-15 CIRCULATION CHANGES IN THE MESOSPHERE DURING STRATOSPHERIC SUDDEN WARMING EVENTS

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Stratospheric sudden warming (SSW) events are considered to be caused by enhanced planetary waves propagating from the troposphere. On the other hand, recent satellite observations show the appearance of easterly winds in the upper mesosphere just before the occurrence of the SSW event in the upper stratosphere in January 2009 (Manney *et al.* 2009). This is considered to be strong manifestation of stratosphere-mesosphere dynamical coupling; in order to understand this phenomenon, the accumulation of detailed investigation of SSW events would be necessary for the region throughout the atmosphere up to the mesopause level. In this study, we make dynamical analyses for wind and temperature fields up to the mesopause level during the recent SSW events by the use of Aura MLS data since 2004. It is found that easterly winds in the mesosphere do not always appear before SSW easterlies of the upper stratosphere. For the appearance of preceding easterlies in the upper mesosphere, wave driving due to internally formed or refracted large-scale waves may be necessary in that region; the enhancement of such waves seems to be owing to changing background wind structure of the lower mesosphere prior to the SSW occurrence.

2.5-16 MULTI-YEAR OBSERVATIONS OF MID-LATITUDE MIDDLE ATMOSPHERIC WINDS, WAVES, AND TEMPERATURE ASSOCIATED WITH SUDDEN STRATOSPHERIC WARMING EVENTS OVER NORTHERN UTAH

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We investigate the behavior of 14 years of wind, wave, and temperature observations in the middle atmosphere over northeastern Utah, USA during periods of sudden stratospheric warming events. This systematic review of the impacts of sudden stratospheric warming events on the middle atmosphere at a northern mid-latitude site is conducted using ground based measurements from imaging Doppler interferometry and meteor wind radar and Na and Rayleigh lidar and space based measurements made by the Sounding of the Atmosphere Using Broadband Emission Radiometry sensor onboard the NASA sponsored Thermosphere Ionosphere Mesosphere Energetics Dynamics mission.

2.5-17 DISTURBANCES OF THE WINTERTIME POLAR UPPER STRATOSPHERE AND LOWER MESOSPHERE: OBSERVATIONS, MODELING, AND MECHANISMS

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2.5-18 COUPLING EFFECTS BETWEEN THE LOWER AND UPPER ATMOSPHERE IN CMAT2: PRELIMINARY RESULTS USING NEWTONIAN RELAXATION TECHNIQUES

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The first step in producing a weather forecast is to determine the state of the atmosphere at any one time ($t=0$). This is undertaken through a process called ‘data-assimilation’, the combination of model-calculated variables (temperature, moisture etc) with synoptic experimental observations. By assimilating observations periodically (typically every six hours), we can constrain the trajectory of model variables, and estimate a ‘best-guess’ of Meteorological parameters. Then the model can be run forward in time to produce a forecast.

These techniques have been developed within the field of Meteorology, but they can theoretically be used in middle/upper-atmosphere research and the relatively young field of whole-atmosphere modeling. One of the primary driving forces of the Thermosphere-Ionosphere system is winds and waves generated below by meteorological processes. As these processes are predictable several days in advance, their inclusion and representation in upper-atmosphere models provides the possibility to forecast various ‘Space-Weather’ effects.

In order to investigate this possibility, we examine the response of an upper-atmosphere model (UCL’s CMAT2) coupled to various lower atmosphere Meteorological models/reanalysis through a simple data assimilation technique called Newtonian relaxation. This technique compares mutual variables within the co-located middle atmosphere region, and nudges the CMAT2 variables towards that of the Meteorological model, thereby simulating Stratospheric and Mesospheric ‘weather’ within CMAT2.

It has been shown that perturbations in the lower atmosphere (such as Sudden Stratospheric Warmings), can have upwardly propagating effects on the coupled Thermosphere-Ionosphere system. By obtaining a more realistic representation of lower atmosphere circulation and temperature, we simulate various lower atmosphere weather phenomena within CMAT2, and show the effects on MLT dynamics, chemistry, and electrodynamics.

2.5-19 COMPARISON OF LOCAL SEVERE STORM SIMULATIONS USING WRF-ARW AND WRF-NMM MODELS- A CASE STUDY

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Simulation of severe thunderstorm events which occurred over Bangladesh and adjacent area are performed using ARW and NMM dynamic cores of fine grid version of the Weather Research and Forecasting (WRF) modeling system. The thunderstorms are typical mesoscale systems dominated by intense convection, is one of the most incredible weather phenomena in the atmosphere. They frequently occur over Bangladesh and adjoining regions during hot and humid weather conditions of pre-monsoon season (March to May). These storms are also known as Nor'wester (locally called "Kalbaishakhi"), as they usually travel from northwesterly direction. Mesoscale models are essential for the accurate prediction of such high-impact weather events. In the current research, an attempt has been made to compare the simulated results of a thunderstorm event on 3rd May 2012 using ARW and NMM model core of WRFV3.3 with 4 km horizontal resolution and validated the model results with observations. Both models performed well in capturing stability indices which are indicators of severe convective activity. Comparison of model simulated radar reflectivity imageries with observations revealed that NMM model has simulated well the propagation of the squall line than ARW model. It is also observed that model simulated spatial plots of cloud top temperature, NMM model captured the genesis, intensification, and propagation of thunder squall little better than ARW model. The outcomes of these studies show that the high resolution WRF_NMM model has better capability for simulating the thunderstorms in comparison with WRF_ARW model.

Keywords: Mesoscale model, thunderstorm, Nor'wester, stability indices, reflectivity, cloud top temperature.

2.5-20 MIDLATITUDE, RAYLEIGH-MIE-RAMAN LIDAR FOR OBSERVATIONS FROM 15 TO 120 KM

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The original Rayleigh scatter lidar system that ran from 1993-2004 at the Atmospheric Lidar Observatory (ALO; 41.7° N, 111.8° W) in the Center for Atmospheric and Space Sciences (CASS) on the campus of Utah State University (USU) has undergone a series of upgrades to transform it into a Rayleigh-Mie-Raman (RMR) scatter lidar, the final stages of which are being completed. The original lidar covered the mesosphere from 45 to 90 km. The scientific impetus for these upgrades was to extend the observing altitude range both higher and lower than the previous Rayleigh lidar system, which was achieved by increasing the sensitivity by 70 times. This will enable for measurements of relative densities and absolute temperatures throughout the stratosphere, mesosphere and lower thermosphere, from approximately 15 to 120 km. The intent, as was done with the original Rayleigh lidar, is to observe as often as possible. This will provide an extensive data set for many types of analyses. Initially, it will provide good information about the poorly observed region between 90 and 120 km. By normalizing the relative densities to NCEP or radiosonde densities below 30 km, an absolute density profile will be obtained up to 120 km. So far, we have found significant temperature differences at the highest altitudes when compared to the MSISE00 empirical model. By examining densities or temperatures on varying time scales, we will also be able to study waves of different time periods as they propagate through the stratosphere then through the mesosphere and then into the thermosphere. By comparing the new observations with those from the existing 11-year data set from the original ALO Rayleigh lidar, we will be able to examine temperature trends in the mesosphere. We will present early results from this new, much more sensitive system.

2.5-21 RECENT PROGRESS OF GROUND-BASED OBSERVATIONS OF THE MIDDLE AND UPPER ATMOSPHERE OVER SYOWA STATION, ANTARCTICA (69S, 39E)

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Japanese Antarctic Research Expedition (JARE) has started the VIII-th six-year mid-term project in 2010, and the 52nd JARE departed in November 2010 commenced observations of the six-year project. The middle and upper atmosphere study in the VIII-th therm, named as 'Global environmental change revealed by observing the Antarctic middle and upper atmosphere', is one of the sub-projects of the prioritized research project entitled "Global warming revealed from the Antarctic". PANSY (Program of the Antarctic Syowa MST/IS) radar, and a Rayleigh/Raman lidar system have been newly installed besides the existing radio and optical instruments such as an MF radar, HF radar

(SuperDARN radar), ionosondes, an OH spectrometer and an all-sky airglow imager in Syowa station, in order to clarify variabilities in the atmosphere from the ground to the upper atmosphere. A millimeter wave spectrometer for profiling minor constituents was also collocated and installed.

PANSY radar is a 47 MHz VHF radar with 500 kW output power and 20,000 m² antenna array. The radar observes wind velocities from the troposphere to the mesosphere, as well as plasma parameters in the ionosphere. Three groups of antenna (1/18 of full system) was installed during summer operation of the 52nd JARE. Operation was expanded with 12 groups of antenna (about 1/4), and continuous scientific observation started in April 2012 and the tropospheric and lower stratospheric winds has been measured without a long data gap. Mesospheric echoes were also observed during summer and winter months. The Rayleigh/Raman lidar observes temperature and clouds in the mesosphere, the stratosphere and part of the troposphere, and providing data of gravity wave characteristics in the middle atmosphere, as well as high altitude clouds of PMC (polar mesospheric clouds) and PSC (polar stratospheric clouds). In order to extend the height coverage to include mesosphere and lower thermosphere region, and also to extend the parameters observed, an external laser system for multi-wavelength resonance scatter lidar measurement is being developed. The millimeter spectrometer measures density profiles of O₃ and other species. Since January 2012, NO density has been measured in order to observe day-to-day variation, in order to investigate NO variations due to high energy particles and electrons. Analyses of observations by an all-sky airglow imager, recently concentrating to sodium airglow, an OH spectrometer for temperature measurement, and and MF radar are also ongoing. Recent results will be presented.

2.5-22 **TURBULENCE IN THE STRATOSPHERE: COMPARISON OF THREE LITOS-FLIGHTS AND RELATION TO THE RICHARDSON NUMBER**

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The stratosphere influences the whole middle atmosphere by transmission and filtering of waves typically excited in the troposphere. Several experimental and modeling studies show that a distinct amount of wave energy is already dissipated within the stratosphere, but quantitative results are rare. We have developed the balloon-borne instrument LITOS (Leibniz-Institute Turbulence Observations in the Stratosphere), resolving structures in the atmospheric wind and temperature field down to the scales of millimeters, i.e. covering both the inertial and viscous subrange of the turbulent spectrum. By this, LITOS allows the direct calculation of energy dissipation rates from the transition to the viscous subrange. Depending on instrument configuration, both kinetic and thermal energy dissipation can be observed up to ~30 km altitude. We will show results from three soundings during different BEXUS campaigns at Kiruna/Sweden (68°N, 21°E). The LITOS-BEXUS flights reveal a typical thickness of turbulent layers of only 20–200 m. The energy dissipation rate varies often by several orders of magnitude within only a few meters vertical distance, with an average value of 5–40 mW/kg in the stratosphere (depending on flight). Typically, the turbulent layers are thinner in the tropopause region compared to the mid-stratosphere, and thinner in the temperature field compared to the wind field. Even though the largest turbulent layers have been found in a region of dynamic instability (observed by a simultaneous radio-sounding), generally the relation between turbulent layers and stratospheric instabilities is weak. We will compare different available flights in terms of dissipation rate profiles and their particular relation to the background stratospheric wind and temperature field. Additionally, we will compare the results of our very high-resolved data with the method of Thorpe analysis that has recently been adapted for standard radiosonde profiles.

2.5-23 **NORTHERN WINTER CLIMATE CHANGE: UNCERTAINTY IN CMIP5 PROJECTIONS RELATED TO STRATOSPHERE - TROPOSPHERE COUPLING**

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Stratospheric climate change and its potential to influence surface climate change as simulated by the Coupled Model Intercomparison Project – phase 5 (CMIP5) model ensemble are assessed. We focus on Northern winter climate projections for the period 1961 to 2100, RCP8.5 scenario. It is found that for about 70% of the CMIP5 models, polar stratospheric zonal winds will weaken at high latitudes and strengthen at low latitudes by the end of the century. While the weakening of the polar stratospheric zonal winds is in agreement with previous single model studies carried out with models with tops above the stratopause, within the CMIP5 model set it is found that the location of the model top and better performance of stratospheric variability at all time scales are not good predictors of the polar stratospheric zonal wind response to anthropogenic climate change. A multiple linear regression analysis used to isolate the implications of the spread in the polar stratospheric wind response shows that there is a considerable inter-model spread in sea level pressure change that can be associated with the inter-model spread of the Arctic winter stratospheric change.

2.5-24 CHANGES IN THE BREWER-DOBSON CIRCULATION IN CMIP5 MODELS**Calvo, N.; Palmeiro, F.; Hardiman, S.; Garcia, R.; Butchart, N.**Universidad Complutense de Madrid; Universidad Complutense de Madrid; Met Office Hadley Center; National Center for Atmospheric Research; Met Office Hadley Center
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Recent studies have shown an acceleration of the Brewer Dobson circulation under increasing greenhouse gases. These works mainly focused in the lower stratosphere and used climate models with prescribed sea surface temperatures (SSTs) from other atmosphere-ocean models. In fact, the role of tropical SSTs in driving future changes in tropical upwelling in the lower stratosphere has also been recognized.

We characterize the vertical and latitudinal structure of the shallow and deep branches of the Brewer Dobson circulation in models participating in the CMIP5 activity with a well resolved stratosphere and a coupled ocean. Results shown that the strength of the tropical mass upwelling is found to increase at all altitudes throughout the stratosphere in relation to climate change. However, the width of the tropical upwelling region narrows below around 20hPa and widens above this level, suggesting different mechanisms driving these changes. A detail analysis of the role of different waves in forcing changes in the BDC is presented for CESM1(WACCM). Differences in the seasonality of the changes in both branches of the BDC are also discussed.

2.5-25 MODELING OF THE ATMOSPHERIC CHEMISTRY AND CLIMATE RESPONSE TO THE LONG-TERM SPECTRAL SOLAR IRRADIANCE VARIABILITY.**Rozanov, Eugene**

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The solar magnetic activity variations influence the deposition of energy in the Earth's atmosphere modulating the solar spectral and total irradiance. The direct effects of this forcing consist of the alternation of the heating rates and ozone content in the atmosphere leading to the changes of temperature distribution and circulation pattern in the stratosphere. The reconfiguration of the stratospheric winds can propagate downward or influence the tropospheric wave pattern leading to a shift of the surface air temperature distribution. This chain of the physical processes can be detected either from the surface temperature field or from the depression of Brewer-Dobson circulation. The absorption of the solar visible and infrared radiation at the surface is also able to alternate the energy balance and temperature fields at the surface which can penetrate upward influencing the atmosphere. Modeling of these processes requires application of sophisticated numerical models which include all relevant processes and their interactions. In this review talk I will discuss most of the involved mechanisms and their representation in the state-of-art climate-chemistry models. Different features of the simulated atmospheric response to solar irradiance variability will be presented and compared with the observation data. The implications of the potential weakening of the solar activity in the future will be also discussed.

2.5-26 POSSIBLE IMPACTS OF A FUTURE GRAND SOLAR MINIMUM ON REGIONAL SURFACE CLIMATE ()**Maycock, Amanda**Centre for Atmospheric Science, University of Cambridge Department of Chemistry, University of Cambridge,
*acm204@cam.ac.uk***2.5-27 POLAR OZONE DEPLETION, CLIMATE CHANGE, AND THE KEY ROLE OF THE TROPICAL WEST PACIFIC****Rex, Markus**

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The degree of chemical loss of ozone in the Arctic is very variable and is typically much smaller than in the Antarctic. But based on data from a large network of ozone sounding stations the presentation will show that the degree of Arctic ozone loss continued to increase, a development that cumulated in spring 2011 when unprecedented Arctic ozone depletion reached values so far only know from Antarctic ozone holes. It will be shown that increasing degrees of Arctic ozone loss are due to long term changes in the climatic conditions in the Arctic lower stratosphere. The presentation will discuss the degree of our theoretical understanding of the ozone loss process and how mature global chemistry transport models are in reproducing the observed polar ozone loss, highlighting the advantages of a fully lagrangian model architecture. The important role of tropical processes for modeling polar ozone loss will be discussed.

2.5-28 THE RESPONSE OF ARCTIC OZONE TO FUTURE CLIMATE CHANGE

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In spring 2011, the polar stratosphere was characterized by a well developed polar vortex with unusually low temperatures and severe ozone depletion in the Arctic lower stratosphere. This development seemed to confirm observational studies that found an enhanced polar stratospheric cooling in dynamically undisturbed winters of the past decades. It was hypothesized that this cooling might be due to increased greenhouse gas (GHG) concentrations. Consequently, more northern winters with extremely low polar stratospheric temperatures and associated severe Arctic ozone depletion should be expected in the future.

Simulations with global climate and chemistry-climate models (CCMs) however tend to project an enhanced dynamical forcing of the polar winter stratosphere in a future climate, leading to more frequent stratospheric sudden warmings and counteracting the global GHG induced radiative cooling of the stratosphere.

Here we investigate the effect of increasing GHG concentrations on the future evolution of the northern polar stratosphere in winter. In particular, we study the question which effect of increasing GHGs is more relevant: the radiative effect on the background stratospheric climatology or the enhancement of dynamic activity due to increased sea surface temperatures. We analyze results from transient simulations of the ECHAM/MESSy (EMAC) CCM of the period 1960-2100 including ozone depleting substances and different future GHG scenarios (RCP4.5 and RCP 8.5) according to the CCMi recommendations. The focus of our analyses is on stratospheric dynamical variability, such as the frequency of stratospheric warmings, as well as changes in the occurrence of strong vortex events with extremely low temperatures. With the help of time-slice simulations with individual forcings we isolate the effect of GHG increases on the future polar meteorology and the conditions for Arctic ozone depletion.

2.5-23p MESOSPHERIC DENSITY CLIMATOLOGIES DETERMINED AT MIDLATITUDES USING RAYLEIGH LIDAR

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The original Rayleigh-scatter lidar that operated at the Atmospheric Lidar Observatory (ALO; 41.7°N, 111.8°W) in the Center for Atmospheric and Space Sciences (CASS) on the campus of Utah State University (USU), collected 11 years of data between 1993 and 1994. From Rayleigh lidar photon-count returns, relative densities throughout the mesosphere, from 45 to 95 km, were determined. Using these relative densities, three climatologies are derived, each using a different density normalization method at 45 km: the first method normalized the relative densities to a constant; the second normalized them to the NRLMSISE00 empirical model; and the third normalized them to the NCEP reanalysis model, a first principles, assimilative, meteorological model. From there, the average density profile for each night of the composite year is found by averaging the nighttime density profiles in a multi-year, 31-day window centered on that particular night. From these three density climatologies, some different and many common features in the mesospheric densities are evident. In the future, with improvements to the lidar, it will be possible to provide an absolute normalization for future profiles.

2.5-24p NEAR TROPOPAUSE O₃ – VARIABILITY AND CLIMATE IMPLICATION

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Unlike the current understanding for prevailing dynamical control over the lower stratospheric ozone distribution, some recent research [1] show that simulated by climate-chemistry models E39/C and MAECHAM4/CHEM local ozone concentration is dominated by local ozone production at most stratospheric regions. This result and some other peculiarities in lower stratospheric ozone distribution motivated our thorough analysis of the ion-molecular chemistry, initiated in the lower stratosphere by galactic cosmic rays. We will show that there is another source of ozone – an autocatalytic cycle – continuously producing O₃ in the lower stratosphere. The efficiency of this source depends on the intensity of GCR, which is modulated by solar magnetic field in heliosphere, and geomagnetic field in Earth's atmosphere. The real foundation of this mechanism is supported by the discovered 22 year periodicity and geomagnetic control inserted on the spatial-time variations of lower stratospheric O₃.

An important implication of these findings is that they offer a new understanding for factors and mechanisms influencing climate variability. We present a mechanism through which the near tropopause ozone variability could affect the near surface air temperature.

This mechanism is especially effective at middle and high latitudes and consists of modulation of temperature profile and thermodynamical stability of the air near the tropopause. Thus cooling of the tropopause reduces stability

allowing more water vapour to propagate upward into the lowermost stratosphere, while warming - increases stability and blocks vapour propagation upward. The radiative efficiency of this super cold H₂O vapour is very high, due to its very small emissivity, and has a dramatic non-linear impact on Earth's radiation balance, as was shown previously.

2.5-25p RELATIONSHIP BETWEEN STRATOSPHERIC AGE OF AIR AND FRACTIONAL CHLORINE RELEASE

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In the stratosphere the inorganic chlorine loading is crucial for the distribution of ozone. In spite of equal boundary conditions for chlorine source gases, model simulations show differences in the stratospheric distribution of inorganic chlorine and hence in ozone. As it is known from previous studies, the fractional chlorine release depends on the residence time of air masses in the stratosphere and on the altitude they are transported to. In models the stratospheric age of air is a suitable proxy for the residence time.

This study is based on timeslice simulations with the chemistry-climate model EMAC under present and future conditions. To explain the horizontal and vertical distribution of inorganic chlorine the age of stratospheric air is analyzed. With the help of the age spectrum it is possible to specify the probability of different ages, indicating pathways of various length in the stratosphere. In addition to the understanding of present-day conditions the impact of climate change on the connection between the age of stratospheric air and the fractional release of chlorine is addressed. Due to the future strengthening of the Brewer-Dobson Circulation a reduction of the age of stratospheric and therefore a decrease in the fractional chlorine release is expected.

2.5-26p STATISTICAL ANALYSIS OF GRAVITY WAVES OBSERVED BY AIRGLOW IMAGING AT SYOWA STATION (69S,39E), ANTARCTICA

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Atmospheric gravity waves (AGWs), which are generated in the lower atmosphere, transport significant amount of energy and momentum into the mesosphere and lower thermosphere and cause the mean wind accelerations in the mesosphere. This momentum deposit drives the general circulation and affects the temperature structure. Observational techniques, such as radar, lidar, airglow imaging, and so on, have been used for investigating AGWs. Especially airglow imaging is useful for investigating the horizontal structures of AGWs at around 90 km altitude. However, in Antarctica observations of airglow imaging are very limited because of the lack of observation site. The Japanese Antarctic Research Expedition (JARE) have operated airglow imagers at Syowa Station (69S, 39E), Antarctica in 2002 and between 2008 and 2012. We perform statistical analysis of image data in 2011. 81 wave events in the sodium airglow images were picked up from 71 clear sky nights while observation had been made from March to September for 139 nights. We determined horizontal characteristics such as propagation direction, horizontal phase speed, horizontal wavelength, and observed period. The distributions of horizontal wavelength, and observed period are similar to those obtained by the other imaging observations at middle and low latitudes, but the distributions of propagation direction, horizontal phase speed show east-west anisotropy and seasonal variation. The observed waves propagating eastward have faster phase speed (0m/s-150m/s) than these propagated westward (0m/s-60m/s) and faster waves (30m/s-150m/s) were only observed in July and August. The anisotropy of the phase velocity distribution to the east could be explained if wave sources are located at the eastward wind such as stratospheric polar night jet.

2.5-27p IMPACTS OF FUTURE COMPOSITION CHANGES ON STRATOSPHERIC RADIATIVE DAMPING RATES IN THE UM-UKCA MODEL

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Previous studies have evaluated the approximation of local linear relaxation to a reference temperature state (i.e., "Newtonian cooling") in the middle atmosphere in models and observations. Here we evaluate the validity of this approximation for both longwave and shortwave heating rates in the UM-UKCA model for the first time. We also investigate the impacts of projected future composition changes (e.g. Antarctic ozone recovery and increases in carbon dioxide concentrations) on radiative damping rates in the middle atmosphere. We present evidence for potentially important changes in the net radiative damping rates under increased greenhouse gas concentrations, particularly in the upper stratosphere. We further elucidate the sources of these changes using offline radiation codes and analysing species dependent heating rates from the online model.

2.5-28p OI 5577, O2 AND OH ALTITUDE PROFILE REPRESENTATIONS FROM INTEGRATED GROUND-BASED AIRGLOW MEASUREMENTS AT BRAZILIAN EQUATORIAL SECTOR

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Quasi-simultaneous integrated volume emission rate measurements of OI 557.7 nm, O₂ (0,1) Atmospheric Band and OH (6,2) Meinel Band nightglow carried out at São João do Cariri (7.4° S, 35° W), Brazil, by a multi-channel tilting filter photometer, have been used to represent their altitude profiles. In order to recover the vertical profile of the emissions, we had applied an approximation for the distribution of atomic oxygen density in the MLT region, which considers a Chapman function and a background atmosphere from the MSISE-90 model. In this study, the nocturnal and seasonal behavior of the altitude profiles of atomic oxygen density and nightglow emissions are presented and discussed.

2.5-29p RESULTS OF 15 YEARS CONTINUOUS RADAR OBSERVATIONS OF MID-LATITUDE MESOSPHERE SUMMER ECHOES

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The very strong radar returns from the upper mesospheric heights in polar and mid-latitude regions during the summer months are observed by VHF radars for several years. These echoes are connected to the very low temperatures at these regions resulting in the formation of ice clouds. Charged ice particles prevent, by an effective reduction of the electron diffusivity, the normal fast destruction of irregularities of the refraction index of half the radar wavelength by viscous forces, and radar waves are backscattered.

Mesosphere summer echoes at mid-latitudes (MSE) are remarkably more seldom and therefore a less prominent research object than the mesosphere echoes at polar latitudes (PMSE). Nevertheless the study of these signals coming from the mesosphere outside the more extreme conditions in the polar regions could be crucial to understand the existence and lifetime of the mesosphere ice clouds.

Beginning in 1998 mid-latitude MSE were observed with the OSWIN VHF radar in Kühlungsborn (Germany). Based on a nearly continuous operation of the radar a large data set with altogether more than 1000 hours of MSE detections has been obtained.

We present and discuss the results of these observations. MSE and PMSE are characterized by very strong radar returns with high aspect sensitivity and a restriction to the summer mesosphere. Beside these analogies their main differences will be discussed too. MSE occur in a shorter time interval in the summer months and normally only during daytime. They are still observable although the low temperatures and the sufficient degree of saturation necessary for the existence of ice particles cannot be reached at all times. We show the diurnal and seasonal MSE distribution, scattering characteristics, aspect sensitivity, winds and turbulence characteristics during the occurrence of MSE.

2.5-30p GLOBAL MECHANISMS IN THE EARTH ATMOSPHERE MODELS AND ANGLE MOMENTUM BALANCE: ATMOSPHERIC CIRCULATION, TELECONNECTION AND RADIO-WAVEGUIDES.

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The satellite data and data of observing the radio-waveguide parameters (especially in the low troposphere layers) by means of radio-technical devices (in the ultra short-wave diapason) is the informative basis of the modern atmosphere long-term forecasts. As any water quantities in atmosphere are formed on the basis of the cycle- and front-genesis (or in the convective non-stability lines) one can introduce the corresponding model on the basis of thermodynamics and hydro-mechanics of the corresponding processes. For example, physics of these processes can coincide with the a soliton mechanics, which has the long-periodical basis of the energy support. The action mechanics of such a soliton defines the key thermo-hydro-dynamical parameters of the atmosphere ultra-short-wave radio-waveguide. We present principally new methods of monitoring the Earth system low-frequency scale processes on the basis of observing some summated contributions of low frequency oscillations for geophysical factors. They base on the energy and angle moment balance relations and new scheme for calculation of the macro-turbulence regime in typical atmospheric processes, which are known as atmospheric circulation forms [1,2]. The balance analysis allows to predict the large-scaled atmospheric transformations and teleconnection phenomena and to give their quantitative description. We carried out a series of the computer experiments at the Pacific ocean region in order to study global mechanisms in the atmospheric models and check the seasonal sequences of the conservation (or disbalance) of the Earth atmosphere angle momentum and to provide new predictors for the long-termed and super long-termed forecasts of the low frequency atmospheric processes. The current function (complex velocity) fields are calculated for typical atmospheric circulation's forms. The experiments allowed quantitatively defining a direct link between an

atmospheric turnover and atmospheric circulation forms through the front divider position and typical low frequency process of conservation of the angle moment balance. Besides, we have adapted the modified theory of the macro-turbulence for possible using the atmosphere radio-waveguides as a special effective predictors in the long-termed plan.

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SESSION 3.1

ULF WAVES SPACE-GROUND COORDINATION

3.1-1 OCCURENCE CHARACTERISTICS OF ULTRA-LOW FREQUENCY WAVES IN LAGOS,

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Investigations for the presence of geomagnetic field pulsations and simultaneous Doppler variations in ionospherically reflected high frequency radio waves have been carried out in Lagos (GG: 3.4°E, 6.5°N; L-shell value = 0.98). Pc 4-5 pulsations were mostly observed and so are reported in this work. A total of 24 correlated events were observed from data collected between February 2011 and March 2012. Results obtained gave Kp index during correlated events as less than 3, showing that geomagnetic pulsations and corresponding Doppler variations happened during periods of low magnetic activity. Phase measurements showed the Doppler variations mostly out of phase with the H-component of geomagnetic field pulsations and amplitude ratio of Doppler variations to geomagnetic pulsations was in the range 0.06 – 0.6 Hz/nT.

Observations from this study also showed that the amplitude of variations in the H – component was higher than in the D-component when correlated with Doppler variations. Phase difference between the longitudinally spaced magnetometers showed Abuja H-component leading Ilorin H-component by about 60 degrees while Ilorin D-component led Abuja D-component by approximately 4 degrees. The amplitude of the H-component geomagnetic pulsation at Abuja was higher than that at Ilorin.

The time-of-day of occurrence of these events showed a peak appearing between 0600 and 0700 UT followed by a decline, and then a steady rise up till noon. The gradual rise in occurrence of events from 0700-1200 Hrs follows the diurnal variation of electron density in the ionosphere. Good correlation was found between simultaneous ionospheric variations and geomagnetic pulsations with oscillations in solar wind bulk speed. From our results we conclude that the occurrence of ULF waves with periods in the Pc4-5 frequency range, occurring in the daytime equatorial ionosphere, is directly linked with the presence and movement of electrons in the ionosphere which gives rise to currents. Currents in the ionosphere produce perturbations that can be sensed at the ground and in the ionosphere. For future work we will investigate the possibility of other mechanisms, besides the presence of electrons in the ionosphere, being responsible for the peak of ULF wave events appearing at 0600-0700 Hrs UT.

3.1-2 USING GROUND-BASED MAGNETOMETERS TO PREDICT SPACE-BASED ELECTRIC FIELDS

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Traditionally, identifying both the duration and location of wave activity is difficult to do with either ground- or space-based instrumentation only. In-situ measurements provide the most precise method to determine in-situ electric field, though only at specific times and in specific locations. On the ground magnetometers are widely available, but there are several assumptions to be made to use these measurements as a TV screen of what is happening in the magnetosphere in even the most advanced mapping techniques (e.g., Ozeke et al., 2009; Sciffer and Waters, 2011). In this talk we compare specific case studies of the ground-based magnetic fields and mapped electric fields, with measured space-based electromagnetic fields. We further present a statistical characterisation of ground-based Ultra-Low Frequency (~1-15 mHz) magnetic wave power spectral densities (PSDs) as a function of latitude (corresponding to dipole L-shells from L~2.5-8), local time and solar wind speed. We then map the ground-based magnetic ULF wave power measurements into electric fields in the equatorial plane, and compare and contrast these findings with CRRES and THEMIS electric fields across a wide range of L-shells.

3.1-3 ESTIMATING THE LATITUDINAL PROFILES OF THE FLR FREQUENCY AND THE RESONANCE WIDTH BY USING THE IMPROVED HODOGRAPH METHOD AND THE APGM METHOD

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There are methods called the improved hodograph method (IHM below) and the amplitude-phase gradient method (APGM below) that are used to obtain the latitudinal profiles of the field-line-resonance (FLR) frequency and the resonance width by using data from two ground magnetometers latitudinally separated by ~100km. The both methods apply FFT to the two magnetometers' data, and calculate the amplitude ratio and the cross phase from the two stations' data as functions of the frequency. From there the two methods use different approaches: IHM fits a curve to the obtained ratio (as a complex number including both the amplitude ratio and the cross phase) on the complex plane to separate out the non-FLR signal in the data, while APGM assumes that the obtained amplitude ratio and cross phase include FLR signal only and obtains the FLR frequency and the resonance width in an algebraic manner. In this paper we apply the two methods to the Scandinavian BEAR stations and a station pair of Wadena (belonging to MAGDAS) and Weyburn (belonging to CARISMA), show that IHM can properly estimate the latitudinal profile of the resonance width (which is the improved point of IHM over the original hodograph method), compare the results of applying IHM and APGM, and see how the latitudinal profile of the resonance width differs between geomagnetically quiet times and active times.

3.1-4 MODULATION OF TOTAL ELECTRON CONTENT BY ULF WAVES

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The intriguing effect was found while analyzing the small-scale variations of total electron content (TEC) derived from global positioning system (GPS) signals. This effect is seen in TEC variations observed in association with intense global Pc5 pulsations with period about few mHz during the recovery phase of the strong magnetic storm on Oct. 31, 2003. Earlier studies demonstrated that the GPS-TEC technique is a very powerful method to study the propagation pattern of transient disturbances in the ionosphere, generated by seismic or internal gravity waves. This technique has turned out to be unexpectedly sensitive to ULF waves as well. During periods with intense Pc5 geomagnetic wave activity very clear pulsations with the same periodicity were found in the TEC data from high-latitude GPS receiving stations in Scandinavia. Moreover, the relative amplitude of TEC periodic fluctuations $\Delta\text{TEC}/\text{TEC}$ was about the same or even larger than the relative amplitude of geomagnetic variations $\Delta B/B$. So far, the effect of TEC modulation by Pc5 waves has not been well understood and is still a challenge for MHD wave theory.

3.1-5 SPATIAL AND TEMPORAL PHASE DISTORTIONS OF SPACE TO GROUND ELECTROMAGNETIC SIGNALS DUE TO ULF WAVES.

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Temporal and spatial variations in the electron content of the ionosphere alter the propagation characteristics of electromagnetic (EM) radiation. For frequencies above a few megahertz (MHz) variations of the ionosphere electron content influence highly sensitive, ground based spatial measurements such as those used in radio astronomy and Global Positioning System (GPS) applications. In this work the associated time delay of MHz signals introduced by variations in the ionosphere electron density caused by the natural spectrum of ultra-low frequency (ULF) wave activity that originates in near-Earth space is modelled. The temporal and spatial characteristics of the associated time delays on MHz signals is explored using a multidimensional, time dependent model of ULF plasma waves in the magnetosphere. The model includes a height distributed conductances (and electron) profiles as well as a field aligned electric field. The time delays and associated phase shifts are shown to depend on the temporal development, spatial structure, amplitude, ULF wave mode mix and the arrival angle of the MHz signal.

3.1-6 STATISTICAL STUDY OF ULF WAVES OBSERVED BY CHAMP AND ON THE GROUND

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Based on magnetic field measurements from the satellite CHAMP, a detailed picture could be obtained of the compressional and shear Alfvén waves in the topside ionosphere. The low, near-polar orbit of CHAMP, covering all local times, allows the global distribution of these types of pulsation to be revealed. The observations from space are compared to observations made at the European Meridional Magnetometer Array (EMMA). Low latitude compressional Pc3s were identified as waves of upstream origin entering near the subsolar point of the magnetosphere. Their spatial distribution was found to be modified by the geomagnetic field topology. According to space-ground comparisons compressional waves in the topside ionosphere have large (6-10 000 km) coherence length.

Due to the fast movement of CHAMP across the narrow resonance regions, FLRs are Doppler shifted and not

easily detected. However, on a statistical basis, their average features could be clearly established. Comparison with ground observations made possible the estimation of their Doppler-shift. Using a simple model the resonance width of FLRs (in the topside ionosphere) could also be obtained. The well-known 90° rotation as a result of transmission of Alfvén waves through the ionosphere was also investigated.

Some promising possibilities yielded by the upcoming SWARM mission are also discussed briefly.

3.1-7 EMPIRICAL MODEL OF PC3 ACTIVITY BASED ON SOLAR WIND INPUTS

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Since the first in situ measurements of the solar wind plasma became available, statistical analyses employing linear fits of solar wind data to ground based measurements have shown that certain solar wind plasma and magnetic parameters control the occurrence and intensity of Pc3 pulsations (regular oscillations of the geomagnetic field in the 22 – 100 mHz band). We use a large data set of solar wind and geomagnetic field measurements at 1 minute resolution from a middle latitude station to develop a non-linear empirical model capable of predicting 5 minute running means of Pc3 intensity from solar wind-based input parameters. This is the first model of its kind employing such a high time resolution. A robust, iterative process is followed to find and rank the set of solar wind input parameters that optimally predict Pc3 activity. According to the parameter selection process the input parameters are, in order of importance: solar wind speed, inter-planetary magnetic field orientation, solar wind density and local solar zenith angle.

It is observed that Pc3 activity ceases when the density in the solar wind is very low, even while other conditions are favourable for the generation and propagation of ULF waves.

The influence that solar wind density has on Pc3 activity is studied by analysing six years of solar wind and Pc3 measurements at one minute resolution. It is suggested that the pause in Pc3 activity occurs due to two reasons: firstly, the ULF waves that are generated in the region upstream of the bow shock does not grow efficiently if the solar wind density is very low; and secondly, waves that are generated cannot be convected into the magnetosphere because of the low Mach number of the solar wind plasma.

3.1-8 STATISTICAL STUDY OF GLOBAL MODES OUTSIDE THE PLASMASPHERE: A COMPARISON BETWEEN IN SITU AND GROUND BASED OBSERVATIONS OF GLOBAL MODES

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Global modes, trapped fast mode magnetohydrodynamic (MHD) waves in the Earth's magnetosphere, may exhibit a monochromatic frequency spectrum even in the presence of a driver with a broadband frequency spectrum and can drive standing Alfvén waves at discrete frequencies via field line resonance (FLR). Direct observations of global modes are limited to a few case studies due to unique challenges associated with detecting them in situ. In this study, we use electric field, magnetic field, and plasma data from multiple THEMIS spacecraft as well as ground-based observations to identify and characterize global modes outside the nominal plasmopause location, finding 72 events. We use this event ensemble to find a lower bound of 1.0% for the occurrence rate of global modes in the 3 to 20 mHz range; we also examine how the occurrence rate depends on different solar wind driving conditions. Finally, we compare the in situ observations with ground magnetometer observations in several case studies, and we discuss how these comparisons can inform the interpretation of ground magnetometer observations in future studies.

3.1-9 SOURCES OF PC 1-2 WAVES AT HIGH LATITUDES

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Waves in the highest range of the ULF frequency band, denoted Pc 1-2 waves (0.1 to 5 Hz), are understood to be generated by the electromagnetic ion cyclotron (EMIC) instability. Although the most commonly studied source region for these waves is in the inner magnetosphere, often near or just outside the plasmopause, equatorial satellite studies have found that their occurrence probability increases with increasing L values toward the dayside magnetopause. Pc 1-2 waves have also often been observed in ground data near the ionospheric footpoint of the dayside cusp, and early studies suggested that the cusp itself might be an additional source region. Although spacecraft observations have shown that the cusp itself is not a source of Pc 1-2 waves that reach the ground, they have also revealed additional source regions both slightly poleward and slightly equatorward of the cusp. Polar and Cluster observations as well as detailed ground-based observations have identified the plasma mantle, poleward of the cusp, as an unexpected source of quasi-monochromatic Pc 1-2 waves, generated by tailward-streaming, highly anisotropic protons during intervals of strong dayside reconnection. In addition, recent low-altitude satellite and radar observations, in conjunction with ground-based magnetometers and auroral imagers, have located Pc 1-2 emissions on

magnetic field lines just equatorward of the open-closed field line boundary, in association with traveling convection vortex (TCV) events, which themselves are triggered by dayside transients occurring near the subsolar bow shock. Although these latter emissions are likely to be generated near the magnetic equator, recent theoretical and simulation studies have also suggested a source of EMIC waves in ions executing Shabansky orbits, which can lead to trapping at high latitude field line minima on closed dayside field lines near the exterior cusps, and we review early evidence of such effects.

3.1-10 ELECTROMAGNETIC ION CYCLOTRON (EMIC) WAVES ASSOCIATED WITH TRAVELING CONVECTION VORTICES (TCV): INITIAL RESULTS FROM THE 40-DEGREE MAGNETIC MERIDIAN CONJUGATE MAGNETOMETER NETWORK

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A magnetometer array has recently been established in Antarctica to provide measurements conjugate to the Greenland west coast magnetometer chain along the 40-degree magnetic meridian. Currently, there are four conjugate pairs in operation. Utilizing the ground magnetometer network together with THEMIS satellites near the dayside magnetopause, we present interhemispheric conjugate measurements of two transient events initiated by sudden increases in solar wind dynamic pressure. Simultaneous with the inward displacement of the magnetopause produced by the increase in dynamic pressure, we observed the generation of a pair of ionospheric traveling convection vortices (TCV) in both polar ionospheres propagating away from local noon. The conjugate ground network also observed ULF Pc1 waves identified as electromagnetic ion cyclotron (EMIC) waves in association with the initiation of the TCVs. The spectral features of the wave events are compared between the ground conjugate points in relation to the solar wind and magnetospheric conditions to investigate the relationship between solar wind dynamic pressure pulses and the generation of EMIC waves.

3.1-11 PC2 EMIC WAVES GENERATED HIGH OFF THE EQUATOR IN THE DAYSIDE OUTER MAGNETOSPHERE

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It is generally accepted that electromagnetic ion cyclotron (EMIC) waves are generated in the minimum field region near the equator where there will be minima in the parallel energetic trapped keV particle energy and the wave group velocity, favorable for triggering the ion cyclotron instability. The waves then propagate along field lines to the conjugate ionospheres. However, this picture neglects field line distortion in the outer magnetosphere which results in minimum field regions located higher off the equatorial plane. These are sites for particle trapping in Shabansky orbits, which can lead to temperature anisotropies off the equator. We use data from the Cluster spacecraft constellation to examine a Pc2 EMIC wave event detected near magnetic noon near the cusp, around L~13, over 13 - 20 degrees magnetic latitude north of the equator. The event was not associated with any solar wind related magnetospheric compression. Wave packet energy propagated dominantly along the geomagnetic field direction, confirming this was a traveling EMIC wave. The energy packets propagated in alternating directions rather than unidirectionally from the equator, implying the satellites were located within a high latitude wave source region away from the equator, where a minimum in the B field is located. The CIS-CODIF H⁺ ion data provided evidence that the waves were generated locally via the ion cyclotron instability. We believe the off equatorial region may be an important site for the generation of EMIC waves observed by spacecraft and on the ground in the polar regions.

3.1-12 INTERACTION OF THE LONG-PERIOD ULF WAVES WITH THE IONOSPHERE: COMBINED RADAR AND MAGNETOMETER OBSERVATIONS AND MODELING

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Pc5 and Pi2 pulsations are examined using ground magnetometer data and SuperDARN/EISCAT radar data. To identify the physical nature of Pc5 pulsations and to determine the relative contributions of different MHD modes into their structure, we applied the method of apparent impedance. An approximate analytical relationship from the theory of ULF wave transmission through the thin ionosphere has been compared with the measured ratio between the simultaneous EISCAT ionospheric electric field data and ground magnetic fields data. The calculated apparent impedance of Pc5 waves indicates that the global Pc5 pulsations above the ionosphere are predominantly composed of Alfvén waves with a small contribution of fast compressional mode waves. Comparison of magnetometer data with the ionospheric parameters from EISCAT shows a significant (up to 60%) modulation of the electron density,

height-integrated conductance, and ion temperature by Pc5 pulsations, even in the absence of quasi-periodic electron precipitation. Comparing the combined SuperDARN - magnetometer observations of Pi2 waves with theoretical predictions, we suggest that the conception of a cavity mode is not sufficient to explain the mechanism of mid-latitude Pi2 waves; it requires a contribution from an Alfvén mode.

3.1-13 COORDINATED STUDIES OF ULF WAVES WITH SUPERDARN AND SPACECRAFT

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This talk will present our recent studies of ULF wave event conjunctions between ground-based observations made with the Super Dual Auroral Radar Network (SuperDARN) and spacecraft at the magnetopause boundary and in the solar wind. Various case studies will be presented. Key results to be highlighted include: 1) SuperDARN observation of the discrete driver wave in the polar cap region associated with field line resonances (FLRS); 2) ULF waves in the solar wind directly driving discrete ULF waves in the magnetosphere; 3) in-situ observation of magnetopause boundary oscillations associated with FLRs within the magnetosphere; and 4) Kelvin-Helmholtz instability analysis of ULF oscillations observed at the magnetopause boundary.

3.1-14 PROPERTIES OF ULF WAVES OBSERVED IN HF OVER-THE-HORIZON RADAR DOPPLER DATA

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High Frequency (HF; 3-30 MHz) coherent scatter radars probe the F-region ionosphere where plasma motion imposes Doppler velocity shifts on the backscattered signal. ULF waves incident from the magnetosphere perturb the ionosphere electron density introducing ULF wave induced Doppler clutter on radar returns. The SuperDARN is an international network of HF over-the-horizon radars that ring the northern and southern auroral zones, providing experimental data on the motion of the ionosphere plasma. Data recorded over 2006-2009 using the Australian SuperDARN radars, located in Tasmania and south New Zealand, have been analysed using statistical and case studies. We present the diurnal occurrence, latitude dependence and ULF frequency properties of the radar data that contained ULF signatures. These results will be discussed within the context of favored, discrete ULF frequencies, and magnetosphere boundaries such as the plasmapause.

3.1-15 MODELING GROUND AND IONOSPHERIC SIGNATURES OF ULF WAVES AT HIGH AND MID-LATITUDES

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A new model to describe the propagation of ULF waves in the dipolar regions of the magnetosphere has been developed. This model includes distributed Hall, Pedersen and parallel conductivities in the ionosphere, allowing for a realistic description of electric fields in this region. The ground magnetic fields are calculated assuming a perfectly insulating atmosphere and a perfectly conducting Earth. This model will be used to describe the ionospheric and ground signatures of waves trapped in the ionospheric Alfvén resonator, in the Pi1 and Pc1 bands, as well as Pi2 pulsations generated during substorms. Particular attention will be given to the transmission of ULF waves between the ionosphere and neutral atmosphere both from magnetospheric sources and atmospheric sources.

3.1-31p INVESTIGATING THE IMF CONE ANGLE CONTROL OF PC 3-4 PULSATIONS OBSERVED ON THE GROUND AT HIGH LATITUDES

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Many previous studies have shown that narrowband Pc3-4 pulsations are observed during daytime hours on the ground at high latitudes when the cone angle of the interplanetary magnetic field (IMF) is below 45°. To further investigate this IMF dependence, associated with the generation of “upstream waves” in the ion foreshock, data from June 2010 to June 2011 from Svalbard, Norway (74.2° to 76.3° GMLAT, local noon ~ 0900 UT) and Halley Bay, Antarctica (-62.2° GMLAT, local noon ~ 1445 UT) were examined for the presence of Pc3-4 pulsations. Values of the IMF cone angle and empirically predicted frequency ($f \sim 0.06 \times \text{BIMF}$), calculated from OMNI data, were then compared to Fourier spectrograms displaying the pulsations. It was discovered that the presence of Pc3-4 pulsations did not completely correlate with cone angles below 45°. Ten days of very good agreement with the hypothesis at both stations and ten days of large disagreement with the hypothesis at both stations were selected. These days were then analyzed to see whether widening the criteria to include cone angles of up to 60° explained the discrepancy between the observed results and the above expectations; it did not. The cone angle from OMNI was then compared

to upstream data from ACE, Cluster, Geotail, THEMIS, and Wind. In both the days of agreement and the days of disagreement there were times when OMNI cone angles completely matched the values at all other available spacecraft, and times when OMNI angles differed from those at other spacecraft. The frequencies of the waves always closely matched the predicted values even when the cone angles did not. In approximately half of the days with large disagreement one or more of the upstream spacecraft had data that differed from OMNI and showed cone angles below 45°. To attempt to relate the observation of Pc3-4 waves to other parameters, the components of the magnetic field vector and the flow pressure were examined during periods of agreement and disagreement. Thus far no pattern has been found. However, these data suggest the difficulty of characterizing the upstream IMF during conditions conducive to the generation of upstream waves.

3.1-32p SIMULTANEOUS TRAVELING CONVECTION VORTEX (TCV) EVENTS AND PC 1 WAVE BURSTS AT CUSP LATITUDES OBSERVED IN ARCTIC CANADA AND SVALBARD

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Traveling convection vortices (TCVs), which appear in ground magnetometer records at near-cusp latitudes as solitary ~5 mHz pulses, are a signature of dynamical processes involving the interaction of the solar wind with Earth's bow shock and magnetosphere. These interactions can generate instabilities in the ion foreshock just upstream of Earth's bow shock that can subsequently stimulate transient compressions of the dayside magnetosphere. These compressions can also sharply increase the growth rate of electromagnetic ion cyclotron (EMIC) waves, which also appear in ground records at near-cusp latitudes as bursts of Pc1 pulsations. In this study we have identified TCVs and simultaneous TCV – Pc1 burst events occurring from 2008 through the first 7 months of 2010 in Eastern Arctic Canada and Svalbard, using a combination of fluxgate magnetometers (the MACCS and IMAGE arrays) and search coil magnetometers in each region. During 16 of the 73 of the TCV events in Arctic Canada (22%) a simultaneous Pc1 burst occurred; these combined events were more tightly clustered near local noon than the population of all TCV events. We attribute the low occurrence percentage of combined events, (much lower than that found in two earlier studies using data from this same region) to the unusually low EMIC wave activity during this deep solar minimum interval. Magnetometer observations at GOES 12 are also used to characterize the strength of the magnetic perturbations near the magnetic equator at geosynchronous orbit. A correlation to changes in total magnetic field at GOES 12 was found in 57% of the Canadian events.

3.1-33p HIGH-LATITUDE SOURCE DRIVES GLOBAL PI2 AND FLR

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Global geomagnetic pulsations, such as field line and cavity resonances, are eigenmodes of the system. Ground observations of global Pi2s in the nightside have been attributed to a broadband pressure pulse, launched during substorm onset, that excites such resonances. Here we report two consecutive events that were observed over more than 10 hrs MLT and from low to high latitudes. Such "super" global Pi2s have not been satisfactorily explained yet. Using in-situ data from THEMIS and GOES, it was found that the pulsations are a combination of various modes including field line resonance, cavity mode, and possibly transient Alfvén waves. Furthermore, it is shown that the source of the pulsations, providing energy and periodicity, lies in the plasma sheet, ruling out the broadband-driven global mode mentioned above. Possible mechanisms will be discussed.

3.1-34p POSSIBLE SIGNATURES OF FAST MODE RESONANCES OBSERVED IN GROUND-BASED AND SATELLITE MAGNETOMETER DATA

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Ground-based magnetometer data recorded at the MM100 stations in Europe and fluxgate magnetometer data from the CHAMP low Earth orbit satellite are used to study the spectral structure of Pc3-4 pulsations observed at low and mid-latitudes. The results of our analysis suggest that at least three mechanisms contribute to the spectral content of Pc3-4 pulsations typically observed at these latitudes. We confirm that Pc3-4 pulsations typically contain a field line resonance (FLR) contribution, with latitude dependent frequency, and an upstream wave (UW) contribution, with frequency proportional to the IMF magnitude BIMF, as previously reported. However, besides these contributions, the Pc3-4 pulsations consistently contain signals at other frequencies which are independent of latitude

and BIMF. We suggest that the most likely explanation for these additional frequency contributions is that they are fast mode resonances (FMRs) related to cavity, waveguide, or virtual modes. We compare our observations with numerical simulations of MHD eigenmodes published in the literature.

SESSION 3.2

ULF WAVES IN THE INNER MAGNETOSPHERE

3.2-1 MEANS OF ULF WAVE ENERGY TRANSFER FROM THE SOLAR WIND TO THE INNER MAGNETOSPHERE: INVESTIGATING THE FREQUENCY AND SPATIAL DEPENDENCE OF THE POYNTING VECTOR

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Ultra Low Frequency (ULF) waves create a number of different pathways for energy to be transferred through the inner magnetosphere. For example, substorms and solar wind dynamic pressure pulses generate fast mode waves which couple to standing Alfvén waves in the inner magnetosphere via the field line resonance (FLR) mechanism; these Alfvén waves in turn transfer energy into the ionosphere via processes such as Joule dissipation. The electromagnetic energy flux (Poynting vector) associated with ULF waves is a useful diagnostic tool for determining which energy transfer mechanisms are most important for different frequencies/regions/external driving conditions. It can also be used to directly compare with other energy transfer mechanisms in the inner magnetosphere and thus place the ULF wave energy transfer rates in context. In this study, we use THEMIS spacecraft observations to statistically analyze the Poynting vector in the frequency domain. We consider the 2-80 mHz frequency range and all local time sectors.

3.2-2 ULF WAVES AS DIAGNOSTICS FOR INNER MAGNETOSPHERIC DYNAMICS

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Standing Alfvén waves (FLRs) are a specific manifestation of ULF waves in the magnetosphere. The action of the solar wind under a variety of guises can drive both discrete frequency compressional ULF waves and discrete frequency FLRs. Magnetospheric FLRs are most often studied at dayside local times, where they can be prevalent on the flanks. However FLRs have also been seen on the nightside (*e.g.*, Takahashi *et al.* 1988; Nose *et al.*, 1998; Keiling *et al.*, 2003; Zheng *et al.*, 2006). We present case studies of dayside driven ULF wave activity and relate it to solar wind driving conditions. Furthermore, we use the same basic framework to investigate the prevalence of FLRs in the nightside magnetosphere and apply tested ground-based analysis such as cross-phase to space-based data in order to demonstrate that FLRs can provide crucial information on the whereabouts of substorm onset, whilst also representing a viable candidate for triggering the substorm process itself.

3.2-3 GLOBAL Pc5 PULSATIONS DURING STRONG MAGNETIC STORMS: EXCITATION MECHANISMS AND EQUATORWARD EXPANSION

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The dynamics of global Pc5 waves during the magnetic storms on 29-31 October 2003 are considered, using data from the trans-American and trans-Scandinavian networks of magnetometers nearly in the opposite MLT sectors. We study the latitudinal distribution of spectral characteristics of the Pc5 waves with the purpose to determine how deep into the magnetosphere these Pc5 waves can extend and what is the wave energy transmission mechanism. In particular, we examine whether the self-excited Kelvin-Helmholtz instability could serve as an excitation mechanism for the global Pc5 waves. Examination of the spatial structure of geomagnetic Pc5 pulsations has prompted that the physical mechanisms of intense Pc5 pulsation on October 29 and October 31 are different. The first Pc5 event is produced by the resonant excitation of Alfvénic oscillations at the magnetospheric field lines. When during the October 31 event resonant features were very weak, and this event is better described as a result of the magnetospheric waveguide excitation. The rigid excitation of magnetospheric waveguide modes is produced by the enhanced fluctuations of the solar wind density. When the waveguide regime is excited, MHD wave can penetrate much deeper into the magnetosphere. The described features of Pc5 wave activity during recovery phase of strong magnetic storm are to be taken into account during the modeling of the relativistic electron energization by ULF waves.

3.2-4 AZIMUTHAL OCCURRENCE AND MODE STRUCTURE OF PC5 ULF WAVES, AND IMPLICATIONS FOR RADIATION BELT DYNAMICS

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Global Pc5 waves, ULF oscillations with frequencies at mHz time scales, can effectively transport and energize trapped energetic radiation belt particles through a drift-resonant interaction. Quantitatively, the drift resonance condition depends on the azimuthal mode structure of the waves driving the transport; rates of radial transport depend also on the azimuthal extent of the waves along a particle drift path. However, the limited availability of in situ observations makes it difficult to unambiguously determine both the global mode structure and azimuthal occurrence for a given population of Pc5 waves. In this work we describe efforts to characterize these quantities based on the available distribution of in situ and ground based measurements, and from global simulations of the solar wind/magnetosphere interaction. We discuss the adequacy of commonly-used assumptions about the dominant mode numbers in the magnetosphere, and examine implications of limited azimuthal occurrence of ULF waves for particle transport in terms of the effect of externally-driven wave populations.

3.2-5 SOLAR ACTIVITY DEPENDENCE OF THE RELATIONSHIP BETWEEN THE SOLAR WIND AND PC5 ULF WAVES

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We have studied the dependence of the amplitude of magnetic field variations in the Pc5 band (1.6-6.7 mHz) on the solar wind and solar activity. Solar wind parameters considered are the bulk velocity V_{sw} and the variation of the solar wind dynamic pressure dP_{sw} . The solar activity dependence is examined by contrasting observations made in 2001 (solar activity maximum) and 2006 (solar activity declining phase). We calculated hourly Pc5 amplitude using data from geostationary satellites at $L = 6.8$ and ground stations covering $1 < L < 9$. The amplitude is positively correlated with both V_{sw} and dP_{sw} , but the degree of correlation varies with L and magnetic local time. The V_{sw} (dP_{sw}) dependence of the amplitude, as measured by the correlation coefficient, is higher on the dayside than on the nightside and it is higher at higher (lower) L , with the transition occurring at $L \sim 5$. We attribute the V_{sw} control to the Kelvin-Helmholtz instability on the magnetopause, occurring both at high and low latitudes, and the dP_{sw} control to buffeting of the magnetosphere by variation of solar wind dynamic pressure. The GOES amplitude is higher at the solar maximum at all local times and the same feature is seen on the ground in the dawn sector at $L > 6$. A radial shift of the fast mode wave turning point, associated with the solar cycle variation of magnetosphere mass density, is a possible cause of this solar activity dependence.

3.2-6 RBSP OBSERVATIONS OF MONOCHROMATIC POLOIDAL ULF WAVES AND DRIFT-RESONANCE WITH RING CURRENT IONS

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The Van Allen probes (RBSP), with their near-equator orbits covering the region from $L \sim 1.1$ to ~ 6 , are well suited to study ULF waves in the inner magnetosphere. Here we present the first RBSP observation of poloidal ULF waves and their drift-resonance with ring current ions on Oct 23th 2012. Intense azimuthal electric field (E_{ϕ}) oscillations as large as 15mV/m are observed in association with radial magnetic field (B_r) oscillations by the RBSP spacecraft in the dawn-noon sector near the southern vicinity ($-17 < Mlat < -11$) of the magnetic equator from $L = 4.7$ to 5.6 outside the plasmasphere. The intense azimuthal wave electric field and a high E_{ϕ}/B_r ratio ($\sim 4,000$ km/s) indicate an anti-node of the E_{ϕ} in combination with a node of B_r at the equator for the observed ULF waves. Such an equatorial anti-node of the electric field along with the observations of the wave period (65-80s) and the 90 degrees phase lag from B_r to E_{ϕ} are all consistent with the identification of fundamental ($n=0$) poloidal standing waves. Evidence from particle flux show that the observed fundamental poloidal waves are in drift resonance with ~ 90 keV ions. A minor decrease in the DST index occurred in this event. The ions injected

into the ring current may account for the free energy source for the poloidal waves. In general, the azimuthal electric fields of the fundamental poloidal ULF waves allow for a strong resonance between the waves and drifting particles. The overall effect of such drift-resonance on the ring current evolution remains an interesting subject to be evaluated.

3.2-7 ESTIMATION OF THE AZIMUTHAL WAVENUMBER OF HIGH-M ULF WAVES OBSERVED BY MULTIPLE LOW-ALTITUDE SATELLITES

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The ultra-low-frequency (ULF) waves in the inner magnetosphere with small azimuthal scale lengths, large azimuthal wavenumbers (m) have important implications in identifying the condition of wave-particle interactions. These high- m waves are invisible to ground magnetometers due to ionospheric screening, and the estimation of m using multi-satellite observations is often difficult because of the stringent requirements in satellite separation. Recently Le et al. [2011] discovered that the Pc 2-3 waves frequently observed by the ST-5 satellites at low altitudes were in fact Doppler shifted high- m waves with much lower frequencies (Pc 5) in the Earth's frame. In this study we develop a simple model of the high- m waves in the inner magnetosphere to predict the expected waveform observed by low-altitude satellites. We compare the model waveforms with the observations by ST-5 satellites in a string-of-pearl configuration and estimate the m number and the carrier frequency of waves. Our results based on the data-model comparison show that the estimated wave numbers for the available wave events range from 40 to 250. We also discuss how the expected waveform can vary with the trajectory of the low-altitude satellite.

3.2-8 THEMIS OBSERVATIONS OF COMPRESSIONAL PULSATIONS. WAVE STRUCTURE

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We present results from a statistical study of compressional pulsations with periods ranging from 3 to 15 min in the dawn magnetosphere. We employ publicly available THEMIS magnetic field, plasma, and energetic particle observations to determine the occurrence patterns and properties such as amplitudes, periods, spectral characteristics, duration and spatial extent as a function of local time, L shell, latitude, and geomagnetic and solar wind conditions for the compressional waves. We compare velocities obtained by the finite Larmor radius method with those from timing consideration for pairs of satellites separated in the azimuthal directions and show that the compressional pulsations in the dawn sector of the magnetosphere propagate sunward. No azimuthal wave propagation was observed when two satellites were located very close to each other. We show how the amplitude of the second harmonic changes in dependence on the latitude and radial distance.

3.2-9 COMPRESSIONAL HIGH-M PC5 ULF WAVES IN THE MAGNETOSPHERE: THEORETICAL CONSIDERATIONS

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The compressional Pc5 waves with high azimuthal wave numbers ($m \gg 1$) are often observed in the magnetosphere at high level of the geomagnetic activity. The four ULF modes were suggested as a possible explanation of these waves: Alfvén ballooning mode, slow magnetosonic mode, drift compressional mode, and drift mirror mode. These modes are considered for the following issues: field aligned structure, transverse structure, generation mechanism, instabilities. Both MHD and kinetic approaches are used. It is concluded that the most probable modes are Alfvén ballooning and drift compressional modes coupled with each other. In a gyrokinetic framework, these modes are described by a system of two integro-differential equations. This system takes into account drift-bounce wave-particle interaction, finite plasma pressure, plasma and magnetic field inhomogeneity along field lines and transverse to magnetic shells, and mode coupling due to field line curvature. The conditions of the stability of these modes and their spatial structure are studied.

3.2-10 ULF WAVES AND DISCRETE AURORA

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Localized packages of intense electromagnetic waves with frequencies of several mHz are frequently observed in the near-Earth space environment in the vicinity of discrete auroral arcs. One of the main questions which remain unanswered for a number of years is how and where these waves are generated. Results from our numerical studies suggest that they can be generated in the process of electromagnetic coupling between the ionosphere and the magnetosphere, and parameters of these waves (in particular, frequencies and perpendicular wavelengths) are defined

by the sates of the magnetosphere and the ionosphere. The wave dynamics becomes particularly interesting inside density cavities produced in the low-altitude magnetosphere and the ionosphere by intense ultra-low-frequency magnetic field-aligned currents associated with the discrete auroral arcs. Our studies demonstrate that these cavities 1) localizes the development of the instability in the direction across the ambient magnetic field; 2) saturate the amplitude of the ULF waves and corresponding density perturbations and 3) broaden the spectrum of the generated waves. We discuss relations between our numerical results and observations.

3.2-11 **ULF WAVE PROPERTIES: RESULTS FROM MHD SIMULATIONS WITH REALISTIC IONOSPHERE BOUNDARIES**

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ULF plasma waves transfer energy from the magnetosphere to the ionosphere, particularly through resonance mechanisms such as the field line resonance. Recent experimental studies have compared ULF magnetic field data obtained from ground magnetometers with instrumentation in space. Measurements from space have been obtained from low Earth orbit (e.g. CHAMP) while others have come from further out (e.g. THEMIS). Reconciling the ground and space data is challenging, mostly due to the dynamics and spatial properties of the intervening ionosphere. This paper will present results using experimental data and outputs from a time dependent, 2 1/2-D MHD simulation. The simulation results reveal the complex interplay between field line resonances and plasmasphere cavity quasi-resonance structures which then interact with the ionosphere Hall conductance to give the ground signal. ULF wave structures such at dayside Pc4 and nightside Pi2 are discussed.

3.2-12 **LOCAL-TIME VARIATIONS OF ULF MODE FREQUENCIES IN THE ASYMMETRIC PLASMASPHERE**

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The plasmaspheric density (or the Alfvén speed) distribution plays a crucial role in determining the characteristic mode frequencies of the geomagnetic ULF pulsations such as plasmaspheric virtual resonances (PVR) and field line resonances (FLR). We have performed three-dimensional MHD simulations to examine how the asymmetry in the plasmasphere affects both of compressional and transverse modes in the Earth's inner magnetosphere. Local-time density variations are applied so that the plasmapause is located close to the Earth at dawn and bulges out at the dusk region. Our results show that the mode frequencies increase near the dawn and decrease near the dusk. It suggests that the radial density structure of the Earth's plasmasphere is able to significantly affect the peak frequencies of the geomagnetic ULF pulsations, which are recently confirmed in observations.

3.2-13 **TRAPPED MODES OF COMPRESSIONAL MHD WAVES IN THE MAGNETOSPHERE**

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It has been suggested that the excitation of virtual resonances is the strong candidate for the Pi2 pulsations in the magnetosphere, on the sidelines of the cavity mode excitation. When the coupling to transverse mode is included, the situation is more complicated. We study the transport characteristics of MHD compressional waves incident on the plasmasphere from the outer region and their resonant absorption into transverse mode via mode conversion where the Alfvén speed has a typical non-monotonic profile owing to the presence of the inner plasmasphere and plasmapause. By using invariant imbedding method (IIM) which allows numerically exact calculations, we find that the excitation of virtual resonance modes can be closely related to the strong mode coupling with the transverse modes. Our results indicate that Pi2 modes may appear as mainly trapped fast modes, but also excite field line resonances at certain locations, which are consistent with the recent observational feature.

3.2-14 **THE RELATIONSHIP BETWEEN DIPOLARIZATION FRONTS, BURSTY FLOWS AND PI2 PULSATIONS: AN MHD CASE STUDY**

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Using global magnetohydrodynamic (MHD) simulations of substorm events that occurred on October 23-24, 2002 and September 14, 2004 we investigate Pi2 perturbations at 6 RE and their relationship to dipolarization fronts (DFs) and bursty flows in the plasma sheet. We demonstrate that the simulations contain both DFs and fluctuations at Pi2 frequencies. The DFs are accompanied by fast earthward flows and originate from a neutral line at ~15-30 RE.

Pi2 period fluctuations are identified in total pressure, velocity and magnetic field components at -6 RE only after a DF disrupts and penetrates the braking region boundary, the boundary between dipole field lines and stretched tail field lines. This indicates that the DFs are driving the Pi2 perturbations in the inner magnetosphere.

3.2-35P MULTI-SPACECRAFT OBSERVATION OF A ULF WAVE FREQUENCY TRANSITION DURING THE HALLOWEEN 2003 MAGNETIC STORM

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We present and discuss a rare simultaneous multi-spacecraft and ground observation of Pc3 and Pc4-5 wave activity during a period of intense radiation belt enhancement. We have examined the ULF wave activity in the Pc3 (22--100 mHz) and Pc4-5 (1--22 mHz) frequency bands within a short time interval of the Halloween 2003 magnetic storm, using data from the Geotail, Cluster and CHAMP spacecraft, and the Fort Yukon and Dawson ground magnetometer stations in Alaska and Canada respectively. The Cluster and CHAMP spacecraft and the ground stations were in good local time conjunction. The spectral analysis of the measurements shows a remarkably clear transition of the wave frequency into a higher regime within the Pc3 range, which was simultaneously detected in the magnetosphere (Cluster), topside ionosphere (CHAMP) and on the ground. The commonly observed wave parameters (i.e., onset, duration and frequency content) at various locations suggest that we are, indeed, observing the same phenomenon and offer insights into the energy transfer traced all the way from the solar wind through the magnetosphere and ionosphere to the ground. The work leading to this paper has received funding from the European Union's Seventh Framework Programme under grant agreement no. 284520 for the MAARBLE (Monitoring, Analyzing and Assessing Radiation Belt Energization and Loss) collaborative research project. This paper reflects only the authors' views and the Union is not liable for any use that may be made of the information contained therein.

SESSION 3.3

WAVE AND PARTICLE DYNAMICS IN THE RADIATION BELTS AND RING CURRENT

3.3-1 BANDED CHORUS: THEORY, SIMULATIONS, AND OBSERVATIONS FROM THE VAN ALLEN PROBES

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Whistler fluctuations in the terrestrial magnetosphere are often observed in two distinct bands separated by a gap at approximately one-half the equatorial electron cyclotron frequency. A number of possible explanations for this peculiar phenomenon have been advanced [See Liu *et al.*, *Geophys. Res. Lett.*, 38, L14108 (2011)]. The research described here addresses the hypothesis that the upper and lower frequency bands are driven by two, distinct, anisotropic (in the sense of $T_{\perp} > T_{\parallel}$) electron components corresponding to warm ($< \sim 1$ keV) and hot ($> \sim 5$ keV) temperatures, respectively [Li *et al.*, *J. Geophys. Res.*, 115, A00F11 (2010)].

The recently launched two-spacecraft Van Allen Probes mission has become a rich source of observations of both particles and fields in the Earth's radiation belts. Our research will follow a four-step procedure to test the above-stated hypothesis: (1) We will examine wave instrument data to identify events corresponding to clearly-defined observations of banded chorus. (2) We will use measurements from the HOPE instrument to establish electron component parameters during these banded chorus intervals. (3) We will insert the observed parameters from the first two steps into a full linear kinetic dispersion theory [Gary *et al.*, *J. Geophys. Res.*, 117, A07203 (2012)] to estimate growth rates of both upper band and lower band whistler instabilities. (4) We will use the linear theory results to define and carry out particle-in-cell (PIC) simulations to determine the fully nonlinear properties of both instabilities. If the PIC simulations confirm the conclusion of Liu *et al.* (2011) that the two instabilities act independently of each other, we will then attempt to generalize the results of MacDonald *et al.*, *J. Atmos. S-T Phys.*, 70, 1789 (2008), which provide an estimate for the upper bound of the temperature anisotropy of a single hot electron component, to the more realistic case of a two-component (warm + hot) electron velocity distribution.

3.3-2 ELECTRON ACCELERATION BY WAVE-PARTICLE INTERACTIONS IN THE HEART OF THE VAN ALLEN RADIATION BELTS

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Since the discovery of the Van Allen Radiation belts in 1958, a fundamental unanswered question has been how electrons are accelerated from typical energies of a few thousand electron volts (keV) to relativistic energies of many millions of electron volts (MeV). Current controversy involves two classes of processes: transport and acceleration of electrons by radial diffusion from a source population located outside the radiation belts (“radial acceleration”); or, in situ acceleration of lower-energy electrons to relativistic energies by resonant wave-particle interactions (“local acceleration”). Previous studies have provided evidence for local acceleration but have allowed enough ambiguity that significant debate continued to exist. Some past limitations included limited spatial coverage, limited energy coverage or resolution, orbital limitations that confine analysis to only small equatorial pitch angles, etc. The orbital configuration and instrumentation on NASA’s Van Allen Radiation Belt Storm Probes (RBSP) mission were designed specifically to remove such potential ambiguities and to provide definitive evidence for or against local acceleration of radiation belt electrons. We report here on multi-satellite measurements from RBSP and other satellites of the temporal evolution of radial profiles of phase space density. The phase space density profiles observed in an event in October 2012 provide unambiguous evidence for local acceleration with the rapid formation of a radial peak in phase space density centered around $L^*=4.2$ [Reeves *et al.*, 2013]. These observations prove that local acceleration is a viable mechanism for relativistic electron acceleration in the radiation belts. However radial diffusion remains a key process and we discuss the relative roles of both processes.

3.3-3 WHISTLERS IN THE RADIATION BELT

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Propagation of whistler-mode waves (whistlers) in the magnetosphere and interactions between these waves and energetic electrons in the Earth’s radiation belts is one of the most important and interesting problems of modern geophysics. Currently, this problem is the main focus of the NASA Van Allen Radiation Belt (RBSP) mission. We present results from the numerical study of propagation of whistler-mode waves in the magnetosphere with strong transverse gradients of the background plasma. Our results demonstrate that such gradients can significantly modify spatiotemporal characteristics of the waves. In particular, the transverse inhomogeneity of the background plasma can 1) convert moderately oblique whistlers to highly oblique whistlers, and 2) efficiently guide whistlers along the ambient magnetic field. The last effect is particularly important when the ambient magnetic field has a transverse gradient in the same direction as the plasma. These results provide a new explanation for the observations of whistler waves in the radiation belt.

3.3-4 CONSTRUCTING THE FREQUENCY AND WAVE NORMAL DISTRIBUTION OF WHISTLER-MODE WAVE POWER

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Wave-particle interactions in the outer radiation belts result in transport, energisation and loss of particles. The balance of these three processes is critically important for modeling the behaviour of energetic particles in the magnetosphere. One type of wave that can mediate the energisation and loss of plasma is the whistler-mode wave. State-of-the-art models of the radiation belts describe the wave-particle interaction as a diffusive process, and require the frequency and wavenormal spectra of whistler-mode waves in order to calculate the diffusion coefficients. However, whistler-mode waves grow in amplitude over large distances as they travel through the magnetosphere, and so predictions of the wave distribution are challenging. Instead, simple mathematical functions (*e.g.* Gaussian distributions) are commonly used to approximate the spectra of whistler-mode waves. We describe a new non-local method to model whistler-mode wave spectra that result from temperature anisotropy in the magnetosphere. Our new method utilizes a combination of raytracing and the equations of radiation transfer, and can provide amplitude spectra of growing waves at any location as a function of frequency and wavenormal angle, using only the magnetospheric plasma conditions as input. The waves are assumed to grow from isotropic background noise. For observed quiet-time plasma conditions, we predict that the wave distribution resembles a Gaussian distribution in frequency close to the equator, but a skew normal distribution at higher latitudes. As a function of wavenormal angle, the wave distribution always resembles a skew normal distribution, regardless of distance from the equator, and most importantly does not peak for wavenormals parallel to the magnetic field, but for small angles ($\sim 10\text{-}15^\circ$). We compare our theoretical predictions with observed whistler-mode wave distributions.

3.3-5 STRUCTURE OF LARGE AMPLITUDE CHORUS ELEMENTS: MEASUREMENTS FROM THE CLUSTER WBD AND VAN ALLEN PROBES EMFISIS INSTRUMENTS

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Cluster electric field measurements revealed fine structure of chorus wave packets. Sub-packets with a wide range of amplitudes were observed at time scales of less than 40 ms. For amplitudes larger than 15 mV/m, the occurrence rate was, however, below 0.1%. Subsequent observations by the Stereo and Themis missions have shown that whistler-mode waves with electric fields of a few hundreds mV/m can also exist in the inner magnetosphere. These large-amplitude waves can have consequences for acceleration of energetic electrons in the outer Van Allen radiation belt through microscopic wave-particle interactions.

Analysis of observations of high resolution magnetic field waveforms by the four Cluster spacecraft shows that magnetic field fluctuations linked specifically to chorus wave packets can reach amplitudes of a few per cent of the background field. During a very intense event, these sub-packets with amplitudes larger than 1 nT are again found with an occurrence rate below 0.1%.

Multicomponent waveform measurements recorded by the Van Allen probes EMFISIS instrument show similar amplitudes of chorus and allow us to estimate propagation parameters at the time scales of the sub-packet structure. This leads to new results on variations of wave vector directions during generation of chorus wave packets, challenging our current theoretical understanding of this process.

3.3-6 NEW PERSPECTIVES ON THE ROLE OF THE ION FORESHOCK IN DRIVING ULF WAVES

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The ion foreshock drives ultra-low frequency (ULF) waves in the Earth's magnetosphere, and it is usually considered most important for driving waves with frequencies above the Pc5 (2-7 mHz) range. Several studies have established a clear link between ion cyclotron waves in the ion foreshock and both fast mode and standing Alfvén waves in the Earth's magnetosphere, but there are other potential energy sources in the ion foreshock. We present results from three studies which explore the relationship between the ion foreshock and ULF waves in the magnetosphere from different perspectives: multipoint in-situ observations (THEMIS, GOES, and Cluster), multipoint ground-based observations, and statistical results from individual satellite observations (THEMIS). Using multipoint in-situ observations, we find that transient ion foreshock phenomena are an important energy source for Pc5 ULF waves. Using multipoint in-situ and ground-based observations, we find a statistical relationship between the ion foreshock and the occurrence of global modes, or trapped fast mode waves, for frequencies above the Pc5 range. This result builds on earlier case studies establishing this relationship. Finally, we present results from a statistical study of the ULF wave Poynting vector to determine how energy from the ion foreshock enters the magnetosphere via ULF waves and to explore the role energy from the ion foreshock plays in ring current/radiation belt interactions.

3.3-7 FIELD-ALIGNED STRUCTURE OF COMPRESSIONAL PC5 WAVES OBSERVED BY POLAR NEAR THE GEOMAGNETIC EQUATOR

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While the field-aligned structure of azimuthally large-scale toroidal pulsations has been well modeled as field line Alfvén oscillations, the field-aligned structure of azimuthally small-scale poloidal Pc5 pulsations is still practically unknown. These pulsations are observed during the recovery phase of magnetic storms in the region of injected ring current protons and are commonly attributed to ballooning modes. During 2002, the orbits of Polar satellite nearly coincided with the magnetic field lines in the vicinity of the magnetospheric equator. During these times Polar observed several compressional Pc5 waves in the dusk sector. Thus, using Polar observations a possibility to resolve undoubtedly the field-aligned structure ambiguity in storm-time compressional Pc5 waves has emerged. Most events exhibited the 1-st and 2-nd harmonics near the equator with node/antinode at the geomagnetic equator. The ~10 keV/e hydrogen ion flux varied in anti-phase with the total magnetic field oscillations. The amplitude-phase field-aligned structure of each harmonic has been constructed with the use of analytical signal method. The theoretical modeling was applied to the interpretation of Pc5 wave observations by the Polar satellite during its passes along a field line. Ballooning modes are described by coupled MHD equations for Alfvén and slow magnetosonic modes. Using the self-consistent Voigt model of the finite-pressure plasma immersed in a curved magnetic field the spectral characteristics and field-aligned structure of various ballooning modes have been calculated. This modeling shows the possibility of different field-aligned scales for compressional and transverse magnetic components. However, a very narrow Pc5 wave localization near the magnetospheric equator, with a scale much less than the expected Alfvén wave length, is still a challenge for ULF wave theory.

3.3-8 NATURES GRAND EXPERIMENT: LINKS BETWEEN SOLAR WIND SPEEDS, SUBSTORMS, AND THE RADIATION BELTS

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The last solar minimum was unusually deep and long-lived. In the later stages of this period the electron fluxes in the radiation belts dropped to very low levels over most of the year 2009. Energetic electrons (>100 keV) decreased by several orders of magnitude, while the flux of relativistic electrons (>1 MeV) dropped below instrument thresholds both for spacecraft located in geostationary orbits (*e.g.*, GOES) and also those low-Earth orbit (*e.g.*, SAMPEX, POES). This period has been described as a "grand experiment" allowing us to test our understanding of basic radiation belt physics and in particular the acceleration mechanisms which lead to enhancements in relativistic electrons in the radiation belts.

In this study we will report on the relationship between high speed solar wind streams, substorm occurrence and radiation belt electron flux enhancements. We demonstrate that while individual substorms are clearly linked to radiation belt electron flux variation, it is the occurrence rate of substorms (which is itself controlled by the solar wind speed), that is the primary controlling factor in this time period. This is consistent with the idea that multiple rapidly occurring substorms provide the particle populations to trigger waves which then accelerate radiation belt electrons to relativistic energies.

3.3-9 PENETRATION OF SOLAR WIND DRIVEN ULF WAVES INTO THE EARTH'S INNER MAGNETOSPHERE: ROLE IN RADIATION BELT AND RING CURRENT DYNAMICS**Mann, Ian; Murphy, Kyle; Rae, Iain J.; Ozeke, Louis; Milling, David**

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Ultra-low frequency (ULF) waves in the Pc4-5 band can be excited in the magnetosphere by the solar wind. Much recent work has shown how ULF wave power is strongly correlated with solar wind speed. However, little attention has been paid the dynamics of ULF wave power penetration onto low L-shells in the inner magnetosphere. We use more than a solar cycle of ULF wave data, derived from ground-based magnetometer networks, to examine this ULF wave power penetration and its dependence on solar wind and geomagnetic activity indices. In time domain data, we show very clearly that dayside ULF wave power, spanning more than 4 orders of magnitude, follows solar wind speed variations throughout the whole solar cycle \square during periods of sporadic solar maximum ICMEs, during declining phase fast solar wind streams, and at solar minimum, alike. We also show that time domain ULF wave power increases during magnetic storms activations, and significantly demonstrate that a deeper ULF wave power penetration into the inner magnetosphere occurs during larger negative excursions in Dst. Interestingly, we also show that both ULF wave power and SAMPEX MeV electron flux show a remarkable similarity in their penetration to low-L, which suggests that ULF wave power penetration may be important for understanding and explaining radiation belt dynamics. We further show results from radial diffusion transport models of the dynamics of MeV electrons using statistical characterisations of ULF wave power (Ozeke *et al.*, JGR, 2012) and compare them to in-situ observations. The correlation of ULF wave power with Dst, which peaks at one day lag, also suggests the ULF waves might also be important for the inward transport of ions into the ring current, in addition to the role they play in radiation belt electron dynamics.

This work has received funding from the European Union under the Seventh Framework Programme (FP7-Space) under grant agreement n 284520 for the MAARBLE (Monitoring, Analyzing and Assessing Radiation Belt Energization and Loss) collaborative research project.

3.3-10 EQUATORIAL NOISE: PROPAGATION DIRECTIONS OBSERVED BY THE CLUSTER SPACECRAFT AND IMPLICATIONS FOR THE SOURCE LOCATION**Nemec, Frantisek; Santolik, Ondrej; Pickett, Jolene S.; Parrot, Michel; Hrbackova, Zuzana; Cornilleau-Wehrlin, Nicole**Faculty of Mathematics and Physics, Charles University in Prague; Institute of Atmospheric Physics, Academy of Sciences of the Czech Republic; Department of Physics and Astronomy, University of Iowa; LPC2E/CNRS Orleans; Laboratoire de Physique des Plasmas, Ecole Polytechnique, CNRS, Palaiseau; LESIA, Observatoire de Meudon
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We present results of a systematic analysis of propagation directions of equatorial noise (EN) determined using the data measured by the Cluster spacecraft. EN emissions are electromagnetic waves at frequencies between the proton cyclotron frequency and the lower hybrid frequency routinely observed within a few degrees of the geomagnetic equator at radial distances from about 2 to 6 Earth radii. They propagate nearly perpendicularly to the ambient magnetic field. Detailed wave analysis allows us to determine azimuthal angles of wave propagation in all > 200 EN events for which the data from the WBD instruments are available. Moreover, spectral matrices measured by the STAFF-SA instruments allow us to resolve the ± 180 degrees ambiguity, and to estimate the plasma number density. It is found that while principally all directions of EN propagation are observed inside the plasmasphere, the propagation outside the plasmasphere is rather strictly azimuthal. This can be explained in terms of a simple raytracing

model, assuming that the waves are generated inside the plasmasphere, close to its outer boundary. Finally, a possibility of EN propagation to low altitudes is discussed, and relevant observations performed by the low-altitude DEMETER satellite are shown.

3.3-11 CHANGES IN DAILY LEVELS OF RELATIVISTIC ELECTRONS: RESULTS FROM MULTIPLE REGRESSION

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A number of parameters of the solar wind and magnetosphere are correlated with the production of relativistic electrons. These include the level of relativistic electrons the previous day, seed electron flux, solar wind velocity and number density, the variation in velocity and number density, IMF Bz, AE and Kp indices, ULF and VLF wave power, and pressure and electrical field. However, as all these variables may be intercorrelated between each other as well, simple correlations between each predictor variable and electron flux may not tell the whole story. We use multiple regression analyses to determine which are the most predictive of flux when other variables are controlled for, and to produce a predictive model.

We obtained hourly averaged electron fluxes for relativistic electrons (> 1.5 MeV) and seed electrons (100 keV) from several spacecraft (Los Alamos National Laboratory geosynchronous energetic particle instruments -- 1992-2002). For each day, we found the log10 maximum relativistic and seed electron flux for each satellite. No spacecraft was in operation for this entire period, so we standardized the observations to a common mean and standard deviation and then averaged over all available satellites in each hour.

We produced predictive models using the coefficients from the regression models, and assessed their effectiveness in predicting novel observations.

The daily maximum of relativistic electron flux is best explained by a set of variables rather than by one or two factors. The most predictive single variable is the flux itself one day earlier. However, the model can be improved by adding further variables, which also allows the determination of which exogenous variables are responsible for changes in flux. Seed electron flux, ULF, Vsw and its variation, and IMF Bz are the most significant explanatory variables. Both the current value of these, as well as their values in the days previous, influence flux.

3.3-12 MAGNETIC FLUCTUATIONS EMBEDDED IN DIPOLARIZATION INSIDE GEOSYNCHRONOUS ORBIT AND THEIR POSSIBLE ROLE IN SELECTIVE ACCELERATION OF O⁺ IONS

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Magnetic field dipolarization is a distinct phenomenon observed in the magnetosphere at substorm onset. According to previous studies, magnetic field dipolarization can be mostly seen at the geosynchronous altitude or farther down the tail (i.e., radial distance of ≈ 6.6 RE), and is accompanied by strong magnetic fluctuations. The characteristic time scale (TC) of the magnetic fluctuations is reported to be a few seconds to a few tens of seconds, that is, TC=0.3-30 s at $r=7-9$ RE by AMPTE/CCE [Lui *et al.*, 1992; Ohtani *et al.*, 1995], TC=8-28 s at $r\sim 8$ RE by SCATHA [Ohtani *et al.*, 1998], TC ~ 5 s at $X=-8$ to -11 RE by Geotail [Shiokawa *et al.*, 2005], TC ~ 10 s at $X=-8.3$ RE by THEMIS [Lui *et al.*, 2008], and TC=10-50 s at $X=-17.5$ RE by Cluster [Huang *et al.*, 2012]. These time scales are longer than local gyroperiods of H⁺ by a factor of 2-20, and rather close to those of He⁺ and O⁺ ions. A recent study employing the MDS-1 satellite revealed that magnetic field dipolarization can be observed in the deep inner magnetosphere ($L=3.5-6.0$) and is accompanied by the magnetic fluctuations that have a period range between the local gyroperiods of He⁺ and O⁺ ions [Nosé *et al.*, 2010]. To our knowledge, there are few studies reporting TC just inside geosynchronous orbit ($L=5.0-6.6$).

In this study, we analyze magnetic fluctuations embedded in dipolarization events at the geosynchronous altitude, using the ETS (Engineering Test Satellite)-VIII satellite. From the period of 2010-2012, we select 6 dipolarization events that showed an increase of the northward magnetic field more than 60 nT. It is found that all of the events are accompanied by strong magnetic fluctuations with TC close to the local O⁺ gyroperiods. We also study a dipolarization event in the inner magnetosphere ($L\sim 4.9$) observed by the AMPTE/CCE satellite on December 10, 1987. This event is found with magnetic fluctuations that have a period range between the local gyroperiods of He⁺ and O⁺ ions. When the fluctuations appear, the O⁺ flux is enhanced in the energy range of <10 keV.

These results suggest that magnetic fluctuations associated with dipolarization have generally TC close to the local gyroperiod of heavy ions, and may play an important role in selective acceleration of O⁺ ions.

3.3-13 MULTIPOINT OBSERVATIONS OF EARTH'S OUTER RADIATION BELT

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We are currently in an era of unprecedented data coverage throughout Earth's outer radiation belt. A constellation of constellation missions now provide observations of energetic particles, fields, and waves from a variety of orbits; these missions include: NASA's THEMIS and Van Allen Probes (RBSP), NOAA's GOES and POES, NSF CubeSats, and ESA's Cluster. Here, we will examine some of the recent discoveries that have been made with this array of outer belt observatories. We will focus on how we have clarified our understanding of certain source, loss, and transport mechanisms as well as the many new and outstanding questions concerning outer belt electron dynamics. Three main points will be reviewed in detail: 1) the energy-dependence of different outer belt sources, including those due to local acceleration and inward radial transport; 2) the nature of outer belt "dropout" events, their effective ranges in energy, equatorial pitch angle, and radial distance, and how these events can lead to the formation of two, distinct outer belts; 3) the critical importance of radial transport and the waves that can enhance it.

3.3-14 RESONANT INTERACTION OF RELATIVISTIC ELECTRONS WITH AN OBLIQUE MONOCHROMATIC WHISTLER-MODE WAVE

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One of the most challenging problems of the radiation belts' studies is the problem of particles energization. Being related to the process of particle precipitation and posing a threat to scientific instruments on satellites, the problem of highly energetic particles in the radiation belts turns out to be very important. A lot of progress has been made in this field, but still the question of energization remains open. One of the mechanisms of such energization is thought to be resonant particle interactions with whistler-mode waves. In considering this mechanism, there are two possibilities: the first one is to study wave-particle interactions with a wide spectrum of waves. Such an interaction is usually studied in the framework of quasi-linear theory, and leads to particle energy and pitch-angle diffusion. The second possibility is to consider the resonant interaction with a quasi-monochromatic wave. Such an interaction involves nonlinear effect, namely, phase trapping, which can lead to significant increase of particle energy. A fraction of energetic electrons populating the radiation belts has relativistic energies, which calls for relativistic approach for their description. In this report, we present a consistent theory of oblique whistler-mode wave interactions with energetic electrons in the radiation belts, placing the main emphases on relativistic effects as they reveal themselves in inhomogeneous plasma. This includes the consequences of modification of resonance conditions, analysis and solution of the equations of motion for relativistic electrons, and energy exchange between whistler-mode wave and resonance electrons, as well as energy transfer between various groups of energetic electrons mediated by the wave.

3.3-28p A FOUR POINTS STUDY OF THE EVOLUTION OF THE MAGNETIC FIELD IN IN THE INNER MAGNETOSPHERE

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The curlometer technique allows calculating the current density from the magnetic field measured at four different positions inside a given current sheet using the Maxwell-Ampere's law. In 2009 the CLUSTER perigee pass was located at about 2 RE allowing a study of the ring current deep inside the inner magnetosphere. The curlometer has been applied in such an orbit to calculate the current density from measured and modelled magnetic fields and for different sizes of the tetrahedron. The results showed that the current density cannot be calculated using the curlometer technique at low altitude perigee pass. It also demonstrates that the parameters used to estimate the accuracy of the method are necessary conditions but not sufficient ones. In this paper, we present a study of the evolution of the magnetic field in the inner magnetosphere as seen by the four CLUSTER satellites along a low perigee pass orbit. The purpose of the study is to define how to change the curlometer technique in order to make it usable in regions where the magnetic field spatial evolution scale is much more greater than the size of the constellation tetrahedron.

3.3-29p **EXTREMELY HIGH-ENERGY PLASMA/PARTICLE SENSOR FOR ELECTRON (XEP-E) OF ERG SATELLITE**

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It is well known that satellites are always in danger in space and especially high-energy radiation damages them. One of the sources that cause them is the radiation belt (the Van Allen belt). It was thought to be static, but in the 1990s it rediscovered the radiation belt fluctuates greatly. There are some reasons to occur this phenomenon, but we have not understood a clear reason of this yet. On the other hand, it is well known that the energetic particle flux vary during geomagnetic disturbances and the relativistic electrons in the other radiation belt change with solar wind speed. Recently solar activity is getting larger, so now we are trying to develop the satellite (ERG) to reveal this mechanism in this solar maximum phase. ERG (Energization and Radiation in Geospace) satellite is the small space science platform for rapid investigation and test satellite of JAXA/ISAS, and our group is developing the instrument (XEP-e) to measure high-energy electrons (600keV~20MeV), that is one of many ERG satellite instruments. XEP-e (eXtremely high Energy Plasma/ particle sensor for electron) is consists of five SSDs (Solid-State Silicon Detectors) and a GSO single crystal scintillator. It has one-way conic sight and an electric part is unified with a part of sensor that is covered with aluminum to protect from contamination. The front part of the SSDs discriminate a radiation enters into the sensor and the back part of the plastic scintillator get the value of its energy. We can get the data of high-energy electron by using this sensor and it will be useful to reveal the detail of the radiation belt's fluctuation

3.3-30p **SLOT REGION RADIATION ENVIRONMENT MODELS**

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The energetic charged particle fluxes in the slot region between the inner and outer Van Allen belts are highly dynamic and are known to vary by several orders of magnitude on both short and long timescales. During quiet times, the particle fluxes are much lower than those found at the peak of the inner and outer belts and the region is considered benign. During geospace magnetic storms, though, this region can fill with energetic particles as the peak of the outer belt is pushed Earthwards and the fluxes can increase drastically.

In the ongoing SRREMs project (Slot Region Radiation Environment Models) we aim at improving the current radiation belt models, most of which do not model the extreme variability of the slot region and instead provide long-term averages between the better-known low and medium Earth orbits (LEO and MEO).

This paper is presenting the main characteristics and first results of the electron-SRREM (e-SRREM). e-SRREM is based on the analysis of a large volume of available energetic electron flux data and on the subsequent construction of a virtual database of slot region electron fluxes. A large number of different datasets has been used for the construction, evaluation and inter-calibration of the e-SRREM virtual dataset. Special emphasis has been given on the use and analysis of data from the ESA Standard Radiation Environment Monitor (SREM) units on-board PROBA-1, INTEGRAL, and GIOVE-B due to the sufficient spatial and long temporal coverage of the slot region by these spacecraft. In addition, other datasets such as DEMETER/IDP, CRRES/MEA and XMM/ERMD were also used.

The analysis that we have followed retains the long-term temporal, spatial and spectral variations in electron fluxes as well as the short-term enhancement events at altitudes and inclinations relevant for satellites in the slot region. As a result, the output of the e-SRREM model can provide energetic electron flux spectra for user defined orbit, time-scales and confidence levels, including the mean average and the peak flux levels. The SRREMs project has been commissioned by ESA/ESTEC through contract 4000104839.

3.3-31p **ENERGETIC ELECTRON FLUX ENHANCEMENTS AND THEIR ASSOCIATION WITH EARTHWARD PENETRATION OF Pc 4-5 WAVES DURING GEOSPACE MAGNETIC STORMS**

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Geospace magnetic storms, when sufficiently strong to exceed key thresholds of the Dst index, lead either to increases or decreases of the fluxes of electrons with energies > 1 MeV in the outer radiation belt. We examine the responses of energetic electrons to moderate and intense magnetic storms and compare these with concurrent variations of ULF wave power. The interaction between ULF waves and radiation belts electrons may diffuse particles across field lines or energise them on field lines over hours and days. Here, we present multipoint observations from a multitude of ground-based magnetometer arrays. We discuss the excitation, growth and decay characteristics of Pc 4-5 waves during the different phases of the magnetic storms with particular emphasis on the distribution of Pc 4-5 wave power over a variety of L shells. We investigate whether Pc 4-5 wave power penetrates to lower L shell values during storms characterised by enhanced fluxes of the radiation belts' electrons as compared to storms with reduced fluxes. Structural changes of the magnetosphere during intense magnetic storms can play an important role

in the generation and penetration of Pc 4-5 waves deep into the inner magnetosphere, which in turn is of significance for the wave-particle interactions contributing to the acceleration, transport and loss of electrons in the outer radiation belt. We present preliminary statistics of Pc 4-5 waves observed during periods of varying electron fluxes, which occurred over the course of the previous solar cycle. The work leading to this paper has received funding from the European Union's Seventh Framework Programme under grant agreement no. 284520 for the MAARBLE (Monitoring, Analyzing and Assessing Radiation Belt Energization and Loss) collaborative research project. This paper reflects only the authors' views and the Union is not liable for any use that may be made of the information contained therein.

SESSION 3.4

MAGNETOSPHERIC BOUNDARY LAYERS

3.4-1 HISTORY AND RECENT ADVANCES IN MAGNETOSHEATH RESEARCH AND ITS IMPORTANCE FOR MAGNETOSPHERIC DYNAMICS

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The Earth's bow shock and magnetosheath actively change the properties of the solar wind plasma, as it flows around and past the magnetosphere. The magnetosheath plasma also self-consistently determines via pressure balance and other processes the shape and location of the magnetopause, and is important for driving internal magnetospheric dynamics. Thus, it is critical to understand both the overall global properties as well as the detailed physical processes of the magnetosheath region over a large span of spatial and temporal scales. This presentation provides a brief overview of the history of the magnetosheath as well as a synopsis of the latest studies of this region using the most recent observational data sets and models. These new studies are helping to improve our overall understanding of the role of magnetosheath plasmas on the dynamics of the magnetosphere.

3.4-2 LLBL THICKNESS DEPENDENCE ON THE IMF AND SOLAR WIND PARAMETERS

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Plasma and magnetic field parameters of LLBL crossings are studied using data of THEMIS mission. More than 70 cases of LLBL crossings are selected. Method of LLBL thickness determination using results of plasma velocity measurements is developed. The dependences of LLBL thickness on Bz IMF and VBz (V-solar wind velocity) are studied. The results are explained using the hypothesis of regular and quasi-diffusional transport in Y-direction inside the magnetosphere. The problem of magnetosheath plasma penetration inside the magnetosphere and LLBL formation is discussed.

3.4-3 ON THE NATURE OF MAGNETOSHEATH FTES?

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Cluster multipoint measurements are used to study a magnetosheath Flux Transfer Event (FTE), with a classical boundary normal coordinate signature. The topology of magnetic field lines is probed by energetic electrons. The FTE signature is divided in two parts. During the first part (the leading edge) of the FTE signature, while the normal component Bn is positive and the density is low, magnetic field lines are found to be closed (two magnetic footprints on Earth). Conversely, during the second part of the FTE signature (the trailing edge), while Bn is negative and the density is large, magnetic field lines are found to be open (only one footprint on Earth). Changes in the number of footprint on the Earth are shown to correspond to sharp variations, discontinuities, in the ion flow velocity, in the density, and in the magnetic field. The nature of these discontinuities is determined via multipoint data analysis.

The magnetosheath (MSh) plasma is found to be accelerated at the trailing edge of the FTE as it moves across a rotational discontinuity (RD). This accelerated plasma being faster than the FTE tends to overtake it. As it moves towards the front side the accelerated magnetosheath plasma crosses a second discontinuity as it penetrates on closed field lines. This second discontinuity has mixed properties between a shock and a RD. A tangential discontinuity (TD) is identified at the leading edge of the FTE; there is hardly any exchange of plasma through it.

In addition to the 3 discontinuities described above that correspond to changes in magnetic topology, a fourth discontinuity is observed while the spacecraft are on closed field lines. After crossing the second discontinuity the magnetosheath plasma is still fast. The latter discontinuity is a shock that reduces the speed down to the magnetosheath value. It corresponds to a strong decrease in the density down to that of the magnetospheric plasma.

Magnetosheath electrons are heated, mainly along the guide field, in the parallel and antiparallel directions.

Electron heating is found to take place between the RD (at the trailing edge) and this last shock. It coincides with intense ultra low frequency waves. We analyze the nature of the waves and discuss their potential role at enabling magnetic reconnection.

3.4-4 ION TEMPERATURE ANISOTROPY THRESHOLDS IN THE MAGNETOSHEATH

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The magnetosheath plasma often exhibits proton temperature anisotropy which may develop several instabilities. We have used plasma and magnetic field observations from magnetosheath passes of THEMIS spacecraft to examine the anisotropy boundaries and compare the observations with the theoretical stability boundaries. Three wave parameters $|B_{\text{para}}/B_0|$, $|B_{\text{perp}}/B_0|$, and the magnetic compressibility, $B_{\text{para}}^2/(B_{\text{para}}^2 + B_{\text{perp}}^2)$, are calculated and distributions of their intensities on the $T_{\text{perp}}/T_{\text{para}}$ vs β_{para} plane are examined. The data are shown to cluster around the thresholds of the mirror mode and the EMIC mode. For compressional waves there exist enhancements above the mirror mode threshold, which may indicate evolving process of the magnetosheath unstable plasma. The transverse variations are better constrained by the theoretical EMIC marginal curve. The distributions are notably different compared to the ones in the solar wind. Results from a quasi-linear analysis of the temperature anisotropy-driven instabilities with time-varying local magnetic field, assuming arbitrary initial temperature ratios and parallel betas, show that in the magnetosheath the saturated states in $\beta_{\text{para}}-T_{\text{perp}}/T_{\text{para}}$ space are nearly bounded by the mirror and proton-cyclotron instabilities, but significant fluctuations also occur beyond the mirror mode curve indicating evolving process. The results are consistent with the observations.

3.4-5 NONLINEAR EVOLUTION OF THE MIRROR INSTABILITY: GYROKINETIC SIMULATION

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Mirror instabilities are typically observed in compressed high beta plasma, associated with shocks in the solar wind and at planetary magnetospheres. Observations suggest that these waves regulate the temperature anisotropy in the solar wind and magnetosheath. Nonlinear structures observed in planetary magnetosheaths and magnetospheres have been associated with the late stage development of mirror instabilities. In order to understand the nonlinear evolution of the mirror instability including regulation of anisotropy and the development of nonlinear structuring known as “peaks” and “dips,” we have developed an electromagnetic gyrokinetic simulation code. The model is implemented in a noise reducing delta-f, particle-in-cell method, and has been successfully verified against previous studies with a single unstable mode present, showing saturation due to particle trapping. Simulations of a 2D spectrum of unstable modes display formation of a saturated state with peaked magnetic structures. We discuss the physical mechanisms responsible for saturation and nonlinear evolution of the instability and compare the qualitative features with observations of anisotropy control, period doubling, and skewness in the magnetic field structures.

3.4-6 HISTORY AND RECENT ADVANCES IN THE PHYSICS OF HOT FLOW ANOMALIES

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Hot flow anomalies (HFAs) are events observed near planetary bow shocks that are characterized by greatly heated solar wind plasmas and substantial flow deflection. HFAs were discovered upstream from the Earth’s bow shock in 1980s. Recently, HFAs have also been observed near the bow shock of Venus, Mars, and Saturn, indicating that HFA is an universal phenomena. HFAs are thought to be produced by the interaction of some very special interplanetary current sheets that satisfy several strict conditions with planetary bow shocks. When the current sheet (discontinuity) is connected to the bow shock and the motional electric fields point towards the discontinuity, ions reflected from the bow shock are trapped in the current sheet. The relative streaming energy of the original solar wind beam and the reflected beam is converted to the thermal energy. However, we found recently that HFAs can be generated spontaneously (in the absence of any current sheets) at quasi-parallel bow shocks where the interplanetary magnetic field lies nearly parallel to the shock normal. Statistical studies show that 60% of the HFAs are not associated with clear discontinuities. In addition, there are 13% of the HFAs with the motional electric fields on neither leading nor trailing edge pointing towards the discontinuity. These new results indicate that this phenomenon is still not well understood although it was discovered almost 30 years ago.

3.4-7 ANOMALOUS MAGNETOPOUSE DEFORMATIONS AND THEIR UPSTREAM DRIVERS**Safrankova, J.; Nemecek, Z.**

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A number of transient phenomena as interplanetary shocks, IMF discontinuities, magnetic holes, foreshock cavities, hot flow anomalies, and others can be observed in front of the bow shock. A part of them is blown down with the solar wind from far upstream regions, whereas the other part originates near the bow shock. However, all these phenomena affect dynamics of the magnetospheric boundaries. For example, many authors reported unusual events when the magnetopause was swept in several minutes to the original bow shock location and back. The cause of such motion was often identified as the interaction of the bow shock with an interplanetary current sheet, and no source of the magnetopause motion was often registered in the solar wind.

The contribution presents a detailed case study of a large deformation of the magnetopause on November 26, 2008 based on observations of five THEMIS spacecraft located at the dawn flank in the magnetosphere and magnetosheath, on Cluster measurements at the dusk magnetosheath, and ACE monitoring of solar wind conditions. The main revelation of our study is that the interaction of the IMF discontinuity with the bow shock creates either one very elongated hot flow anomaly (HFA) or a pair of them that is (are) simultaneously observed at both flanks. Whereas the dusk HFA is weak and does not cause observable deformation of the magnetopause, the pressure variations connected with the dawn HFA lead to a magnetopause displacement by 5 Re outward from its nominal position followed by a rapid inward motion of the magnetopause 4 Re with respect to the model location. The surface deformation is so large that the outermost THEMIS spacecraft was in the magnetosphere, whereas the spacecraft located 9 Re inbound entered into the magnetosheath at the same time.

3.4-8 ON ENERGY PUMPING AND CASCADING IN DAYSIDE BOUNDARY LAYERS OF MA**Savin, S.; Amata, E.; Kozak, L.; Zelenyi, L.; Safrankova, J.; Nemecek, Z.; Buechner, J.; Daly, W.P.; Kronberg, E.A.; Blecki, J.; Budaev, V.; Krasnosielskikh, V.**

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We present a case on March 27, 2005 from Double Star, Cluster, Geotail and ACE data on dynamic pressure (P_{dyn}) with both direct magnetosheath (MSH) driving by the solar wind (SW) disturbances at the lowest frequencies and with pumping of the SW kinetic energy into the outer magnetospheric resonances. We infer the pre-dissipation of the SW energy in the foreshock and at the rippled bow shock (BS), the energy being concentrated in the BS/foreshock resonances and in the cavity MSH modes. Those modes initiate nonlinear (3-wave) discrete cascades towards the higher frequencies, then the cascades transform into the turbulent one with the power slope ~ -1 due to the nonlinear modes merging. In the cascades the main energy carriers are Supermagnetosonic Plasma Streams (SPS) having P_{dyn} in few times larger than that in SW. We explore the 4-point correlations and structure functions of the P_{dyn} and demonstrate that namely SPS are the extreme events, which govern the super-ballistic anomalous transport in MSH and magnetopause boundary layers. The SPS, being modulated by the outer magnetospheric resonances, can provide both direct penetrating of the MSH plasma under flank magnetopause (with several times larger effectiveness versus e.g. that of a reconnection) and control O^+ outflow into MSH.

3.4-9 AN ANALYSIS OF SOLAR WIND PLASMA MAGNETIC FIELD INFLUENCE ON THE PRESSURE BALANCE AT THE MAGNETOPOUSE BOUNDARY**Verigin, M.; Kotova, G.; Tatrallyay, M.; Erdos, G.; Bezrukikh, V.; Remizov, A.**

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It is generally accepted that the solar wind pressure to the magnetopause nose is approximately equal to solar wind ram pressure multiplied by coefficient k , which is a function of solar wind specific heat ratio and sonic Mach number. IMF influence on the magnetopause boundary position was considered mainly via its empirical dependence only on B_z component. Recent THEMIS data revealed the dependence of the magnetopause nose position on the IMF cone angle (Duík et al., JGR, 37, L19103, 2010). This dependence was interpreted as a consequence of magnetic pressure addition outside the magnetopause (Tatrallyay et al., Ann. Geophys., 30, 1675-1692, 2012). On the other hand, IMF rotation (variation of the clock angle) leads to variation of the magnetopause Chapman-Ferraro current layer system and thus to variation of the magnetic pressure in the magnetosphere. Both factors influencing the pressure balance are discussed in the present talk, based on analytical consideration, empiric and 3-D MHD modeling. Resulting magnetopause model is compared with observations by PRGNOZ's orbiters.

3.4-10 ION ACOUSIC SOLITARY WAVES IN A MULTICOMPONENT PLASMA CONTAINING

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Electrostatic solitary waves (ESWs) are large amplitude acoustic-mode or kinetic-scale structures which have been frequently observed in the boundary layers of the magnetosphere where large gradients in particle properties often generate beam or acoustic instabilities leading to large amplitude electrostatic fluctuations. Such microscale structures play significant roles in energy and particle transport and are important to understand the complete sun-earth. It is often customary to model the ESWs using the theory of ion or electron acoustic solitary waves. In recent days, there is a lot of interest in EPN (Electron-Positive ion-Negative ion) plasmas. Presence of negative ion impurities in the ionosphere and comet's corona has been verified. Recent laboratory experiments confirmed generation of ion acoustic solitary waves in the presence of negative impurities. It is observed that the presence of negative ions modifies the charge neutrality condition and affect the corresponding solitary wave solutions significantly. In the present work, we have studied fully nonlinear ion acoustic solitary waves in the presence of warm positive and negative ions and two temperature electrons. It was previously observed that, in the presence of two electron temperatures, a rarefactive (negative amplitude) solitary wave shows anomalous width variations where for large amplitude solutions the width increases with the amplitude. On the other hand, a compressive (positive amplitude) solitary wave solution shows forbidden regions in the ion temperature or the cold electron concentration. In the present work, preliminary investigations revealed that the presence of negative ions inhibit the anomalous width variation while expand the forbidden regions. The effect of negative ions on possible compressive double layers and supersolitons (i.e., solitary waves with Mach numbers higher than the Mach number of the corresponding double layer) have also been investigated in detail. The results have been compared with the recent laboratory experiments and space observations.

3.4-11 OCCURRENCE, EVOLUTION, AND EFFECTS OF KELVIN-HELMHOLTZ WAVES UNDER DIFFERENT INTERPLANETARY MAGNETIC FIELD CONDITIONS

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Understanding how the interaction of the solar wind with Earth's magnetic field transfers plasma, momentum, and energy across the magnetopause is one of the most important questions in magnetospheric physics. Kelvin-Helmholtz waves (KHW) and their nonlinearly developed form, Kelvin-Helmholtz vortices (KHV) have been studied using theoretical analyses, numerical simulations, and in-situ observations as a mechanism for controlling that transfer. To date, most studies of the role of the KH mode have been carried out during periods of northward interplanetary magnetic field (IMF), which minimizes the magnetic tension forces that stabilize the KH instability at the subsolar side of the magnetopause and low latitude boundary layer (LLBL). In-situ observations of KHV have also been reported preferentially for northward IMF. We recently reported on observations of fully-developed KHW for southward IMF that suggested new insights into the preferential detection of KHW and KHV under northward IMF that derive from the fact that southward IMF typically generates dynamically active subsolar environments that cause the formation and evolution of KHW to be temporally intermittent and irregular. The IMF orientation also determines the regions on the surface of the magnetopause where the KHW can easily become unstable. Previously, KHW/KHV were detected primarily at the flanks or LLBL of the magnetosphere. We will discuss the implications of the first observation of KHW at the high latitude magnetopause near the northern cusp during strongly dawnward IMF. The magnetic configuration across the boundary layer near the northern duskward cusp region during dawnward IMF is similar to that in the low-latitude boundary layer under northward IMF, in that 1) both magnetosheath and magnetospheric fields across the local boundary layer constitute the lowest magnetic shear, and 2) the tailward propagation of the KHWs is perpendicular to both fields. This result demonstrates that differences in IMF orientations are associated with the properties of KHW via variations in thickness of the boundary layer and/or width of the KH-unstable band on the surface of the dayside magnetopause. Using coordinated in-situ observations of KHW by THEMIS and/or Cluster and the inner magnetosphere dynamics including the generation of ULF waves by the Van Allen Probes, we will address the effects of KHW for different solar activities.

3.4-12 THREE-DIMENSIONAL DYNAMICS OF VORTEX-INDUCED RECONNECTION

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The Kelvin-Helmholtz instability (KHI) is a key process for transport of solar wind plasma into the Earth's magnetosphere. In the presence of both magnetic and velocity shear, the resulting KHI leads to the generation of a vortex

and the subsequent triggering of magnetic reconnection. Here we present results from a series of the first 3D fully kinetic simulations of the VIR process with a focus on the transport and mixing of the plasma. We compare and contrast the results with 2D simulations. In 3D, the current sheets compressed by the vortex flow give rise to magnetic flux ropes over a range of oblique angles and along the entire extent of the compressed layer around the periphery of the vortex. These flux ropes propagate with the shear flow and eventually merge with the vortex. The 3D dynamics of the flux ropes quickly destroys the flux surfaces and leads to efficient mixing within the vortex layer. Interestingly, the structures and the relative size of the flux ropes are in reasonable agreement with the THEMIS observations at the dusk-flank magnetopause. Furthermore, 3D simulations with density and temperature asymmetries across the boundary showed that electron-scale KH instabilities can develop along the electron-scale edge layer of the parent vortex. The 3D evolution of these secondary instabilities further enhances the mixing rate. Based on these results, we will discuss the roles of the VIR at the Earth's magnetopause.

3.4-13 **MAGNETIC FIELD VARIATIONS AT THE SUBSOLAR MAGNETOPAUSE ACCORDING**

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An advanced theory of the solar wind interaction with the Earth's magnetosphere and magnetospheric boundary layers formation requires the consideration of the existence of high level of turbulence in the magnetosheath. Therefore, it is of great interest to compare the magnetic field parameters just in front of the magnetopause with the interplanetary magnetic field. We analyze the dependence of the magnitude of the magnetic field, its three components, and the clock angle in the magnetosheath just in front of the magnetopause on the same values in the solar wind before a bow shock using data of the THEMIS mission. The present study compares the magnetic field parameters near the magnetopause, measured for 3 s (spin resolution of the THEMIS satellites), 30 s (the characteristic correlation time according to certain estimates), and 90 s (the threefold longer interval than the characteristic correlation time). The aim of this study is to determine the average dependences of the magnetic field parameters at the magnetopause on the corresponding parameters in the SW for the selected averaging times. The time delay of the solar wind arrival at the subsolar point of the magnetopause was taken into account. We selected events for which the direction of the magnetic field at the magnetopause is highly different from the direction of the magnetic field in the solar wind up to the sign change.

3.4-14 **COUPLED DRIFT-MIRROR AND ALFVEN MODES IN NON-UNIFORM SPACE PLASMA**

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The stability of the coupled Alfvén and drift-mirror modes in 1-D inhomogeneous plasma in a gyrokinetic framework is studied. A dispersion relation for the modes has been obtained and solved for different values of the coupling parameter, proportional to the radial pressure gradient squared. The frequency of the drift-mirror mode is substantially different than in the decoupled case, the drift-mirror instability can develop for lower values of the plasma anisotropy. The weak coupling also causes decrease of the Alfvén mode frequency and leads to an instability whose growth rate is proportional to the coupling parameter. If the coupling is strong, the notions of the Alfvén and drift-mirror modes lose their meaning since their respective oscillation branches merge and further split at some anisotropy value. Other nomenclature is suggested, the unstable and stable Alfvén-mirror modes, the former being unstable at any anisotropy value, and the latter, on the contrary, is always damped. Another effect of the coupling is the transverse dispersion of the modes, that is, the dependence of the wave frequency on the wave vector transverse component. This effect can be responsible for the mode structure across the magnetic field and perpendicular energy transfer.

3.4-51p **ION ANISOTROPY INSTABILITIES IN SOLAR WIND MAGNETOSPHERE SYSTEM**

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The mirror and ion cyclotron instabilities are the two major low frequency instabilities that are observed to compete with each other in various space plasma regions. We consider a theoretical magnetosheath plasma model for the Earth and study the various factors that affect the growth rates of these two competing modes. Our study assumes multi-component plasma model with anisotropic protons, anisotropic heavy ions like helium (He^{2+}) and oxygen (O^{6+}) and isotropic as well as anisotropic electrons. Electron anisotropy effects on the low frequency instabilities are studied for the first time. It is shown that anisotropic electrons reduce the ion cyclotron growth rate and increases the growth of mirror modes significantly thereby enhancing the chances of mirror mode occurrences in planetary magnetosheaths. The parameters proton plasma beta (β_p), ion temperature anisotropy ($T_{\perp i}/T_{\parallel i}$), concentration of heavy ions and electron temperature anisotropy can determine whether ion cyclotron or mirror modes dominate in a given

plasma regime. For $T_e/T_i = 1.2$ mirror mode growth exceeds the ion cyclotron growth at a beta value $\beta_p = 0.5$ with a helium concentration $n_h = 0.10n_p$, where n_p is the proton concentration. An increase in electron temperature anisotropy to $T_e/T_i = 1.8$ further brings down the growth rate of ion cyclotron mode and mirror modes dominate for helium ion concentration $n_h = 0.01n_p$. The presence of anisotropic electrons, perhaps due to bow-shock heating and magnetic field line draping effects, can explain the growth of mirror mode waves when the magnetosheath plasma beta is as low as 0.5. The studies will be extended to the parameters in other space plasma regions like solar wind, heliosheath and other planetary magnetosheaths.

3.4-52p **MULTIPOINT OBSERVATIONS OF PLASMA DENSITY AND MAGNETIC FIELD VARIATIONS IN THE DAYSIDE MAGNETOSHEATH**

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We present multipoint observations of plasma parameters and magnetic field variations in the magnetosheath by THEMIS spacecraft. We discuss time scales, spatial orientation of observed structures and their dependence on upstream IMF parameters. The anti-correlation between magnetic field and plasma density, that may indicate the presence of slow mode or mirror-mode fluctuations, was observed for these plasma structures. We compare results with 2.5 dimensional hybrid simulations to investigate the mechanism of generation and evolution of plasma structures toward the flanks.

3.4-53p **PLASMA JETS IN MSH: A MULTIPOINT STUDY**

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An important feature of solar wind (SW) interaction with magnetosphere is concentrating of the plasma flows into magnetosheath (MSH) jets with dynamic pressure being typically over that of SW. The majority of the jets is supermagnetosonic and modulated at frequencies 0.3-10 mHz. The interaction of such jets with planetary and astrophysical magnetospheres and in laboratory plasmas can be inherently non-local and non-equilibrium, and even explosive due to self-generation of coherent structures in the multiscale system with the scales ranging from the micro to global scales.

The main objective of our case study is using unique multi-spacecraft data from DOUBLE STAR, CLUSTER, GEOTAIL, ACE and THEMIS for comparison of the global and local jet features versus the SW input. The local jet properties from CLUSTER and THEMIS constellations infer the transverse jet scales of several thousand km. No global cross-correlation is obvious. We discuss visible modulations of the jets and magnetopause dynamics in terms of the resonances which are characteristic for the outer magnetospheric boundaries: membrane/ surface and cavity MSH modes. Preliminary statistics of the DOUBLE STAR data shows that in more than 50% cases the jets are modulated by the outer magnetospheric resonances. Our case study belongs to this majority.

3.4-54p **MAGNETIC FIELD AND FLOW VARIATIONS ASSOCIATED WITH A TRANSIENT EVENT OBSERVED AT THE MAGNETOPAUSE BY THE THEMIS SPACECRAFT**

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Earth's magnetopause is the abrupt boundary layer between the magnetosphere and the magnetosheath. A rich variety of plasma phenomena occur in its immediate vicinity due to the different plasma regimes on both side. We present a case study of a structure near the magnetopause observed by the THEMIS spacecraft. During the interval from 22:32 UT to 22:35 UT on June 10, 2007, four of the five THEMIS spacecraft recorded clear bipolar FTE variations in the magnetic field component normal to the nominal magnetopause. The perturbation was associated with other variations in the magnetic field and plasma parameters, including a high ion flow speed immediately behind and ahead of the structure and a distinct flow variation inside the structure. THEMIS B, located deepest inside the magnetosphere, observed plasma perturbations but no significant magnetic field variation. Consequently the extent of the plasma perturbations exceeded that of the magnetic field perturbations. We can interpret the observations as evidence for a flux rope-like structure moving faster than the ambient plasma. The structure occurred during an interval of radial IMF and may have corresponded to a pressure pulse.

3.4-55p ASSESSING GLOBAL DAYSIDE MAGNETOPAUSE RECONNECTION VIA OBSERVATIONS AND THEORETICAL MODELS

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Magnetic reconnection plays an important role in a great variety of environments where magnetized plasmas are present. Magnetic reconnection on the Earth's magnetopause has received considerable attention. Reconnection on the dayside magnetopause seems to occur in two ways: locally in the form of the so-called flux transfer events, with a characteristic time scale of minutes or less; and globally over wide regions of the magnetopause (several Earth radii) and over much longer time scales (few hours). Recent work provides evidence for global reconnection on Earth's dayside magnetopause. We revisit the 14 Jun 2007 simultaneous satellite crossing event studied by Dunlop et al. [PRL, 2011]. Using the simple theoretical model of Gonzalez and Mozer [JGR, 1974] for the location and orientation of the reconnection X-line, we analyze whether global reconnection is active on the dayside magnetopause, i.e., we verify whether there is a single sub-solar X-line which can account for the reconnection signatures detected by the satellites.

SESSION 3.5

DIFFERENT RESPONSE MODES OF THE MAGNETOSPHERE TO SOLAR WIND DRIVING

3.5-1 ENERGY BUDGET OF INTENSE, CONTINUOUS AURORAL ELECTROJET (AE) ACTIVITY EVENTS

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The characteristics and energy input for intense, continuous auroral electrojet (AE) activity events are investigated. The AE events were selected so that they occurred outside storm main phases (SH events) and during quiet conditions (H events). The AE events were characterized by wave-like variations in AE amplitude with periods varying from ~2 to 6 h. These are shown to be well correlated with long-period waves in the interplanetary magnetic field (IMF) Bz component. It is shown that these variations are part of interplanetary Alfvén waves. These negative IMF Bz dips led to energy input into the magnetosphere through magnetic reconnection. Higher frequency IMF Bz fluctuations (~23 to 110 min) were found to cause smaller-period (~1 h or less) AE amplitude waves.

The integrated, average and peak strengths and durations of the SH-events were larger (~50%, 9%, ~14%, ~43%, respectively) than those of the H-events. The total solar wind kinetic energy (Esw) and energy available for redistribution in the magnetosphere (Em) were significantly larger for SH-events (average $E_m \sim 117 \times 10^{17}$ J, $E_m \sim 91 \times 10^{15}$ J) than for the H-events ($E_{sw} \sim 67 \times 10^{17}$ J, $E_m \sim 60 \times 10^{15}$ J). E_{sw} ($\sim 32 \times 10^{17}$ J) and E_m ($\sim 59 \times 10^{15}$ J) were much lower during main phases of magnetic storms. On the average, ~1.9% of total solar wind kinetic energy was available for redistribution in the magnetosphere during storm main phases, while during the intense AE events, it was reduced to ~1%. In the storm main phases, ~50% of magnetospheric input energy was found to be dissipated as ring current, Joule heating and auroral particle energy dissipation. During the AE events, the dissipation was as high as ~74% for the H-events and ~90% for the SH-events. In any phase, larger part of magnetospheric energy was dissipated as auroral precipitation and Joule heating compared to ring current dissipation. The event strength and duration were found to increase with increasing solar wind kinetic energy and magnetospheric energy input.

3.5-2 HIGH SPEED STREAM EFFECTS IN THE INTERPLANETARY AND ON-GROUND ULF ACTIVITY AND IN THE GEOSTATIONARY ELECTRON FLUX

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A superposed epoch study of the ULF oscillations associated with two main types of the solar wind high speed streams has been performed using 13 ICME events and 31 CIR events during a period of 1999-2006. Data from magnetic and plasma measurements onboard ACE spacecraft along with on-ground magnetic data were used for the analysis. The zero epoch of each event was set to the time of ACE observation of the current sheet coinciding with the stream front. The results demonstrate that CIR events produce a more intense and more continuous ULF activity both in the solar wind and in the magnetosphere. Data from GOES measurements of energetic electrons at geostationary orbit were also included in our superposed epoch study. Higher effectiveness of CIR events in enhancement of electron population in outer radiation belt is confirmed. A new feature is that higher amplitude of ULF on-ground oscillations gives more intense flux of 2 MeV electrons but it does not influence flux of less energetic electrons (600 keV).

The work was partly supported by RFBR grants 13-05-00529 and 13-05-00066.

3.5-3 GLOBAL SCALE SIMULATIONS OF THE INTERACTION BETWEEN THE SOLAR WIND**Amaya, Jorge; Deca, Jan; Lapenta, Giovanni**

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Numerical simulations are a valuable tool in space plasma physics research as they give an insight into the detailed physical processes involved at a global scale, which are in general not available through in situ measurements. But the results given by a simulation only address the physical phenomena at the time and length scale of the numerical method used. Up until recently MHD simulations have been used to study the effects of the global interaction between the solar wind and the planetary magnetospheres. However, such kind of simulations can not describe in detail the physics involved at all the characteristic length scales. Progress has been achieved recently by Omidi et al. [1] to approach a kinetic description of this plasma at the global scale using hybrid codes in which the electrons are treated as a fluid and the ions as particles.

In this work we go one step further: using the moment-implicit Particle-in-Cell code iPIC3D (Markidis et al. [2]) we study the interaction between the solar wind and a dipolar magnetosphere using a fully kinetic description where electrons and ions are treated as particles. The spatial resolution of the simulation has been set to values below the electron skin depth. To the authors knowledge this is the first time that a fully kinetic self-consistent simulation involving such scales, from planetary to electron characteristics, have been performed. The results of this 2D simulation show the formation of the general features observed in planetary magnetospheres, including bow shock, magnetosheath, magnetotail, cusps and radiation belts. The numerical results were only possible to obtain thanks to the use of the most powerful supercomputers in Europe.

[1] N. Omidi, X. Blanco-Cano, C.T. Russell, H. Karimabadi, Global hybrid simulations of solar wind interaction with Mercury: Magnetospheric boundaries, *Advances in Space Research*, Volume 38, Issue 4, 2006, Pages 632-638, ISSN 0273-1177, 10.1016/j.asr.2005.11.019.

(<http://www.sciencedirect.com/science/article/pii/S0273117705014067>)

[2] Stefano Markidis, Giovanni Lapenta, Rizwan-uddin, Multi-scale simulations of plasma with iPIC3D, *Mathematics and Computers in Simulation*, Volume 80, Issue 7, March 2010, Pages 1509-1519, ISSN 0378-4754, 10.1016/j.matcom.2009.08.038.

(<http://www.sciencedirect.com/science/article/pii/S0378475409002444>)

3.5-4 GLOBAL KINETIC SIMULATION OF THE EARTH AND THE MOON**Lapenta, G.; Amaya, J.; Deca, J.; Markidis, S.; Divin, A.; Lebege, B.**

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The full kinetic model of the interaction of the solar wind, its perturbances and solar energetic particle with the Earth magnetosphere and with the Moon is the ultimate goal of space physics. A fully physics-based model based on first principles. Developments in hardware (massively parallel petascale supercomputers) and software (implicit moment method, iPIC3D, Markidis, Lapenta, Uddin, *Mathematics and Computers in Simulation*

Volume 80, Issue 7, March 2010, Pages 1509-1519, <http://www.sciencedirect.com/science/article/pii/S0378475409002444>) have finally made it possible. We review the approach (G. Lapenta, *Journal of Computational Physics*

Volume 231, Issue 3, 1 February 2012, Pages 795-821, <http://www.sciencedirect.com/science/article/pii/S0021999111001860>) and show two types of recent results:

- 1) Full models in 2D and 3D of the Earth magnetosphere interaction with the solar wind, demonstrating the possibility to model fully kinetically the various features of the interaction
- 2) Models of magnetic anomalies on the Moon, these are regions of crustal magnetic field producing local mini-magnetospheres on the surface of the Moon at scales of ten to hundreds of km.

3.5-5 INVESTIGATING SOLAR WIND-MAGNETOSPHERE-IONOSPHERE COUPLING WITH SUPERDARN AND AMPERE**Milan, Steve; Coxon, John; Imber, Suzie; Anderson, Brian**

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The dynamics of the Earth's plasma environment are driven by coupling between the solar wind, with its embedded interplanetary magnetic field, and the magnetosphere through magnetic reconnection occurring at the magnetopause. Terrestrial magnetic field lines which are connected to interplanetary space in this way are subsequently released by magnetic reconnection occurring in the magnetotail. These two processes lead to increases and decreases in the proportion of the terrestrial flux that is open, as observed in changes in the latitude of the auroral zones. A circulation of plasma and magnetic flux is effected, the Dungey cycle, with a sympathetic plasma convection signature in the ionosphere. In this talk we review recent advances of our understanding of the coupling process, provided by measurements of ionospheric convection with the Super Dual Auroral Radar Network (SuperDARN) and the Active

Magnetosphere and Planetary Electrodynamics Response Experiment (AMPERE) which measures the coupling currents that transfer stress from the magnetosphere into the ionosphere.

3.5-6 INTERHEMISPHERIC BIRKELAND CURRENT ASYMMETRY DURING LARGE IMF MAGNITUDE
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When the IMF becomes very large, and the solar wind evolves to a low magnetosonic Mach number state, the forces on the solar wind at the bow shock and in the magnetosphere transition from being dominated by the plasma pressure gradient to being dominated by the $J \times B$ force. Under these conditions, the bow shock current becomes very large and the bow shock becomes essentially the only dynamo in the system where solar wind mechanical energy is extracted from the flow. The bow shock current closes through the magnetosheath, providing the $J \times B$ force in the magnetosheath that diverts the shocked solar wind flow and accelerates it back up to solar wind speeds. Some of this current closes through the ionosphere as a Birkeland current. For large dipole tilts, MHD simulations indicate that there is an asymmetry in the net Birkeland current due to geometric factors. We will present observational evidence to support this simulation result, and we will discuss some of the implications for solar wind driving of geospace activity during periods of large IMF magnitude perpendicular to the solar wind flow.

3.5-7 MAGNETIC INDICES AND GEOEFFECTIVENESS OF THE SOLAR WIND FROM THE RADIATION BELTS POINT OF VIEW

Rochel Grimald, Sandrine; Boscher, Daniel; Bourdarie, Sébastien; Sicard-Piet, Angelica; Maget, Vincent; Lazaro, Didier; Rolland

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The SALAMMBÔ code is a physical model of the radiation belts. It is well known that the radiation belt changes are indirectly linked to the solar wind parameter evolution. It is well known that CME and CIR disturb the magnetosphere in a different way and that they are more or less geoeffective. Then the impact in the radiation belts will also be different. Unfortunately, it is quite difficult to establish a direct link between the inner magnetosphere populations state and the solar wind parameters. As a consequence, the SALAMMBÔ code uses the magnetic index K_p as a proxy. In this paper, we will discuss the use of K_p and other magnetic indices and of the geoeffectiveness of the solar wind structures from the radiation belts point of view.

3.5-56p THE INTERPLANETARY SHOCK MANIFESTATION IN THE EARTH'S MAGNETOTAIL AT THE LUNAR DISTANCES

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A large number of interplanetary (IP) shocks were observed in the second half of the 2011 year in front of the Earth. At the same time, since August 2011, the ARTEMIS mission (previous THEMIS B and C probes) began to study the geomagnetic tail near a lunar orbit at ~ 60 RE. They spend about four days in the Earth's magnetotail each month. Using these sporadic locations, we are able to investigate effects such as reconnection, high-speed flows and flux rope due to the impact of the IP shock on the magnetosphere. The goal of this study is a detailed analysis of the IP shock propagation through the solar wind and magnetosheath, to find response at the surface of the Earth and to describe their large-scale effects in the middle magnetotail, utilizing dual ARTEMIS probe observations.

3.5-57p JOINT NONLINEAR STUDY OF GROUND-BASED AND POLAR CUSP MAGNETIC RECORDS

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In the paper the nonlinear properties of geomagnetic time-series recorded on different geomagnetic latitudes are studied. We use the observations of the MM100 magnetometer chain, which comprise 11 observatories located along the magnetic meridian of about 100 degrees. The scaling behaviours of the power spectral densities of the magnetic variation in different geomagnetic conditions are studied in order to identify frequency ranges relying on possible turbulent dynamics. The time-series exhibit intermittent fluctuations whose properties vary according to the observation point and the geomagnetic activity. For quantitatively deducing the variation of intermittent properties vs. space (i.e. along the magnetic meridian) and time, analyses operating with the higher order moments of the time records are carried out (probability density function or structure function analyses). Beside the geomagnetic field, the in-situ time-series of the polar cusp magnetic variations are also investigated with the use of the records of the Cluster space mission. The statistical comparison of the nonlinear properties of ground-based and spaceborne observations are carried out.

3.5-58p **QUADRUPOLE CONFIGURATION OF THE GENERAL MAGNETIC FIELD OF THE SUN AND ITS MAGNETOSPHERIC MANIFESTATIONS IN 23 AND 24 SOLAR CYCLES**

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The topology of the solar magnetic field is undergoing dynamic transformation during 22- years cycle. During this period, the general dipole magnetic field (GMF) of the Sun is transformed back to its original state. A lot of investigations were devoted to relationship of even and odd 11-years cycles of solar activity (SA). Their similarity and distinctions, features of maxima and minima, heliophysical characteristics at each stage of a cycle were investigated. The most of the works contain consideration of magnetosphere manifestations as result of active solar events (solar flares, coronal mass ejections, filament eruptions, proton events, migrations of active longitudes, etc.) impact on Earth magnetosphere. Solar - terrestrial communications were studied specifically in various cyclic phases: in a minimum and maximum, growth and decay of SA. Nevertheless, variations of stochastic processes in solar plasma from the photosphere to heliosphere, in a solar wind up to Earth's magnetosphere, - are clearly connected with a course of a SA cycles. However, the improvement of the SA registration is not increase the accuracy of SA forecast. Authors propose that features of geomagnetic activity in situation of quadrupole configuration GMF of the Sun are different from the magnetosphere disturbance in situation at more often registered quasi-dipole configuration of GMF. In our work we are considering a questions of comparison of SA processes and their manifestations in the Earth's magnetosphere on the base of observational data of 23 and 24 solar cycles, connected with GMF configuration of the Sun. Using the experimental data we study the GMF of the Sun and select the time periods, when GMF of the Sun had a quadrupole configurations. SA realizations in condition of quasidipole and quadrupole structure of GMF are received and their manifestations in geomagnetic activity were investigated.

3.5-59p **A COMPARATIVE STUDY OF KP, AP, KM, AM, DST AND AE INDEX**

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Because of its current system, the magnetosphere balances the solar wind impact. If the solar wind parameters changes, the magnetospheric balance is upset. The magnetospheric currents react in order to prevent the magnetosphere to be crushed and to re-establish a new equilibrium state. The changes in the different current sheets can be measured on the ground and are used to estimate the magnetospheric activity through the magnetic activity indices. The ring current, or storm, activity is usually estimated using the Dst index, the auroral, or substorm, activity using the AE index, and the global activity using the Kp index. However, Kp is not the only global magnetic index: Ap, Km and Am could also be used. This paper presents a comparative analysis between those six indices using autocorrelation and cross correlation in order to study the inertia of each index and the link which could exist between them.

3.5-60p **AVERAGE AND EXTREME POSITIONS OF THE MAGNETOPAUSE AND THEIR RELATION TO SOLAR WEATHER CONDITIONS**

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Many empirical models describing the magnetopause position and shape were built on the basis of satellite observations of magnetopause crossings. Each new mission has contributed to model improvements and/or inspired a development of new models. Most of them take into account the solar wind conditions - the interplanetary magnetic field orientation and solar wind dynamic pressure. Although the last models predict the position of the magnetopause well in most cases, there is still a great number of events where the observed and predicted positions significantly differ.

Over six years of the Themis observations, we have collected rich set of magnetopause crossings and compared observed positions with predictions of Shue et al. [1997] and Jelinek et al. [2012] models. In our contribution, we discuss the cases with differences exceeding 2.5 RE. We have found two main sources of these deviations; (1) Interaction of the interplanetary current sheet with the bow shock that leads to the HFA creation; and (2) Presence of the cold dense plasma of plasmaspheric origin at the magnetopause.

SESSION 3.6**THE PLASMA SHEET-IONOSPHERE COUPLED SYSTEM: SINKS, SOURCES, TRANSPORT AND THE ROLES OF FIELD-ALIGNED CURRENTS AND ION OUTFLOW****3.6-1 SIMULATION OF WAVE MODE CONVERSION AT THE DAYSIDE MAGNETOPAUSE****Lin, Yu; Johnson, Jay; Shi, Feng; Wang, Xueyi**Auburn University; Princeton Plasma Physics Lab; Auburn University; Auburn University
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Mode conversion from fast mode compressional waves to kinetic Alfvén waves (KAWs) at the magnetopause is investigated with three-dimensional (3-D) local and global hybrid simulations. (1) In the simulation for a local boundary layer in a slab geometry, across which a compressional mode propagates into a region of increasing Alfvén velocity, the mode conversion is found to be through a multi-stage process. In a first stage dominated by linear physics, KAWs with large perpendicular wave numbers are generated near the Alfvén resonance surface. Then, the growth of KAW modes with large perpendicular and azimuthal wave number is observed in the nonlinear stage when the amplitude of KAWs generated by linear mode conversion becomes large enough to drive a nonlinear parametric decay process. The transfer of energy to large perpendicular and azimuthal modes is crucial to provide large cross-field line particle transport across the boundary, as also demonstrated with a test-particle simulation. (2) In the global simulation, the mode conversion process is examined for the self-consistent interaction between the solar wind and the magnetosphere, in which the foreshock compressional structures of the quasi-parallel shock continuously impinging onto the magnetopause boundary layer (MPBL). The wave phase relationship between the magnetic field and density changes from in-phase in the magnetosheath to anti-phase in the MPBL perturbations, and the wave polarization changes from compressive to transverse. The short-wavelength KAWs in the MPBL are identified by the sharp increases in the parallel electric field and the wave polarization relations of KAWs. The structure, global evolution, and propagation of these KAWs are illustrated for the first time.

3.6-2 SOLAR WIND ENTRY AND PLASMA LOSS AT THE BOUNDARIES OF PLANETARY MAGNETOSPHERES**Otto, A.; Ma, X.; Delamere, P.**Univ. Alaska Fairbanks
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The sources and losses of plasma in planetary magnetospheres are still a major puzzle of magnetospheric physics. Observations show a good correlation of solar wind plasma properties and plasma density and temperature in the terrestrial magnetosphere particularly for northward IMF. In this case cusp reconnection, reconnection induced by three-dimensional Kelvin-Helmholtz modes, and diffusive transport by kinetic Alfvén waves have been suggested for the plasma entry. While there is good evidence that all of these mechanisms may operate under certain conditions their relative importance and mutual interaction are not well understood. Particularly, large increase in plasma entropy indicates that the newly captured plasma undergoes strong non adiabatic heating which is not easily reconciled with the proposed entry mechanisms. A related unresolved issue is that of plasma entry during periods of southward IMF. We will discuss the different mechanisms of plasma entry, their properties, and how these relate to observed plasma properties for different IMF orientations. Ironically the situation for giant magnetosphere appears reverse in that a significant loss of plasma is expected in such magnetospheres. However, conditions at the boundary of giant magnetosphere are rather different from those at the Earth's magnetosphere. We will compare these different boundaries and discuss their impact on plasma transport between the solar wind and the magnetosphere.

3.6-3 GIANT PLANET MAGNETODISCS: SOURCES, SINKS AND TRANSPORT**Delamere, Peter**University of Alaska Fairbanks, Physics Department & Geophysical Institute
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Jupiter's and Saturn's immense magnetospheres differ considerably from Earth's. These magnetospheres are generated in part by a strong planetary dynamo and by rapid rotation (~10 hour period). However, key differences lie in the internal sources of plasma (100s kg/s) provided by Io and Enceladus. Centrifugal stresses acting on the corotating, low-beta plasma in the inner magnetosphere leads to radial transport of plasma via a centrifugally-driven flux tube interchange instability. Instead of cooling on adiabatic expansion, the plasma is observed to be hotter at larger radial distances. In the outer magnetosphere the systems are governed by high-beta, centrifugally-confined plasma sheets, or magnetodiscs. We will discuss the flow of mass and energy through these giant magnetodiscs starting with the source regions near the moons. We will describe the poorly understood problem of radial transport to the outer magnetosphere and the related field-aligned currents that transfer angular momentum from the planet to the magnetodisc. Ultimately the magnetospheric plasma is lost to the solar wind, in stark contrast to the problem of plasma entry from the solar wind at Earth. We will discuss the solar wind interactions at the giant planets and the implications for plasma loss down the tail.

3.6-4 RCM-E SIMULATION OF ELECTRODYNAMICS IN THE IONOSPHERE DURING AN SMC EVENT
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The large-scale field-aligned currents (FACs) play a primary role in coupling the inner and middle magnetosphere to the ionosphere. The FACs are balanced by the divergence of the ionospheric currents that are associated with the ground magnetic disturbances in the high-latitude region. Accurately modeling the FAC distribution is of vital importance for predicting ionospheric electric field, currents and ground disturbances. In this paper, we use the Rice Convection Model - Equilibrium (RCM-E) to simulate a Steady Magnetospheric Convection (SMC) event that occurred on May 25, 2010. The RCM-E calculates the FAC densities using the Vasyliunas- equation and solves the current conservation law in the ionosphere, assuming the plasma is isotropic along a magnetic field line and is in quasi-equilibrium. We aim to determine the plasma distribution in the magnetosphere by fine-tuning the tailward boundary conditions to best match multipoint observations in the magnetosphere, ionosphere and on the ground. We will also compare the RCM-E calculated FACs and electric potentials with those obtained by the Assimilative Mapping of Ionospheric Electrodynamics (AMIE) procedures and by global magnetohydrodynamic magnetospheric simulations produced by the LFM. Special attention will be paid to the Harang Reversal, where we will discuss possible mechanisms for its formation.

3.6-5 BOUNCING AND BALLOONING
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Processes in the near-Earth (~10-15 RE downtail) plasma sheet determine the current wedge and auroral dynamics at its ionospheric footprint. Reportedly, the radial entropy gradient in the near-Earth plasma sheet may be directed either tailward or earthward. In the case of a normal tailward entropy gradient, damped oscillations (bouncing) of a depleted flux tube may occur. In the case of an inverted earthward entropy gradient, the ballooning instability may grow. Both bouncing and ballooning operate in a similar frequency range, and seem to cause Pi2 pulsations and periodic auroral patches (sequential auroral streamers in the case of bouncing and longitudinally propagating arc wave in the case of ballooning). Using THEMIS space and ground observations we discuss similarities and differences of the magnetospheric and ionospheric counterparts of bouncing and ballooning.

3.6-6 POLOIDAL PC5 PULSATIONS IN THE DAWN MAGNETOSPHERE
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Poloidal Pc5 pulsations are common in the dawnside magnetosphere. Unlike similar pulsations that occur in the duskside magnetosphere and are associated with unstable distributions of substorm-injected ions, the dawnside pulsations occur during quiet intervals. The compressional perturbations associated with the pulsations are limited to the immediate vicinity of the geomagnetic equator, although the weaker Alfvénic perturbation may elicit corresponding signatures in the ionosphere. Interestingly, the pulsations are almost invariably coupled to meridional oscillations in the equatorial line of nodes, resulting in frequency-doubled compressional signatures. Many mechanisms have been proposed to account for the pulsations, the most likely being drift-mirror waves. This presentation employs recent multipoint THEMIS and Cluster observations to define the meridional and azimuthal wavelengths of the pulsations, important factors in determining their ability to interact with and energize ring current ions.

3.6-7 MULTI-INSTRUMENT OBSERVATIONS OF THE ELECTRODYNAMICS OF THE IONOSPHERIC TROUGHS DURING SUBSTORMS
Zou, Shasha; Moldwin, Mark B.; Nicolls, Michael J.; Ridley, Aaron J.; Coster, Anthea J.; Lyons, Larry R.; Yizengaw, Endawoke; Donovan, Eric F.

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The ionospheric troughs are regions of remarkable electron density depression at the subauroral and auroral latitudes, and are categorized into the mid-latitude trough or high-latitude trough, depending on their relative location to the auroral oval. Substorms are one fundamental element of geomagnetic activity, during which structured field-aligned currents (FACs) and convection flows develop in the subauroral and auroral ionosphere. The auroral/trough region is expected to experience severe electron density variations during substorms. Accurate specification of the trough dynamics during substorms and understanding its relationship with the structured FACs and convection flows

are of important practical purpose, including providing observational foundations for assessing the attendant impact on navigation and communication. In addition, troughs are important since they map to magnetospheric boundaries allowing the remote sensing of magnetosphere-ionosphere coupling processes. In this talk, we discuss the dynamics of the mid-latitude and high-latitude troughs during substorms based on multi-instrument observations. Using GPS total electron content (TEC) data, we characterize the location and width of the mid-latitude trough through the substorm lifecycle and compare them with existing trough empirical models. Using a combination of incoherent scattering radar (ISR), GPS TEC, auroral imager and a data assimilative model, we investigate the relationship between the high-latitude trough and FACs as well as convection flows. The high-latitude trough is found to be collocated with a counter-clockwise convection flow vortex and downward FACs as part of the substorm current system. In addition, complex ionospheric electron temperature within the high-latitude trough is found, i.e., increase in the E region while decrease in the F region. We discuss possible processes responsible for this complex temperature change, such as ion composition change and/or presence of downward FACs.

3.6-8 POLAR CAP FLOW CHANNELS: CONTRIBUTIONS TO MAGNETOSPHERE-IONOSPHERE DISTURBANCES

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Flow channels are now appearing to be common within the polar cap, making polar cap flow much more interesting than has often been pictured. The flow channels may come from deep within the polar cap and impinge on the nightside polar cap boundary, where they can trigger localized regions of enhanced tail reconnection. This can lead to reduced entropy flow channels within the plasma sheet, along with auroral PBIs and streamers, including those leading to substorm onset and those during the substorm expansion phase. Surprisingly, expansion-phase flow channels appear to make the dominant contributions to ground and space magnetic signatures of substorm current wedge formation. Examination of such events has shown an additional surprising feature. Occasionally, an auroral streamer lies along or adjacent to the auroral poleward boundary and tilts slightly equatorward as it extends eastwards towards the auroral onset longitude. Its contact location with the onset arc sweeps westward, and as it does, dramatic auroral expansion is touched off at the contact location in conjunction with signatures of current wedge development. These observations add evidence that low-entropy plasma flow channels moving through the plasma sheet that may be brought into the plasma sheet by polar cap flow channels are critical to PBIs, streamers, substorm onset, and substorm expansion phase dynamics.

3.6-9 GLOBAL PICTURE OF DISTRIBUTION OF PLASMA PRESSURE IN THE EARTH'S MAGNETOSPHERE AND HIGH LATITUDE PART OF THE RING CURRENT

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The value and distribution of plasma pressure determine the configuration of large-scale transverse and field-aligned currents in the magnetosphere of the Earth in the conditions of the magnetostatic equilibrium. The obtaining of the picture of plasma pressure distribution requires proper measurements of particle fluxes near the equatorial plane. However, due to slow motion of high apogee satellite such picture can be obtained only using statistically averaged measurements. The averaged distribution of plasma pressure until geocentric distance $\sim 15R_E$ is obtained using data of ESA and SST devices of 5-satellite THEMIS mission. Near to monotonic growth of plasma pressure with the decrease of geocentric distance is demonstrated. Such feature means the existence of westward-directed transverse current. The distribution of plasma pressure is compared with the results of magnetic field measurements by FGM magnetometer. The distribution of transverse current density is obtained. Obtained distribution demonstrates high values of current densities at the night sector and much low density near noon. However the distribution of current density does not show the distribution of the integral transverse current at geocentric distances $> 7R_E$ as minimal values of the magnetic field are shifted from the equator to large Z in GSM coordinate system due to the daytime compression of the magnetosphere. Integral along field line values of transverse current are obtained using distribution of the magnetic field along field line in accordance with Tsyganenko-2001 model. It is shown that the obtained global distribution of transverse current demonstrates the existence of the high latitude continuation of the ordinary ring current until the magnetopause near noon. The role of this current system (named earlier the cut ring current - CRC) in the magnetospheric dynamics is discussed including magnetic storms and isolated substorms.

3.6-10 ION BEAMS IN PSBL AND THEIR AURORAL AND GROUND MANIFESTATIONS**Koleva, Rositza; Grigorenko, Elena; Zelenyi, Lev; Sauvaud, J.-A.**

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The plasma sheet boundary layer (PSBL) is characterised by field-aligned high-velocity ion beams and it is naturally to expect associated field-aligned currents (FAC) streaming in the lobe-plasma sheet interface. Recent statistical analysis revealed two different types of ion beams. Ion beams typical for quiet and slightly disturbed geomagnetic periods (Type I) are collimated in energy and are accompanied by isotropic electrons. Under these conditions no FACs or FACs of very small current density are registered. In active periods, powerful field-aligned ion beams with large parallel temperatures are observed, along with anisotropic electron fluxes, with distributions bearing the signature of a separatrix. Electrons produce a pair of FACs: at the lobeward edge directed earthward, and inside PSBL - tailward. We studied statistically a database of 364 CLUSTER observations of PSBL ion beams. Their auroral and ground manifestation was investigated using POLAR and IMAGE UV images and magnetograms of appropriate ground stations. As a rule in cases of Type I ion beams CLUSTER footprints are in the region of diffuse aurora and the magnetograms exhibit no or small variations in the horizontal magnetic field component. In cases of Type II beams (with currents), CLUSTER footprints are located adjacent to the brightest auroral spot and the magnetograms exhibit large negative variations of the horizontal magnetic field component. However, in considerable number of cases PSBL currents are observed in quiet conditions. CLUSTER spectrograms for these cases reveal that the electrons are accelerated to energies lower than usually in substorm conditions. There are several noteworthy exceptions, when PSBL ion beams of Type I without currents are observed in quite active periods. This could imply energy deposition from the near tail coexisting with acceleration process on closed field lines in the distant tail.

SESSION 3.7**AURORAL PROCESSES****3.7-1 MECHANISMS OF MULTIPLE AURORAL ARC FORMATION AND FIELD-ALIGNED ELECTRON ACCELERATION****Antonova, E.E.; Stepanova, M.V.; Kornilov, I.A., Kornilova, T.A.**

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The splitting of auroral arc and formation of multiple arcs is a common and well-known phenomenon of auroral arc dynamics. However, it is not well studied until now. Formations of multiple structures with scales ~100 km (multiple inverted V structures) can be described as the results of the development of the instability of the band of upward field-aligned current connected with the variation of the distribution of magnetospheric plasma pressure under the influence of the variation of magnetospheric potential. Electrostatic field-aligned potential drop located in auroral plasma cavity accelerate magnetospheric electrons in inverted V structure. Accelerated electrons have near to isotropic pitch-angle distribution excluding the source cone. Formation of multiple arcs with scales 1-10 km is ordinarily attributed to the development of the feedback instability and acceleration of electrons of ionospheric origin. Such electrons have much larger densities and form arcs which are much brighter than inverted V arcs/bands. Field-aligned electron beams produce thin auroral arcs. Field-aligned electric field of shear Alfvén waves is ordinarily considered as the reason of field-aligned acceleration of cold ionospheric electrons. Difficulties of such approach are summarized including observations of electron beams at the boundaries or inside inverted V structures, the existence of upper limit of the energy of field-aligned electron beam, which does not exceed the energy of simultaneously observed inverted V electrons etc. The model named the auroral grader is developed which gives the possibility to overcome these difficulties. It is shown that the observed cases of arc splitting is possible to explain using discussed mechanism.

3.7-2 ALFVÉN WAVES AND AURORAL PARTICLE ACCELERATION**Lysak, Robert; Song, Yan**

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Electrodynamic coupling between the magnetosphere and ionosphere is accomplished by means of the passage of Alfvén waves between these regions. These waves can be accompanied by parallel electric fields when the perpendicular scale size becomes small. There are two main regimes of this acceleration. At lower altitudes where the plasma is cold, electron inertial effects becomes important and can lead to the bulk acceleration of the cold plasma. At higher altitudes, the primary particle acceleration mechanism is Landau damping, which preferentially accelerates electrons with velocities near the Alfvén wave phase velocity. These mechanisms are favored in regions where there are sharp plasma gradients, such as at the plasma sheet boundary layer or on the edges of the auroral density cavity, since phase mixing is an efficient mechanism for reducing the perpendicular wavelength.

These waves may be generated in a number of ways. One common mechanism is generation due to shear flows,

such as the bursty bulk flows often observed in the plasma sheet. This mechanism can explain the connection between these flows and auroral streamers. In addition, shear Alfvén waves can be produced by linear mode conversion of fast mode waves. One less explored mechanism is generation of electromagnetic ion cyclotron waves, which become shear Alfvén waves when the ion gyrofrequency becomes much greater than the wave frequency. Theory and modeling of these processes will be presented.

3.7-3 KINETIC AND FLUID DESCRIPTIONS OF ALFVÉNIC AURORAL ACCELERATION

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There is now a sound body of evidence that supports the acceleration of auroral electrons in shear Alfvén waves that propagate along the geomagnetic field toward the ionosphere. This acceleration mechanism has been shown to be important for dynamic aurora, and more specifically for aurora at or near substorm onset. Kinetic models have revealed where and how the energy transfer between shear Alfvén waves and electrons take place. Comparisons between the simulation predictions and in-situ measurements have shown close agreement at both high altitudes, where the nonlinear interaction leads to pronounced low-energy anisotropy in the electron distribution function, and at low altitudes, where the accelerated electrons often display energy dispersion. However, the theory and numerical models that have been used to describe the acceleration of auroral electrons by shear Alfvén waves are necessarily limited. The important kinetic physics of the interaction between shear Alfvén waves and magnetospheric electrons dictate that numerical simulations must be reduced to one, or at most two, spatial dimensions. In order to compare theoretical predictions and numerical models with observations of dynamic aurora, it is clear that a three-dimensional description is necessary to attempt to capture the rich spatial structure of moving auroral displays. We use reduced one-dimensional kinetic simulations to suggest a parameterization of Alfvénic acceleration that may allow the effects of the kinetic wave-particle interaction to be included in a three-dimensional multi-fluid numerical simulation. We demonstrate that at high altitudes, in the warm plasma of the plasma sheet and plasma sheet boundary layer, it is important to include the modifications to plasma temperature and pressure that occur as a result of the wave-particle interaction, and suggest some ways that this could be achieved.

3.7-4 MIRROR FORCE INDUCED WAVE DISPERSION IN GLOBAL SCALE ALFVEN WAVES

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Hybrid MHD-kinetic electron simulations of standing shear Alfvén waves along the closed dipolar magnetic field lines of the Earth show that the upward parallel current region within these waves saturates and broadens perpendicular to the ambient magnetic field and that this broadening increases with the electron temperature. Using resistive MHD simulations, with a parallel Ohm's law derived from the linear Knight relation, we explore the nature of this broadening in the context of the increased perpendicular Poynting flux resulting from the increased parallel electric field associated with mirror force effects. This increased Poynting flux facilitates wave energy dispersion across field lines which in-turn allows for electron acceleration to carry the field aligned current on adjacent field lines. This mirror force driven dispersion can dominate over that associated with electron inertial effects for global scale waves.

3.7-5 AURORAL MORPHOLOGY AND BEAM-INDUCED TURBULENCE

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The central objective of auroral research is to understand plasma energization. In situ sensors provide direct evidence for the presence of suprathermal particle populations, but the measurements are of limited utility in studies of spatially-localized, time-dependent interactions owing to inherent space-time ambiguities. This paper reviews recent experiments conducted at the PFISR facility designed to investigate electron beam properties and beam-induced ionospheric turbulence associated with dynamic substorm auroras. A unique feature of these experiments is the focus on rapid sampling in time (<20-ms cadence). Electron beam properties are derived from geometric analysis of high frame-rate, narrow-field auroral imagery. These results are compared with Langmuir and ion-acoustic wave spectra derived from measurements of coherent backscatter at 440MHz (Bragg wavelength 34 cm). Results suggest the existence of a latitudinally confined region of cavitating Langmuir turbulence at the poleward edge of the substorm expansion, produced by the presence of dense, low-energy electron beams. Analysis of the vertical redistribution of optical emissions in these events suggests that these are ionospheric manifestations of time-dispersive field-aligned bursts observed by in-situ sensors.

3.7-6 AURORAL MORPHOLOGY AND IMPLICATIONS FOR GENERATION MECHANISMS**Samara, Marilia**

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We present examples of different types of auroral structures, viewed on different temporal and spatial scales and in different wavelengths. Simultaneous multi-spectral and multi-scale imaging enables an enhanced level of quantification which can lead to new insights into the fundamental questions of auroral arc generation processes. The recent advances in auroral imaging technology during the last half decade, lower noise, increased gain and dynamic range, have opened up new spatio-temporal realms of auroral morphology in addition to improving our understanding of the previously defined auroral morphology. Remote operation capabilities have resulted in an increased volume of data suitable for thorough statistical analyses, particularly in combination with existing databases. An overview of accepted morphological definitions will be presented, along with supporting auroral images from the historical perspective, as well as the relation to the multitude of auroral images recorded and being discussed today. The complexities in researching the possible physical processes behind the aurora continue to reveal the need for viewing these science questions on a global scale, further emphasizing the necessity for coordinated collaboration between countries and across continents.

3.7-7 SUB AURORAL OVAL AURORA**Michell, Robert; Samara, Marilia**

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There are two main types of sub auroral oval aurora that we will discuss. The first type is observed at auroral latitudes, but at local times and geomagnetic activity levels that place the auroral oval at much higher latitudes. These quiet-time, sub auroral patches are observed in the early evening and pre-dawn sectors from Poker Flat and are thought to be associated with high-energy electron precipitation from the radiation belts. The patches appear as very irregular shaped regions of luminosity that have little temporal variation. We present observations from both all-sky and narrowfield imagers in different wavelengths. The other type of sub auroral oval aurora is the mid latitude highly variable aurora that occurs with major geomagnetic storms. We present observations from Montana during the 14 November 2012 storm, where auroral structures were observed with all-sky imagers in both 557.7 nm and 630.0 nm at a high time resolution of 3 frames per second. These low latitude structures resemble pulsating aurora in their temporal variability but contain much different spatial characteristics. Potential generation mechanisms for these sub auroral oval structures will be discussed.

3.7-8 A UNIFIED MECHANISM OF THE INVERTED-V AURORAL ACCELERATION AND ALFVEN WAVE AURORAL ACCELERATION**Song, Yan; Lysak, Robert**

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Parallel electric fields are necessary and crucial for efficient acceleration of charged particles creating discrete auroras. For both the quasi-static (inverted-V) and Alfvénic auroras, the generation of parallel electric fields obeys the same laws of physics. In both cases, parallel electric fields are generated by Alfvénic interactions in the inhomogeneous magnetosphere-ionosphere coupling system, rather than by diffusive or passive processes, because (1) the Poynting flux, a major energy source for auroral formation, is carried by Alfvén waves, and (2) the localized enhancement of magnetic and mechanical stresses which can create and support parallel electric fields is caused by the interaction of Alfvén waves, Alfvén wave packets (Alfvénons) or Alfvén wave fronts in M-I coupling system.

The dynamical processes necessary to create parallel electric fields have not been emphasized in most previous KAW studies, and have been totally overlooked in the study of quasi-static auroras. In this presentation, by including the parallel displacement current in Ampere's law, in a simple two fluid approximation, we present the dynamic theory of the generation of High Energy Particle Accelerators (HEPAs) by Alfvénic interactions in the auroral zone. The HEPAs include strong local electrostatic parallel electric fields, and are accompanied by (i) enhanced low plasma density cavities and (ii) enhanced surrounding magnetic and mechanical stresses.

Our dynamical theory provides not only a unified mechanism of the formation of both Alfvénic and quasi-static inverted-V auroras, but also provides a theoretical basis for understanding the mechanisms of the generation of plasma energization and acceleration to high energy in cosmic plasmas [1].

[1] Y. Song and R. L. Lysak, Fall AGU Meeting 2011, abstract #SM31A-2073, (Bibliographic Code:2011AGUFMSM31A2073S).

3.7-9 SUBSTORM PRECURSOR SEQUENCE DETECTED BY HIGH-RESOLUTION RADAR AND ASI MEASUREMENTS

Nishimura, Toshi; Lyons, Larry; Zou, Ying; Angelopoulos, Vassilis; Bristow, William; Hampton, Donald; Nicolls, Michael; Chen, Steven; Donovan, Eric; Spanswick, Emma; Mende, Stephen

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A critical, long-standing problem in substorm research is identification of the sequence of events leading to substorm auroral onset. Recent THEMIS all-sky imager (ASI) array observations have shown a repeatable pre-onset sequence, which is initiated by a poleward boundary intensification (PBI) and is followed by a north-south (N-S) oriented streamers moving equatorward. Substorm auroral onset occurs soon after the streamer reaches near the substorm onset location. Because of the linkage of fast magnetotail flows to PBIs and streamers, this sequence indicates that onset is preceded by enhanced earthward plasma flows associated with localized, enhanced reconnection near the pre-existing open-closed field line boundary. On the other hand, THEMIS satellite and ASIs also show that substorms are preceded by azimuthally propagating waves of ~1-2 min periodicity, indicating an importance of wave instability for triggering substorm onset. However, it has been difficult to identify the link between fast earthward flows and near-Earth waves. We have found a well-instrumented substorm event with the Poker Flat incoherent scatter radar (PFISR), THEMIS white light ASI, and multi-spectral ASI, where the auroral onset occurred within the PFISR field of view near the zenith of the ASIs. The substorm onset was preceded by a PBI, and one of the radar beams going through the PBI detected equatorward flows crossing the PBI and reaching the growth phase arc. This flow provides evidence that flows from open magnetic field lines propagated across the open-closed boundary and reached the near-Earth plasma sheet prior to the onset. We also identified oscillations of auroral luminosity along the growth phase arc with ~1 min period. These waves propagated westward, and they amplified abruptly at the onset time, soon after the equatorward flows reached the growth phase arc. This sequence indicates that pre-existing waves acted as a seed of the onset instability and became more unstable as a result of the equatorward flows. Interestingly, the westward flow speed along the growth phase arc ionization increased quasi-periodically in positive correlation with the density. This suggests that the pre-onset waves involve flow generation processes such as through shear flow ballooning instability rather than pure interchange or ballooning instability.

3.7-10 THE IONOSPHERIC INFLUENCE ON AKR BURST STRUCTURE FORMATION

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Auroral kilometric radiation (AKR) is a powerful natural electromagnetic radio emission in the frequency range of 30 kHz to ~ 1 MHz which is generated in the near-Earth plasma and propagated from the Earth. For the first time, AKR was detected by scientists of Radiophysical Research Institute (NIRFI) at the satellite Electron-2 in 1965. AKR is connected with discreet auroras and its sources are situated above the auroral ionosphere, generally, in the evening and night sectors of the magnetosphere at invariant latitudes of ~ 700°, at a height of ~ 2-10 thousand kilometers, and also in the magnetospheric cusp. AKR is generated by energetic electron beams injected from the magnetotail into the auroral zone. Currently, cyclotron maser instability at the local electron gyrofrequency is considered to be a generally recognized mechanism of AKR generation. Such instability appears in the regions with low plasma density called Calvert's cavity where plasma frequency f_{pe} is lower than electron gyrofrequency f_{ce} . Auroral kilometric radiation is generally observed in the frequency range of 100 – 700 kHz, and AKR spectrum width changes slowly during several dozens of minutes.

We present results of the analysis of wide-band AKR structures obtained by the POLRAD experiment on board the INTERBALL-2 satellite. These structures represent a quasiperiodic sequence of splashes which were called bursts by analogy with astrophysical bursts. The main characteristics of bursts are:

- characteristic burst repetition period is ~ 6 – 10 min;
- burst intensity is by one or two orders higher than background AKR intensity;
- as a rule, the front edge of a burst (0.5-2 min) is more abrupt in comparison with the back edge (up to 10 min).

The mechanism of AKR burst formation is proposed which is connected with ionospheric plasma influence on the source's region.

3.7-11 DYNAMIC FRACTAL OF ELECTROJET AURORAL (AE) MAGNETIC SIGNATURE ON THE CHAMP SATELLITE MAGNETIC MEASUREMENTS.

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In this work, we studied the effects of magnetic Auroral Electrojet (AE) observed on the magnetic vector measurements of CHAMP mission. We focused on the effects during the magnetic storm. Thus, we have developed

several algorithms that allowed us to isolate the effects of the Auroral Electrojet (AE) on the three vector components using internal model of geomagnetic field.

We have selected magnetic field observed before, after and during strong the magnetic storm that took place on 2004 11 08. The different results obtained allowed us to verify the following facts that the effects of Auroral Electrojet (AE) are much visible mainly on the horizontal component (Y) either in the northern or southern polar zones. These effects are much more intense in the dayside especially during the magnetic storm which can reach a few thousand nT. The orbits analyzed during the storm did not show a significant effect in the night side. The wavelet analysis shows that high frequencies are much more concentrated in the polar regions.

The spectral analysis show that the magnitudes of the observed magnetic field were intensely affected which the phases remain practically unchanged during the storm. These analyzes confirm the fractal of the effects of Auroral Electrojet on the components of magnetic CHAMP measurements. To complete our studies we still analyze all strong magnetic storms that occurred during the decade 2000-2010. In addition, we will integrate terrestrial data in order to compare with the AE indices help to deepen the study.

3.7-12 FRACTAL APPROACH TO STUDY IONOSPHERIC CONDUCTIVITY IN THE AURORAL ZONE

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Fractal geometry is used to describe the spatial structure of the ionospheric conductivity. Topological values of fractal dimension and connectivity index, characterizing the structure of the Pedersen and Hall conductivities on the night side of the auroral zone, are analytically obtained and the results are compared to observed statistical properties of ionospheric electric field fluctuations and auroral activations. It is assumed that the nontrivial fractal properties lie in the transversal ionospheric spatial scales and that they are a reflection of the distribution of precipitating particles. A criticality condition for the percolation threshold of the Pedersen and Hall currents is invoked to place bounds on the fractal dimensions and connectivity indices of the Pedersen and Hall conductivities. These bounds are satisfied by the observed properties of the fluctuating electric field and the auroral glow. It is shown that the Pedersen conductivity is characterized by a path-connected set while the Hall conductivity can be characterized as an asymptotically path-connected set, which is related to the structures of multiple auroral arcs. Correspondence of theoretical estimates and experimental results indicates validity of the fractal approach to describe processes in the auroral region.

3.7-13 EULER POTENTIALS FOR TWO CURRENT SHEETS OF NON-ZERO THICKNESS ALONG AMBIENT-UNIFORM MAGNETIC FIELD

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Euler potentials of two current sheets of finite width and thickness with parallel or antiparallel to each other currents and aligned with a uniform

ambient magnetic field are constructed analytically. It is shown how analytic treatment can be simplified using complex number analysis. The paper generalizes our results obtained earlier for a system of two line currents and for a system of two current sheets of zero width. The solution is applied for study of bouncing motion of particles trapped between mirror points of this field structure. The result is relevant to physics of Birkeland currents.

SESSION 3.8

HIGH LATITUDE ELECTRODYNAMICS AND ION OUTFLOW

3.8-1 QUIET-TIME THERMAL-ENERGY OXYGEN ION UP-FLOWS AND OUTFLOWS

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The presence of energetic O⁺ ions in the ring current at the onset of a magnetic storm prompts the question of the possible role of in-transit ionospheric O⁺ ions between the ionosphere and the inner magnetosphere (plasma sheet and ring current) in the quiet period immediately preceding the main phase of a magnetic storm. We study the transport of observed low-energy (thermal) O⁺ ions in the high-altitude polar wind in the periods preceding a number of large magnetic storms. Due to centrifugal ion acceleration at higher altitudes, about 10-20% of such ions reach the plasma sheet during such periods; the actual percentage is a factor of ~3 larger in the dusk sector on average compared with the dawn sector and dependent on the IMF and the O⁺ ion temperature. This provides a low but non-negligible flux of O⁺ ions between the ionosphere and the inner magnetosphere, and a significant in-transit oxygen ion population preceding a magnetic storm, which could explain the presence of energetic O⁺ ions at the onset of the main phase of the storm.

3.8-2 COUPLING BETWEEN THE POLAR IONOSPHERE AND THE MAGNETOSPHERE DURING PERIODS OF NORTHWARD IMF: CLUSTER OBSERVATIONS

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Polar cap arcs are the signature of magnetosphere-ionosphere coupling processes occurring at high latitudes. Observations from the Cluster satellites above the polar caps give new insight on the magnetosphere-ionosphere interactions associated with these high latitude auroral features.

Polar cap arcs can occur on a variety of scales, from large-scale arcs called transpolar arcs or theta aurora to small-scale isolated arcs.

There is strong evidence that large-scale transpolar arcs are located on field lines that have been closed by magnetotail reconnection but remain embedded within the lobes. Recent observations from the Superdan radar array and from the IMAGE and Cluster satellites confirm this closed field line topology.

During prolonged periods of northward IMF the Cluster spacecraft detects smaller scale structures consisting in a succession of current sheets with opposite polarity. Cluster and TIMED observations reveal that they are associated with thin polar cap arcs. The upward current region is characterized by upflowing ionospheric ions with typical inverted-V structure and with downward accelerated electrons. Like for auroral inverted-Vs the acceleration is caused by quasi-static electric fields. The precipitating electrons are cold and likely of solar wind origin. However, for half of the events, plasmashet-like isotropic ions are detected simultaneously. Consequently the magnetic field lines do not neatly fit into either a closed and open configuration.

A detailed review of these observations is proposed, which are subsequently used to constrain ideas on magnetosphere-ionosphere interactions and on magnetospheric configuration at high latitudes during prolonged periods of northward IMF.

3.8-3 IDENTIFICATION AND TRACKING OF PLASMA SHEET FLOW CHANNEL/DISTURBANCE PRECURSORS USING POLAR CAP PATCHES AND ARCS

Nishimura, Toshi; Zou, Ying; Lyons, Larry; Gallardo-Lacourt, Bea; Donovan, Eric; Angelopoulos, Vassilis; Ruohoniemi, Mike; Nishitani, Nozomu; Mende, Steve

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Localized, transient polar cap flows impinging on the poleward boundary of the nightside auroral oval have been suggested to precede poleward boundary intensifications (PBIs), which are often followed by auroral streamers, some of which propagate equatorward and appear to lead to substorm auroral onset. While echo coverage often limits radar flow measurements, imaging of polar cap patches and arcs has the potential to monitor localized polar cap flows by tracing emission structures, previously associated with enhanced flows, over long distances. We use such imaging to examine if polar cap patches and arcs moving over large distances can be seen as possible precursors to pre-substorm-onset PBIs. We find evidence that such features, which are longitudinally narrow, propagate from the dayside polar region toward the nightside polar cap boundary prior to pre-onset PBIs. This sequence indicates that transient activity in the dayside polar region may initiate polar cap patches and arcs that propagate across the polar cap and are followed by pre-onset PBIs. Furthermore, we find evidence that expansion-phase active aurora expanded poleward soon after additional polar cap patches and arcs reached close to the nightside polar cap boundary. The expansion phase auroral activity significantly weakened when polar cap patches/arcs disappeared. Our findings suggest that plasma transport originating from the dayside and reaching the nightside open-closed boundary may trigger plasma sheet flow bursts and play a crucial role in pre- and post-onset auroral activity. Polar cap imaging offers the possibility for monitoring such localized, transient plasma transport over large distances.

3.8-4 IONOSPHERIC ION HEATING ON POLEWARD MOVING POLAR BORDER OF THE AURORAL REGION

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Data of thermal ion heating on auroral polar border measured by Interball-2 (Auroral Probe) satellite is presented. When the satellite crossed of the polar cap on auroral polar border during high geomagnetic activity intense low frequency electromagnetic perturbations are detected. At the same time local transverse heating of thermal ions occurs. Heating rates were up to 80 eV/sec and 300 eV/sec for H⁺ and O⁺ ion correspondingly. Electromagnetic wave power was not sufficient for ions heating by cyclotron resonance. AKR generation just under the satellite also measured near the border. In the presentation the mechanism of simultaneous thermal ion heating and AKR generation is given.

3.8-5 HOT AND COLD ION OUTFLOW, OUTFLOW TRAJECTORIES AND FINAL FATE**Nilsson, Hans**

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Ions apparently emanating from the same source, the ionospheric polar cap, can either end up as energized to keV energies in the high altitude cusp / mantle, or appear as cold ions in the magnetotail lobes. We use Cluster observations of ions and wave electric fields to study the spatial variation of ion heating in the initial outflow path of these different ion populations. The data shows that the cusp is the main source of oxygen ion outflow, whereas a polar cap source would be consistent with the average outflow paths for cold ions observed in the lobes. A majority of the cusp O⁺ flux observed in the high altitude polar cap magnetosphere is sufficiently accelerated to escape into interplanetary space. Significant O⁺ fluxes are also seen in the magnetosheath. Colder ions with lower parallel velocities pass through regions with less heating and acceleration. These populations form cold ion beams in the tail. The largest number fluxes correspond to ions with too low energy to be detected by ion spectrometers. These ions appear to be mostly protons. Oxygen ion populations in the lobes are also typically cold, but attain significantly higher bulk energy. These lobe oxygen beams have a total number flux much less than the population escaping into the magnetosheath.

3.8-6 EFFECT OF THE BETATRON MECHANISM ON THE FIELD ALIGNED ION FLOW IN THE HIGH LATITUDE IONOSPHERE AND POLAR WIND**Lemaire, Joseph**

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During geomagnetically disturbed conditions $\partial F/\partial t$, the local time derivative of the geomagnetic field intensity, $F(r,t)$, changes erratically (or periodically) from positive to negative values back and forth. These variations occur sporadically with time constants ranging from less than a millisecond to more than hours. The wide spectrum of local time variation of F induces betatron electric fields in the whole ionosphere, plasmasphere and magnetosphere.

Beside the increase (or decrease) of W , the perpendicular energy which is experienced by all charged particles trapped in the ionosphere, plasmasphere and magnetosphere, as a consequence of the betatron mechanism when F increases (or decreases), there are additional effects that are generally overlooked in the studies of Radiation Belts, Ring Current, Plasmasphere, and Ionosphere.

Lemaire *et al.* (2005) pointed out that a decrease of $F(r,t)$ with time t , uplifts the mirror points and guiding centers of all charged particles of all masses, energies, and pitch angles, as a consequence of the adiabatic betatron mechanism.

Conversely, when F increases as a function of t (e.g. at low latitudes, during recovery phases of geomagnetic storms) the altitudes of all guiding centers decrease deeper into the ionosphere.

The effect of the adiabatic betatron mechanism during geomagnetic storms on the low latitude ionosphere and plasmasphere has been presented at the poster session ST2.3 of EGU 2013 by Lemaire *et al.* (2013). The aim of the current presentation at the session 3.8 of IAGA 2013 is to point out the effects of the betatron mechanism produced by some characteristic geomagnetic disturbances on the electrons, protons and heavier O⁺ ions of mid and high latitude ionosphere.

3.8-7 IONOSPHERIC OUTFLOW IMPACTS THROUGHOUT THE MAGNETOSPHERE**Mouikis, Christopher; Kistler, Lynn; Liu, Yanhua; Wang, Guanwen;**

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The CLUSTER spacecraft have now been operating for 13 years covering more than a full solar cycle. The CODIF instrument has provided a wealth of data over this time, allowing the solar cycle dependence of the ion composition over the energy range 40 eV/e to 40 keV/e throughout the magnetosphere to be determined for the first time. The ion outflow from the high-latitude ionosphere varies significantly in relation to the solar EUV activity and the geomagnetic and solar wind conditions. The variation due to the solar EUV radiation follows the 11 year solar cycle while the geomagnetic activity related changes have time scales that are of the order of hours to a few days. However, during solar maximum, the greater number of CMEs leads to more and larger geomagnetic storms, which also increases the outflow, both in the cusp and in the nightside auroral regions. In addition, the solar cycle impacts not only the ionospheric outflow, but also the transport, through changes in convection. Thus, different regions of the magnetosphere may be impacted in different ways. Here we present results using mainly the ion composition data from the CIS/CODIF instrument on Cluster to determine the ion composition changes of the plasma sheet at ~ 20 Re, the effect of O⁺ on the tail stability and the ensuing reconnection rate, and the impact on the inner magnetosphere as a function of the solar activity and the geomagnetic and solar wind conditions.

3.8-8 SOLAR WIND AND IONOSPHERIC CONTROL OF DAYSIDE FIELD-ALIGNED CURRENTS DURING THE SOLAR CYCLE

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Field-aligned currents and energetic electron precipitation are closely linked with solar wind and ionospheric parameters [Wing et al., 2011]. Field-aligned currents on the dayside are closely linked with velocity shear layers. We present a simple analytical model that couples a shear layer to the ionosphere through field-aligned currents. In the model, we use the Knight relation to express the upward field-aligned current in terms of the potential drop between the magnetosphere and ionosphere and solve for the ionospheric potential using current continuity. We obtain an analytic expression for the dependence of the current, the current maximum, and the current thickness on the magnetosheath velocity, magnetopause shear layer thickness, magnetospheric density and temperature, and ionospheric conductivity. We compare the analytical results for the current profiles using the magnetic field instruments on board the DMSP satellites. Because solar wind and ionospheric conditions vary significantly over the solar cycle, it is useful to consider the solar cycle dependence of field-aligned currents in order to isolate their dependence on ionospheric conductivity, solar wind density, and solar wind velocity.

SESSION 3.9

REPORTER REVIEWS - DIVISION III

3.9-1 REVIEW OF RECENT ADVANCES IN GLOBAL MAGNETOSPHERIC DYNAMICS

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The excitation of magnetospheric convection through coupling of the solar wind, with its embedded interplanetary magnetic field (IMF), and the terrestrial magnetic field is a topic of perennial interest and considerable international research. The magnetosphere displays a broad range of behaviours in response to weak and strong solar wind coupling, from periods of apparent quiescence during northward-directed IMF to storm conditions driven by extreme solar wind conditions. This talk will review recent advances in our understanding of global magnetospheric dynamics, including the areas of theory, observations, and modelling.

3.9-2 MAGNETOSPHERES OF SOLAR SYSTEM BODIES OTHER THAN THE EARTH

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In this invited review we present recent findings on the magnetospheres of solar system bodies other than the Earth. Amongst other aspects, we address: seasonal and solar cycle variability from observations and theoretical considerations; solar wind driving of giant planet magnetospheres; the structure of the high latitude magnetosphere at Jupiter and Saturn, considering the cusp, field-aligned current systems, and auroral radio emission source regions; details of the cusp at Saturn and Mercury; the effect of Kelvin-Helmholtz vortices for viscous solar wind-magnetosphere interaction at Mercury, Saturn and Jupiter; recent auroral observations; plasma loss at Mars and Titan.

3.9-3 TAIL DYNAMICS

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Magnetotail dynamics plays a critical role in the overall dynamics, energy storage and release, and magnetic flux transport of planetary magnetospheres. Tail physics is of particular importance for the evolution of substorms and storms in the Earth's and similar magnetospheres. Tail processes also facilitate the outward transport of large amounts of material from the inner part of giant magnetospheres. A central aspect of tail dynamics is magnetic reconnection and processes that lead to the onset of reconnection. During the past years our field has made major advances in these areas. This presentation reviews the research on magnetotail dynamics during the past two years.

3.9-4 AURORAL PHENOMENA

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3.9-5 MAGNETOSPHERIC ULF WAVES

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For the period 2011-2013, the literature related to the entire spectrum of magnetospheric ultra-low frequency (ULF) waves, as defined in 1963 by the International Association of Geomagnetism and Aeronomy (IAGA), has been reviewed by the author, and a selection of new and interesting publications will be presented to the audience. Among the ULF waves will be the usual Pc1-5, P1-2, and some oddballs.”

3.9-6 MAGNETOPOUSE AND BOUNDARY LAYER STUDIES IN 2011

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On this 50th anniversary of the first reports of unambiguous spacecraft encounters of Earth’s magnetopause, we will review advances made during the last couple of years in our understanding of the magnetopause, its boundary layers, their roles, and the processes occurring there. Observational, modeling, and theoretical works mostly on, but not limited to, the Earth’s magnetopause will be reviewed.

3.9-7 WAVE-PARTICLE INTERACTION IN THE INNER MAGNETOSPHERE

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Wave particle interactions have been a known part of the Earth’s radiation belt processes since the beginning of the space age, but only recently has their importance in controlling the dynamics of energetic electrons and ions in the radiation belt / ring current region been fully appreciated. These interactions control the lifetimes and transport processes for energetic particles, and for energetic electrons acceleration processes as well. However, in spite of a significant body of theoretical and modeling work our community is still incapable of accurately predicting the outcome of any one geomagnetic storm - will it lead to enhanced trapped radiation, or a decrease, or will there be no change?

The recently launched Van Allen Probe mission was specifically designed to address this mystery. In this talk we will review the current state of the art of wave-particle interaction research in the Earth’s magnetosphere, with specific attention to the energetic electron dynamics. In particular, we will explore the reasons for our current inability to accurately model storm behavior: Is this due to insufficient knowledge of processes or is it simply due to insufficient knowledge of the required boundary conditions for known processes? Finally we will interpret recent results from the Van Allen Probes Mission in the context of these questions.

SESSION 4.1

NEW SOLAR AND INTERPLANETARY RESULTS

4.1-1 FIRST RESULTS OF NASA'S IRIS MISSION

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NASA's IRIS mission provides high-cadence and high-resolution observations of the solar chromosphere and transition region. We will present an overview of the instrument specifications and different operation modes of the instrument. We will also present first results of the IRIS mission, especially on the structure and dynamics of the solar transition region.

4.1-2 NEW INSIGHTS INTO THE PHYSICS OF THE ACCELERATION REGION OF THE SOLAR WIND

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The acceleration region of the fast and the slow solar wind is often identified with the distance range of 2-3 solar radii above the limb. This is also the region where the solar magnetic field undergoes both quiescent and dynamic changes. The physical processes that define the properties of this magnetized flow in this distance range can only be explored with model studies. On the other hand, remote sensing observations of this region play a key role for setting the necessary boundary conditions for these models and their validation. Despite the proliferation of space-based observatories, it is ironic that, at present, the only remote sensing observations covering this distance span are imaging and spectroscopic made during total solar eclipses. This presentation will focus primarily on new insights gained from these observations, and their impact on existing models.

4.1-3 THE RELATION BETWEEN THE RADIAL TEMPERATURE PROFILE AND THE SPECTRUM AT MILLIMETER, SUB-MILLIMETER, AND INFRARED WAVELENGTHS IN THE SOLAR CHROMOSPHERE

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Solar observations at millimeter and ultraviolet wavelengths show that at chromospheric altitudes there is a temperature minimum. Analysis based on semi-empirical models locate this point at about 500 km over the photosphere and, their consistency is tested by means of millimeter to infrared observations. In the present work, we show that variations of the theoretical radial temperature profile near the minimum, does not change the shape of the spectrum, i.e. the millimeter – sub-millimeter continuum does not depend on the temperature minimum value. Therefore millimeter to infrared observations are not useful to test the semi empirical chromospheric models around the temperature minimum. On the other hand, we show that the spectrum is correlated with the length of the region around the minimum and that the region around the temperature minimum is underestimated in temperature in the current models.

4.1-4 X-RAY SPECTRA OF SOLAR CORONA DURING 2009 LOW ACTIVITY PERIOD

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Soft X-Ray spectra obtained during recent minima of activity will be presented and discussed. In particular SphinX data will be shown indicating for presence of coronal component with temperature ~ 10 MK. Differential emission measure analysis of common data sets between Hinode XRT and SphinX will be shown and interpreted. Localisation of different plasma temperature regions will be shown.

4.1-5 SOLAR RADIO OBSERVATIONS BY CHINESE SPECTRAL RADIOHELIOGRAPH

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Radio imaging-spectroscopy over wide frequency range is in its infancy and important for addressing fundamental processes in the solar eruptive phenomena. It will to open new observational windows on solar arcs and CMEs by mapping the radio emission from unstable electron populations during the basic processes of energy release. The coronal magnetograms will also be obtained through imaging-spectroscopy. The Chinese Spectral Radioheliograph (CSRH) to cover wide frequency range (0.40-15.00GHz) with high spatial, spectral, and temporal resolutions will be introduced. The array of CSRH-I in 0.4-2 GHz with 40 4.5m antennas has been established and is in test observations. The array of CSRH-II in 2-15 GHz with 60 antennas just starts field assembling and will be established by 2013. The first observations from CSRH-I of the Sun and solar burst events are introduced.

4.1-6 NEW RESULTS ON TYPE II AND III SOLAR RADIO BURSTS

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Type II and III solar radio bursts are the most intense, prominent, frequent, and important radio emissions produced by the Sun. They signal events likely to drive space weather at Earth but are also two of the four known archetypes for collective radio emission in plasmas. Type IIs are excited by shock waves, either driven by CMEs or else blast waves, which reflect electrons and form electron beams upstream of the shock. The electron beams in type IIIs, in contrast, result from outrunning of energetic electrons from magnetic reconnection regions. Both classes of bursts are produced near the electron plasma frequency f_p and near $2f_p$ due to the generation of Langmuir waves near f_p by electron beam instabilities and then the subsequent conversion of Langmuir wave energy into radio emission by nonlinear and perhaps linear coupling processes. This paper presents our latest work on type II and III bursts, including: (i) prediction of dynamic spectra for type III bursts in realistic density profiles with turbulence superposed on a monotonic background profile, showing fine structures very similar to observations; (ii) detailed analyses of STEREO spacecraft data to identify the active nonlinear Langmuir wave processes in type III sources, finding strong evidence for the electrostatic decay process; and (iii) detailed prediction of the dynamic spectrum of a well-observed type II burst with the "bolt-on" radiation theory and the BATS-R-US MHD code, showing excellent agreement with observations.

4.1-7 IMAGING OBSERVATIONS OF A MULTIPLE CORONAL TYPE II RADIO BURST**Feng, Shiwei; Yao, Chen**

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Coronal metric type II radio bursts can sometimes occur in multiples within a relatively short period during a solar eruption. The origin of these multiple type II radio bursts remains unresolved. In this presentation, we report a multiple-type II event with a combined multi-wavelength and multi-viewpoint analysis of the imaging data recorded by the Nancay Radioheliograph, the STEREO and SDO instruments. The type II spectrum is composed of harmonic and fundamental branches of two type II bursts with different starting time and frequency drift. One of them also presents splitting bands. Our study is focused on the spatial relationship between the type II emitting sources and the large-scale shock front. The type II sources are determined by the NRH radio imaging and the RSTO/BIR dynamic spectral data, and the shock dome is induced with the 3-dimensional reconstruction of the STEREO and SDO data. It is found that the two type II bursts originated at different parts along the expanding large-scale CME-driven shock front. Both sources seem to move along the shock front and approach each other during their outward propagations. The sources accounting for the splitting bands are adjacent to each other at the shock front. Physical implications of these novel observations are discussed.

4.1-8 INITIATION AND DYNAMICS OF CME FLUX ROPES REVEALED BY SDO AND STEREO**Xin, Cheng; Jie, Zhang; Ming-de Ding**

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Recent SDO observations reveal that coronal mass ejections (CMEs) often originate from the eruption of magnetic flux ropes. In the slow rise phase of CMEs, the flux rope lies along the polarity inversion line and first appears as a twisted channel in the AIA high temperature passbands, such as 131 Å and 94 Å. The hot channel will rise slowly with the velocity of 10-100 km/s typically, probably due to the increase of magnetic pressure of the flux rope or the decrease of magnetic tension over the flux rope.

In the impulsive acceleration phase of CMEs, the hot channel quickly develops into the semi-circular flux rope-like structure with rapid increasing of upward movement velocity. In the meantime, the expanding of the hot channel compresses the surrounding magnetic field and plasma, which successively stack and form the CME leading front. Detailed kinematical analysis reveal that: (1) the impulsive acceleration of the hot channel begins prior to the onset of impulsive energy releasing of associated flare, (2) the speed of the hot channel is always faster than that of the LF in the field of view of AIA. These results suggest that the hot channel is the flux rope that solar community is looking for. It can exist prior to the solar eruption and its ideal instability probably plays a key role in the transition from the slow rise phase to the impulsive acceleration phase of CMEs.

4.1-9 MAGNETIC TORNADOES IN THE ATMOSPHERE OF THE SUN**Wedemeyer, Sven**

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Rotating magnetic field structures have been observed on the Sun over a large range of spatial scales. Recent observations with the Solar Dynamics Observatory and the Swedish 1-m Solar Telescope suggest that “giant” solar tornadoes are likely the rotating legs of prominences. The connection to their small-scale analogues, so-called “magnetic tornadoes”, is yet to be investigated. These magnetic tornadoes are so far detected as chromospheric swirls, i.e., apparently rotating plasma that form rings or spirals when seen from above. They are formed by photospheric vortex flows that cause the footpoints of magnetic field structures to rotate. These structures protrude into the corona, this mediating the rotation into the upper layers of the solar atmosphere. This mechanism provides an alternative way of channeling energy from the low into the upper solar atmosphere. The exact amount of the transported energy and with it the role of solar tornadoes for heating the solar corona is still under debate.

4.1-10 PLASMA PROPERTIES IN ERUPTIVE PROMINENCES**Labrosse, Nicolas**

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Prominence eruptions are one of the most spectacular manifestations of our Sun's activity. Yet there is still some mystery around their relevant physical conditions. What are their plasma parameters? How different are they from those of quiescent prominences? How do they relate to those within coronal mass ejections?

I will briefly review some recent results which contribute to our knowledge of the plasma properties in eruptive prominences, with a slight emphasis towards advances in modelling. In particular I will discuss how non-LTE radiative transfer modelling, combined with observational data analysis, can help us achieving this goal. Open issues will be discussed.

4.1-11 THE PERIOD RATIO FOR STANDING KINK AND SAUSAGE MODES SUPPORTED BY MAGNETIZED STRUCTURES WITH SIPHON FLOW IN THE SOLAR ATMOSPHERE

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In the applications of solar magneto-seismology (SMS), exploiting the ratio of the period of the fundamental mode to twice the one of its first overtone, $P_1/2P_2$, plays an important role. We examine how field-aligned flows affect the dispersion properties, and hence the period ratios, of standing modes supported by magnetized structures in the solar atmosphere. We examine both the slab and cylindrical geometries. To this end, we numerically solve the dispersion relations and devise a graphic means to construct standing modes. For coronal structures, the flow effects are significant for the fast kink and sausage modes alike. For the kink ones, they may reduce $P_1/2P_2$ by up to ~23% compared with the static case, and the minimum allowed $P_1/2P_2$ can readily fall below the lower limit derived for static structures. For the sausage modes, while introducing the flow reduces $P_1/2P_2$ by typically ~5%, it significantly increases the threshold aspect ratio only above which standing sausage modes can be supported, meaning that their detectability is restricted to even wider structures. In the case of photospheric structures, the flow effect is not as strong. However, standing modes are distinct from the coronal case in a number of aspects, among which the most important one is that standing sausage modes no longer suffer from a threshold aspect ratio. We conclude that transverse structuring in plasma density and flow speed should be considered in seismological applications of multiple periodicities to solar atmospheric structures.

4.1-12 ON THE SPECTRAL HARDENING AT ABOVE ~300 KEV IN SOLAR FLARES

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The observed hard X-ray and gamma-ray continuum in solar flares are interpreted as bremsstrahlung emissions of accelerated nonthermal electrons. It has been noted for a long time that the spectra of observed continuum emissions in many solar flares are consistent with double power-laws with a hardening at energies >300 keV. It is now largely believed that at least in electron-dominated events the hardening in photon spectrum reflects an intrinsic hardening in the source electron spectrum. In this paper, we point out that a power-law spectrum of electron with a hardening at high energies can be explained by diffusive shock acceleration of electrons at a termination shock with a finite width. Our suggestion is based on an early analytical work by Drury *et al.* (1982), where the steady state transport equation at a shock with a tanh profile was solved for a p-independent diffusion coefficient. Numerical simulations with a p-dependent diffusion coefficient show hardenings in the accelerated electron spectrum which are comparable with observations. One necessary condition for our proposed scenario to work is that high energy electrons resonate with the inertial range of the MHD turbulence and low energy electrons resonate with the dissipation range of the MHD turbulence at the acceleration site, and the spectrum of the dissipation range $\sim k^{-2.7}$. A $k^{-2.7}$ dissipation range spectrum is consistent with recent solar wind observations.

We also perform a systematic examination of 185 flares from the Solar Maximum Mission (Vestrand *et al.* 1999). We identify 23 electron-dominated events whose energy spectra show clear double power-laws. We find that both the spectral index before the break (γ_1) and the spectral index difference ($\gamma_1 - \gamma_2$) anti-correlate with the break energy (E_b). A hardening spectrum and a correlation between γ_1 and E_b provides a stringent constraint on the underlying electron acceleration mechanism. It supports our proposal of electrons being accelerated diffusively at a finite-width flare termination shock.

4.1-13 RECENT DEVELOPMENTS IN THE STUDY OF THE EARLY STAGES OF CORONAL MASS EJECTIONS

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Despite knowing the existence of Coronal Mass Ejections (CMEs) for about 40 years there are significant gaps in our understanding of this fascinating and important phenomenon in the fields of solar and heliospheric physics as well as in the frame of the Sun-Earth relationships. The initial stages of CMEs, when the CME is still in the inner corona, represent a very small fraction of the total "life-time" of CMEs. However, studying the CME genesis currently represents the most promising avenue to discriminate between competing models and mechanisms of CME formation: once a CME is in the outer corona essentially all models look the same! We hereby focus on the following important facets of the CME genesis phenomenon. (1) initial magnetic structures and paths to instability and ejections; (2) flare-CME relationships and (3) "side-products" of the early CMEs: waves and shocks. Emphasis will be given to recent results from high-quality CME observations in HXR, SXR, EUV and WL taken from SOHO, RHESSI, Hinode, STEREO and SDO as well as from MHD models.

4.1-14 GEOMETRIC SCALES AND PHYSICAL PROPERTIES OF THE CME/FLARE CURRENT SHEETS

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Large scale current sheets (CSs) are important structures in solar eruptions. Models of coronal mass ejection (CME)/flare include the large scale CS connecting the ejected flux rope to the post-flare loops. Studies of geometric features and physical properties of the CME/flare CS could improve our understanding on rapid magnetic reconnection during a solar eruption, instabilities and turbulence and high-energy particle acceleration taking place inside the CS.

Both observations and numerical experiments repeatedly showed plasma flows continuously moving along CSs toward and away from the Sun, and they were recognized as the reconnection outflow in CSs. Associated with these results, the CME/flare CSs are continuously observed as thick as $\sim 10^5$ km. This constitutes a serious challenge to our long-existing understanding and knowledge on the reconnecting CS. Numerical experiments displayed, on the other hand, the co-existence of various diffusive structures in the single CME/flare CS. These structures include plasma blobs, the Petschek-type slow mode shock, turbulent region, and a Sweet-Parker segment of the CS, which indicated significant complexity of magnetic reconnection in reality. This review will go through the development of theories on the CS and the consequent observations, present possible mechanisms for large scale CS, and discuss the coupling of various scales of processes through which magnetic reconnection takes place in the thick CS at a reasonably fast rate required for the rapid energy release during the major flare. The results of the most recent observations and numerical experiments will also be displayed.

4.1-15 CORONAL DISTURBANCES AND GEO-EFFECTIVE FLARES/CMES BASED ON RECENT OBSERVATIONS

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Solar flares are very spectacular, and they are accompanied by various phenomena. Coronal shocks or disturbances seen on or near the solar surface are one of such flare-related phenomena. We discuss flare-related coronal disturbances and the relation with plasmoid ejections and CMEs. We also report coronal features of active regions which are located in the middle of coronal holes. These active regions often show a "see-anemone" like structure, and it has been known that CMEs from these active regions tend to be very fast, and therefore, that they are geo-effective. We examined these coronal features by using observational data in soft X-rays, in extreme ultraviolet, and in microwaves, and so on.

4.1-16 A STUDY OF FAST FLARELESS CORONAL MASS EJECTIONS

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It is generally believed that there exist two major processes converting the coronal magnetic energy into the kinetic energy of a coronal mass ejection (CME): resistive magnetic reconnection and ideal macroscopic magnetohydrodynamic instability of magnetic flux rope. However, it remains elusive whether both processes play a comparable role or one of them prevails during a particular solar eruption. To shed light on this issue, we carefully studied energetic but flareless CMEs, i.e., fast CMEs not accompanied by any flares. Through searching the Coordinated Data Analysis Workshops (CDAW) database of CMEs observed in Solar Cycle 23, we found 13 such events whose speeds were larger than 1000 km/s. Other common observational features of these events are: (1) none of the events originated in active regions; they were associated with eruptions of well-developed long filaments in quiet-Sun regions, (2) no apparent enhancement of flare emissions were present in soft X-ray, EUV and microwave data. In addition, detailed studies of two events reveal that there existed only weak reconnection electric fields which were inferred from the product of the separation speed of post-eruption ribbons and the magnetic field measurement on the solar surface. These observations indicate that, for these fast CMEs, the responsible coronal magnetic energy was released mainly via the ideal flux rope instability through the work done by the large scale Lorentz force acting on the flux rope currents rather than via magnetic reconnections. We also suggest that magnetic reconnection plays a less important role in accelerating CMEs in quiet Sun regions of weak magnetic field than those in active regions of strong magnetic field.

4.1-17 SUPER-ELASTIC COLLISION OF CMES: OBSERVATIONS AND SIMULATIONS

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4.1-18 DYNAMICS OF INTERPLANETARY CORONAL MASS EJECTIONS**Lara, Alejandro; Subramanian, Prasad; Borgazi, Andrea**

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Coronal Mass Ejections (CMEs) are large scale plasma and magnetic field structures expelled from the solar atmosphere to the interplanetary medium with a large range of velocities. In the interplanetary space, ICMEs interact with the ambient solar wind (SW) and with previous and slower ICMEs expelled in the same direction. In general, the ICME-SW interaction has been modeled as the effect of a drag force. In this work we revise some ICME-SW interaction drag models and in particular, we describe our one dimensional model and its validation using type II radio emission, and its extension to two dimensions. We also present a model to quantify the viscosity and the drag coefficient γ_{Cd} in the interplanetary medium using basic micro-physics.

4.1-19 EXPANSION OF MAGNETIC CLOUDS: OBSERVATIONS VERSUS MODELS**Vandas, Marek; Romashets, Eugene**

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Magnetic clouds are commonly interpreted as large interplanetary flux ropes ejected from the Sun, propagating in the solar wind, and expanding during their travel. We study velocity measurements inside magnetic clouds in detail and compare them with model predictions. Our aim is to investigate what this type of analysis can reveal on magnetic cloud global shape and if it can restrict or distinguish between models used.

4.1-20 INTERPLANETARY PROPAGATION OF CORONAL MASS EJECTIONS OBSERVED BY THE RADIO SCINTILLATION METHOD**Iju, Tomoya; Tokumaru, Munetoshi; Fujiki, Ken'ichi**

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Interplanetary scintillation (IPS) observations have been carried out since the early 1980s using the 327 MHz radio-telescope system of Solar-Terrestrial Environment Laboratory, Nagoya University. These are a kind of ground-based remote sensing using radio waves, and allow us to probe into the inner heliosphere between 0.2 and 1 AU with a cadence of 24 hours.

In this study, we take advantage of the IPS observations to determine speeds and accelerations of coronal mass ejections (CMEs) in the interplanetary space. Combining our IPS observations with data of the Large Angle and Spectrometric Coronagraph onboard the Solar and Heliospheric Observatory and in-situ measurements at 1 AU, we examine the interplanetary propagation of 46 CMEs during 1997 – 2011. Our analyses yield the following results: Fast CMEs (with $V_s - V_b > 500$ km/s, where V_s and V_b are the initial speed of CMEs and the speed of background solar-wind, respectively) rapidly decelerate, moderate CMEs (with $0 \text{ km/s} < V_s - V_b < 500$ km/s) show either gradually decelerating or uniform motion, and slow CMEs (with $V_s - V_b < 0$ km/s) accelerate. The radial speeds converge on the speed of background solar-wind during their outward propagation. We subsequently find that a linear equation is more appropriate than a quadratic one to describe the relationship between the acceleration and the difference in speed for the fast and moderate CMEs.

We report kinematic properties of the above CMEs, and propose an equation for the CME motion in the interplanetary space.

4.1-21 INTERPLANETARY SHOCKS AND FORESHOCKS**Blanco-Cano, Xochitl**

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The heliosphere is perturbed by large scale structures such as interplanetary coronal mass ejections (ICMEs) and stream interaction regions (SIR). Fast ICMEs can drive shock waves ahead of them, and SIRs are preceded by a forward shock. In this work we will discuss the properties of interplanetary (IP) shocks and the upstream and downstream regions associated to them. These regions are perturbed due to shock effects. Upstream from the shock a foreshock can develop and be permeated by suprathermal ions and electromagnetic waves. Downstream the plasma is heated and compressed with a very perturbed magnetic field. Shocks play a very important role in particle acceleration. During the years 2007-2010 STEREO observed around 80 IP forward shocks driven by stream interactions, and 20 shocks driven by ICMEs. Most of the SI shocks were locally quasi-perpendicular ($\theta_{Bn} > 45^\circ$) with only 20 quasi-parallel ($\theta_{Bn} < 45^\circ$) shocks. In all cases the Mach number was moderate with values $1.1 < M_{ms} < 3.8$, and the plasma beta reached values up to 29. During the same years the shocks driven by ICMEs have Mach numbers 1.2-4, and plasma beta up to 15. Observations upstream from the shocks have revealed a variety of waves, including whistlers and ultra low frequency (ULF) fluctuations. Upstream whistler waves may be generated at the shock

and upstream ULF waves can be driven locally by ion instabilities. In contrast to planetary bow shocks, most of the waves upstream of the quasi-parallel forward SI shocks observed to date by STEREO are mainly transverse and no steepening occurs. Another difference with Earth's bow shock is the fact that many locally quasi-perpendicular shocks can be accompanied by wave and ion foreshocks. This indicates that at an earlier time the geometry of the shock was quasi-parallel. The downstream wave spectra can be formed by both, locally generated perturbations, and shock transmitted waves. Downstream fluctuations associated with quasi-parallel shocks tend to have larger amplitudes than waves downstream of quasi-perpendicular shocks. Proton foreshocks of shocks driven by stream interactions have extensions ≈ 0.05 AU. This is smaller than foreshock extensions for ICME driven shocks (≈ 0.1 AU). The difference in foreshock extensions is related to the fact that ICME driven shocks are formed closer to the Sun and therefore begin to accelerate particles very early in their existence, while stream interaction shocks form at ~ 1 AU and have been producing suprathermal particles for a shorter time. It is expected that stronger ICME shocks are observed as the solar cycle of activity reaches maximum. Stronger IP shocks may be able to drive more complex and extended foreshocks, where steepened waves such as shocklets may be present. We will compare the properties of foreshock morphology associated to stronger ICME shocks with observations during years 2007-2010.

4.1-22 STUDY OF SOLAR WIND DISTURBANCES DURING SOLAR MAXIMUM 24 EMPLOYING MEXART INTERPLANETARY SCINTILLATION (IPS) OBSERVATIONS

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The Mexican Array Radiotelescope (MEXART) is a new ground instrument fully dedicated to perform Interplanetary Scintillation (IPS) observations to track large-scale solar wind disturbances within the Sun and the Earth. The MEXART is located at Michoacan (19 degrees 48' North, 101 degrees 41' West) and has an operation frequency of 140 MHz. The IPS technique is based on the scintillations that interplanetary disturbances (e.g., ICMEs) causes on the signal of small diameter cosmic radio sources detected by a radiotelescope. This technique obtains two-dimensional projections of solar wind disturbances along the line of sight of the different radio sources. The IPS data includes the relative increments in solar wind electron density (scintillation level) and solar wind velocities. We report the tracking of solar disturbances during the maximum of solar cycle 24. These observations correspond to events detected between April and July of 2013. We combine the observations of other instruments (white light chronograph observations, solar radio burst, in-situ measurements) to discuss the evolution of these events in the interplanetary medium.

4.1-23 STRUCTURE OF SUBCRITICAL INTERPLANETARY SHOCKS

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Interplanetary (IP) shocks are complex structures that are often accompanied with waves in upstream and downstream magnetic fields. The resolution of plasma measurements did not allow a detailed analysis of the shock front and/or associated waves. The Spektr-R spacecraft can significantly help with this task because the onboard BMSW instrument measures solar wind parameters with a unique resolution of 31 ms. We present several examples of changes of plasma moments across the IP shock with such time resolution as well as observations of thermalisation of the ion distribution on the time scale of ~ 1 s. Our analysis reveals that the IP shock ramp scales with the proton thermal gyroradius being as thin as 2 radii. The wavelength of the downstream wave-packets correlates well with the ramp thickness. These relations suggest that the observed shocks are built up by kinetic processes, in contrast to typical MHD shocks.

4.1-24 DYNAMICS OF SOLAR WIND PARAMETERS AT DIFFERENT ANGLES OF IMF SPIRAL FOR PERIOD OF SPACE MEASUREMENTS AT NEAR-EARTH ORBIT

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 Aim of our study was to find connection between solar wind parameters and angles of IMF spiral for period of four solar cycles N20-23. We take as our data base interplanetary magnetic field (IMF), solar wind velocity (V) and density (N) measured at 1 a.u. near ecliptic plane for period of 1963-2007. As result we obtained statistical dependencies B, N, V on the longitude angle ϕ in range of 0-360 deg for period of each solar cycle. Such approach allows also to identify wind streams. In particular, high speed solar wind originates from coronal holes. The streams have open magnetic fields with low plasma density; ones were known earlier as "M-regions" and considered as sources

of recurrent geomagnetic activity invisible on Earth. So, all the V maxima accompanied by the N minima near the same angle θ can be interpreted by the high speed streams. We discuss below our results. Maxima of the IMF B, N and associated minima of V for all solar cycles are observed at angles $\theta=90\pm 30$ and $\theta=270\pm 30$ deg. Absolute maxima of B occurred in 21 ($W_m=164$) and 23 ($W_m=121$) cycles at $\theta=90-100$ deg. ($B_y>0$, GSE). Special feature of the V maximum of the 23d cycle is that one is accompanied by relative high V and low N at this θ compared with the V and N for the other cycles. So, odd cycles of 21, 23 (independent on difference in sunspot numbers W_{max}) initiated the highest equal maxima of B in wind accompanied by rise of N and decline of V (but relative high) that should lead to high geomagnetic activity of the slow streams. Maxima of V and associated minima of B, N are observed during all solar cycles at $\theta=180\pm 30$ and 360 ± 30 deg. The highest V in range of $\theta=330-360$ were during 20 ($W_m=111$) and 22 ($W_m=158$) cycles. So, even cycles of 20 and 22 (independent on W_{max}) gave almost equal maxima of V at $\theta=330-360$ deg. ($B_y<0$, $B_x>0$). The other interval of $\theta=150-180$ deg ($B_y>0$, $B_x<0$) was marked by absolute maximum of V for all period of analysis during cycle 23; the second maximum of V (according to its value) near the same θ was in cycle 20. The latter points to connection of low W_m in cycles and high V in wind for $\theta=150-180$ deg. Moreover, V at $\theta=180-360$ deg for cycle 23 were considerably lower than value of V averaged for all cycles that points to strong asymmetry of the V values relative sign of the IMF. It also follows from our study that absolute maximum of V (high speed stream) and sufficiently high B at the same angle in wind of the 23d cycle should cause high geomagnetic activity. Really, our analysis showed that number of 3-hour intervals with $K_p=8-9$ has increased (more than twice) in cycle 23 compared with previous one. We also discuss connection of our results with slow wind associated with streamer belts. At last we summarize our findings for possible development of the 24-th current cycle in solar wind to understand.

4.1-25 THE STUDY OF THE 3HE RICH SEP EVENTS WITH A COMPARISON OF NUMERI

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It is considered that impulsive Solar Energetic Particle (SEP) events are usually produced by the solar flares. Recently, observations from different spacecraft, e.g., the STEREO A and B, and ACE, show that some impulsive events can cover a very wide longitudinal extent. Therefore, it could be assumed that SEPs can be observed on the field lines disconnected far away from the source. One possibility of such a large longitude extend is through cross-field transport. In this work, we compare the spacecraft observations from different longitude with simulation results using a Fokker-Planck focus transport equation in three-dimensional Parker interplanetary magnetic field. In this way, we can investigate how SEPs propagate in the heliospheric space.

4.1-26 QUIET-TIME SOLAR WIND SUPERHALO ELECTRONS

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We survey the statistical properties of $\sim 2-20$ keV superhalo electrons in the solar wind measured by the STEREO/STE instrument during quiet-time periods at solar minimum. The observed quiet-time superhalo electrons have a nearly isotropic angular distribution and a power-law spectrum, $f \sim v^{-(\gamma)}$, with γ ranging from 5 to 8.7, with nearly half between 6.5 and 7.5, and an average index of 6.69 ± 0.90 . The integrated density of quiet-time superhalo electrons at $2-20$ keV ranges from $10^{(78)} \text{ cm}^{(73)}$ to $10^{(76)} \text{ cm}^{(73)}$, about $10^{(79)} - 10^{(76)}$ of the solar wind density, and it, as well as the power-law spectrum, shows no correlation with solar wind protons. The density of superhalo electrons decreases by approximately one order of magnitude between early 2007 and early 2009, probably reflecting the decay of solar cycle 23 and the approach to its unusually deep activity minimum, while the power-law spectral index γ has no solar-cycle variation. These quiet-time superhalo electrons are present even in the absence of any solar activity, e.g., active regions, flares or microflares, type III radio bursts, etc. Our test-particle simulation suggests that these superhalo electrons may be produced by the acceleration in the magnetic reconnection in the solar wind source region.

4.1-27 CLUSTER OBSERVATION OF MAGNETIC RECONNECTION AT THE TURBULENT BOUNDARY LAYERS OF INTERPLANETARY MAGNETIC FLUX ROPES

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We report two magnetic reconnection events detected by Cluster at the turbulent boundary layers of interplanetary magnetic flux ropes: (i) the trailing edge of a small-scale interplanetary magnetic flux rope, (ii) the leading edge of an interplanetary coronal mass ejection. In the first event, Phan et al. (Nature 439, 175, 2006) presented observation made by Cluster on 2002 February 2 of a reconnection exhaust, with evidence of accelerated flows associated with

reconnection in a current sheet embedded in the solar wind flow, where the reconnection X-line extended at least 390 RE. We apply the technique developed by Feng et al. (JGR 112, A02102, 2007) for finding the boundary layers of interplanetary magnetic flux ropes to this event and identify it as the trailing edge of a small-scale interplanetary magnetic flux rope seen in the interval of intermittent turbulence studied by Chian & Miranda (AG 27, 1789, 2009) and Miranda et al. (ASR 51, 1893, 2013). In the second event, Chian & Munoz (ApJL 733, L34, 2011) investigated the relation between current sheets, turbulence, and magnetic reconnections at the leading edge of an interplanetary coronal mass ejection measured by Cluster upstream of the Earth's bow shock on 2005 January 21. We discuss the observational evidence of two magnetically reconnected current sheets in the vicinity of a front magnetic cloud boundary layer with the following characteristics: (1) a Kolmogorov power spectrum in the inertial subrange of the magnetic turbulence, (2) the scaling exponent of structure functions of magnetic fluctuations exhibiting multifractal scaling predicted by the She–Leveque magnetohydrodynamic model, and (3) bifurcated current sheets with the current density computed by both single- and multi-spacecraft techniques.

4.1-28 WHISTLER TURBULENCE AT VARIABLE ELECTRON BETA: THREE-DIMENSIONAL PARTICLE-IN-CELL SIMULATIONS

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Three-dimensional particle-in-cell simulations of whistler turbulence at three different initial values of the electron beta are carried out on a collisionless, homogeneous, magnetized plasma model. The simulations begin with an initial ensemble of relatively long wavelength whistler modes and follow the temporal evolution of the fluctuations as wave-wave interactions yield a forward cascade into a broadband, turbulent spectrum at shorter wavelengths with a wavevector anisotropy in the sense of $k_{\perp} > k_{\parallel}$. Here “perp” and “parallel” denote directions perpendicular and parallel to the background magnetic field, respectively. In addition wave-particle interactions lead to fluctuating field dissipation and electron heating with a temperature anisotropy in the sense of $T_{\parallel} > T_{\perp}$. At early time the wave-wave cascade dominates energy transport, whereas wave-particle Landau damping dominates at late simulation times. Larger values of the electron beta correspond to a faster forward cascade in wavenumber and to a faster rate of electron heating, as well as to a less anisotropic wavevector distribution and to a less anisotropic electron velocity distribution.

4.1-29 RADIAL DEVELOPMENT OF WAVE-VECTOR ANISOTROPY FOR SOLAR WIND TURBULENCE FROM 0.3 TO 1AU

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What the turbulence anisotropy looks like in the wave-vector space and how it evolves in interplanetary space is a key issue unsolved in solar wind physics. Motivated by the above question, we use magnetic field measurements from the Helios-2 spacecraft at three positions (0.29, 0.65, and 0.87 AU). To derive the power spectral density (PSD) in $(k_{\perp}, k_{\parallel})$ -space on the basis of single-satellite measurements is a challenging task not yet accomplished previously. Here we derive the spectrum $PSD_{2D}(k_{\perp}, k_{\parallel})$ from the spatial correlation function $CF_{2D}(r_{\perp}, r_{\parallel})$ by a transformation according to the projection-slice theorem rather than by a direct 2D Fourier transform. The so constructed PSDs are found to be distributed in k -space mainly along a ridge that is more inclined toward the k_{\parallel} than k_{\perp} axis, a new result that probably indicates preferential cascading of turbulent energy along the k_{\parallel} direction. Furthermore, this ridge of the distribution is found to gradually get closer to the k_{\parallel} axis, as the correlation length (outer scale length of the turbulence) becomes larger while the solar wind flows further away from the Sun. The radial evolution of this ridge relative to resonance threshold lines seems to hint a transition of cyclotron resonance to Landau resonance with increasing distance. In the vicinity of the k_{\parallel} axis, there appears a minor spectral component that probably corresponds to quasi-parallel Alfvénic fluctuations. Their relative contribution to the total spectral density tends to decrease with radial distance. These findings suggest that solar wind turbulence undergoes an anisotropic cascade transporting most of its magnetic energy towards larger k_{\parallel} , and that the anisotropy in the inertial range is radially developing further at scales that are relatively far from the ever increasing outer scale. The empirical results of this work constrain, and thus help to improve, the theories of anisotropic solar wind turbulence and interplanetary solar wind heating.

4.1-30 MHD AND KINETIC SCALE TURBULENCE IN THE SOLAR WIND

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Space plasmas are almost always in a turbulent state but a complete physical understanding of such plasma turbulence remains elusive. In recent years, however, high resolution data from solar wind spacecraft have enabled us to make significant progress. I will discuss some recent measurements that have helped reveal the nature of the

turbulence and how it brings energy from large scale motions to the plasma kinetic scales, where it is thought to heat the plasma, and therefore influence the macroscopic properties of the heliosphere. In particular, I will discuss how recent velocity, magnetic field and electric field spectra and single- and multi-spacecraft anisotropy measurements compare to popular models of strong Alfvénic turbulence in the MHD scale range. I will then discuss how high frequency data, in particular the density, allows us to probe the kinetic scale range, showing that the fluctuations here are predominantly kinetic Alfvén turbulence. Finally, I will discuss the relevance of microphysical turbulence properties to the macroscopic properties of the heliosphere.

4.1-31 SOLAR WIND TURBULENCE AT ION KINETIC SCALES

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Using Cluster data, we analyse the solar wind turbulence at ion kinetic scales. The issue is important since it is often believed that kinetic effects may dissipate the energy of turbulence at these scales resulting in plasma heating. Using the *k*-filtering technique, the magnetic field data of Cluster/FGM are used to determine the turbulence power distribution in the wave number space. The nature of turbulence at such scales is subject to debates. A popular view is that linear waves (such as linear kinetic Alfvén waves), although unable to account for the turbulent cascade at the scales, may still be used to describe the main property of turbulence. These waves are easier to understand and their property is well known. Another view is that due to the nonlinear nature of turbulence, linear waves are insufficient to describe the nature of turbulence at ion kinetic scales. Instead, 2D turbulent structures (such as solitary Alfvén vortices), whose properties are often illusive, must be used to describe the nature of turbulence at the kinetic scales. In this talk, we present evidence of these waves and solitary Alfvén vortices at ion scales in the solar wind.

4.1-32 ON THE ORIGIN OF THE EUV LATER PHASE OF SOLAR FLARES

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Solar flares typically have an impulsive phase followed by a gradual phase as best seen in soft X-ray emissions. A recent discovery based on the EUV Variability Experiment (EVE) observations onboard the Solar Dynamics Observatory (SDO) reveals that some flares exhibit a second large peak separated from the first main phase peak by tens of minutes to hours, which is coined as the flare's EUV late phase (Woods *et al.* 2011). In this paper, we address the origin of the EUV late phase by analyzing in detail two late phase flares, an M2.9 flare on 2010 October 16 and an M1.4 flare on 2011 February 18, using multi-passband imaging observations from the Atmospheric Imaging Assembly (AIA) onboard SDO. We find that: (1) the late phase emission originates from a different magnetic loop system, which is much larger and higher than the main phase loop system. (2) The two loop systems have different thermal evolution. While the late phase loop arcade reaches its peak brightness progressively at a later time spanning for more than one hour from high to low temperatures, the main phase loop arcade reaches its peak brightness at almost the same time (within several minutes) in all temperatures. (3) Nevertheless, the two loop systems seem to be connected magnetically forming an asymmetric magnetic quadruple configuration. (4) Further, the footpoint brightenings in UV wavelengths show a systematic delay of about one minute from the main flare region to the remote footpoint of the late phase arcade system. We argue that the EUV late phase is the result of a long-lasting cooling process in the larger magnetic arcade system.

4.1-36p OBSERVATIONS OF CORONAL MASS EJECTIONS IN THE OUTER CORONA

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Over the last 15 years continuous monitoring of the Sun provided by the space based observatories gave us a new view of solar storms (or Coronal Mass Ejections - CMEs), the main drivers (together with the solar wind and solar energetic particles – SEPs) of geomagnetic storms on our planet. The development of CMEs in the outer corona has been studied with radio antennas, white light coronagraphs and UV/EUV spectrometers. UV spectra sampled during solar eruptions allowed us to study their 3D expansion velocities, their thermal energies, to characterize CME-driven shocks, to study the evolution of post-CME current sheets and small scale eruptions (like narrow CMEs, polar jets, streamer puffs). At the same time, coronagraphic white light images and radio dynamic spectra provided estimates of the CME kinetic energies, masses and densities, information on CME-driven shocks, and on the acceleration and propagation of Solar Energetic Particles (SEPs) during flares/CMEs. This talk will be aimed at reviewing these results and discussing problems on the CME origin, energetic and evolution unsolved so far. Focus will be also given to the new possibilities that will be offered by the Solar Orbiter mission, in coordination with other future missions/observatories like Solar Probe Plus.

4.1-37p CORONAL TYPE II RADIO BURSTS ASSOCIATED WITH HELMET STREAMERS**Chen, Yao; Kong, Xiangliang; Feng, Shiwei; Wang, Bing; Li, Gang; Guo, Fan**Shandong University, University of Alabama in Huntsville, Los Alamos National Laboratory
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Two type II radio bursts, separated by ~24 hours in time, are examined together. Several common observational features are found and listed below. Firstly, both events are associated with coronal mass ejections (CMEs) erupting from the same active region beneath a well-observed helmet streamer. Secondly, the radio shock distances obtained by fitting the type II dynamic spectra are in agreement with the observed CME fronts. Thirdly, the type II emissions ended once the shock fronts passed the white-light streamer tip, which is presumably the magnetic cusp of the streamer. These observations lead us to propose that the closed magnetic arcades of the streamer may play an important role in the shock-electron acceleration and corresponding type II generation. A simple electron-acceleration model considering the magnetic collapsing trap effect caused by a shock sweeping through the closed magnetic field lines is presented. It is further suggested that the scenario may be fundamentally important to the generations of more metric type IIs providing that most CMEs originating from closed field regions. This scenario also provides an explanation of why many metric type IIs are not associated with an interplanetary counterpart.

4.1-38p STATISTICAL STUDY OF AN EVOLUTION OF MAGNETIC RECONNECTION EXHAUST IN THE SOLAR WIND**Enzl, Jakub; Prech, Lubomir; Safrankova, Jana; Nemecek, Zdenek**Charles University in Prague, Faculty of Mathematics and Physics
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Magnetic reconnection is a phenomenon where the energy stored in the magnetic field dissipates into heating and plasma acceleration. It can occur on boundaries connecting plasma with different magnetic field orientation. From spacecraft observations, we can identify magnetic reconnection as its exhaust where the plasma on reconnected field lines leaves the reconnection site.

We present a statistical study based on data from the WIND and THEMIS spacecraft during a period of 1995-2012. We track the signatures of magnetic reconnection exhaust such as a rotation of the magnetic field or acceleration and heating of plasma. Our statistics focus on such parameters as transformation of released magnetic field energy, acceleration of plasma or temperature and density enhancements.

We show the cases where magnetic reconnection was simultaneously observed by more spacecraft. Multi-spacecraft observations of the same event allow us to make conclusions about persistence, evolution of the exhaust and its dependence on the distance from the X-line.

4.1-39p DIAGNOSTICS ON THE SOURCE PROPERTIES OF A TYPE II RADIO BURST WITH...**Feng, SW; Chen, Y; Kong, XL; Li, G.; Song, HQ, Feng, XS; Guo, F.**Shandong University Weihai (SDUWEH), UAH, NSSC,
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In recent studies, we proposed that source properties of type II radio bursts can be inferred through a causal relationship between the special shape of the type II dynamic spectrum (e.g., bump or break) and simultaneous extreme ultraviolet (EUV)/white light imaging observations (e.g., CME-shock crossing streamer structures). As a further extension of these studies, in this paper we examine the coronal mass ejection (CME) event on 2007 December 31 associated with a multiple type II radio burst. We identify the presence of two spectral bump features on the observed dynamic spectrum. By combining observational analyses of the radio spectral observations and the EUV-white light imaging data, we conclude that the two spectral bumps result from a CME-shock propagating across dense streamers on the southern and northern sides of the CME. It is inferred that the corresponding two type II emissions originate separately from the two CME-shock flanks where the shock geometries are likely quasi-perpendicular or oblique. Since the emission lanes are bumped as a whole within a relatively short time, it suggests that the type II radio bursts with bumps of this study are emitted from spatially confined sources (with a projected lateral dimension smaller than $0.05-0.1 R_{\odot}$ at a fundamental frequency level of 20-30 MHz).

4.1-40p A STATISTICAL STUDY ON SPECTRAL HARDENING IN SOLAR GAMMA-RAY FLARES**Kong, XiangLiang; Li, Gang; Chen, Yao**Shandong University, UAHuntsville
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The observed hard X-ray and γ -ray continuum in solar flares are interpreted as bremsstrahlung emissions of accelerated nonthermal electrons. It has long been noted that in many flares the energy spectra show a hardening feature at higher energies (usually above 300 keV) and it is now largely believed that at least in electron-dominated events the hardening in photon spectrum reflects an intrinsic hardening in the source electron spectrum. In this paper, we first conduct a survey on spectral hardening events that were studied in previous literature. We then perform a systematic examination of 185 flares from the Solar Maximum Mission (SMM) mission (Vestrand et al. 1999).

We identify 23 electron-dominated events whose energy spectra show clear double power-laws. We find that both the spectral index before the break (γ_1) and the spectral index difference ($\gamma_1 - \gamma_2$) anti-correlate with the break energy (E_b). A hardening spectrum and a correlation between γ_1 and E_b provides a stringent constraint on the underlying electron acceleration mechanism. It supports a recent proposal of electrons being accelerated diffusively at a finite-width flare termination shock.

4.1-41p REMOTE SENSING OBSERVATIONS OF THE SOLAR CORONA AND SOLAR RADIAT

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The total solar eclipse has been always very attractive to scientists for studying the response of the environment to the abrupt and short-time disturbance in the radiation, and correspondence with its consequence on the thermal balance of the atmosphere and the induced changes in the stratosphere and ionosphere. This event is an opportunity at recent days for objective testing physical hypothesis and for investigating the changes in the sky color, limb darkening, physical processes in the solar corona, etc.

In this study we report the results from videometric and spectrometric observations carried out during the total solar eclipse on 29 March 2006 in the frame of an International scientific program from town of Manavgat, Turkey. Series of digital images of the solar disk and corona as well as of a near-sun sky area were collected during all the phases of the phenomenon using a photometric CCD camera. Synchronous data for dramatic reduction and spectral behavior of the incoming radiation from the visible part of the Sun during the 1st and 2nd contacts of the eclipse and the 3rd and 4th ones were recorded and investigated. The solar spectra were collected by a portable fiber-optic spectrometer in the ultraviolet, visible and near infrared spectral ranges (350-1000 nm) with a high spectral resolution and time interval of 1 min. The changes in the dynamics and spectral distribution of the solar radiation before and after the eclipse totality were analyzed by statistical methods (discriminant analysis and Student *t*-criterion). It was found that the changes were statistically significant in the whole investigated spectral range. Furthermore they were wavelength dependent, expressed themselves in more pronounced decrease in the radiation at the lower wavelengths and an increase in the spectral range after spectra maximum due to the solar limb darkening. The results were compared with 1-D transfer model estimates for the duration of the eclipse except the period close and during the totality.

4.1-42p A SOLAR JET AND ITS ENERGY SOURCE

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We present in this paper the observation and analysis of a solar EUV jet event accompanied by a nano-flare observed by SDO/AIA and STEREO/SECCHI EUVI simultaneously on July 8th, 2012. Torsional motion of the jet with projected line speed of about 62 km s⁻¹ and period of about 1276 s has been observed. The period or angular speed of the torsional motion wasn't vanished when the jet reached its maximum height of about 290 Mm and remained almost the same during the descending phase, which has rarely been observed before. The energy released by the driving force related to the torsional motion during the whole event is estimated to be about 1.04×10^{30} erg, which is almost 2 times of the thermal energy carried by a C6.8 flare, much larger than the energy carried by the nano-flare observed by AIA and not even detected by GOES, and half of the energy introduced into the jet by the reconnection. The kinematics of the jet shows inconsistency with the classical reconnection and relaxation model. A revised model introduced in this paper can successfully explain the behavior of the jet and we suggest that this jet is most likely related to a super solar tornado.

4.1-43p ANALYSIS OF CHARGED PARTICLES TRAJECTORY DYNAMICS ACCELERATED BY THE WAVE PACKET IN SPACE PLASMA

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An analysis of charged particles trajectory dynamics accelerated by the wave packet in space plasma is carried out. The surfatron effect of particle acceleration is investigated through numerical simulations, on the basis of non-linear nonstationarity second order dissipative type of differential equation. Different cases of initial particles energy and their trajectory on the phase plane of the wave packet are considered, in the initial time moment of the motion, when the particle is untrapped and performs cyclotron rotation in the external magnetic field. The temporal dynamics and trapping time by the wave packet in surfing mode for different variants of initial particles parameters are studied. It is shown that the trapping time in surfing mode greatly increases, since the period of the cyclotron rotation significantly increases with the growth of the longitudinal component of the particle momentum. The optimal conditions for maximum ultrarelativistic particles surfatron acceleration by a spatially localized wave packet in space plasma are considered. The figures of different stages of the particle trajectory dynamics as untrapped particle trajectory, the

beginning of surfatron acceleration and strong accelerated particle are shown. Conclusions about changes of accelerated particles parameters and their trajectory dynamics were done.

4.1-44p SIMULATIONS OF ION ACOUSTIC WAVES IN SATURN'S MAGNETOSPHERE

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Existence domains and characteristics of ion acoustic waves are studied in a two-temperature electron, adiabatic ions and low density ion plasma with the electron components being kappa-distributed. Such an environment has been found in Saturn's magnetosphere. Using a Particle-in-Cell (PIC) simulation, the evolution of the spatial electric field is tracked during the entire simulation, after which a dispersion diagram is constructed to study the dispersion characteristics of the ion acoustic mode

4.1-45p EVOLUTION DYNAMICS OF THE LOOP PROMINENCES AND SUBSTANCE MOTION IN MAGNETIC FIELD

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We present new numerical simulation data on modeling formation and evolution dynamics of the loop prominences and response of the solar atmosphere in a loop to bombardment of electrons and other particles. Let us remind that the existed models of creation of the active prominences are usually divided on two groups: i). in first group models explain appearance of the relatively cold and substance in the corona due to the condensation of the coronal gas (Olsson-Likaudis, Lust-Zirin et al); ii). in second group there are presented the mechanisms, when the prominence substance is transit up from low layers of the solar atmosphere (Jeferris-Orral, Goldsmith et al). Our numerical approach generalizes the known Troitzk Ivanov-Platov model. We carried out the numerical modeling dynamics and kinematics of the matter motion in a variable magnetic field in the magnetic hydrodynamical approximation of a strong field and cold (hot) plasma. The variation of magnetic moments of two dipoles system leads to quantitative changing in development of the loop prominences and coronal rain. Besides, the elements of the deterministic chaos are discovered in the dynamics with using a chaos theory methods in the option (A. Glushkov, A chaos theory: Application in Geophysics, Odessa-Astroprint, 2013; V. Rusov, A. Glushkov et al, 2008 Adv. Space Res. 42, 1614; 2010, J. of Atm. and Solar-Terr. Phys. 72, 498).

SESSION 4.2

WAVE PROPAGATION IN THE OUTER SOLAR ATMOSPHERE

4.2-1 PERSISTENT DOPPLER SHIFT OSCILLATIONS OBSERVED WITH HINODE/EIS IN THE SOLAR CORONA: SPECTROSCOPIC SIGNATURES OF ALFVÉNIC WAVES AND RECURRING UPFLOWS

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Using data obtained by the EUV Imaging Spectrometer on board Hinode, we have performed a survey of obvious and persistent (without significant damping) Doppler shift oscillations in the corona. We have found mainly two types of oscillations from February to April in 2007. One type is found at loop footpoint regions, with a dominant period around 10 minutes. They are characterized by coherent behavior of all line parameters (line intensity, Doppler shift, line width, and profile asymmetry), and apparent blueshift and blueward asymmetry throughout almost the entire duration. Such oscillations are likely to be signatures of quasi-periodic upflows (small-scale jets, or coronal counterpart of type-II spicules), which may play an important role in the supply of mass and energy to the hot corona. The other type of oscillation is usually associated with the upper part of loops. They are most clearly seen in the Doppler shift of coronal lines with formation temperatures between one and two million degrees. The global wavelets of these oscillations usually peak sharply around a period in the range of three to six minutes. No obvious profile asymmetry is found and the variation of the line width is typically very small. The intensity variation is often less than 2%. These oscillations are more likely to be signatures of kink/Alfvén waves rather than flows. In a few cases, there seems to be a $\pi/2$ phase shift between the intensity and Doppler shift oscillations, which may suggest the presence of slow-mode standing waves according to wave theories. However, we demonstrate that such a phase shift could also be produced by loops moving into and out of a spatial pixel as a result of Alfvénic oscillations. In this scenario, the intensity oscillations associated with Alfvénic waves are caused by loop displacement rather than density change. These coronal waves may be used to investigate properties of the coronal plasma and magnetic field.

4.2-2 **SELFCONSISTENT HEATING AND ACCELERATION OF THE HOT CORONAL WIND VIA ALFVEN WAVES**

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We have performed 2.5 dimensional MHD simulations that mimic the propagation and dissipation of Alfvén waves in the solar atmosphere. The hot corona and the high speed solar wind automatically emerge in the numerical system as a natural consequence of Alfvén wave injection from the photosphere. Without any prescribed heating mechanisms, the hot coronal wind is maintained via Alfvén wave dissipation due to the nonlinear steepening and the phase mixing. In this talk, we will discuss about the detailed heating mechanisms at different height in our simulation.

4.2-3 **SIMULATIONS OF OBLIQUE ELECTROSTATIC WAVE PROPAGATION**

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The electron-acoustic instability in a magnetised plasma having three electron components, one of which is a field-aligned beam of intermediate temperature, is investigated using a Particle-in-Cell simulation. When the magnetic field strength is such that the plasma frequency of the cool electrons is less than the electron gyrofrequency, the only instability in the electron-acoustic frequency range is the strongly magnetized electron-acoustic instability. Its growth rate and real frequency exhibit a decrease with propagation angle and it grows at small to intermediate wave numbers.

SESSION 4.3

MULTI-SPECTRAL STUDIES OF SOLAR FLARES

4.3-1 **COMBINED RHESSI AND SDO OBSERVATIONS OF SOLAR FLARES**

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X-ray and EUV observations are an important diagnostic of various plasma parameters of the solar atmosphere during solar flares. RHESSI soft X-ray images often show coronal sources near the top of flaring loops and can be used to deduce the temperature, emission measure, and density of these sources. Hard X-ray non-thermal emission is mostly observed from chromospheric footpoints and provides information on the number of accelerated electrons in the flare and, in some cases, can be used to analyze the chromospheric density structure. EUV images typically outline the whole flaring loop. Differential emission measure (DEM) analysis using SDO/AIA data allows for determining temperatures and emission measures with an independent method from RHESSI and at locations where no X-rays are observed. Thus combining RHESSI and SDO observations gives a much more complete picture of a flare than single-wavelength analysis, covering the temperature range between several tens of thousands degrees up to several tens of millions degrees and non-thermal emission up to hundreds of keV.

I will give an overview of recent advances made by combining RHESSI and SDO observations, including density measurements from the chromosphere to the corona and measurements of the heights of X-ray, EUV, and white light sources, along with a description of some of the available techniques, in particular for DEM analysis, for such combined studies.

4.3-2 **INTERPRETATION OF ULTRAVIOLET & X-RAY EMISSIONS DURING SOLAR FLARES USING MAGNETOHYDRODYNAMICS MODELS AND NUMERICAL SIMULATIONS**

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Solar flares are characterized by a fast and important increase of the luminous intensity in the Ultraviolet and X-ray domains. These brightenings are not random within the flaring active region and are spatially strongly localized: e.g. flare ribbons and kernels.

The standard model for flare states that particles, accelerated in the solar corona as a consequence of magnetic reconnection, flow down along the reconnected magnetic field lines and eventually interact with the lowest layer of the solar atmosphere to generate electromagnetic radiations in UV and X-ray. Such model has received strong

confirmations by studies of the magnetic topology, which positively correlated the spacial distribution of UV and X-ray emission with magnetic structures that preferentially reconnect. More recently, dynamical magnetohydrodynamics (MHD) numerical simulations enabled not only to link the spacial location of the flare emission but also its dynamical evolution, i.e. allowing to explain where the electromagnetic emissions appear and how they evolve in time.

During my presentation I will detail how topology allows to identify the magnetic regions involved in the flare and determine the UV and X-ray spacial emission. I'll then present the recent developments in numerical experiments that address the temporal evolution of these emissions.

4.3-3 **PROBING PARTICLE ACCELERATION IN THE MICROWAVE DOMAIN**

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Although the solar flare phenomenon is widely accepted to be a consequence of release of excessive magnetic energy stored in the coronal currents (stated another way in nonpotential magnetic fields), many essential details of this energy release remain poorly understood. Initially, the released flare energy is somehow divided between thermal and nonthermal components through plasma heating and particle acceleration, respectively, although this proportion can then change in the course of the flare due, e.g., to fast particle Coulomb losses leading to additional plasma heating and/or chromospheric evaporation. So far, the thermal-to-nonthermal partition was found to vary greatly from one flare to another resulting in a broad variety of cases from 'heating without acceleration' (Battaglia *et al.* 2009) to 'acceleration without heating' (Fleishman *et al.* 2011). Recent analysis of microwave data of these differing cases suggests that a similar acceleration mechanism, forming a power-law nonthermal tail up to a few MeV or even higher, operates in all the cases. However, the level of this nonthermal spectrum compared to the original thermal distribution differs significantly from one case to another, implying a highly different thermal-to-nonthermal energy partition in various cases. This further requires a specific mechanism capable of extracting the charged particles from the thermal pool and supplying them to a bulk acceleration process to operate in flares in addition to the bulk acceleration process itself, which, in contrast, efficiently accelerates the seed particles, while cannot accelerate the thermal particles. Within this 'microwave' view on the flare energy partition and particle acceleration I present a few contrasting examples of acceleration regions detected with microwave. In addition, I discuss microwave emission produced by flare-created relativistic positrons.

4.3-4 **ORIGIN OF PRECURSOR PHASE AND ITS ASSOCIATION TO MAIN PHASE EMISSION IN SOLAR FLARES**

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Using multi-wavelength data, we study the spatial, spectral and temporal evolution of 20 flare events having precursor and main phase emission during year 2010-2012, the era of SDO operation. Battaglia *et al.* (2009) found the process of conduction-driven chromospheric evaporation to be the origin of emission during precursor phase. However, Falewicz *et al.* (2011), Altyntsev *et al.*, (2012), in their study both the phases emphasized on the fact that beam-driven chromospheric evaporation is sufficient to explain the emission during precursor phase. In this regard, study of the origin of precursor phase and its relation to main phase emission employing statistical and model calculations employing a large set of observations becomes extremely necessary. In order to study the spectral signature of thermal and non-thermal emission, we quantify them in various phases of energy release based on spectral fitting. We fit hard X-ray (> 25 keV) spectra to a power-law function, using RHESSI data integrated over 12 seconds and the low-energy (6-25 keV) components with a multi-thermal function. We estimate temperature (T) and density (n_e) during precursor phase and found T to be 1.5 times and n_e to be 2 order lesser than that attained during the main phase. This enables us to perform a comparative study of evolution of cooling of the flaring plasma during various phases of emission. Further, LOS magnetograms obtained from HMI onboard SDO have been employed to study the role of magnetic-flux in triggering the precursors prior to the (usually) observed main phase. Further, we employ H α and EUV observations to study spatial evolution of T and EM in conjunction to the role of filament eruption in producing precursor and main phase emission. This study enables us to propose a model of energy release during precursor and main phase emission under unified umbrella of physical processes.

4.3-5 **OSCILLATIONS, PULSATIIONS AND WAVES IN SOLAR FLARES**

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Solar flares are natural drivers of magnetohydrodynamic (MHD) propagating disturbances in the elastic and compressible plasma of the solar corona. These waves are directly detected in the EUV, soft X-ray and radio bands as, e.g. standing kink, sausage and longitudinal oscillations of coronal structures or slow magnetoacoustic waves

progressing along the neutral line. Periods of the oscillations induced by flares range from a few seconds to several hours. The mechanisms for the periodicity are usually geometrical resonances or wave dispersion. Also, flaring energy releases can be induced by MHD waves by, e.g., triggered magnetic reconnection. In this case the periodicity of the triggering wave can appear in the flaring hard X-ray, gamma-ray, white-light and microwave light curves as quasi-periodic pulsations. Another possibility is the modulation of the non-thermal particle dynamics by an MHD perturbation of the magnetic configuration. Recent observational and theoretical results on flare-induced MHD oscillations and quasi-periodic pulsations in flares are reviewed.

4.3-6 ENERGY RELEASE MECHANISMS OF SOLAR FLARES STUDIED BY RADIO EMISSION

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During the impulsive phase of solar flares, we often observe nonthermal emissions from accelerated particles in hard X-rays, gamma-rays, and microwaves. These intense nonthermal emissions are undoubtedly associated with strong energy release processes in the impulsive phase of flares. We sometimes observe nonthermal emissions even before the impulsive phase, preflare phase, of flares. By analyzing these emissions, we can derive a key information on particle acceleration and energy release mechanisms during solar flares. We overview observational features of gyrosynchrotron emission and discuss the energy release mechanisms of solar flares.

4.3-7 THE GEOEFFECTIVENESS OF SOLAR ENERGETIC EVENTS: PROBLEM REVISED

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The geoeffectiveness of solar X-ray flares was initially analysed by the present authors on data from the period 1996 - 2004. It was shown that the probability of geomagnetic response depends on the solar flare class and its position on the solar disc. The flares in the central region were found to be more geoeffective. The probability further increased if the flare was accompanied by Type II and/or Type IV of solar radio bursts. In the next step a neural network model was developed to determine the probability, with which flares will be followed by a geomagnetic response of a particular intensity. Enhancement of solar energetic particle flux was added to the set of input parameters. The results indicated that X-ray flares accompanied by solar radio bursts represent a good proxy of coronal mass ejections which are believed to be the principal cause of increased geomagnetic activity. The present study is aimed at (i) verifying the original results on the data from the period 2005 - 2012 and (ii) studying in more details the relation between solar flares and coronal mass ejections as observed near the Sun as well as in the Earth's environment.

4.3-8 TURBULENT PITCH-ANGLE SCATTERING AND DIFFUSIVE TRANSPORT OF HARD-X-RAY PRODUCING ELECTRONS IN FLARING CORONAL LOOPS

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4.3-9 FUNDAMENTAL EMISSION OF TYPE III BURSTS PRODUCED IN NON-MAXWELLIAN CORONAL PLASMAS WITH KAPPA-DISTRIBUTED BACKGROUND PARTICLES

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Quasilinear-based simulations are presented for fundamental (fp) emission of type III bursts produced in non-Maxwellian, suprathermal background coronal plasma by injection of energetic electrons during flares with power-law or Maxwellian speed spectra, where fp is the electron plasma frequency. The background plasma is assumed to have a kappa distribution, as inferred from solar wind data and proposed by theories for the corona and solar wind. The predicted type III beam speeds, Langmuir wave levels, and the drift rate and flux of fp emission are strongly sensitive to the presence of suprathermal background electrons in the corona. The simulations show that: (1) Fast beams with speeds $v_b > 0.5c$ are produced for coronal background electrons with small $\kappa \leq 5$ by injected electrons with power-law spectra. (2) Moderately fast beams with $v_b \sim 0.3-0.5c$ are generated in coronal plasma with $\kappa \leq 8$ by injections of power-law or Maxwellian electrons. (3) Slow beams with $v_b < 0.3c$ are produced for coronal background electrons with large $\kappa > 8$, including the asymptotic limit $\kappa \rightarrow \infty$ where the electrons are Maxwellian, for both power-law or Maxwellian injections. The observation of fast type III beams (with $v_b > 0.5c$) thus suggests that these beams are produced in coronal regions where the background electrons have small kappa distributions by injected electrons with power-law spectra, at least when such beams are observed. The simulations, from the viewpoint of type III bursts, thus support:

(i) The presence, at least sometimes, of suprathermal background electrons in the corona and the associated mechanisms for coronal heating and solar wind acceleration. (ii) Power-law spectra for injected energetic electrons, consistent with observations of such electrons in situ and of X-ray emission.

4.3-10 RADIO EMISSION FROM SOLAR FLARES

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I will review recent progress on our understanding of radio emission from solar flares with emphasis on those aspects of the subject that help us address questions about energy release and its properties, as well as particle acceleration and transport. Radio emission from electron beams can provide information about the electron acceleration process, the location of injection of electrons in the corona, and the properties of the ambient coronal structures. Mildly relativistic electrons gyrating in the magnetic fields of flaring loops produce radio emission via the gyro-synchrotron mechanism, which provides constraints on the magnetic field and the properties of energetic electrons.

4.3-11 RADIO EMISSION AND ESCAPE OF FLARE ACCELERATED ELECTRONS

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Electrons accelerated during solar flares are able to escape the confines of the coronal magnetic field and can propagate through the interplanetary medium. We are able to detect these electron beams in-situ near the Earth with spacecraft. The transport of electron beams, travelling near the speed of light, can also result in radio emission being produced via nonlinear plasma processes. These impulsive radio bursts (known as type IIIs) can be used to diagnose properties of electron beams we are unable to measure directly. I will start the talk by giving an introduction to type III bursts and escaping electron beams from flares. I will then review some of the recent observational results and theoretical developments that have been advancing this area of research. I will also mention how type IIIs can be combined with other wavelengths of light to further understand the energetics during solar flares.

4.3-34p ANALYSIS OF X-RAY FLARE SPECTRA SEEN BY RESIK

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The results of flare X-ray spectra analysis in the range 3.3-6.1 Å are presented. The spectra have been recorded with RESIK spectrometer aboard Russian satellite Coronas-F. The intensities of the lines of H- and He-like ions of argon, potassium, sulfur and silicon have been used to determine the absolute abundances of the emitting plasma. Based on the observed lines the differential emission measure calculations have been performed for selected events.
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Recent observations from RHESSI have revealed that the number of non-thermal electrons in the coronal part of a flaring loop can exceed the number of electrons required to explain the hard X-ray (HXR) emitting footpoints of the same flaring loop. Such sources cannot, therefore, be interpreted on the basis of the standard collisional transport model, in which the HXR-emitting electrons stream along the loop while losing their energy through collisions with the ambient plasma; additional physical processes, to either trap or scatter the energetic electrons, are required. Motivated by this and other RHESSI observations that suggest that high energy electrons are largely confined to the coronal region of the source, we here consider turbulent pitch angle scattering of fast electrons off low frequency magnetic fluctuations as a confinement mechanism. We model this phenomenon as a spatial diffusion parallel to the mean magnetic field that occurs contemporaneously with energy loss through Coulomb collisions. In general, turbulent scattering leads to a reduction of the collisional stopping distance of non-thermal electrons and hence to an enhancement of the coronal HXR source, with a corresponding decrease in the intensity of footpoint emission. When turbulent scattering dominates, the variation of source size with electron energy becomes weaker than the quadratic behavior pertinent to collisional transport, with the slope of $L(E)$ depending directly on the effective mean free path associated with the non-collisional scattering mechanism. Comparing the predictions of the diffusive model with observations, we find that the mean free path against scattering around 1-10 Mm, less than the length of a typical flaring loop and smaller than, or comparable to, the size of the electron acceleration region.

SESSION 4.4**CROSSING THE HELIOPAUSE INTO THE INTERSTELLAR MEDIUM****4.4-1 VOYAGER 1 OBSERVATIONS OF THE HELIOSHEATH****Richardson, John; Team, Voyager**

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The Voyager spacecraft are traversing the heliosheath, the region of shocked solar wind between the termination shock and the heliopause. The heliosheath was expected to be a region where the flow smoothly rotated ahead of the heliopause to flow down the heliotail. While Voyager 2 has so far observed a relatively smooth flow deviation, Voyager 1 has observed several unexpected features. The first was a stagnation region between 113 and 122 AU where the flow radial flow speed decreased to zero and sometimes below (inward flow) and the non-radial flows were small. After travelling 9 AU through this stagnation region V1 crossed another unpredicted boundary, presently named the heliocliff, where the energetic particles from inside the heliosphere dropped out, the galactic cosmic ray intensity increased, the magnetic field magnitude increased by a factor of 3-4, and the magnetic field direction did not change. The first three characteristics are those expected for the heliopause crossing into the interstellar medium, but since the magnetic field remains in the Parker spiral direction we believe we are still inside the heliosphere. We will present the data from these new regions and discuss physical mechanisms which may produce the observed signatures.

4.4-2 HELIOSPHERIC PARTICLES AT THE EDGE OF THE SOLAR SYSTEM**Florinski, Vladimir**

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I discuss the origin of the dropouts and the subsequent disappearance of energetic charged particles of heliospheric origin observed by Voyager 1 in 2012. The magnetic boundary crossed by Voyager 1 evidently separated a turbulent region (the heliosheath) from a new region (the magnetic highway), where turbulent fluctuations are greatly reduced. A simple model is presented explaining the pancake pitch-angle distributions of ions measured shortly after the boundary crossing. The model is based on a concept that particle scattering rates are much smaller in the magnetic highway region than in the heliosheath, and only requires a boundary magnetic connection region of considerable extent (a few tens of astronomical units). The measured width of the energetic particle transition region and its implication for the theory are also discussed.

4.4-3 NATURE OF THE FLOWS IN THE HELIOSHEATH**Opher, M.; Drake, J.F.; Provornikova, E.; Toth, G.**

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We discuss the nature of the flows in the heliosheath (HS) when reconnection is taken place within the sector region. Observational constraints of reconnection within the sector are challenged by the resolution limitations of the magnetometer. However, indirect constraints such as the lack of conservation of magnetic flux in the heliosheath (Richardson *et al.* 2013) and the correlation of the variability of energetic particles with the location with respect to the sector region (Hill *et al.* 2013) indicate that reconnection might be taking place within the sector zone (Opher *et al.* 2011). The reconnected sector region in high beta plasma has a multitude of elongated islands and is very similar to a crossing of a normal sector in terms of the overall configuration of the magnetic field and intensity. However, there is substantial reduction of large-scale magnetic tension. We show, that Rayleigh-Taylor (RT) instabilities can take place within the sector region where there is no magnetic tension to stabilize the interchange instability (Opher *et al.* 2013). The RT instability is triggered by the flow of interstellar neutrals down the steep density gradient at the termination shock and produces radially elongated flows that disturb the heliosheath flow pattern. This instability can explain the large differences between the flows at Voyager 1 and 2. V1 measurements revealed a steady decrease in the radial speed ending in a region with zero radial speed while the V2 radial speeds are constant. We compare these results to simulations where we included the full solar cycle time dependent boundary conditions (Density is derived from the measurements of backscattered Lyman-alpha emission (Quemerais *et al.* 2006, Lallement *et al.* 2010). Velocity is obtained from the interplanetary scintillation data (Sokol *et al.* 2012)). The time-dependent model (Provornikova *et al.* 2013) predicts similar radial speeds for V1 and V2 in contrast to what is seen in the observations indicating that the differences between V1 and 2 flows stem from the spatial nature rather than temporal.

4.4-4 THE HELIOSPHERIC 2-3 KHZ RADIATION, THE IBEX RIBBON, AND THE 3-D SHAPE OF THE HELIOPAUSE**Cairns, Iver; Fuselier, Stephen**

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Intense episodic bursts of radio emission at 2-4 kHz are observed by the Voyager spacecraft. Most likely the radiation is produced in the outer heliosheath as the shock wave in front of a Global Merged Interaction Region (GMIR) moves across the heliopause and through the region where the interstellar magnetic field is draped over the heliopause. Pick-up ion instabilities due to charge-exchange of neutrals from the solar wind or inner heliosheath also play a major role. Recently the IBEX team observed a ribbon of energetic neutrals from the vicinity of the heliopause and argued that the interstellar medium (ISM) - solar wind interaction is sub-Alfvénic, with no bow shock for the solar system. The ribbon is believed to follow the locus where the interstellar magnetic field is tangential to the heliopause. Here we address the striking correspondance between the ribbon location and the

time-varying source locations of the radiation inferred from Voyager observations: in both ecliptic and galactic coordinates the radiation sources form a line parallel to, but offset by about 20 degrees, from the ribbon. We present the following new ideas and analyses: (i) a plasma depletion layer (PDL) forms in the draping region beyond the heliopause, (ii) a Rankine-Hugoniot analysis shows that the region of maximum pressure is no longer along the relative Sun - ISM velocity vector but is instead in the magnetic draping region under sub-Alfvénic conditions, (iii) the minimum distance to the heliopause from the Sun and minimum heliosheath thickness are then found on the ribbon, and (iv) the heliopause is no longer symmetric about the relative Sun - ISM velocity vector and its shape can be inferred from the angular offset of the radio sources and ribbon. These ideas are elaborated, arguing that the density gradients and temperature structure of the PDL are well suited to the radiation's generation and then propagation into the heliosphere, with a strong role for scattering of the radiation by enhanced density turbulence. Initial constraints on the shape of the PDL-dominated heliopause are also given.

4.4-5 **CONDITIONS NEAR THE HELIOPAUSE AND ENERGETIC PARTICLES TRANSPORT**

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With the help of simplified models of the distant heliosphere we discuss the possible flow and magnetic field structure in this region and their effect on the energetic particle transport, in particular on the escape process across the heliospheric boundary. We consider possible mechanisms that could lead to sharp drops of particle population. Monte Carlo models are used as an illustration. The results are compared to presently available observations from Voyager 1.

4.4-6 **VOYAGER 2 OBSERVATIONS OF PLASMA IN THE HELIOSHEATH**

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The Voyager 2 spacecraft has a working plasma instrument and is making the first direct measurements of plasma in the heliosheath. The plasma in the heliosheath has been turning tail ward while retaining a near constant velocity magnitude. The radial speed has decreased by half since the termination shock crossing but the azimuthal and meridional components have increased. The non-radial speed components have decreased in 2012; this is the same time as models predict the termination shock should start moving outward due to enhanced solar wind pressure which may cause these speed changes. The density decreased by a factor of two in 2008, then recovered in 2011; we think this change is a solar cycle effect. This paper presents and discusses the most recent plasma data.

SESSION 4.5

REPORTER REVIEWS – DIVISION IV

4.5-1 **THE PHYSICS OF SOLAR FILAMENTS (PROMINENCES)**

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The physics of filaments is both in their field-aligned fine structure and in the magnetized plasmas of the filament environment. The photospheric-chromospheric environment provides the mass for the thread-like fine structure of filaments while the greater volume of the coronal environment restricts the volume that the threads may occupy within rather tight limits. As the fundamental building blocks of filaments, threads are typically less than 1 arc second in width and they have a broad range of lengths from a few thousand kilometers to tens of thousands of kilometers depending upon their location within the structure of a whole prominence. However, the density of the visible mass of threads does not remain constant along their length thereby limiting the length along which speeds of the mass motions can be measured. The ever-present mass flows along the threads ranges from 5-40 km sec⁻¹ but their most remarkable property is counterstreaming. In common circumstances, approximately half of the threads in a filament

flow in one direction while interspersed among these, are the other half whose mass flows are in the opposite direction. From the study of relatively high resolution images in the wings of the H α line, the origin of the mass flows in both directions have been tracked through the chromosphere to their footpoints in the photosphere. We find the key dynamic at the footpoints of the threads is the phenomenon known as cancelling magnetic fields. While there are at least 4 different interpretations of field changes that could result in observed cancelling magnetic fields, it is demonstrated that only one interpretation is consistent with observations and that is magnetic reconnection at the photosphere. Although difficult to trace, it has been suggested that every thread along a prominence spine has a source end and a sink end and no evidence yet for repeated filling of the same magnetic thread. Threads that extend from the spine to cancelling magnetic fields to the sides of filaments are called “barbs”. Barbs involve more than photospheric reconnection. Invisible, steady, magnetic reconnection in the low corona also seems to be necessary to divert some threads of the spine to connect to small cancelling magnetic features adjacent to the spine. Such reconnection alone does not account for the asymmetric pattern among barbs known as chirality. The right or left handedness of barbs, known as chirality, is also a feature of the filament channels within which filaments are embedded. Because the channel magnetic fields have higher magnetic flux density than the barb magnetic fields, the barbs are constrained to match the chirality of the channel. Similarly the height of the spine and its narrowness are also dictated by the surrounding magnetic fields in the corona, respectively first by the overlying coronal loop system and secondly by surrounding coronal fields to each side of a filament known as coronal cells and plumes. Since all of these surrounding fields also exhibit specific patterns of chirality, we are led to see that filaments lie at the center of a very specific magnetic field pattern known as a chiral system. Understanding the evolution of chiral systems is hypothesized to be the new key to unlocking the mystery of erupting filaments.

4.5-2 THE INITIATION OF CORONAL MASS EJECTIONS

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Coronal mass ejections (CMEs) and eruptive flares are believed to result from a sudden explosive release of the free magnetic energy stored in the previously quasi-equilibrium, twisted/sheared coronal magnetic fields. I will review results from recent theoretical models and numerical simulations aimed to understand the nature of the CME precursor structures and the cause of their sudden eruption. The role of the ideal MHD processes (e.g. the onset of the torus instability and the kink instability), and current sheet formation and the associated magnetic reconnections in the development of CMEs will be discussed. I will show how MHD models using coronal flux ropes containing helical field lines as the basic underlying magnetic structure of CMEs can produce observed signatures that are in many ways consistent with multi-wavelength observations of CMEs.

4.5-3 THE OUTER HELIOSPHERE REVEALED BY RECENT VOYAGER AND ENERGETIC NEUTRAL HYDROGEN OBSERVATIONS

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The in-situ exploration of the interface between the Local Interstellar Medium (LISM) and the heliosphere in the nose region by Voyagers 1 and 2, and through the first global observations of Energetic Neutrals (ENAs) by IBEX and Cassini yielded numerous surprises: (1) the termination shock (TS) did not accelerate the Anomalous Cosmic Rays (ACRs); (2) the unexpected discovery of the ENA ribbon and belt; (3) contrary to expectations, north or south solar wind flows decreased with radial distance to 0 ± 20 km/s about 30 AU downstream of the TS in the Voyager 1 (V-1) direction; (4) at a sharp boundary (the heliocliff), V-1 entered a new, entirely unexpected region, still part of the heliosheath, where ACRs (that had finally reached maximum intensity in the prime acceleration region just before the heliocliff was crossed) disappeared entirely, the Galactic Cosmic Rays reached and stayed at their maximum intensity, and the magnetic field, while retaining the Parker spiral (nearly azimuthal) direction, became extremely smooth (nonturbulent) and doubled its strength. In view of these unexpected findings, we reexamine our current concepts concerning the nature of the LISM-Heliosphere interface and how and where particles are most efficiently accelerated, and present a model for the outer heliosphere that can account for all of the puzzling Voyager observations as well as the IBEX ribbon. We predict that, although the motion of the Sun relative to the LISM is only ~ 26 km/s, the nose region of the heliosphere must be surrounded by jets of supersonic solar wind with speeds of many hundred km/s flowing opposite to the direction of motion of the sun through the local interstellar medium. Decisive V-2 observations of the plasma flows near the heliocliff will be essential for validating our model.

4.5-4 THE SOLAR WIND TURBULENCE**Velli, Marco**

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*mvelli@jpl.nasa.gov***SESSION 5.1****ADVANCES TOWARDS AN IMPROVED GLOBAL GEOMAGNETIC OBSERVATORY NETWORK****5.1-1 CHALLENGES OF OBSERVATORY ESTABLISHMENT, MANAGEMENT AND DATA QUALITY ~ THE GFZ POTSDAM (GERMANY) CONTRIBUTIONS AND EXPERIENCES****Linthe, Hans-Joachim**

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Observatory data are the basement for the international scientific research. Valuable results can be achieved only from a suitable network of observatories and if the data are precise and faultless. The Helmholtz Centre Potsdam □ German Research Centre for Geosciences contributes by modernizing of existing observatories or by the establishment of new ones to the improvement of the international observatory network. Regions of special scientific interest, for instance the region of the South Atlantic Anomaly, were especially considered. This required to establish observatories at remote places, which often created special challenges.

Besides the increasing of the number of observatories it is necessary to emphasise issues of data quality, which is based on modern and excellent instruments and a careful data processing. Observatory data quality is not an implicitness, but it is a challenge.

The observatory data base, which is the basement of the international research can be improved by the combination of quantity and quality. Quantity stands for the increase of the number of observatories, considering regions of special interest. Quality stands for the improvement of the methods of data quality validation.

The paper presents the GFZ Potsdam contributions on the establishment, management of observatories and data quality validation. Special challenges are shown.

5.1-2 DEVELOPMENT OF THE RUSSIAN GEOMAGNETIC OBSERVATORY NETWORK**Krasnoperov, Roman; Soloviev, Anatoly; Sidorov, Roman**

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Acquisition of relevant data on the Earth's magnetic field requires a developed network of globally distributed geomagnetic observatories. Due to certain economical and logistical constraints currently the INTERMAGNET observatories are distributed very irregularly. This problem is critical for the territory of ex-USSR countries which cover approximately 15% of the Earth's land. Because of the political and economical difficulties of 1990-s regular measurements at the most of the geophysical observatories of the CIS countries were terminated. To overcome this problem and provide the geophysical community with accurate and reliable geomagnetic data the national academies of sciences of Russia and Ukraine initiated a project of development of an interregional INTERMAGNET segment. This project includes renovation and equipment upgrade for existing observatories to make them suitable with INTERMAGNET requirements. This part is performed in close cooperation between scientific institutions of the Russian Academy of Sciences (Geophysical Center; Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radiowave Propagation; Bulashevich Institute of Geophysics; Schmidt Institute of Physics of the Earth; etc.) and the National Academy of Sciences of Ukraine (Subbotin Institute of Geophysics). Another significant part of the project is deployment of new observatories of the INTERMAGNET standard in Russia (mostly in its northern regions). This is an attempt to fill up the spatial gaps in the geomagnetic observation network coverage in the mid- and high-latitude territories of Russia.

5.1-3 IMPROVEMENTS ON THE MAGNETIC OBSERVATORY NETWORK IN BRAZIL**Pinheiro, K.; Linthe, H.-J.**

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Magnetic observatories provide valuable information for a better understanding of both the deep Earth and the ionosphere-magnetosphere systems. Short-time magnetic variations, from seconds to years, are used in studies about the external magnetic field, such as pulsations and magnetic storms. Although long-time variations allow researches on dynamic processes in the outer core that are responsible for the generation of the main Earth magnetic field. Motivations for new observatories in Brazil are many, including the recognizable uneven distribution of observatories in the globe and the presence of the South Atlantic Magnetic Anomaly and the Equatorial Electrojet in the Brazilian territory. Currently, there are only three magnetic observatories in Brazil: Vassouras that is located in Rio de Janeiro State and provides magnetic data since 1915; Tatuoca which is placed on an island in Belém

city and measures the magnetic field since 1957; and the recent installed Pantanal observatory, located in central Brazil. Pantanal observatory was installed in October 2012 by an international cooperation between the National Observatory (Rio de Janeiro), GFZ (Potsdam) and SESC-Pantanal (Cuiabá). This work presents the first magnetic data registered in Pantanal Observatory and the comparison with the other observatories in Brazil. We also present the future improvements of instrumentation and data processing of Vassouras and Tatuoca observatories. The installation of five more magnetic observatories in Brazil is showed in this study. There is a work in progress for the installation of a new magnetic observatory in Amazon (Tefé city) in collaboration with GFZ- Potsdam and Mamirauá Institute. The first tests of this future observatory are also presented in this work.

5.1-4 **ADVANCES AND DEVELOPMENTS IN GEOMAGNETIC OBSERVATORIES MAINTAINED BY INDIAN INSTITUTE OF GEOMAGNETISM, INDIA**

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Indian institute of geomagnetism is maintaining 12 magnetic observatories covering equatorial and mid latitudes at various stations in India. Some of the observatories have the long geomagnetic records of 150 years old. The gradual transition from classical magnetic instruments to new modern geomagnetic measurements and related development in geomagnetic data processing in Indian longitude chain of observatories will be discussed. All magnetic observatories are functioning with modern magnetic instruments and generating the good quality of high resolution magnetic data which is a major contribution to world data center. The digitization of old records and storing capacity, dissemination of geomagnetic data and all other aspects will be discussed detail.

5.1-5 **GEOMAGNETIC DATA CENTER OF RUSSIAN-UKRAINIAN INTERMAGNET SEGMENT**

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Since the beginning of 2012 the Russian-Ukrainian geomagnetic data center was launched on the basis of Geophysical Center of the Russian Academy of Sciences (Moscow, Russia). It serves as a core of the Russian-Ukrainian interregional segment of the INTERMAGNET network. As on April 2013 the center receives magnetic data from 13 observatories and stations located in Russia and Ukraine. A particular feature of the center is automated quality control system, which continuously performs recognition of artificial disturbances in incoming magnetograms, thus simplifying preparation of definitive data. The results of recognition and incoming data are stored in a relational database managed by DBMS MySQL. In particular, such approach provides higher performance and flexibility of data requests comparing to file storage. It becomes even more relevant with transition of many magnetic observatories from 1-minute to 1-second data registration. For a user's interaction with the data a set of Java classes and web services have been developed. The services include data retrieval in ASCII format, plotting, baseline value calculator, etc.

5.1-6 **MODERN METHODS FOR ACQUISITION AND REAL-TIME TRANSFER OF GEOMAGNETIC DATA FROM REMOTE OBSERVATORIES**

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A real-time information on geomagnetic variations is very important for goals of the Space Weather monitoring. The modern communication systems and computer technology makes it possible to collect and process the data from remote sites without significant delays.

Two types of the transport protocols, the streaming and secure ones, are used over Internet to transmit data. The streaming protocols present a simple transmission model with a minimum of protocol mechanism. These protocols are not enough stable but they are very fast and light to transmit real-time data. The secure protocols ensure a reliable but relatively slow communication. Appropriate combination of streaming and secure protocols can considerably improve the real-time data transfer to the data centers and suppliers. The embedded computing platform should be used to ensure the communication and data logging at stations. This small and powerful platform is much more stable than ordinary computers and it can provide a full remote access.

The real-time transmitting and processing the 1-second geomagnetic data is the more difficult task, since the common procedure of the data collecting in form of the text files (for example, IAGA-2002 format) can not provide the fast and multi-task access to the data. In the case of 1-second (or faster) data it is better to apply the software methods using the database management system. A method for asynchronous data exchange between browser and server could be applied for on-line distribution of magnetic data and their analysis on the WEB. We suggest to use these techniques in on-line derivation of the 1-minute PC and AE induces.

This paper demonstrates realization of the method for collecting, processing and presentation of the 1 second

magnetic variations in real-time regime in case of two remote magnetic stations Mineyama (MNY) and Amderma (AMD).

5.1-7 AN ABSOLUTE VECTOR MAGNETOMETER DEDICATED TO GROUND OBSERVATORIES
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Derived from the Absolute Scalar Magnetometer designed for the Swarm mission, an instrument with additional vector capabilities specifically optimized for ground magnetic observatories has been developed by CEA-Leti with the support from CNES and IPGP. This paper presents the operation principles and main features of this instrument. A first test campaign, carried out at the Chambon la For t magnetic observatory operated by IPGP, has demonstrated that the instrument's resolution is in accordance with our performance predictions. However the vector measurements long term stability was affected by mechanical effects due to the sensor's support which did not allow to guarantee the sensor's attitude with sufficient accuracy. A new sensor holder has therefore been designed and the upgraded magnetometer will be evaluated over a six month period at Chambon la Fort. Its data will be compared to the ones delivered by the classical combination of an NMR scalar reference magnetometer and a three-axis vector fluxgate calibrated on a regular basis, representative of the standard procedure adopted in most ground observatories. Preliminary results will be discussed and the potential of this device for fully autonomous magnetic observatories will be assessed.

5.1-8 OPTICAL PROCEDURE TO CONTROL DECLINATION BASELINE OF DIDD MEGNETOMETER
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Delta declination - delta inclination (dIdD) magnetometer is an absolute instrument for the total field value (F) and is absolute instrument for declination (D) and inclination (I) in it's own reference system. If we can determine the position of it's coil system in the geographic reference frame, we get the absolute value of geomagnetic declination and inclination as well.

An optical system was designed and built which is able to record the angle between the D coil axis and a reference mark with subsecond resolution.

5.1-9 MEASUREMENT OF DIGITAL MAGNETOMETER BASELINE VALUES IN THE CONDITIONS OF EXTERNAL INTERFERENCE OR IN THE PERIOD OF THE MAGNETIC DISTURBANCES

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Now the main instruments for conducting absolute geomagnetic measurements are the proton magnetometer and fluxgate declinometer/inclinometer. The standard method of such observations is a measurement of declination D and inclination I of the magnetic field in the 4 positions of the theodolite. This eliminates errors due to misalignment of the inclinometer magnetic and optical axis. Then, from measured module T, D and I the absolute values of three components are calculated and comparing them with the values of the digital magnetometer, baseline values are determined. The magnetic field should remain constant over the entire observation period. So, it is necessary to choose the special time interval for observation, but in case of significant industrial noise, the errors associated with the variability of the field are always present.

Most modern fluxgate inclinometers already have analog signal output and by connecting it through ADC to a computer, you can register the values of the components of the magnetic field along the axis of fluxgate magnetometer sensor. In a sensor position for the measurement of D or I, these values are recalculated into variations of D or I. Using data of the proton magnetometer and I, we can calculate the absolute values of H and Z components every second, and comparing them with magnetometer data, calculate baseline values. The advantage of this approach is that we will calculate baseline values that remain constant for any changes of magnetic field. This allows carrying out the absolute measurements in any conditions. To perform the measurements in this way, two programs were developed. The first program generate a form, that resembles a standard form for the absolute observations, in which you need to enter the theodolite readings and also writes the digital inclinometer one second data to file. The second program reads inclinometer, proton magnetometer and digital magnetometer data and calculates the baseline values.

The use of these programs increases the accuracy of measurements, simplifies the measurement procedure and reduces the requirements to the qualification of the observer.

5.1-10 THE ACQUISITION OF DIGITAL DATA FROM DIGITAL IMAGES OF OBSERVATORY MAGNETOGRAMS DURING MAGNETIC STORMS

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Using modern technology continuous automated measurements of the geomagnetic field can be recorded digitally and delivered in near real-time. However, prior to the development of digital data acquisition systems in the 1970s, analogue systems were the only option and required significantly more manpower than operations do today. Time series of the originally hand-scaled products such as hourly means and K-indices are amongst the longest running homogeneous geophysical data-sets, since it was relatively simple to continue production of them into the digital era. Studies of geomagnetic storms and changes in geomagnetic activity levels on century time scales would benefit from similarly long time series of higher time resolution geomagnetic data, such as 5-minute or even 1-minute values. Some of the largest storms since continuous geomagnetic recording began occurred at times prior to the digital era and study of them thus far has been limited.

In 2009 BGS began a project to create a digital archive of the collections of original UK observatory analogue magnetograms by taking digital photographs of every record. This mammoth task was completed at the end of 2012 and more than half a million images of magnetograms (front and back), from eight different observatories ranging from 1846 to 1986, are available on-line. The next, equally enormous, task is to extract useful digital data from the images to provide new data sets for research. In this presentation we describe progress in this project, including examples of typical difficulties encountered. The potential effectiveness of two different software options was considered and we present the method preferred to acquire digital data for a selection of some of the largest geomagnetic storms from the period. We also present the data, which have been acquired at the highest time resolution considered feasible in each case. We investigate the accuracy of the magnetogram digitisation process by comparing results from two different operators of the software and, where possible, comparing results against originally derived data products. We also compare results for storms recorded at more than one location. The usefulness of the data obtained thus far and the potential for further acquisition of data using the method developed is discussed.

5.1-11 FIRST RESULTS OF A NEW MEASUREMENT METHOD FOR MAGNETIC REPEAT STATIONS

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The French magnetic repeat station network is currently made of 32 stations and has been reoccupied every five years since 1947. During recent surveys, it was found that several stations became unusable due to the increase of nearby human activity. Also, traditional azimuth markers such as church steeples are fragile and easily lost due to new constructions and/or vegetation growth. As a result, it is increasingly difficult to maintain a traditional repeat station network providing accurate measurements over an extended period of time. Another frequently noted limitation of the traditional methodology is the error caused by diurnal variations of ionospheric origin when making measurements during the day. Using a nearby observatory (Chambon-la-Forêt in the case of the French network) to remove these variations is not a satisfactory solution, as the ionospheric field and its induced counterpart may significantly vary over a few hundreds of km.

We have developed a new method for magnetic repeat measurements and implemented a network of 11 stations during May-June 2012, where repeat stations are located on airport premises, azimuth sightings are determined using GPS geodetic receivers and magnetic measurements are performed at night (02:00 AM local time) in order to prevent ionospheric field contamination effects. At the time of this XIIth Scientific Assembly, a reiteration after a one-year interval will have been carried out. First results of secular variation observations compared with IGRF predictions will be reported, as well as operational and technical aspects of the method.

5.1-12 PROGRESS ON ASSESSING THE STABILITY OF THE LIVINGSTON ISLAND REMOTE OBSERVATORY

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Data from geomagnetic observatories deployed at remote sites, such as in Antarctica, which are only manned during restricted periods of time (*e.g.* in summer), are subject to uncertainties during periods with no absolute control, and assumptions must be made concerning the baselines evolution during those periods. When different kinds of variometers are simultaneously operating and temperature is also recorded, data comparisons help to assess the validity of such assumptions. We will describe the lessons learnt from our experiences at Livingston Island Observatory, LIV (Antarctica), where the two main instruments in the automatic magnetic observatory are a proton vector magnetometer designed by the British Geological Survey, and a suspended tri-axial fluxgate magnetometer (model FGE) designed by the Danish meteorological institute. It has been revealed that both instruments are sensitive to temperature variations, but in a dynamic way, and differently depending on the magnetic element.

Intercomparisons of quiet-day, midnight values from LIV and Argentine Island (AIA), the nearest INTERMAGNET magnetic observatory (i.e. having full absolute control), for the last years of corrected data available provide other qualitative and quantitative tests. Other factors affecting the mechanical stability of the suspended variometer, such as wind and seismic waves, need also to be taken into account, especially in observatories settled on harsh environments. Their effects can be attenuated from an appropriate selection of the oil used to damp the sensor oscillations.

5.1-13 **QUARTZ DYNAMIC MAGNETOMETER FOR GEOMAGNETIC ACTIVITY MEASUREMENT**

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The degree of disturbance of the geomagnetic field is evaluated by the internationally adopted indices of magnetic activity, the most common of which are K or A-indices and AU/AL-indices. These indices are calculated from measurements of the two horizontal component of the geomagnetic field - H and D (X, Y). Although magnetic disturbances are a global phenomenon, the intensity of disturbance depends on the location, and in some cases it is necessary to know the degree of disturbance of the magnetic field or magnetic activity index at a specific point in real time. Three-component magnetic station, used to measure magnetic field variations and calculate the indices, is a costly device, and the main contribution to the total cost provides fluxgate or quartz sensors. Early the theory of measurement of two horizontal components of the magnetic field with only one quartz sensor was suggested. The classic method of the deflection of freely suspended magnet used for measurement of D-component, a dependence of the oscillation period of elastic string suspended magnet from the magnetic field strength used to measure the H-components.

Now this station was realized and data from this station were compared with digital data of standard magnetic observatory station. The analysis shows that there are no difference between 1-minute data, and the dynamic magnetometer data reliably reproduce the horizontal components of the observatory data and allow to calculate the indices of geomagnetic activity.

5.1-14 **GEOMAGNETIC ABSOLUTE MEASUREMENT DATA AT ABDUS SALAM OBSERVATORY**

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Pakistan is operating Abdus Salam geomagnetic observatory since July 2008. For the absolute observations of inclination and declination, a Z-010 Zeiss theodolite type is used and total field value is acquired by dIdD magnetometer. Variation of geomagnetic field is measured with a fluxgate magnetometer are not absolute but are relative to a baseline. The baseline values acquired by the magnetic theodolite are used to correct the variation data but these baseline values contain outliers. To distinguish spurious baseline values in the absolute measurements, robust statistical method is used. As a result, 4, 7 and 23 outliers are detected for Total field (F), Declination (D) and Inclination (I) respectively. In this study baseline values of F, D and I from Jul 2008 to Dec 2012 observed at Abdus Salam Observatory are presented first time after the establishment of observatory.

5.1-15 **GEOMAGNETIC OBSERVATORIES: IMPROVING DATA QUALITY, SIMPLIFYING OPERATIONS**

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In the early 2000s recording of 1 Hz samples was introduced in the Danish and Greenlandic observatories, however, these high resolution data was used very little (a notable exception was their use in baseline determination). In recent years, the observatory operation was shifted from a 20 second mean value data stream to 1 Hz samples. With the higher time resolution it was possible to solve a number of known data issues and previously unnoticed problems could be identified. In 2009, we established a new geomagnetic observatory on Tristan da Cunha with a very small, thermally well insulated variometer enclosure. This principle was further developed when renovating the Greenlandic geomagnetic observatories in Narsarsuaq and Qeqertarsuaq, resulting in very stable baselines and low energy consumption, and shall be used for key variometer stations in the future. In this presentation we will present our data quality check methods based on 1 Hz samples. We will also report on the development of miniaturized heating systems for variometer sensors and electronics; power line conditioning units that can be set up close to the variometer, and an outdoor aluminum box intended to fully replace the electronics hut of a geomagnetic observatory in the future.

5.1-32p GEOMAGNETIC MEASUREMENTS AT THE OBSERVATORY "ARTI"

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Geomagnetic measurements in the Urals held since 1836. Observatory hourly mean data are available since 1886. Digitize archival magnetograms for minute values. Have access to the minute data in digital form from 1948 to the present. All digital stations are operating in real time. Data is transferred to the Geophysical Center RAS (Moscow), INTERMAGNET Geomagnetic Information Node (Edinburgh), International Service of Geomagnetic Indices (Paris). These are also available online observatory "Arti" at: <http://arudaemon.gsras.ru>

5.1-33p SPARKLING GEOMAGNETIC FIELD: INVOLVING SCHOOLS IN SPACE WEATHER OBSERVATIONS

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Solar activity will be reaching a maximum in 2013/2014 as the sun reaches the end of its cycle, bringing with it an opportunity to study in greater detail the effect of solar wind or "space weather" on our planet's magnetic field. Heightened solar activity leads to a larger amount of clouds of energetic particles bombarding the Earth. Although the Earth's magnetic field shields us from most of these particles, the field becomes distorted and compacted by the solar wind, which leads to magnetic storms that we detect from the surface. These storms cause aurorae at higher latitudes and can lead to widespread disruption of communication and navigation equipment all over the Earth when sufficiently strong.

This project, "Sparkling Geomagnetic Field," is a part of Austria's Sparkling Science programme, which aims to involve schools in active scientific research to encourage the interest in science. Researchers from the Central Institute for Meteorology and Geodynamics (ZAMG) in Vienna will be working hand-in-hand with three schools across Austria to set up regional geomagnetic stations consisting of state-of-the-art scalar and vector magnetometers to monitor the effects of the solar wind on the geomagnetic field. The students are an active part of the research team from the beginning, first searching for a suitable location to set up the stations as well as later overseeing the continued running of the equipment and analysing the data output. Through this project the students will gain experience in contemporary scientific methods: data processing and analysis, field work, as well as equipment setup and upkeep.

A total of three stations will be established with the schools at roughly equal distances across Austria and these will run alongside the already active station in the Conrad Observatory near Vienna. This network will allow for evaluation of both the spatial and temporal development of magnetic storms across the longitudes. Currently the students are searching for suitable locations for the equipment. Soon, the locations will be tested by the research team and the equipment will be set up. The geomagnetic network should be running and delivering continuous data by summer 2013.

5.1-34p DIGITISATION OF SAN FERNANDO MAGNETIC OBSERVATORY RECORDS

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Long-running magnetic observatories are important for studies of the Earth's magnetic field. They are used to model and study the core field and its secular variation, and are important for analyses of the solar driven regular and irregular variations in the geomagnetic field. Hourly magnetic data (H- and D- components) are being digitized from San Fernando year book tables for the years 1891-1960 using an OCR software.

Several strategies were developed to check, and correct unrecognized data, like Matlab scripts, or the use of daily aa-indices (which are available since 1868). The time series of hourly magnetic values reveal slow secular variations as well as transient and regular geomagnetic variations of external origin. As the quality and homogeneity of the data seems satisfactory, it lead us to support that this magnetic data rescued is well suitable for various reconstructions for studies of the long-term variation of the space weather in the 20th century.

5.1-35p THE NEW GEOMAGNETISM DATA PORTAL FROM THE WORLD DATA CENTRE FOR GEOMAGNETISM IN EDINBURGH

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Since 2007, the World Data Centre (WDC) for Geomagnetism in Edinburgh has made geomagnetic observatory datasets available via its Geomagnetic Data Master Catalogue website. This website is widely used by scientists looking for definitive geomagnetic observatory data, and has served over 1 million requests for data since first opening. Current data holdings span 150 years and 350 observatories. The original website, based on work at the Danish Meteorological Institute, provided a simple catalogue of data showing data availability on a per-observatory basis,

and FTP download of data files in WDC format. Useful features such as search, visualization, and delivery of data in other formats were missing.

In 2013, work began on replacing this website with one that takes advantage of advances in web technology to provide an enhanced service to users. The new website (the Geomagnetism Data Portal) offers the following functionality:

- Users may query the data repository using various attributes such as geodetic coordinates, time and cadence, in order to discover data of interest.

- Users may create and save plots of datasets or collections of datasets, allowing for quick checking of data quality, etc., without having to first download the data.

- Users may download datasets in a number of common data formats, such as WDC, IAGA-2002, ImagCDF, INTERMAGNET BINARY, JSON, XML, and CSV.

- All functionality is also available via easy-to-use web services, allowing for direct integration of the Data Portal with software such as Matlab, R, Excel, etc.

In this poster we present a tour of the various features provided by the Geomagnetism Data Portal.

5.1-36p THE ACTIVITIES OF THE WORLD DATA CENTER FOR SOLAR TERRESTRIAL PHYSICS, MOSCOW, RUSSIA IN THE NEW WORLD DATA SYSTEM

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World Data Center for Solar Terrestrial Physics (WDC for STP) in Moscow, Russia was established in 1956 as a vital part of the largest scientific project of XX century The International Geophysical Year (IGY) 1957-59 to provide archives and long-term preservation for the data and access to these data. WDC for STP is hosted by the Geophysical Center of the Russian Academy of Sciences. WDC for STP maintains and provides services for the archive of historical and modern results of global observations related to the wide range of disciplines involved in Solar-Terrestrial Physics: Solar Activity and Interplanetary Medium, Cosmic Rays, Ionospheric Phenomena, Geomagnetic Variations.

Since December, 2011 WDC for STP, Moscow is the Regular member of the new World Data System of the International Council of Science (ICSU WDS). In the activities WDC for STP is guided by the principles of the WDS Constitution and completely supports and agrees with the ICSU WDS data policy directed on support of full and open exchange of data, meta-data and products shared within WDS, which is based on the international instruments and national policies and legislation.

For 56 years the larger geophysical data sets, received from global networks of observatories, during the IGY and subsequent international projects, were accumulated at the WDC for STP. The most part of the archive is geomagnetic data: Geomagnetic Indices, Sudden Commencement, Hourly and Minute Values of Geomagnetic Field Components, Images of Magnetograms, Catalogues of Geomagnetic Storms and Pulsations. The historical analog data sets (paper, film, etc.) are converted to the digital form for their saving and convenient to use. WDC for STP supports the actual state of archives, preserving data and providing free access to them on the WDC for STP website <http://www.wdbc.ru/stp/index.en.html>.

5.1-37p GEOPHYSICAL OBSERVATORY AT "ALEXANDROVKA" BASE OF MOSCOW UNIVERSITY

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Alexandrovka base of Moscow University is situated 250 km to the south-west from Moscow, in Kaluga region. It is located on the outskirts of the village of the same name and far from sources of industrial electromagnetic (EM) noise. Since 1992 the base is used for practical training of students in methods of applied geophysics: electrical and EM, gravity, magnetic and near-surface seismic.

In 2008 the creation of a geophysical observatory at the Alexandrovka base was started. Non-magnetic building was constructed with a room with four pillars for sensors and a room for the recording equipment. Long-period magnetotelluric station LEMI-417M, 3-component 1-second observatory magnetometer LEMI-025, digital broadband seismometer CMG-6TD and seismic recorder GeoSIG GSR-24 are currently operating.

The data is used for remote reference processing of magnetotelluric and microseismic data, obtained in the central part of the East-European craton to study the structure, fluid, thermal and rheological regimes of the Earth's crust and upper mantle. We also gladly share the data with specialists in other areas of science.

Our further plans are to organize declination-inclination and scalar measurements of magnetic field, as well as to arrange data transfer using the Internet satellite system, available at the base.

There is a problem with noise from controlled sources, used in some EM geophysical methods, applied in the vicinity of the base. It occasionally occurs mainly within two months in summer and two weeks in winter, during practical training of students. On the other hand, Moscow University students, who specialize in applied geophysics, as well as some students of other Russian and foreign universities, study the observatory equipment, methods of data acquisition, processing and interpretation at Alexandrovka base.

This work was supported in part by M.V.Lomonosov Moscow State University Program of Development.

5.1-38p BASELINE ANALYSIS AT THE MAGNETIC OBSERVATORY OF PILAR (31° 40' S, 63° 53' W)

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The achievement of the baseline (BL) is one of the most important tasks to be made at a geomagnetic observatory, both at an analogic as well as a digital modern one. The calculation of the BL is used to determine the absolute values which will generate the database of every magnetic component.

This work shows a review of the results obtained from classical (analogic) and the modern (digital) instrumentation used at the permanent magnetic observatories. It furthermore studies the different methods applied to determine the baselines regarding the frequency of absolute observations. The analysis of the baseline values at the Magnetic Observatory of Pilar is made by adjusting the results to different types of mathematic models.

5.1-39p GEOMAGNETIC REPEAT NETWORK IN ARGENTINA

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In order to get a better knowledge of the changes in the earth magnetic field strength over the years in Argentina, a network of geomagnetic repeat station (GRS) has been designed.

In this work, the main characteristics of GRS, their geographic distribution, and the survey and data processing methods are reported.

5.1-40p INDIGO PROJECT AT THE PERMANENT GEOMAGNETIC OBSERVATORIES OF THE ARGENTINEAN NATIONAL METEOROLOGICAL SERVICE

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The Argentinean National Meteorological Service (NMS) is the oldest institution over South America which studies the earth magnetic field. Their permanent magnetic observatories (PMO) have been functioning since 1904, when the Pilar PMO (31° 40' S, 63° 53' W) was first installed. After that, in 1907, a new observatory was established at the Orkney Islands, the Base Orcadas MPO (60° 44' S, 44° 47' W). And finally, in the northwestern region of the country, in 1917, the La Quiaca MPO (22° 6' S, 65° 36' W) was incorporated.

Over the last few years, the observatory records have been upgraded to digital systems. The Pilar and Orcadas PMOs have been using the classical instrumentation (analogic) until the years of 2010 and 2012, respectively, when the classical instruments were improved to digital ones. On the other hand, the La Quiaca PMO has been in operation until 1971, when the records were interrupted due to inconveniences with the analogic equipment and, up to now, the instruments have not been upgraded to modern ones.

The aim of this work is to report the geomagnetic records taken from the PMOs where the INDIGO (Intermagnet Digital Global Observatory) system has been installed, and furthermore, present the project of reactivation of the observatory installed in La Quiaca.

5.1-41p VECTOR-VECTOR CALIBRATION OF A FLUXGATE MAGNETOMETER AT A MAGNETIC OBSERVATORY BY ROTATION AROUND THE DIRECTION OF GRAVITY

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The calibration of a vector magnetometer requires the determination of scale factors, offsets and non-orthogonality angles. We describe a method to determine these parameters at a magnetic observatory by rotating the magnetometer by means of suspending it at a nylon thread. Niemeck observatory data are used as reference for the vector components X, Y, and Z. An optically pumped potassium magnetometer is used as reference for total intensity F. The instrument to calibrate is an airborne magnetometer used in the GEOHALO Project.

We hung the entire magnetometer rack with a nylon thread in different positions so that the rack could spin freely around the direction of gravity. In a first step a scalar-vector calibration was done: The readings of the three components are used to calculate F. This calculated F value depends on the current calibration values. The difference between the calculated F and the actual F measured by the reference magnetometer is used to set up a linear system of equations (LSE) for the determination of improved calibration parameters. The conditioning of this LSE depends on number and variety of available sensor orientations.

A vector-vector calibration requires the exact knowledge of the sensor orientation at each measurement. The

magnetic field is known in the laboratory and in the sensor coordinate system. For the determination of the sensor attitude in laboratory system another vector needs to be known in both systems. Due to the suspension at a thread, the sensor rotates exactly around the direction of gravity being the Z-axis of the laboratory system. The pathway of the magnetic field vector in the sensor coordinate system forms a circle. The centre of this circle is the direction of gravity, i.e. the magnetic vertical (Z) direction in the laboratory system. These two vectors are used to unequivocally define the sensor attitude at each measurement.

By means of the sensor attitude in space the projections of the actual field in all three sensor components can be calculated. Comparison to the observatory readings allows determining the calibration parameters. One LSE is produced for each component. The data used for attitude determination are measured with the instrument which is yet to be calibrated using first estimated values and improving them iteratively. Numerical experiments have proven the convergence of this procedure.

The two methods scalar-vector- and vector-vector-calibration are compared. Vector-vector calibration leads to three LSEs which are better conditioned than the LSE produced within the scalar vector calibration. On the other hand vector data of the actual field might be less accurate than F measurements, as additional errors in the attitude determination can be expected. We assess and compare both methods. We will check if it makes sense to combine both methods.

5.1-42p CORRECTING OBSERVATORY DATA PRIOR TO SCIENTIFIC ANALYSES

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Using geomagnetic data submitted to the World Data Centre (WDC) for Geomagnetism in Edinburgh (part of the ICSU World Data System) we have undertaken two campaigns to identify data quality issues which may have an impact on the outcome of subsequent scientific analyses. The first campaign concerned the detailed checking of observatory hourly means, initially focussing on the satellite era (late 1990s onwards), but latterly going back in time to the earliest values in the 1880s. Particular attention is paid to identifying steps, spikes and drifts and the emphasis is on deriving multi-year series of geomagnetic field measurements uncontaminated by these measurement artefacts. For the satellite era residuals to hourly models fitted to the observatory data were examined in detail.

The second campaign concerned the preliminary checking of observatory minute means, in particular detecting large spikes in the data by annual global coherence tests. These may have a strong effect on analyses involving any extreme value statistics widely used in deriving worst-case space weather scenarios. These data extend back to the late 1960s.

In both cases corrections have been made to the WDC holdings, with appropriate updates to relevant metadata and retention of earlier versions of the files offline. Data can be downloaded from www.wdc.bgs.ac.uk.

5.1-43p CREATION OF HIGH-RESOLUTION DIGITAL DATA FROM OLD ANALOG MAGNETOGRAMS

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Records of geomagnetic field variations before 1970s are preserved as analog magnetograms on photographic paper. We developed a method to convert photographic records into digital data with high time resolution automatically. The procedure of the method is as follows:

1. High-resolution graphic files are obtained as scans of analog magnetograms.
2. Lines and curves in the graphic files are distinguished automatically with image processing program that we developed.
3. The positions of identified pixels are output as coordinates in the time direction and the amplitude direction.
4. The coordinates are converted into numerical time and geomagnetic field data.

In this way, we have converted high quality analog magnetograms of Kakioka Magnetic Observatory (KMO) from 1964 through 1975 into digital data. Digitized one-minute data in 0.1 nT of that period are available in the www server of KMO (http://www.kakioka-jma.go.jp/metadata/geomagnetic/geomag_kak) and that of World Data Center for Geomagnetism, Kyoto (<http://wdc.kugi.kyoto-u.ac.jp/index.html>). That conversion is underway, and the digitized data of KMO will date back to 1924.

5.1-44p THE 1ST EVER WORKSHOP ON GEOMAGNETISM IN PAKISTAN: EXPERIENCES

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Islamic countries generally lack scientific knowledge and have fewer related scientific research and development activities. Few Islamic countries including Pakistan possess geomagnetic observatories and engage in the associated activities. From 03 to 13 April, 2012, international researchers and observers gathered at the Geomagnetic

Observatory in Islamabad, Pakistan to take part in the first ever OIC workshop on Geomagnetic Observatories and their Applications. The workshop was jointly organized by Pakistan Space and Upper Atmosphere Research Commission (SUPARCO) with the collaboration of Royal Meteorological Institute (IRM), Belgium, Inter Islamic Network on Space Sciences and Technology (ISNET) & National Centre for Physics (NCP). About 30 participants including 15 from various countries such as Belgium, Iran, Iraq, Kuwait, Mozambique, Indonesia and Turkey attended the Workshop. The main aim of the workshop was to provide opportunity to develop cooperation among OIC countries regarding the geomagnetic field research as well as for knowledge-sharing and capacity-building in the area of geomagnetism. The workshop covered all elements of geomagnetic research including lectures/talks on all interrelated themes of geomagnetism & geomagnetic field monitoring, practical sessions together with astronomical observations and absolute measurements, visits to cultural, historical and tourist sites at Islamabad, Taxilla and Murree, and technical visit to NCP. Moreover, beneficial informal discussions were held at the end of the day's programmes to address the geomagnetic research issues.

5.1-45P UPGRADE OF THE DANISH OBSERVATORY-GRADE FGE VARIOMETER FOR 1 HZ DATA

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The widespread use of the Danish FGE variometer (magnetometer that measures magnetic field changes from an arbitrary offset-value) has significantly improved the quality of the global geomagnetic observatory data over the last 20 years. The instrument is easy to install and has a very good baseline stability, which significantly simplifies observatory operations. The FGE was originally designed to produce 1 minute mean values by digitally filtering from higher sample rates (*e.g.* 1 Hz) with a resolution of 0.1 nT. In its present version, the FGE does not meet all of the new Intermagnet specifications for 1 Hz data, especially not the 0.01 nT noise level. Currently, we are developing new versions of the FGE electronics that keep the aforementioned positive features of the original instrument and that do have timing accuracy and filter characteristics that are compliant with the new Intermagnet specifications. The magnetometer electronics in existing systems can either be exchanged or upgraded, while the sensor remains unchanged. One development is the version FGE TD with differential output to connect a seismological data logger. The other development is the FGE TO, which integrates the newest version of the Hungarian obsDaq ADC into the FGE electronics together with a Palmacq time stamping unit and an optional Magrec data logger. The hardware configuration, applied analog and digital filtering and test results are presented in this paper for the two new versions.

5.1-46p GEOMAGNETIC OBSERVATORY GAN

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The geomagnetic observatory GAN was established in April 2011 as a joint project of ETH Zurich, Gan Meteorological Office, and NGRI Hyderabad. The observatory is located at the Gan International Airport on Gan, the southernmost island of the Addu Atoll and the entire Maldives archipelago (73°09'13.47" E, 00°41'40.55" S). The new establishment thus considerably improves the spatial coverage of the geomagnetic observatory network in the Indian ocean. The observatory is equipped with a DTU Space FGM-FGE triaxial suspended fluxgate variometer, and a Gemsys GSM-90F1 Overhauser scalar magnetometer, providing 1-minute data. Baselines are provided by absolute measurements on a weekly basis. A long-period telluric instrument LEMI-417E provides complementary measurements of horizontal electric field for induction studies since September 2012. Initial analysis of first two years of magnetic data, and initial estimates of magnetotelluric responses will be presented. The observatory is operational and will be sustained at least for the duration of ESA Swarm satellite mission, and hopefully beyond.

5.1-47P PANTANAL MAGNETIC OBSERVATORY: INSTALLATION AND NEW DATASET

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A magnetic observatory measures variations in the geomagnetic field of internal and external origin in a long time scale. External variations include interactions between the magnetosphere and the solar wind; in general they occur in a short time scale. These variations are closely linked to solar activity. The internal field is generated by convection of a high electrical conductivity fluid in the external core, by a mechanism known as geodynamo. The internal magnetic field variations, or secular variation, are longer than the external field time variations. There are techniques that allow the separation of these different frequencies, related to internal and external sources, in observatory dataset.

The global distribution of magnetic observatories is uneven, with few observatories in South America. In Brazil, there are three magnetic observatories, but only Vassouras Observatory (VSS-RJ) is part of the INTERMAGNET. The National Observatory has plans to install five new observatories in Brazil. Pantanal was the chosen location for

installing the first observatory because of its privileged location, close to the SAMA region. Pantanal dataset may contribute to learn about SAMA origin. Measurements carried out over the last century suggest that field intensity is decreasing rapidly. The decreasing of the field's intensity is not the same around the globe, especially at the SAMA (South Atlantic Magnetic Anomaly) regions, where this reduction is occurring faster.

This work will present all the stages of the installation of the new Magnetic Observatory in Pantanal. We followed the procedures suggested by the IAGA to build this observatory. In the construction several steps were followed: first, a magnetic survey is done in order to avoid strong magnetic gradients in the location where the absolute and variometers houses will be installed. Next, all the materials selected for the constructions of houses are tested using a proton magnetometer GSM-19. After confirming that the selected materials have a very low or null magnetization, the houses are built. After construction of the whole infrastructure, the equipment was installed. The local staff was trained to perform absolute measurements twice a week.

In addition, some analyzes were made in the first data recorded by the observatory in order to demonstrate the reliability and stability of the data. During the construction, a magnetic station was installed near the site of the observatory. This station was intended to analyze the data quality of the region and the comparison of these data with other observatory data. In addition to this analysis, the first records and temperature tests are shown.

This Project is cooperation between Brazilian Institutions (The National Observatory and SESC-Pantanal) and a German Institution (GFZ- Potsdam). The construction of the houses was done with financial assistance from the SESC-Pantanal and the National Observatory, and all supervision of the construction was done by the National Observatory. All equipment installed in Pantanal Observatory was donated by the GFZ-Potsdam. The installation of the equipment was made with the cooperation of all project partners.

5.1-48p SURLARI OBSERVATORY, READY FOR PRESENT AND FUTURE, IN THE THIRD MILLENIUM

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Since March 2009, in the frame of an international cooperation agreement with GFZ-Helmholtz Centre Potsdam, the Surlari observatory has continuously respond to national and international requirements for geomagnetic data, in terms of quality and rapid availability. The very first aim of the observatory is to preserve its present INTERMAGNET standards. A highest accuracy for all magnetic measurements is the main goal and an absolute accuracy less than 1 nT is foreseen. As for all modern ground observations, Surlari uses comparable instrumentation to produce similar data products. A Bartington fluxgate-theodolite (DI-Flux) and an Overhauser proton magnetometer for scalar measurements are the magnetic reference instruments for a FGE variometer, which is subject to instrumental drift. Surlari observatory has also plenty considered the new worldwide needs for new and better products, like quasi-definitive data or 1-second data, relevant for some specific scientific topics and for real-time applications. Since January 2012, Surlari quasi-definitive data have been published within 30 days after recording, their accuracy being very similar to that of the definitive data. This is due to the large recent efforts in a continuous scrutiny of the quasi-definitive data: visual inspection of the quasi-definitive baseline, checking of the continuity between the current quasi-definitive and previous year definitive data, checking of the scalar residuals (ΔF), and visual review of all components at different time-scales. Additionally, an algorithm to remove spikes and jumps, and to replace the missing FGE one-minute values from a back-up system has been developed. These new developments in the actual standard of the Surlari observatory are presented, together with some specific examples of the use of data.

SESSION 5.2

RECENT MAGNETIC SURVEYS FOR REGIONAL AND GLOBAL CHARACTERIZATION OF THE GEOMAGNETIC FIELD

5.2-1 ITALIAN MAGNETIC REPEAT STATIONS NETWORK: 2010.0 SURVEY RESULTS

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In Italy, Istituto Nazionale di Geofisica e Vulcanologia (INGV) undertakes measurements of the Earth's magnetic field on a network of more than 110 points (repeat stations) every 5 years. The latest survey has been reduced to the date 2010.0. Main aims of the activity are: the determination of secular variation and the update of the Italian magnetic maps. In this presentation we will describe: network characteristics, measurement methods, reduction procedures and global and local mathematical models used for data elaboration. As done also in previous recent surveys, four magnetic maps at map scale 1:2,000,000 were drawn and printed. They are inserted in a booklet in which a CD rom is also enclosed, allowing to have a full digital geomagnetic field information system available on a PC screen. This last survey was carried out in a very low solar activity phase. Results of comparisons with previous surveys, carried out in different conditions of solar activity, e.g. during recent solar maxima and minima, will also be shown.

5.2-2 THE AEROMAGNETIC MAP OF ROMANIA IN THE CONTEXT OF WDMAM

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The paper deals with the achievement of the new airborne geomagnetic compilation for the Romanian territory and the added value brought to the WDMAM project.

In the absence of a direct Romanian contribution, the first WDMAM version had included a geomagnetic dataset for the Romanian territory based on the transformation of the published ground vertical component geomagnetic anomaly. Unfortunately, the so far published vertical component ground geomagnetic map of Romania is significantly distorted mainly due to data scarcity and secular variation effects. Other shortcomings are provided by the inappropriate local geomagnetic reference field model (unable to take into consideration the altitude of the observations) subtracted while computing the geomagnetic anomaly. Consequently, the image provided by the first version of WDMAM over the Romanian territory contains several artefacts that need to be removed.

Following the Romania's decision to contribute to the WDMAM project a new geomagnetic dataset has been prepared based on the old regional airborne geomagnetic survey of Romania (1962-1969). Space-time inconsistencies in the old airborne geomagnetic data have been removed by using a genuine methodology, and a global geomagnetic reference model has been used to determine the geomagnetic anomaly of the total intensity scalar of the geomagnetic field. High-order derivatives applied to the new dataset have confirmed the quality of the merging operation. Finally, a space-time consistent geomagnetic grid (10 km x 10 km) of the total intensity scalar of the geomagnetic field valid for the epoch 2007.5 at 3000 meters above the sea level has been prepared and delivered to the GTK team to be implemented in the new version of the WDMAM.

Comparisons with previous version of WDMAM (as based on the ground vertical component data) clearly reveal the added value of the new geomagnetic dataset.

5.2-3 HISTORICAL SURFACE SURVEYS, AIRBORNE AND SATELLITE CONTRIBUTIONS TO CHARACTERIZE THE CRUSTAL, AND MAIN GEOMAGNETIC FIELD IN MEXICO

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1879 is a landmark for Geomagnetism in Mexico. A series of magnetic Declination and Inclination measurements started in Mexico City, representing the takeoff of this discipline. The characterization of Secular Variation started then with a measured Magnetic Declination of 8.5° East (current value is approximately 5.5°).

The Interest for Crustal Magnetic Field started with the first magnetic chart carried out between 1906 and 1907, by the Astronomic Observatory of Mexico. The Magnetic Observatory was a part of this institute. With the help of the Carnegie Institute of Washington D.C. the survey was made almost all over the country (the Baja California peninsula was not included). Several institutions published bulletins with locations of magnetic observations; other surveys were reported for 1924, and 1930 (Sandoval, 1950; Hernández and Orozco, 1997).

In 1948 the Geophysics Institute became a part of National University and started operations; one of its first departments was related to geomagnetism, this department made magnetic surveys in 1950-1952, 1962, 1965 and 1990. The last field survey was made during 2009-2011. The Information of these Charts has been useful in order to describe the behavior of core-mantle boundary in time.

During this time a new era of aircraft missions started in the first Geophysical year (1957-1958). And aeromagnetic and satellite data, became a new source of information for studies not only in space, but anomalies in Earth crust.

The expression of the magnetic field based on satellite and aeromagnetic data, have been used to evaluate and analyze features and characteristics of the crust (Hernandez-Quintero, 2002; Pilkington et al., 2001). Due to the altitude of observation of such data (approximately 4.5 km for satellite and 0.3 km for aeromagnetic surveys), the source of the anomalies may originate in the crust-mantle boundary or the continental crust, and can be used as additional support to improve models, geological-tectonic framework and character of rocks by means of quantitative analysis.

The present work describes the importance and usefulness of geomagnetic information gathered in Mexico; from the resulting maps of surface surveys, airborne and satellite contributions.

The association between regional tectonics and the geomagnetic expressions is presented by the specific example of large alignments in northern Mexico reported since the early seventies of the twentieth century (Walter, 1980, of Cserna, 1970, 1976, Silver and Anderson, 1974; 2005. Anderson et al., 1982 ; Gose et al. 1982; Pilger, 1978, Charleston, 1981, McKee et al., 1984). Many of these studies have contributed to a good identification and description of such faulting.

The model of the Mojave-Sonora megashear remains as one of the most influential ideas in the geology of the country (R. Molina-Garza and A. Iriondo, 2005) and has been subject of detailed studies generating a lot of controversy. Aeromagnetic data over northern Mexico are used, in order to contribute from the geometrical point of view, in determining this geographical displacement

5.2-4 CAN WE MITIGATE THE EFFECT OF BIAS, SPECTRAL LEAKAGE, AND DATA ERRORS WHEN DEALING WITH MAGNETIC FIELD MEASUREMENTS AT GROUND AND SPACE ALTITUDES?

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The data errors, the spectral leakage, and the biases have an important impact on models of the Earth's magnetic field. The prominence of these effects depends on the considered datasets. For instance, the biases introduced in models by the measurement errors of recent satellite or observatory data are nowadays very small while they are much more significant when dealing with indirect (i.e., archeomagnetic) or older direct measurements. To the contrary, the spectral leakage and the bias due to a poor coverage in space and in time should be considered as the major source of errors in representing the different sources of the magnetic field.

We first try to identify some sources of bias and errors depending on the studied magnetic field contribution and on the availability of measurements. We then carry out synthetic analyzes in order to illustrate the problems of dealing with realistic but incomplete and insufficient datasets for deriving magnetic field models over archeological or historical timescales. We show that the spectral leakage may lead to artificial spatio-temporal variations of the magnetic field, such as an apparent main field secular variation, an asymmetry of the external field, or a regional distortion of the lithospheric field structures. We try to quantify these errors and we propose different ways to account for them statistically or to correct for them. A better understanding of these limits should allow us to avoid the pitfall of geophysical over-interpretation and to prepare some tools for the emerging field of geomagnetic data assimilation.

5.2-5 NEW ADDITIONS TO THE NATIONAL GEOPHYSICAL DATA CENTER'S ARCHIVES OF MARINE AND AIRBORNE GEOMAGNETIC TRACKLINE DATA

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The National Geophysical Data Center (NGDC) maintains a global Geophysical Data System (GEODAS) archive of geophysical trackline data. This archive is an important resource for the Earth science community. Most of the data originate from marine scientific cruises. Recently, GEODAS has been extended to include aeromagnetic trackline data. With a renewed effort to archive and document all available survey data, a significant number of new additions have been made to the data base, which will be shown in this presentation. These include previously unreleased marine data from various research institutions and aeromagnetic surveys of the Naval Research Lab. The NGDC geomagnetism team compiles these data into the global Earth Magnetic Anomaly Grid (EMAG2) in 2 arc minute resolution. EMAG2 then provides the basis for the high-resolution Enhanced Magnetic Model (EMM). The EMM is a spherical harmonic model to degree 720, providing the vector of the internal geomagnetic field for navigation applications with a resolution of 28 km half-wavelength.

5.2-6 GRAVITY AND MAGNETIC FIELD VARIATIONS ASSOCIATED WITH THE BURIED GEOLOGICAL STRUCTURES IN THE NORTH OF MEXICO

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North Mexico is essentially the juncture of two distinctly different tectono-stratigraphic provinces, the eastern Gulf of Mexico (Coastal Plane, Sierra Madre Oriental) province and the western Pacific Mexico (Rivera plate, Meso-American trench, Sierra Madre Occidental) province (Goldhammer & Johnson, 2001). Tectonic evolution in north Mexico is dominated by divergent-margin development associated with the opening of the Gulf of Mexico and overprinted by non-igneous Laramide orogenic effects (Pindell et al., 1988). The structural grain of north Mexico consists of Triassic to Liassic fault-controlled basement blocks, the development of which reflects in part late Paleozoic orogenic patterns of metamorphism and igneous intrusion (Wilson, 1990). There are different tectonic provinces which are recognized interpreting the basement and sediment cover of this area. Mojave-Sonora megashear and San Marcos fault are two principal fault zones crossing the north-northeast Mexico in NW-SE direction.

This paper is presented the integral analysis of the gravity and aeromagnetic data in the north Mexico (Coahuila, Durango and Chihuahua states). Complementing with a Digital Model of Elevations (DME) that combined with the review of previous geological studies it serves to compare the surface structures and blocks of basement in this area. Also the separation of the most important tectonic blocks was done, and 2.5D geological-geophysical model was finally developed. This model represents in a general way the principal structural characteristics of northeast Mexico.

Gravity and magnetic data analysis was used with purpose to study the structure of the substrata in order to allow modeling of the basement structure and its relation with the sedimentary cover features. The Bouguer gravity and the total field aeromagnetic data were supplied by Geological Survey of Mexico (SGM), published data (Mickus et al., 1999), and author's field works.

Gravity data in the north Mexico basins are sensitive to local vertical offsets across high-angle faults, where rocks with different densities are juxtaposed. Yet high densities in some Mesozoic sedimentary rocks just above the basement may smear out the subtle gravity signatures of basement faults. Notably, in the Coahuila block in northwestern part, where vertical basement-fault offsets reach tens and hundreds of meters, the associated gravity anomalies are not strong.

The total-field magnetic data were used, with the International Geomagnetic Reference Field removed. The sedimentary cover in the northeast Mexico is generally considered to be almost non-magnetic, and the anomalies are sourced overwhelmingly in the crystalline basement and buried volcano-magmatic structures. Local intra-sedimentary anomaly sources may be related to depositional concentrations of magnetic minerals in some clastic rocks, or to secondary magnetization of sedimentary rocks by circulating brines.

Steep, straight faults are commonly expressed as subtle potential-field lineaments, which can be gradient zones, alignments of separate local anomalies of various types and shapes, aligned breaks or discontinuities in the anomaly pattern, and so on. Many large magnetic and gravity anomalies represent the ductile, ancient, healed basement structures, obscuring the desirable subtle features. Subtlety of the desirable lineaments necessitates detailed data processing, using a wide range of anomaly-enhancement techniques and display parameters. So data processing includes Fourier transformation, wave-length filters, upward and downward continuation, vertical and horizontal derivative, analytic signal analysis, etc.

This study was supported by the CONACYT Project 129550 “Evolución terciaria de cuencas continentales del norte de México: controles tectónicos heredados, pulsos de deformación, magmatismo y registro bioestratigráfico (continuación proyecto 47071)”.

5.2-7 **STUDY OF THE ANOMALOUS MAGNETIC FIELD STRUCTURE OF THE URAL REGION**

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Study and analysis of the anomalous field structure have practical value for geological mapping, geological survey, and prospecting for mineral resources, and in the sense of revealing peculiarities of the tectonic structure of the lithosphere and building geomagnetic models of the Earth's crust. The information basis for the maps was the airborne and land magnetic surveys data of large, middle, and small scales. The geophysical data were processed using modern parallel computer methods. The data on the anomalous magnetic field for the whole territory are set with a spacing of 250 m. As the result from these works, a digital model of the map for the anomalous geomagnetic field ??? in the Uralian Region and its vicinity (East European Plain and West Siberia) was created. To divide the long and short wave components of the amplitude spectrum of anomalies, we have used numerical methods of field simulation at various altitudes. In order to obtain valid results, it is very important to keep good representation of the high frequency part of the anomalous field in the data arrays during simulation. Since the crystalline rocks in the Urals produce intensive local anomalies, the step of grid data was set at 1 km. The size of the studied area is about 850 km along the latitude and about 1440 km in the longitudinal direction. The total data collection is about 1 224 000 values of the anomalous magnetic field. The calculations were made for the altitudes set (1-200 km). At the altitudes of 5–40 km above the territories of the Urals and West Siberia, the intensive positive anomalies are predominant, while only regional negative fields remain at the altitude of 100 km; in contrast, several large positive anomalies are seen above the East European Plain even at the altitude of 100 km. This result conforms well to the magnetic survey data obtained using satellites at the altitude of 300 km and above. Thus, the anomalies have been distinguished for different wavelengths using transformations. These results reflect the peculiarities in the structure of the anomalous magnetic field within the Uralian Region and have been used for studying of magnetization of the Earth's crust.

5.2-8 **DOES CURRENT SATELLITE MEASURING COMPLETE ALL GEOMAGNETIC NEEDS?**

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During the XXth century, geomagnetic ground data was obtained from either magnetic observatories providing continuous measurements or from repeat stations providing punctual measurements. At that time these data were the main sources of information on geomagnetic field spatial and temporal variations. Currently, the state-of-the-art has dramatically changed and the measurements obtained from Osted, CHAMP and SAC-C satellites provide a new global perspective. The datasets provided by these satellites, over the past decade, have given us the ability to obtain the best-ever description of the geomagnetic field. This year, the Swarm satellites are planned to be launched, which will enhance the resolution and quality of current data.

This development has called into question the role of ground measuring and its contribution to the needs of current research. Given the three principles of geomagnetic field data collection - instruments, methodology and data quality - I will show that current scientific research needs both ground-based and satellites observations, to complement and verify each other.

5.2-9 CURIE ISOTHERM DEPTH FOR CONSTRAINING VOLCANIC HEAT SOURCES**Ravat, D.; De Ritis, R.; Ventura, G.; Chiappini, M.**

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The Salina, Lipari and Vulcano volcanic ridge and the surrounding sea sectors (Aeolian Archipelago, Italy) are characterized by vents responsible for recent (<40 ka-1889/90 AD) effusive and explosive subareal activity and repeated, 56 to 7 ka in age, submarine explosive eruptions from sources located between Lipari and Vulcano. A spectral depth estimation of the magnetic bottom using a fractal method on aeromagnetic data from Vulcano, Lipari and Salina volcanic ridge allows us to constrain the Curie isotherm depth. The elevated portion of the isotherm is between 2 and 3 km below Salina and Vulcano and about 1 km below Lipari. The Curie depth results in the context of other geological and geophysical evidence suggest that the rise of the Curie isotherm is mainly due to the occurrence of shallow heat sources such as magma ponds and associated hydrothermal systems. The short-wavelength magnetic anomaly field reflects magnetic contrasts from highly magnetized volcanic bodies and low magnetization sediments and hydrothermally altered rocks. Borehole temperature data verifies the Curie temperature derived from the magnetic methods on the island of Vulcano. We conclude that the entire Vulcano, Lipari and Salina volcanic ridge may be active and should be monitored.

5.2-10 COMPARISON OF REPEAT STATION DATA TO A HIGH-RESOLUTION GLOBAL MAGNETIC FIELD MODEL**Korte, Monika; Lesur, Vincent; Kotzé, Pieter**

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Geomagnetic repeat station measurements are carried out in several countries to provide additional information on secular variation, continuously monitored by geomagnetic observatories. The satellite missions Ørsted and CHAMP measured the geomagnetic field vector continuously from 1999 to 2010 in near-Earth orbits. Global geomagnetic field models using these satellite data together with ground observatory data offer high-resolution descriptions of secular variation. We compare repeat station data from Germany and South Africa to global magnetic field models GRIMM and CM4. In contrast to observatory data, the repeat station data have not been included in the determination of the models. We investigate the accuracy of secular variation description in the global field model and the influence of external field residuals in processed repeat station data by this comparison. We find that recent detailed field models describe regional secular variation well. Contributions from large-scale magnetospheric fields are present in repeat station data despite careful data processing. Moreover, we obtain estimates of the lithospheric field contribution at the repeat station locations and try to determine information about induced sources of magnetic anomalies by studying time series of these “crustal bias” estimates. The expected signal is very small, and with the presently available length of time series the statistics and signal to noise ratio are not sufficient to reach sound conclusions yet.

5.2-46p UPDATED CATALOG FOR REPEAT MAGNETIC STATIONS AND THE MEXICO MAGNETIC CHART FOR 2010.0 EPOCH**Guzmán-Armenta, B.; Cifuentes-Nava, G.; Hernández-Quintero, E.**

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Between 1950 to 2010, it was necessary an updated database of the Mexican Geomagnetic Repeat Stations and its magnetic components (D, I, H, Z and F). In this poster is reported such database ready to be processed in order to obtain the Mexico Magnetic Charts.

During the period 2008 to 2012 was done a campaign to obtain the data from the repeat magnetic network stations through Mexico with the objective to develop the Mexican Magnetic Chart Epoch 2010.0. The last magnetic chart was done in the 90's by the Geophysical Institute-UNAM, this chart considered 52 repeat magnetic network stations.

Some of the stations used in the 90's were destroyed and lost, for this reason were necessary to find a new place to replace each of these lost sites. This new stations are located surrounding 5 km from the old ones, in places like Schools, Airports and Sportive Fields. The apparent values to elaborate the Magnetic Chart Epoch 2010.0 were obtained from the DI-FLUX ZEISS A-20 and OVERHAUSER GSM-19 magnetometers. The process of the data was done following the Geophysical Institute-UNAM methodology. The real values were process with the software SOLEI and Multiyear Interactive Computer Almanac (U.S. Naval Observatory, 2005), after the use of such software we obtained the real and reduced to 2010.0 data.

Finally with the real values we obtained Declination, Inclination and Total Intensity Magnetic Charts Epoch 2010.0 for Mexico.

5.2-47p THE MAKING OF GROUND-BASED VECTOR MAGNETIC FIELD OBSERVATIONS AND APPLICATION OF RESULTS**Shanahan, Tom; Macmillan, Susan; Swan, Tony; Turbitt, Chris**

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In the UK we have 41 repeat stations with each being occupied once every four years. The measurement technique uses a fluxgate theodolite, two proton precession magnetometers and a geodetic-quality GPS for determining true north with a north-seeking gyro attachment as a the back-up. The data are then processed to reduce the effect of time-varying fields and then a model is fitted to them. The model forms the basis of the service to provide grid magnetic angle to the UK mapping agency for publication on their map products. This ensures navigation using their maps and a compass is possible.

The usefulness of such ground-based vector magnetic observations around the world for assessing local and global model uncertainties is demonstrated. A global database of observations is maintained and can be accessed at http://www.geomag.bgs.ac.uk/data_service/data/surveydata.html.

5.2-48p GEOPHYSICAL APPROACH FOR THE LOCATION OF TECTONIC STRUCTURES WITH PALAEOSEISMOLOGICAL RELEVANCE. CASE STUDY OF THE CONCLUD FAULT (IBERIAN CHAIN, SPAIN)**Pueyo Anchuela, Óscar; Lafuente, Paloma; Arlegui, Luis; Liesa, Carlos; Ezquerro, Lope; Simón, José Luis**

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The study of active faults in intraplate areas presents some handicaps due to their typically wide interseismic periods, being their importance very often overlooked within the instrumental and historical record of seismic events. In such cases, seismic activity must be assessed from paleoseismic record studies. Large recurrence intervals also significantly reduce the surficial morphostructural and geomorphological evidences. In these cases another approaches for the indirect characterization or for the precise location of optimal sites for trenching are needed. In these conditions, the integrated analysis of geophysical signatures obtained from different techniques is considered to evaluate its capability to locate blind geological structures, and to characterize the most recent structures. Here, the synergic analysis of electromagnetic induction multifrequency survey, magnetometry and GPR is used at the expected location of a group of structures with recent evolution within the intraplate Iberian Chain in central Spain. The main geophysical signatures found consist on magnetic inverse dipoles and a very clear sudden increase of apparent conductivity related to the deposits that record the fault activity, as exposed by the EM technique. The multifrequency analysis of such data permits to identify the progressive narrowing of the anomaly between surficial, more extended, and the isolated anomaly peak at the fault at deeper conditions. GPR in this situation serves to confirm the position of the affected units by fault activity. At the optimal location, trench digging exposes the underground structures and deposits, as expected, and also, through back-analysis procedures, is useful to constrain both the geophysical models and to identify target geophysical signatures to seek for in future research campaigns.

SESSION 5.3**MAGNETIC OBSERVATORY DATA AS APPLIED IN SPACE WEATHER/ CLIMATE****5.3-1 DERIVATION AND PROPERTIES OF NEW GEOMAGNETIC INDICES AND THEIR USE IN SPACE WEATHER APPLICATIONS****Chambodut, Aude; Lathuillère, Chantal; Menvielle, Michel; Marcha**

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A great number of Space Weather applications rely on K-derived planetary geomagnetic indices. These indices, namely Kp/ap or Km/am (depending on the number of used subauroral geomagnetic stations) are therefore limited to the 3-hour time resolution of K indices. In addition, they do not represent the intrinsic spatial variations that result from the local time dependency of the solar wind/magnetosphere interaction. We have defined new geomagnetic indices, based on the magnetic variations recorded in the am network of ground based observatories, with a better time resolution and/or a better spatial resolution. Using the root mean square of the horizontal magnetic variations, instead of the 3-hour K indices, we have calculated ?m indices with different time resolution down to 15 minutes. On another hand, the better spatial resolution is achieved by considering sector indices defined with respect to the Magnetic Local Time, the so called MLT sectorial indices. The properties of theses new indices will be presented. As an application, we will present their possible use in thermosphere modelling. We will also present how the ?m index brings new information in the study of the dynamic of the magnetosphere and of the inner magnetosphere.

5.3-2 AVAILABILITY OF THE PLANETARY GEOMAGNETIC INDICES Kp, Ap, Ap, Cp AND C9**Linthe, Hans-Joachim**

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Julius Bartels introduced in 1949 the planetary geomagnetic activity index Kp and the derived activity numbers ap, Ap, Cp and C9. These activity numbers were accepted by the IAGA as official measures to express the geomagnetic activity. The data series expand back to 1932. Kp and its derived numbers got a world wide usage in geomagnetic science. The 10 International Quietest and 5 Most Disturbed Days of every month are determined on the base of this index. The series of definitive indices is routinely updated twice a month on the web. A quick-look indices calculation runs automatically in order to meet the requests of a near real-time availability. The K numbers of the 13 Kp observatories are calculated on the basis of their minute values every 3 hours with a time delay of about 15 minutes. The Kp are calculated by means of the regular algorithm from these K numbers. The Kp, ap, Ap and Cp calculated this way are immediately provided on the web. The quick-look indices are replaced by the definitive numbers after their usual calculation every half month.

5.3-3 USAGE OF 2009 EXTREMELY QUIET GEOMAGNETIC DISTURBANCE LEVEL FOR ESTIMATION OF GEOMAGNETIC VARIATIONS AND GEOMAGNETIC ACTIVITY.**Levitin, Anatoly; Gromova, Lyudmila; Gromov, Sergey; Dremukhina, Lidija; Petrov, Valeriy***Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation (IZMIRAN)**vpetrov@izmiran.ru*

One of the key problems for investigation of geomagnetic variations and geomagnetic activity is a question of the selection of geomagnetic field quiet (undisturbed) level. We present a new technology of calculating the external geomagnetic field hourly amplitudes applicable for any hour and any day of the whole survey period of any observatory proceeding from the ground based magnetometer measurements. We use a periods of 2009, when solar and geomagnetic activity was extremely quiet, as reference level for other periods. The calculated reference values may be used to find the amplitudes of the most magneto-quiet hour (day, month and year) and the most magneto-disturbed one for the whole measurement period. These data allow to estimate and to draw maps of the recent geomagnetic activity and the activity during specific geophysical events in the past at any point on the Earth. As a measure of geomagnetic activity we suggest to use a square of deviation of magnetic field from above determined quiet level.

The possibility of using such method to obtain information about the level of geomagnetic activity will be discussed. On the basis of this method, you can build a map of the geomagnetic activity for the entire planet. Thus, there is a possibility to describe the past and current geomagnetic activity much more accurately than it is described today on the basis of the widely used indices AE(AU, AL), Kp, Dst, introduced more than half a century ago. A detailed description of the method for estimation of the local geomagnetic activity, its seasonal variations and calculation of Dst variation during the magnetic storms is presented.

5.3-4 GEOMAGNETIC SOLAR-QUIET (SQ) VARIATIONS: COMPARISON OF THE NCAR/TIE-GCM WITH GROUND MAGNETOMETER OBSERVATIONS FOR NOVEMBER 2009**Yamazaki, Yosuke; Richmond, Arthur D.; Maute, Astrid; Wu, Qian; the ULTIMA Group**

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The National Center for Atmospheric Research Thermosphere-Ionosphere-Electrodynamics General Circulation Model (NCAR/TIE-GCM) is one of the few upper atmosphere models that incorporate self-consistent electrodynamic. An accurate modeling of ionospheric electrodynamic is important in order to correctly describe and predict distributions of plasma and neutrals in the upper atmosphere. The intention of this study is to evaluate how well the TIE-GCM simulates electrodynamic fields. The TIE-GCM solves for ionospheric electric fields, currents, and resulting magnetic perturbations on the ground, which are known as Sq variations. One of the important model inputs is the distribution of atmospheric tides at the lower boundary(97 km), which imitates the effects of upward propagating tides. Simulations are run with various tidal inputs, and performance of the model is tested by comparing the Sq variations from the TIE-GCM with those globally observed by ground magnetometers for the period of 2009 November 3-7, when geomagnetic activity was extremely low (maximum Kp=1). Magnetometer data from over 100 stations are used for the comparison, including ULTIMA (Ultra Large Terrestrial International Magnetic Array) stations.

5.3-5 SUDDEN COMMENCEMENT PROPAGATION FROM SUN TO THE EARTH, A CASE STUDY ON THE 19 NOVEMBER 2007**Segarra, Antoni; Nosé, Masahito; Curto, Juan José; Araki, Toru**

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The aim of this study is to provide a complete observational scope of a sudden magnetic commencement (SC) event. We used an extensive dataset from different satellite spacecraft and from ground. We chose the event on the 19th

of November of 2007 because the availability of enough and well located satellites at that moment for our purpose. Thanks to that, we reported series of observational facts, when a SC happens, from specific parts of magnetosphere, difficult to be observed, as magnetosheath compression, magnetopause oscillations and different polarization on the geosynchronous orbit. We were able to obtain a global view of the traveling wave front identifying the effects on the whole magnetosphere. At ground, we could study the global distribution of the SC waveform. Finally, we compared these observational facts with those derived from theoretical models, having a good consistence with them.

5.3-6 BEHAVIOR OF PERMUTATION ENTROPY AND LARGE GEOMAGNETIC DISTURBANCES

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The Earth's magnetospheric dynamics in response to solar wind changes displays a very complex behavior, which is not simply related to the energy coupling with solar wind as shown by the wide literature on geomagnetic indices time series. In a preliminary work, based on a novel technique - the permutation entropy analysis - we noticed that this quantity seems to be very promising in detecting the changes of the Markovian character of Sym-H and Asy-H indices in coincidence with large geomagnetic storms. Here, we extend the previous permutation entropy analysis to a large set of events, including data of the Earth's magnetic field directly recorded at ground based observatories. The results are discussed in relation both to the occurrence of dynamical phase transitions at the onset of geomagnetic storms and to a possible application of this technique for forecasting purposes.

5.3-7 ISOLATED AND GROUPED GEOMAGNETIC STORMS DURING THE 23RD SOLAR CY

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The development of geomagnetic storms is controlled mainly by external heliospheric plasma and magnetic field parameters, which, in turn, are determined by conditions on the Sun. According to them there can be isolated, repeated, multiple, or turbulent disturbance of the magnetosphere. To reveal the statistics and external preconditioning of single and multiple perturbations of the magnetosphere, geomagnetic storms were analyzed using the extensive database APEV (<http://dbserv.sinp.msu.ru/apév/index.html>) during the 23rd cycle of solar activity, from which geomagnetic storms have been grouped in 227 events. Results are presented in histograms, graphs, tables, and empirical formulas for the total number of intensification in all events and depending on the different phases of development, the amplitude and duration of geomagnetic grouped storms. Most of geomagnetic storms are complex and characterized by the existence of one or more side-extrema before or after the main one. This is due mainly to the superposition of individual perturbations from the Sun, which closely following one another in the heliosphere, or the internal structure and dynamics of disturbances in the corona.

5.3-8 EXTREME SPACE WEATHER EVENTS AS SEEN IN THE HISTORICAL GEOMAGNET

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Extreme Space weather events as seen in the historical geomagnetic records at Colaba Observatory, India

Ground magnetic measurements provide an unique database in understanding space weather. The geomagnetic data from Colaba Magnetic Observatory (Geog. Long. 72°49'E, Lat. 18°5' N) consisted of systematic hourly eye observations using Grubb's magnetometer from 1847 to 1872 in continuation of the earlier series of observations at Colaba since 1841. The regular daily photographic records of the geomagnetic components are available since 1872 to 1905 from Colaba. Data reduction and analysis techniques evolved at various stages of data processing. The study also deals with some of the interesting storm events prior to 1900. The extreme space weather events recorded on Colaba observatory will be discussed. The Sun and interplanetary conditions will be estimated by comparing with space weather events of solar cycle 23.

5.3-9 LONG-TERM VARIATIONS OF SUBSTORM OCCURRENCE RATE ESTIMATED FROM GEOMAGNETIC OBSERVATIONS OVER 30 YEARS

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We study long-term variations of substorm occurrence rate over 30 years for 1983-2012 including solar cycle 22, 23, and 24. The substorm occurrence rate is evaluated by the number of Pi2 pulsations observed at 2100-0100 magnetic local time (MLT) at the Kakioka observatory (27.4 degrees of geomagnetic latitude, 208.8 degrees of geomagnetic longitude), which provides long-term and continuous digital recordings of geomagnetic field variations at 1-s resolution since 1983. We select Pi2 pulsations by an automated detection program. This program applies wavelet

analysis to the 1-s data and detects Pi2 pulsations with a peak-to-peak amplitude larger than 0.6 nT. The rate of successful detection is ~94% for 2100-0100 MLT according to Nosé *et al.* [1998] who describe details of the detection algorithm. The number of detected Pi2 pulsations is counted once every day to make daily number of Pi2 pulsations. To see solar activity, the daily F10.7 index is used.

Results show that no clear correlation appears between F10.7 index and the substorm occurrence rate (i.e., daily number of Pi2 pulsations), and the correlation coefficient (r) is as small as -0.25. This may be because the substorm occurrence rate is influenced by the amount of energy supplied from the solar wind to the magnetosphere. Even if favorable conditions for substorm triggering are set in the magnetosphere, no substorm will occur if there is no energy supply from the solar wind. This idea leads us to normalize the substorm occurrence rate by the amount of energy from the solar wind. The energy is estimated by a solar wind-magnetosphere coupling function proposed by Kan and Lee [1979]. The normalized substorm occurrence rate (i.e., daily number of Pi2 pulsations divided by the Kan and Lee's coupling function) is negatively correlated with the F10.7 index ($r \sim -0.56$). We interpret this result as that threshold for plasma instabilities that lead to substorm onset depends on ion composition in the plasma sheet, which is strongly controlled by the solar activity.

5.3-10 SUBSTORM IN PULSATIONS - EXPERIMENTS ON THE NORILSK MERIDIAN

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Substorm in irregular pulsations. Experiments on a network of stations of the Norilsk meridian. In this report we summarize the research results on irregular geomagnetic pulsations, based on material from experiments expeditions on the 160-th geomagnetic Norilsk meridian. During the period from 1973 to 2003 ISTP SB RAS conducted experiments on investigating the fine structure of magnetospheric substorm - 9 stations, located along 160 meridian in the latitude range 52-80 degrees, carried out a discontinuous monitoring of the variable magnetic field of the Earth, geomagnetic pulsations, auroras, and of the state of different atmospheric layers. By performing dedicated experiments, we were able to identify and investigate some new regularities in the morphology of this unique class of pulsations. The study revealed four main zones of observation of these pulsations: high-latitude, a latitude of a projection of a plasmopause on Earth surface, mid-latitude and near-equatorial.

In high latitudes, Pi have a primary source located in the auroral zone. These pulsations are caused by variations of currents during electrojet development. The source of such pulsations is located at the southern boundary of the auroral arc and undergoes latitude-longitude trends in time coincidence with the auroral dynamics.

The secondary source lies in the zone of plasmopause projection onto the ground and can be caused by the development of a global mode in the Earth's plasmasphere. Such pulsations have a global character of excitation in mid-latitudes, and their parameters (spectral composition, polarization, and amplitude) in the midnight sector of the magnetosphere depend on the latitude of substorm development.

In middle latitudes Pi pulsation excitement is supervised by an ionosphere F2-layer. The amplitude of these pulsations is minimal at minimum values of the rate of foF2 variation. This fact explains quite well the intensity attenuation or the rare observations of Pi2 pulsations in the morning and evening hours of local time.

In the near-equatorial region there occurs either an intensity enhancement of these pulsations or an attenuation. The amplification or attenuation of amplitude Pi2 (concerning mid-latitude Pi2) can be caused by the presence of one more source, or by the physical mechanism in ionosphere or magnetosphere, resulting to these effects.

5.3-11 USING GEOMAGNETIC OBSERVATORY DATA TO ASSESS THE GIC RISK TO THE SPANISH ENTIRE HIGH-VOLTAGE POWER NETWORK

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After the good results obtained from an assessment of geomagnetically induced currents (GICs) in a relatively small subset of the Spanish power transmission network, we now present the first attempt to assess the vulnerability across the entire Spanish system. We have started by only including the power grid at the voltage level of 400 kV, which contains around 170 substations, with their corresponding single or multiple transformers, and 300 transmission lines; but it might be extended to including the 220 kV, and even the 110 kV lines, if their detailed information becomes available. Preferred geomagnetic/geoelectric field directions in which the maximum GICs occur are automatically given from the grid model circuit. The geoelectric field that drives the GICs is derived with the assumption of plane wave geomagnetic variations and either a homogeneous or 1-D layered earth conductivity models. To assess the maximum expected GICs in each transformer as a consequence of extreme geomagnetic storms, post-event analysis of data from the Spanish geomagnetic observatories during either the 1989 Quebec or the 2003 Halloween storms are performed, although other episodes coincident with very abrupt storm onsets, which have proven to be more hazardous at these mid-latitudes, are analyzed as well. In addition, EBR digital geomagnetic data are used to know statistical occurrence probability values to derive the GIC risk at 100-year or 200-year return period scenarios.

5.3-12 **OBSERVATION OF THE IMPACT OF SPACE WEATHER AND CLIMATE AT GROUND LEVEL THROUGH COMBINED GEOMAGNETIC AND GEOELECTRIC FIELD MONITORING**

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In 2012 we started a program of routine, long-term, real-time geoelectric field monitoring at the three UK geomagnetic observatories, extending the role of the magnetic observatories in environmental research and monitoring. These geoelectric monitoring activities are now a part of the routine observatory operations and provide a valuable new data set for analysis of space weather impacts on technology. Real-time data can already be viewed at www.geomag.bgs.ac.uk/data_service/space_weather/geoelectric.html and obtained from the authors on request. Our aim is initially to validate Earth conductivity models used in studies of the geomagnetically induced current risk within the UK electrical transmission system and therefore to determine what changes are required to improve model accuracy in predicting GIC. At the same time our data, which will be collected over a number of years, will be available for general geophysical study of the British Isles.

We describe aspects of the observatory installation, data capture and its real-time communication. We also present an analysis of measured geoelectric field data in relation to observatory geomagnetic data and models currently in use for space weather risk assessment for the UK National Grid. The results demonstrate how space weather has impact at ground level by inducing a geoelectric field through rapid magnetic variations. This impact poses risks to various grounded infrastructure, such as power grids, pipelines and railways. By monitoring and analysing geomagnetic and geoelectric field data together over a number of years we intend to build a picture of the changing space weather and climate impact at ground level.

5.3-13 **RESPONSE OF THE HIGH LATITUDE MAGNETIC FIELD INTENSITY TO THE EXCEPTIONALLY HIGH SOLAR WIND STREAMS**

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The exceptionally high solar wind stream activity in 2003 caused a record intensity in the westward (substorm) auroral electrojet current, leading to a major reduction of the horizontal field at auroral latitudes and to a notable strengthening of the vertical geomagnetic field in both polar caps. This strengthening is clearly visible in the observatory annual means (OAM) as a significant deflection in the corresponding secular variation. The westward electrojet is enhanced also during the most quiet time of the strongest high speed stream (HSS) years. We show that at polar latitudes the effect of space currents upon the quiet time vertical component OAM (which mostly reflects the Earth's internal magnetic field) might be significant in the case of very intense HSS. A notable deflection also occurs during the strongest HSS years of the earlier solar cycles. The specific characteristics of electrojet under the extreme HSS conditions are discussed.

5.3-14 **SPATIAL DISTRIBUTION OF GEOMAGNETIC ACTIVITY AND ITS RELATION TO SOLAR WIND**

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Geomagnetic activity has been studied systematically since the mid-19th century. While there are numerous papers written on global geomagnetic activity, i.e., studies using standard global geomagnetic indices such as AE, Dst, aa and Kp/Ap, there are only few studies on the spatial structure of geomagnetic activity. This is rather surprising since it is obvious that there is more information included in a large set of local geomagnetic indices than in a single global index. In this paper we study the spatial distribution of geomagnetic activity in 1966-2009 using the hourly Ah indices at 27 magnetic observatories. By applying principal component analysis (PCA) we have found a spatial mode in geomagnetic activity, whose amplitude depends on the time fraction of corotating high speed streams (HSSs) in the solar wind. This shows that the spatial distribution of geomagnetic activity can provide new useful information on solar wind drivers, e.g., for space climate studies.

5.3-15 **INFLUENCE OF SOLAR WIND ELECTRIC FIELD DURING ODD-EVEN SOLAR CYCLE**

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Though semiannual variation of geomagnetic activity (GA) is well established, its cause is a long-standing problem. We suggested earlier a new mechanism for the variation to explain based on change of mutual orientation between large-scale electric field (E) in solar wind and geomagnetic moment (M) during annual and daily rotations of the Earth (Adv. Space Res, v. 47, 2011). Phase of the semiannual variation of GA is determined by annual variation

of the magnetic moment component M_y (GSE) caused by oscillations of the Earth's dipole at the YZ plane during its annual motion: maximal values at equinoxes and minimal ones at solstices. Amplitude of the variation is modulated by the solar wind electric field component $E_z = [V \times B_y]$. As the amplitude depends on E_z , natural step is to study the E_z influence on the amplitude of the variation. Since polarity of the interplanetary magnetic field (IMF) changes from solar cycle to solar cycle, we analyze periods of odd and even cycles. We take as our data base IMF B, solar wind velocity (V) at 1 a.u. near ecliptic plane for period of 1963-2007 (of cycles 20-23). We also use indices K_p (1932-2007). Our results show that semiannual variation of value E (with maxima near equinoxes) exists only for even cycles 20, 22; one is absent for odd cycles 21, 23. All values at the annual profiles of E are less for even cycles than for odd ones except on March, October. The largest relative differences between the E values for odd and even cycles are observed on July (~18%), November (15%) and May (8%) but the smallest differences are in March, October. Annual variation of the difference in K_p for odd and even solar cycles shows extrema: on March (~15%), May (~8%), July (15%) and November (~8%). So, the K_p difference on May, July and November can be explained by the E value differences near the same months. But the difference of K_p in March for even and odd cycles ~15% can not be explained by the E difference ~5%; a cause is efficiency of interaction. Our analysis shows: the highest V were near spiral angle of IMF $\theta \sim 330$ deg. ($B_y < 0$, $B_x > 0$) in 20 ($W_{max} = 111$) and 22 ($W_m = 158$) cycles. So, the even cycles give near-equal maxima of V for $B_y < 0$, sign of which is favorable for the effective dawn-dusk component of E to arise during first half of year. We show that the rise of the E peaks exactly in May, November is connected with orientation of IMF, E relative M : extrema of magnetic flux into polar caps occur during the months independent from sign of IMF. Analysis also shows that the K_p peak in July arises due to maximal southward component along M for the IMF with $B_y > 0$, $B_x < 0$ during year. Our analysis shows that this IMF sign is sign of global magnetic field of the sun during decline phases of the odd cycles that leads to rise of the effective E field, depending also on value of E (which is larger also for odd cycles).

5.3-16 GEOMAGNETIC VARIABILITY ANALYSIS USING HIERARCHICAL CLUSTERING

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A large amount of magnetic observatories is distributed, around the world, to cover in a wide way latitudinal and longitudinal the geomagnetic effects. Many of these observatories are chosen to compose dataset bases for the evaluation of geomagnetic indices, which comply with different physical purposes. This work analyzes the local and global geomagnetic variability taking into account data collected from all of those observatories. The goal is to identify patterns in the magnetic behavior in order to provide a better understanding of this behavior by choosing similar groupings of magnetic observatories for the geomagnetic indices. Not all the stations were selected due to some issues, such as, the availability and the quality of data, erroneous points in the database and the presence of gaps. We used a set of H-component magnetograms from 85 magnetic stations belonging to the INTERMAGNET network for the years 2000 and 2007. Those periods correspond respectively to a high and a low solar activity year. Furthermore, it was analyzed the 5 most quiet and disturbed days of each month in both years. Those days have been selected according to Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences. As methodology, a hierarchical clustering and corresponding dendrogram was evaluated using a minimum variance method based in a euclidean metric. The resultant dendrogram gave a set of clusters of geomagnetic stations divided into accordance with their similarity in behaviors. As a result, the observatories are characterized by presence or absence of similar oscillation patterns, allowing the improvement of the understanding of how those observatories could be grouped to provide in a better way to evaluate the traditional indices.

5.3-17 IMPACTS OF DEEP EARTH PROCESSES ON SPACE WEATHER CLIMATOLOGY

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The magnetic field from inside the Earth plays an important role in determining the long-term patterns in space weather. For example, it provides a shield against energetic charged particles that affect Earth-orbiting satellites and it influences magnetic field variations of origin external to the Earth. Concentrating on the era when we have direct measurements of the magnetic field from observatories, we look at influences that the changing internal field might have on some aspects of space weather.

The South Atlantic Anomaly (SAA) is a region spanning the southern Atlantic and South America where the Earth's magnetic field is at its weakest. In the SAA the field is about one third the strength of the field near the magnetic poles and this affects how close to the Earth energetic charged particles can reach. Additionally, the SAA is deepening with the minimum strength now 6% lower than it was at the start of the space age. The SAA affects the likelihood of satellite radiation damage in the region and also has an impact on radio propagation.

We then demonstrate that there is a developing inter-hemispheric difference in the internal field and investigate whether this is having any detectable effect on geomagnetic activity levels at medium to high latitudes as measured

by observatories. Changing geomagnetic activity levels would affect long-term trends in geomagnetically induced currents in ground-based conductors such as electricity distribution networks and pipelines.

5.3-18 **GEOEFFECTIVE SOLAR ACTIVITY BEFORE GEOMAGNETIC OBSERVATORY ERA. INSIGHTS FROM GLOBAL MODELS OF THE GEOMAGNETIC FIELD**

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It has been known for a long time that geomagnetic observatory annual means are contaminated by external effects, due to incomplete averaging out of the recorded geomagnetic activity. We show that the external contribution leaks into global main field models based (mainly) on ground observations (geomagnetic observatories and prior geomagnetic measurements taken during sea voyages). We assess its evolution in case of IGRF and gufm1 that cover long time spans (1900-2010 and respectively 1580-1980) and model it in terms of geomagnetic activity as described by aa, the longest time series geomagnetic index. The evolution of external effects in gufm1 can be traced to 1600, and provides valuable information on the geomagnetic activity prior to observatory era (~ 1870). Its magnitude is significant even during the Maunder Minimum of the solar activity.

5.3-19 **EMPIRICAL ORTHOGONAL FUNCTIONS USED IN DECADAL-SCALE MAGNETIC FIELD REANALYSIS**

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The Swarm satellite constellation, due for launch in 2013, will provide new measurements of the Earth's magnetic field of unparalleled precision. Induction studies to estimate the distribution of mantle conductivity are a key goal of the scientific mission of the constellation, so it is important that the spatial geometry of the long-period inducing fields be properly resolved.

The annual and semi-annual period fields originating from magnetospheric and ionospheric currents required to estimate mantle conductivity in the depth range 1,200 to 2,000 km are subject to large uncertainty since they overlap with the periods on which the core field also changes significantly. Currently, the spatial structure of the long-period external field is poorly resolved and is commonly assumed to be the P_1^0 solenoidal field term associated with the symmetric magnetospheric ring current.

We use a dataset, developed for the Swarm mission, of ground-based magnetic observatory hourly means in combination with a method called Empirical Orthogonal Functions (EOFs) in order to decompose the external magnetic field over a full 11-year solar cycle. EOFs can be used to infer patterns of maximum variance in a dataset, allowing us to assess the spatial and magnitude changes of dominant spatio-temporal patterns in the external magnetic field. Specifically, our focus is on isolating the spatial pattern associated with the long-period external field oscillations.

We find that the annual periodicity of the external magnetic fields is dominated by a P_2^0 term with additional spatial amplitude peaks at local noon, and between local dusk and midnight. The dominant pattern on shorter periods is a P_1^0 term. The temporal oscillations of both the P_2^0 and P_1^0 patterns exhibit a modulation with a period of the length of the solar cycle. The results of this study should be useful in fulfilling the planned mantle induction objectives of the Swarm mission.

5.3-44p **LONGITUDINAL SECTORIAL INDICES COMPARED WITH PLANETARY K INDEX**

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The planetary three-hour range K_p index was introduced by J. Bartels in 1949. K_p is the average of standardized K-index from 13 observatories between 44° and 60° northern or southern geomagnetic latitude: 11 of them are located in North America and Europe and 2 in Australia and New Zealand. Such a distribution of the K_p observatories results in a UT dependent statistical bias in the estimate of planetary geomagnetic activity, since the geomagnetic activity intensity varies with Local Time. In this paper, we took advantage of the recent developments on sectorial indices to better characterize the description of planetary geomagnetic activity provided by K_p .

5.3-45p THE AA INDEX VARIATIONS**Chambodut, Aude; Menvielle, Michel; Marchaudon, Aurélie; Lathuillère, Chantal; El-Lemdani Mazouz, Farida**

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The aa index represents the activity level at an invariant magnetic latitude of about 50°; it is derived using data from two nearly antipodal observatories. For each three-hour interval, K indices are measured at the two stations and converted back into amplitude (nT). The corresponding aa index is the weighted average of the so-obtained northern and southern amplitudes. aa index makes an homogeneous and continuous data series from 1869 onwards.

In this paper, we considered the whole aa data series and we investigated the influence of the main field variation on the observed aa variations.

5.3-46p ON SPACE CLIMATE FEATURES IN GEOMAGNETIC FIELD AND TERRESTRIAL CLIMATE**Dobrica, Venera; Demetrescu, Crisan**

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The space climate concerns the long-term change in the Sun and its effects in the heliosphere and upon the Earth, including the atmosphere and climate. In this study the temporal behavior of the Sun-Earth system is studied on long-term timescales such as Schwabe and Hale solar cycles (11-yr and 22-yr) based on annual means of measured solar, magnetospheric and terrestrial climate parameters. By simple filtering procedures (successive 11- and 22-year running averages and differences between them) we investigate the long-term solar, geomagnetic and climate variability, which are described by means of the sunspot number (R), the geomagnetic activity indices (aa, IDV, IHV), and, respectively, the mean surface air temperature (SAT) at local, regional and continental scales.

5.3-47p USAGE OF GROUND-BASED MAGNETOMETER DATA FOR THE CHARACTERISATION OF SPACE WEATHER EFFECTIVE ULF WAVES**Georgiou, Marina; Daglis, Ioannis; Balasis, Georgios; Papadimitriou, Constantinos; Tsinganos, Kanaris**

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Ground-based magnetometer data are used extensively in the FP7-Space funded project MAARBLE, which employs multi-spacecraft and ground-based monitoring of the geospace environment, in order to analyze and assess the physical mechanisms leading to radiation belt particle energization and loss. Radiation belt variations are a key process of space weather and the comprehensive understanding of the physical mechanisms driving these variations will enable their accurate forecasting. Radiation belt dynamics has direct impacts on spacecraft and on humans in space. Most satellites operate in regions where they can be exposed to intense fluxes of extremely energetic

radiation belt particles. In addition, the orbit of the International Space Station is such that the exposure of astronauts to relativistic radiation belt electrons is a serious concern. Consequently, understanding the radiation belt environment has important practical applications in the areas of spacecraft operations, spacecraft-system design, mission planning and astronaut safety.

The MAARBLE project pays particular attention to the characterization and role of ULF waves. A database containing properties of the waves is being created from both space and ground-measurements and will be made available to the scientific community. Furthermore, ground magnetic measurements are used to investigate the role of coherent ULF wave transport in outer radiation belt electron dynamics. This paper reports on the progress of the wave database and on selected case studies that shed light on the contribution of ULF wave transport to radiation belt dynamics. The work leading to this paper has received funding from the European Union's Seventh Framework Programme under grant agreement no. 284520 for the MAARBLE (Monitoring, Analyzing and Assessing Radiation Belt Energization and Loss) collaborative research project. This paper reflects only the author's view and the Union is not liable for any use that may be made of the information contained therein.

5.3-48p THE MAGNETIC STORM OF JULY 12 OF 2012 AND THE DIGITAL RECORDS OF THE PERMANENT MAGNETIC OBSERVATORIES IN THE SAMA REGION**Gianibelli, Julio César; Quaglino, Nicolás**

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Permanent Magnetic Observatories (PMO) that controls the South Atlantic Magnetic Anomaly (SAMA) show different features of the storm of 12 July 2013 not symmetric with respect to the magnetic equator. The characteristics of the energy, velocity, density and interplanetary magnetic field of the solar wind are shown as contribution to the

knowledge of aspects of the sun-earth connection that generate the effect of the storm. It is concluded that the PMO network in the SAMA Region must be extended to the knowledge of its evolution and its impact on the future geomagnetic storms.

Keywords: Magnetic Observatories, South Atlantic Magnetic Anomaly, Magnetic storms, Sun-Earth connection.

5.3-49p ON COUPLING BETWEEN MAIN GEOMAGNETIC FIELD AND TECTONIC PROCESSES

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On the base of the International Geomagnetic Reference Field (IGRF-10) model, Digital Tectonic Activity Map (DTAM-1), and the seismological NEIC catalogue (173477 events for 1973-2010 with ≥ 4.5) will be shown:

1. The strength of the main geomagnetic field is influenced, to some extent, by the strong earthquake occurrence. In particular, the IGRF-10 model shows that in the epicenter of a major $M=8.0$ earthquake in 1995 (19.060N; 104.210W) in the Mexican Manzanillo region, the strength of the main geomagnetic field systematically decreased from 42369 nT in 1980 to 41695 nT in 1994 with the mean change of about -48.1 nT per year. After the earthquake on October 9 1995, the decrease in geomagnetic field speeded up, and from 1995 to 2010, the mean change per year was -77.1 nT. In the epicenter of the major 2004 Sumatra earthquake (3.3N; 95.98E), the strength of the main geomagnetic field steadily increased from 41338 nT in 1980 to 41855 nT in 2004 with a mean change per year of about 21.6 nT. After the $M=9.1$ earthquake on December 26 2004, an increase in the geomagnetic field in this area slowed down: from 2005 to 2010, the mean change in geomagnetic field was only 4.7 nT per year.

2. Spatial scale distribution of seismicity at the globe is controlled to some extent by geometry of the main geomagnetic field. This becomes apparent when geomagnetic field components are analyzed using the geocentric solar magnetospheric (GSM) coordinate system. Earthquakes prefer occur in the regions where geomagnetic Z_{GSM} component reaches large positive value, that takes place at low and middle latitudes. In the areas of strongest seismicity, that takes place at low and mid latitudes in the eastern hemisphere, the Z_{GSM} values are largest compared to all other regions of the planet. The possible maximal magnitude of earthquake (M_{max}) has a linear dependence on the logarithm of absolute Z_{GSM} value in the epicenter.

3. At the global map of epicenters, the western and southern margins of now forming Somalian plate are not well defined by tracing earthquakes. Surprisingly, these margins become well defined by tracing earthquakes if one presents the map of epicenters in coordinates: geographic longitude geomagnetic inclination.

4. There is a geomagnetic conjugacy between certain tectonic structures. In particular, the middle ocean ridges located in the southern hemisphere along the boundary of the Antarctic tectonic plate are magnetically conjugate with the areas of junction of continental orogens and platforms in the northern hemisphere. Close magnetic conjugacy exists between southern boundary of the Nazca tectonic plate and northern boundaries of the Cocos and Caribbean plates.

Possible reasons for the observed effects and future research directions in this area will be discussed.

5.3-50p ANNUAL VARIATION OF GEOMETRIC CHARACTERISTICS OF INTERPLANETARY AND ELECTRIC FIELDS IN SOLAR WIND AND GEOMAGNETIC ACTIVITY

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We present results concerning different tilt angles of the interplanetary magnetic field (IMF) and the solar wind electric field (E) to ecliptic plane during year on basis of spaced measurements. Then we study how the annual variation of the angles in the different planes (GSE coordinate system) influences on annual variation of geomagnetic activity. We take as our data base interplanetary magnetic field (IMF), solar wind velocity (V) measured in the solar wind near ecliptic plane for period of 1963-2007. For the planetary geomagnetic activity to evaluate we use geomagnetic indexes of K_p (1932-2005) and Dst (1957-2005). We calculate such angles as: $U_e = \arctg(E_y/E_z)$, $U_{yx} = \arctg(B_y/B_x)$, $U_{zx} = \arctg(B_z/B_x)$ and others. Our analysis shows that the E vector is perpendicular to ecliptic plane on March and September (near equinoxes), but the E vector is inclined to ecliptic plane during the other months in year. Maximal angle of the tilt U_e is observed in May-June, which is twice larger than value U_e in December. The IMF lies at ecliptic field in April and October, but the IMF is inclined to ecliptic plane during the other months. In particular, the angle U_{zx} reaches its maximal values in June and December-January (near solstices). The annual variation of Dst follows the annual variation of U_e with the best correlation coefficient $C_c=0.78$; for annual variations of K_p and of U_e the correlation coefficient is worse: $C_c=0.62$. We also discuss the other results such as connection of the annual variation of Dst and the annual variation of density for magnetic field energy ($\sim B^2$) with peaks on February and November because sharp decrease of the tilt angle U_{zx} is observed just during these months. At last we discuss possible applications of our results to tasks of solar-terrestrial physics.

5.3-51p THE SYMMETRY OF MAGNETIC STORMS**McCreadie, Heather**

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A geomagnetic storm is defined by the enhancement of the ring current. However, the correlation between the upward motion of the equatorial ionosphere and the southward turning of the IMF is attributed to the penetration of the solar wind electric field into the low-latitude ionosphere (Huang *et al.* 2005). Tsurutani *et al.* (2008) ascribe the almost instantaneous response of the equatorial electrojet to changes in the electric field in the solar wind to prompt penetration of the solar wind electric field to equatorial latitudes. The penetration of electric fields from the polar regions to the equator is the Zeitgeist as inferred in the very popular book by Kelly 2009. However there is an alternative view. Vasyliunas (2001, 2005) stated that prompt penetration electric fields are not the transport mechanism of energy in the ionosphere. He suggests the ionosphere is driven by the magnetic tension force felt by magnetic field lines in the polar region. The initial motivation is purely to determine which of these views is more prevalent amongst the geomagnetic ground-based data. If it is assumed a geomagnetic storm is a symmetric event determined by the ring current enhancement then asymmetry in the storm induced magnetic fields should belong to asymmetry experienced in the prompt penetration electric fields. Does this asymmetry exist?

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The PC index has been introduced initially [Troshichev *et al.*, 1988] as a characteristic of the polar cap magnetic activity related to the geoeffective interplanetary electric field EKL which is determined by the formula of Kan and Lee [1979]. However, recent studies show that the implications are more significant: the PC index is an adequate proxy for the solar wind energy that entered into the magnetosphere. This property of the PC index can be used conveniently for space weather nowcasting. The PC index is derived by magnetic data from two near-pole magnetic observatories: Qaanaaq (former Thule) in Greenland at 86.5 deg. corrected geomagnetic (CGM) latitude, and Vostok in Antarctica at 83.4 CGM. Previously, PC indices for these two observatories were calculated in similar fashion, but differed in detail. A cooperation between AARI and DTU Space made it possible to implement identical procedures for the PCS and PCN index derivation.

The main requirements to the unified procedure are:

1. The PC index in any UT time is determined by the value of the polar cap magnetic activity caused by variations of the geoeffective solar wind impacting on the magnetosphere.
2. The value of the polar cap magnetic disturbance vector is counted from the level of the quiet daily geomagnetic field variation to eliminate the daily and seasonal variations of ionospheric conductivity caused by changes in solar UV irradiation.
3. The level of the quiet daily variation is determined with allowance for a solar sector structure to eliminate the long-term variations in interplanetary electric field related to the sector structure.
4. The PC index is statistically related to the value of the coupling function EKL, irrespective of UT time, season and point of observation; this requirement is fulfilled by the choice of an optimal angle for the polar cap magnetic disturbance vector, regression coefficients and smoothing parameters.
5. The PCN and PCS indices, which are calculated independently, should not show any regular daily variation

(i.e. dependence on UT-time) and they should be in close agreement with each other irrespective of season and UT time;

6. All parameters in the procedure for the PCN and PCS indices derivation are calculated with use of the same solar wind data (and the corresponding ground magnetic observations) for full cycle of solar activity (1997-2009);

7. The procedure is described in details, all parameters needed for the calculation of the index are tabulated and available to interested researchers.

8. AARI and DTU, which are responsible for the magnetic data from the Vostok and Qaanaaq stations, provide magnetic observations in agreement with IAGA and Intermagnet requirements.

9. Provisional sets of the PCN and PCS indices are calculated online for space weather monitoring and nowcasting, later they are checked and replaced, if necessary, by definitive sets of indices, corrected for possible outliers and gaps in the data.

5.4-2 **DIFFERENTIATION OF THE SOLAR WIND VARIATIONS EFFECTS IN THE POLAR CAP MAGNETIC ACTIVITY (PROBLEM OF LEVEL OF REFERENCE TO ACCOUNT THE MAGNETIC ACTIVITY VALUE)**

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The PC index was assigned to monitor effects of the solar wind fluctuations on the polar cap magnetic activity. In so doing, the parameters determining correlation between the coupling function EKL and magnetic activity Φ are justified for common (averaged) relationship between the polar cap magnetic activity and solar wind fluctuations. They are not intended for description of extraordinary relationships between EKL and Φ observed, for example, in course of irregular enhancements of the ionospheric conductance during the solar flares or while changing the IMF sector structure (SS).

The value of Φ can be considered as a measure of the cross-polar cap ionospheric electric field providing the ionospheric conductivity is invariant. In actuality, there are regular season and daily variations of the ionosphere conductivity, produced by the solar UV-irradiation. The seasonal variations are caused by the Earth movement around the Sun, the Earth's rotation axis being inclined to the Solar ecliptic. The daily variations are related to the Earth's daily rotation under the differently conducting ionosphere fixed relative to the Sun. As a result, each observatory elapses under the inhomogeneous ionosphere fixed relative to Sun, and the varying ionospheric conductivity related to the solar UV irradiation, affects the regular daily and seasonal variation of geomagnetic field. However, the quiet daily variation, so-called quiet day curve (QDC), has no relation to changes of the solar wind parameters and, therefore, it should be taken away.

Since SS sign changes with period from few to 14 days (depending on the solar activity, maximum or minimum, epoch) the mean value of magnetic field periodically increases or decreases with the same period. To put into use the common procedure of the PC calculation we need in these cases to include the mentioned effects into the quiet daily variation, which serves as a level of reference for counting the Φ value.

Along with the seasonal and the solar cycle variations, the QDC amplitude is modified on time scales less than a month following the solar activity fluctuations and sector structure alterations.

The applied methods of running SS and QDC calculation ensures the on-line determination of PC index even during the maximum solar activity epochs.

5.4-3 **PC INDEX AS A PROXY OF THE SOLAR WIND ENERGY THAT ENTERED INTO THE MAGNETOSPHERE THIS MOMENT**

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Space weather monitoring basically rests on data on the solar wind parameters measured outside of the magnetosphere. These parameters are used to derive a hypothetic coupling function, which is designed to monitor the solar wind geoefficiency and, correspondingly, the state of magnetosphere (i.e. space weather). The coupling function is determined as one or other combination of the solar wind parameters which provides the best correlation of function with the magnetosphere state, which is commonly evaluated either by magnetic activity in the auroral zone (AE index) or intensity of magnetic storm (Dst index). A number of coupling functions designed to monitor the solar wind geoefficiency is over 15 by now, but none of the functions is based on any experimental evidences of physical processes determining the solar wind-magnetosphere interaction. As a result, none of coupling functions is universal, i.e. suitable for adequate evaluation of quite different states of magnetosphere affected by the permanently varying solar wind.

Estimation of the solar wind energy coming into the magnetosphere seems to be more straightforward and reliable way to resolve the problem. In this paper we demonstrate that the PC index characterizing the polar cap magnetic activity appears as an adequate indicator of the solar wind energy that entered into the magnetosphere this

moment. Being calibrated for interplanetary electric field EKL [Kan and Lee, 1979], the PC index varies in conformity with the solar wind geoefficiency irrespective of UT time, season and point of observation. On the other hand, the following experimental facts make it clear that the PC index is steadily related to such space weather indicators, as AL and Dst indices:

- the substorm onsets are preceded and accompanied in all cases by the PC index growth;
- the substorms and storms start only if the PC index reaches the threshold value $\sim 2\text{mV/m}$;
- the substorm intensity and growth phase duration are determined by the PC growth rate;
- substorms and storms decay as soon as the PC index firmly falls below 1 mV/m ;
- the storm length is terminated by the duration of the period, for which $\text{PC} > 2\text{mV/m}$; the storm intensity is linearly related to the PC index averaged over the storm time interval;
- periodicity of saw-tooth substorms is determined by the duration of the PC growth phase and the PC decline phase;
- the substorms occurring under the northward IMF conditions are related to $\text{PC} \approx 2\text{ mV/m}$;
- the PC index adequately responds to impulses in the solar wind dynamic pressure.

Thus, the PC index is the most advantageous for the space weather monitoring and nowcasting.

5.4-4 SEMIANNUAL VARIATION OF PC-INDEX FOR NORTH AND SOUTH POLAR CAPS

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Though the semiannual variation of geomagnetic activity with peaks near equinoxes has long been established, its cause is open for discussion. We have suggested earlier a new mechanism for the variation to explain (Adv. Space Res, v. 47, 2011). Phase of the semiannual variation is determined by the annual variation of the geomagnetic moment component M_y (GSE) caused by sinusoidal oscillations of the moment M at the yz interaction plane during annual motion: extrema at equinoxes ($M_y < 0$ for the first half of year, $M_y > 0$ for the second one) and $M_y = 0$ at the solstices. Amplitude of the annual variation is modulated by the solar wind electric field $E_z = V B_y$. By the other words, annual variation of the M_y makes extrema at equinoxes that produces maxima of the dawn-dusk component $E_{mv} = V B_y M_y$ at the yz plane at spring equinox for toward polarity of the IMF ($B_y < 0$, $B_x > 0$) and at fall equinox for away one ($B_y > 0$, $B_x < 0$). It is logically to search for the semiannual variation of PC-index for north and south polar caps. As is known, the PC index is a measure of the strength of the solar wind electric field derived from magnetic variations measured at a single station near a magnetic pole. We use PC index of south cap P_s and north cap P_n , which we could get from the AARS www-page for years 1995, 1998. We also use data of the IMF B and wind velocity V measured at 1 a.u. near ecliptic plane for the same years. We show that mean value of $E \sim 1\text{ mV/m}$ and mean IMF described by Parker's spiral lies at ecliptic plane. The semiannual variations of both P_n and P_s does not differ from ones of the other indexes (K_p , AA , Dst): smoothed maxima near equinoxes and minima near solstices. As for the other indexes, the spring equinox peak is higher than the fall equinox one. We also obtained annual variations of P_s and P_n for various signs of B_y . We show that the semiannual variation of both P_n and P_s is determined by the B_y component. Both P_n and P_s has peak in February-May during the first half of year for $B_y < 0$, the peak in August-October during the second half one for $B_y > 0$. The same phase of the semiannual variations of all the indexes is explained by the semiannual variation of the effective dawn-dusk E_{mv} component, which does not depend from ionosphere conductivity and terrestrial induction effects. This E_{mv} variation in turn is caused by the variation of mutual orientation of large-scale electric field $E = [V \times B]$ and magnetic moment M in the interaction plane during annual motion of the Earth. The well-known measurements on the balloons showed also the evident dependence of the polar cap electric field on both B_z and B_y IMF. Our results show clearly that PC-index contains significant part of the electric field E_z caused by the B_y IMF that leads to the final result of the PC dependence on season. We hope for our results to be favor further elaboration of the useful PC index, and the aim of the authors to create an index independent on season will be realized.

5.4-35p SIMILAR INTERDECADAL EVOLUTION OF MAGNETOSPHERE AND IONOSPHERE CURRENT SYSTEMS AS SEEN IN GEOMAGNETIC INDICES, PC INCLUDED

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We compare the evolution of several magnetospheric and ionospheric current systems at interannual and interdecadal timescales. A number of geomagnetic indices have been designed to describe this evolution and variability a consequence of the interaction of the solar wind and heliospheric magnetic field with the magnetosphere and ionosphere. The correlation comparison of several indices that show common long-term behavior (aa , AE , Dst), characterized by solar activity signature at Hale and Gleissberg timescales, includes the PC index, a proxy for the electric field and convection in the polar ionosphere. An attempt is made to reconstruct these indices back to 1870.

5.4-36p SOFTWARE FOR THE PC CALCULATION, THE DATA EXCHANGE AND PRESENTATION

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The package of programs was elaborated to derive a proper PC index. The package contains programs for calculation of definitive PC index as well as programs for derivation of index in a real-time. All the programs are written on Matlab programming language and are assigned to operate with relational database management system MySQL.

The programs have been thoroughly tested and implemented in AARI for calculation of the PCS index and in DTU Space for calculation of the PCN index. The same software and data handling were applied in the both institutes.

The main package of the programs includes 4 blocks, as follows:

1. preparation of data for derivation of coefficients and PC index;
2. calculation of the quiet daily variation (QDC) with allowance for solar sector;
3. derivation of coefficients with use of QDC as level of reference;
4. calculation of the certain PC index with use of the certain QDC as level of reference.

Moreover, there are technical programs for the data handling, for the index exchange and for index presentation which are also implemented in the unified form in both institutes.

The paper provides a relevant supporting material explaining the procedure for computation of the PCN and PCS indices.

5.4-37p METHODOLOGICAL BACKGROUND FOR THE PC INDEX DERIVATION

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The PC index derivation is based on several sets of coefficients. Together with the procedures for their determination they have to be documented to assure reproducibility. The angle coefficient is intended to align the horizontal projection of magnetic disturbance to the cross-polar current system produced driven by the geoeffective interplanetary electric field EKL. The other two coefficients are coefficients of linear regression which relate the EKL value with the magnitude of the magnetic disturbance produced by the cross-polar current system. The values of optimal angle and regression coefficients (slope and intersection) have been derived for each minute of each day during the year. Every coefficient is, however, obtained as an averaged quantity from all years in the solar circle (1997-2009). There are two sets of PC indices, one for the northern polar cap (PCN) and one for the southern polar cap (PCS) based on magnetic time series from the station Qaanaaq (Greenland) and the station Vostok (Antarctica). The magnetic data from Qaanaaq (THL) are handled by DTU Space (Denmark) while the magnetic data from Vostok (VOS) are handled by AARI (Russia). Before derivation of the definitive PCN and PCS indices, the magnetic data from both stations are subjected to comprehensive control and verification according to INTERMAGNET standards. The paper gives the description of the unified procedures for the data handling and of the PC index derivation adopted by DTU Space and AARI.

5.4-38p SOLAR UV IRRADIATION AND SOLAR WIND EFFECTS IN THE POLAR CAP MAGNETIC ACTIVITY (PC INDEX): DISTINCTIVE FEATURES OF THE LAST CYCLE OF SOLAR ACTIVITY.

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The PC index has been introduced [Troshichev *et al.*, 1988] as a characteristic of the polar cap magnetic activity induced by the solar wind - magnetosphere coupling. PC index is calculated independently for northern (PCN) and southern (PCS) hemispheres by magnetic data from two near-pole magnetic observatories: Thule (now Qaanaaq) in Greenland at 86.5° corrected geomagnetic (CGM) latitude, and Vostok in Antarctica at 78.4°. The magnitude of the polar cap magnetic activity is counted from level of the quiet daily geomagnetic field variation (QDC) to make allowance for the ionospheric conductivity changes caused by variable solar UV irradiation. The PC index at any instant is determined as a corresponding value of the magnetic activity calibrated for interplanetary electric field EKL [Kan and Lee, 1979] through a series of statistically justified regression coefficients. As a result, PC index turns out to be conforming to the geoeffective field EKL irrespective of UT time, season and point of observation. The recent studies showed that the PC index acts as an adequate proxy of the solar wind energy that entered into the magnetosphere. In this quality the PC index is useful for the space weather monitoring and nowcasting.

Two sets of 1-min indices (PCN and PCS) and corresponding QDC values have been calculated for every day of the last cycle of solar activity (1998-2012). The daily mean QDC were examined to estimate the effect of the solar

UV irradiation and its behavior in course of the last solar cycle, the daily mean PC quantities were analyzed to estimate the solar wind effect and its changes in different epochs of solar activity. Results of the analysis are compared with other evidences on crucial changes of the UV irradiation and the solar wind parameters during last minimum of solar activity (2009-2010).

SESSION 5.5

THE USE OF GEOMAGNETIC OBSERVATIONS IN CONJUNCTION WITH LIDAR, RADAR AND OTHER MEASUREMENTS FOR IONOSPHERIC STUDIES

5.5-1 ASSIMILATIVE MAPPING OF IONOSPHERIC ELECTRODYNAMICS USING GEOMAGNETIC DATA AND OTHER GROUND- AND SPACE-BASED MEASUREMENTS

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Because the ionosphere and magnetosphere are intrinsically coupled via magnetic field lines, distributions of ionospheric convection, electric currents, and auroral energetic particle precipitation are determined by several magnetospheric processes, such as the location and rate of magnetic reconnection along the dayside magnetopause and in the magnetotail, and the energization and dissipation of magnetospheric plasmas. Ground magnetometers provide continuous monitoring of magnetic perturbations as a result of ionosphere-magnetosphere coupling. This paper describes the utility of the Assimilative Mapping of Ionospheric Electrodynamics (AMIE) procedure in obtaining snapshots of global ionospheric convection, currents, and other related physical quantities by synthesizing various ground- and space-based measurements, including a world-wide network of magnetometers, incoherent and coherent high-frequency radar, and satellite in-situ observations of electric and magnetic fields. Examples from selected event studies will be presented to illustrate the importance of ground magnetometers to space science.

5.5-2 INVERSE PROCEDURES FOR HIGH-LATITUDE IONOSPHERIC ELECTRODYNAMICS IN A NEW ERA OF GLOBAL SPACE- AND GROUND-BASED INSTRUMENTATION

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5.5-3 PENETRATION OF LONG-DURATION CONVECTION/OVERSHIELDING ELECTRIC FIELDS TO EQUATORIAL LATITUDES DURING MAGNETIC STORM PERIODS AND THEIR EFFECTS ON F REGION IONOSPHERE

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The magnetospheric convection electric field produced by the solar wind magnetosphere interaction with southward IMF is transmitted to the polar ionosphere along the magnetic field lines, And further penetrates deep into the low latitude ionosphere and to the inner magnetosphere. The penetrated electric field drives DP2 ionospheric currents with enhanced amplitude at the dayside geomagnetic equator, Which also enhances the electron density in the low latitude ionosphere. On the other hand, The low latitude ionosphere tends to be shielded from the convection electric field, And the electric field often reverses its direction when the IMF turns northward. From the electric current point of view, The Region-1 and -2 field-aligned currents flow into the equatorial ionosphere through the polar ionosphere, Resulting in DP2 (intensification of the EEJ) Or reversed DP2 (CEJ) When the R1 or R2 FACs are dominant. During a geomagnetic storm, DP2 currents dominate during the main phase, While CEJ tends to occur in the beginning of the recovery phase. The convection electric field is often observed in the inner magnetosphere during major geomagnetic storms, Which suggests a tight electromagnetic coupling between the low latitude ionosphere and the inner magnetosphere. The reversed electric field associated with the equatorial CEJ may play a role in reducing the ring current during the recovery phase. The long duration of convection and overshielding electric field exists for some long hours with prolonged southward IMF Bz during the main and recovery phase of storm. The long penetration electric fields are not estimated well with modeling and simulations. The time scales of long duration overshielding and convection electric fields will be studied for some complex magnetic storms using ground magnetic data from Indian and Japanese sectors and try to evolve the importance of the substorm occurrence during storm main phase.

5.5-4 THE EQUATORIAL F-REGION DYNAMO: ITS DEPENDENCE ON ZONAL WIND AND PLASMA DRIFT

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The concept of an equatorial F-region dynamo has first been proposed by Rishbeth (1971). Decades later comprehensive studies of F-region dynamo currents as a function of season, local time, geographic longitude, and solar activity has been presented by Lühr and Maus (2006) and Park et al. (2010) based on magnetic field observations from the CHAMP satellite. The intensity of the vertical current generated by the F region wind dynamo is deduced from the bipolar variation of the zonal magnetic field component when the satellite passes the magnetic equator. The current flows downward during daytime and upward in the evening, with a polarity switch occurring around 16h MLT. During June solstice months the current density is significantly reduced compared to other seasons.

In a subsequent study the role of zonal plasma drift for the vertical F region current has been investigated. This quantity is estimated from a combination of electron/neutral density, wind and magnetic field observations by CHAMP. ROCSAT-1 data are used for validating the plasma drift estimates. Investigations reveal that the plasma drifts in the same direction as the wind, but it drives vertical currents in the opposite direction of that caused by the wind. Since the effect of the wind is always larger than that of the plasma drift, the relatively small net F region current is determined by the wind direction; downward currents are caused by westward winds and upward currents by eastward winds.

Sudden Stratospheric Warming (SSW) events are known to change significantly the dynamics of the equatorial ionosphere. For the SSW event of December 2001 we have studied the behavior of the daytime equatorial F-region current. Of particular interest was the enhancement of lunar tidal effects on the two independent drivers that contribute to the F-region vertical current: thermospheric zonal wind (F-region dynamo) and vertical electric field (E-region dynamo). The thermospheric zonal wind, as observed by CHAMP, is modulated by the lunar tide in a similar way as the F-region vertical current. The vertical electric field also shows a lunital modulation but at a different phase. From the observed phase delays we conclude that the F-region vertical current during an SSW event is not only modulated by the lunital variation of the thermospheric wind but also by the variations of the E-region electric field and the F-region plasma density distribution.

5.5-5 BAROMETRIC AND MAGNETIC OBSERVATIONS OF VERTICAL ACOUSTIC RESONANCE AND RESULTANT GENERATION OF FIELD-ALIGNED CURRENT

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Evidences where the excitation of vertical acoustic resonance between ground and ionosphere and resultant generation of field-aligned current just after the earthquakes are shown. In the two inland earthquakes, barometric observations very close to the epicenters (i.e., only 30km apart) were available, and they showed a sharp spectral peak which appeared around 260 seconds which is the period of theoretically expected fundamental mode of the resonance. On the other hand, the magnetic observations on the ground showed dominant period at 220-230 seconds which correspond to the first overtone among theoretically expected major resonance peaks. During the 2010 Chile earthquake, a long period magnetic oscillation in the east-west direction, which has the two major resonance periods at 265 and 190-195 seconds, was observed on the night side magnetic dip equator in Peru, where the distance is more than 2600km from the epicenter, under very quiet geomagnetic condition. The oscillation was interpreted as the effect of field-aligned current generated through dynamo process in the ionosphere over the epicenter caused by the resonance. Possible evidence of small scale field-aligned current generated by the lower atmospheric disturbances observed by the CHAMP satellite will be also shown.

5.5-6 SEASONAL VARIATION OF ATMOSPHERIC ELECTRICITY MEASURED AT MAITRI, ANTARCTICA

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Simultaneous and continuous measurement of atmospheric vertical electric field and air-earth current density made at a polar station, Maitri (70°45'52"S, 11044'03"E, 113m above mean sea level), at Antarctica since 1999. Global signals have previously been identified on atmospheric electricity measured at Maitri. This paper investigates seasonal variations of vertical electric field and current density as measured at the south polar station Maitri, and Vostok (78°27'52"S, 106°50'14"E, 3488 m AMSL), Antarctica between 2006 and 2009. The natural periodic

variations of fair weather electric field and vertical air-earth current at Maitri are compared with the periodic variations of electric field measured at Vostok, Antarctica and the measurements made during the Carnegie expeditions over the oceans where the global component of variations dominates over local component. The diurnal variations of electric field and vertical air-earth current well correlated with Carnegie curve as well Vostok, Antarctic vertical electric field. The diurnal variation of electric field range and amplitude at Maitri and Vostok station is more or less same for the year 2009, but, for the year 2006, the Maitri station vertical electric field is high as compared with Vostok station. This analysis supports the polar ionospheric current system over Maitri which is enhanced the vertical electric field and current density over Maitri during the year 2006 and for the year 2009 is extreme solar minimum year and the ionospheric current over Maitri could not enhance the measured atmospheric electrical parameters, the reasons discussed in detail in this paper.

5.5-7 EFFECT OF SOME ACTIVITIES IN THE IONOSPHERE ON GEOMAGNETIC FIELD

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The solar wind carries energetic charged particles that moves currents. Most activities in the upper atmosphere, particularly the ionosphere are triggered off by solar wind. This study is based on the variations observed in geomagnetic components caused by changes in the solar wind. The solar flare effects (SFEs) as well as geomagnetic storm effects (GMSEs) on geomagnetic field were considered. It was discovered that geomagnetic field was reduced by both SFEs and GMSEs. It was inferred that if this continues for many years, then, geomagnetic field that protects the earth from the solar wind will be destroyed. The implication is that, not only will the UV rays transcend on earth's inhabitant, but also might cause climate change. We suggest more future research work on this, for more robust result.

5.5-61p AURORAL PARTICLE PRECIPITATION EFFECT ON GEOELECTRIC FIELD IN SUB AURORAL REGION

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Surface measurements of the atmospheric electric field and current density have been made at the Indian station, Maitri (70°45'52"S, 11°44'3"E, 117 m above mean sea level), Antarctica for a decade. The vertical component (EZ) of the atmospheric electric field variations, measured at sub auroral (obs. Maitri) and auroral (obs. Vostok) stations in Southern Hemisphere under fair-weather conditions, have been analyzed. The strong effect of EZ increasing in the auroral station was found during the main phase of the moderate magnetic storms. The positive EZ increase peaked simultaneous with the night side particle precipitation over auroral ionosphere. The particle precipitation induced the ionospheric currents which change the downward vertical electric field to the ground. In terms of potential, the overhead ionospheric potential has more influence on EZ which again proves with analyzed the EZ with Weimer model and superDARN. But the polar station parameter does not show any kind of changes in EZ measurement. The observed effects could be interpreted as a result of the influence of the strong westward electrojet, due to the precipitation of charged particle from the inner magnetosphere, caused by substorm associated particle precipitation, to the global electrical circuit. This precipitation enhances the overhead ionospheric potential which causes the change in geoelectric field. The magnetosphere-ionosphere-atmosphere electric coupling to the atmospheric electricity is uniqueness of the individual stations. The mechanism will be discussed using ground based and satellite measurements in this paper.

5.5-62p MODERATE SEISMIC ACTIVITY IN KOYNA WARNA REGION OCCURRED ON 29TH...

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Since 2006, study of magnetic field fluctuations due to earthquakes have been started at Shivaji University, Kolhapur (India) using three axis ULF induction type magnetic sensors. The results of ULF electromagnetic signal observations in seismo-active regions, prior to earthquakes, are presented and discussed. We have considered one moderate earthquake (Magnitude=4.2) for the present study, which occurred in Koyna-Warna region of Maharashtra, India, on 29th July 2008 at 19:10:53 UT. For the study of these signals we have considered the frequency range from 0.01 Hz to 01 Hz. Suitable required data analysis methods like- Polarization Parameter, fractal analysis and wavelet analysis are used. This analysis gives detailed information about the possibilities of precursory signals due to weak earthquakes near the observation site. A variation in the polarization parameter during seismic events is discussed in the light of geomagnetic activities.

Keywords: -Ultra Low frequency; Earthquake precursors; Wavelet Analysis; Polarization parameter; Fractal Analysis.

SESSION 5.6**MODELLING AND INTERPRETATION OF LITHOSPHERIC MAGNETIC ANOMALIES****5.6-1 DIGITIZATION OF LOW-ALTITUDE PROJECT MAGNET DATA****Ishihara, Takemi; Catalán, Manuel; Maus, Stefan**

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Recent attempts to compile global magnetic data such as WDMAM revealed that many oceanic areas, particularly in the southern hemisphere, are inadequately covered by near-surface data. The Project Magnet program carried out by the U.S. Navy includes low-level surveys with altitudes of about 300 m or less, and could be some help to fill such data gaps. However, the Project Magnet CD-ROM published by the U.S. National Geophysical Data Center (NGDC) only includes digital data at five minute intervals, or with spacings of about 30 to 40 km. We are generating more detailed digital data for low-altitude total intensity data collected by the program between 1953 and 1967, by digitizing the analog microfilm images of magnetometer charts, which are also available at the NGDC. There are 663 analogue charts of flight legs that cover mainly oceanic areas globally. We plan to digitize all the track line data, and to obtain digital magnetic data at 30 second or shorter intervals from these analog data. The digitization method and some preliminary results on the digitized data from southern oceanic areas are presented.

5.6-2 IS THE LITHOSPHERIC MAGNETIC FIELD GLOBALLY SELF-SIMILAR ?**Thebault, Erwan; Vervelidou, F.**

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The magnetic field of the Earth's lithosphere arises from rock magnetization contrasts. This field can be described mathematically on a global scale in terms of spherical harmonics from a set of discrete magnetic field measurements. However, a priori information about the nature of the magnetic sources can also be set. In particular, the global crustal field can be assumed to be induced and generated by an equivalent layer of magnetic susceptibility values that vary laterally within a shell of constant thickness. This provides an alternate representation of the magnetic field. We exploit this dual representation and we propose a new theoretical expression for the horizontal spatial power spectrum of the crustal magnetic field for the spatial scales larger than 50 km. The theoretical form depends on three parameters which are the mean apparent susceptibility (or induced magnetization), the thickness of the shell, and a power law for the susceptibility. We fit the theoretical spectrum to the NGDC-720 lithospheric magnetic field model power spectrum that is based on airborne, marine, and satellite magnetic measurements. This comparison allows us to predict a mean global apparent susceptibility of 0.04 SI (or a mean induced magnetization of 0.42 ± 0.02 A/m), a mean magnetic crustal thickness of 26.5 ± 2.0 km, a magnetic field root mean square of about 220 nT at the Earth's mean radius, and a power law for the apparent susceptibility ranging between -1.26 and -1.34.

These values compare favorably to the values inferred from other independent geophysical data. The theoretical form allows us to discuss some statistical characteristics of the Earth's crustal field for wavelengths ranging from 50 to 2500 km. We extrapolate the behavior of the theoretical power spectrum to argue that the crustal field should not be self-similar at any spatial scale. We propose, however, that the crustal power spectrum in a log-log scale could look self-similar for wavelengths smaller than 50 km in regions of thick magnetic crustal thickness.

5.6-3 SPECTRAL AND SPATIAL DECOMPOSITION OF LITHOSPHERIC MAGNETIC FIELD MODELS USING SPHERICAL SLEPIAN FUNCTIONS**Beggan, Ciaran; Whaler, Kathy; Simons, Frederik**

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Global magnetic field models are typically expressed a spherical-harmonic expansion coefficients. Slepian functions are linear combinations of spherical harmonics that produce new basis functions which vanish approximately outside chosen geographical boundaries, but also remain orthogonal within the spatial region of interest. Hence, they are suitable for decomposing spherical-harmonic models into portions that have significant magnetic field strength only in selected areas. Slepian functions are spatio-spectrally concentrated, balancing spatial bias and spectral leakage. Here, we employ them as a basis to decompose the global lithospheric magnetic field models up to degree and order 100, into two distinct regions.

One of the resultant fields is concentrated within the ensemble of continental domains, and the other is localised over its complement, the oceans. Our procedure neatly divides the spectral power at each harmonic degree into two parts. The field over the continents dominates the overall crustal magnetic field, and each region has a distinct power spectral signature. The oceanic power spectrum is approximately flat, while that of the continental region shows increasing power as the spherical-harmonic degree increases. We also compare our results to power spectra from forward models of the ocean lithospheric derived from magnetisation studies of Masterton *et al.* (2013).

5.6-4 ANALYSIS OF CRUSTAL MAGNETISATION IN CARTESIAN COORDINATES**Gubbins, David; Ivers, David**Univ. Leeds, Univ. Sydney
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Most of the short wavelength geomagnetic field is thought to originate from magnetised rocks in the uppermost 50 km of the Earth's crust and upper mantle. This magnetisation produces the potential magnetic field that we observe above the Earth's surface, but a large part of it produces a potential field only observable below the magnetised layer and a non-potential field that could only exist within an insulator. We previously deduced vector spherical harmonics that separate these 3 types of magnetisation and showed them to be complete and orthogonal. We expanded a vertically-averaged model of global magnetisation, based on the known geology, in these basis functions and showed that the major part, over 80%, produced no observable magnetic field at all. This obviously complicates inversion of magnetic field for magnetic structure because the null space for inversion is very large indeed.

Here we extend the analysis to Cartesian coordinates for application to small regions where the curvature of the Earth can be ignored, such as in most studies of mineral and hydrocarbon exploration. The vector harmonics are complete and orthogonal and have components that are combinations of solutions of Laplace's equation as before, this time involving exponentials instead of the spherical harmonics of the spherical case. We use this basis to expand some classical models of crustal magnetisation in an infinite domain and separate the magnetisation that produces external potential fields from those that do not. We further develop the formalism needed for a finite domain with periodic boundary conditions and show how it can be applied to realistic, vertically-averaged, models of crustal magnetisation. Both the periodic and the infinite cases require simple manipulations of Fourier Transforms of the magnetisation, and can therefore be implemented with minor changes to standard software.

5.6-5 AEROMAGNETIC EVIDENCE OF PLATE TECTONICS IN THE PRECAMBRIAN**Rajaram, Mita; Anand, S.P.**Indian Institute of Geomagnetism
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There is an ongoing debate whether plate tectonics was active during the Precambrian times and if its signatures can be deciphered. Recent studies over Peninsular India have discussed in detail a plate-tectonic model of subduction-collision-accretion for the evolution of the Palghat Cauvery shear zone and the Madurai block during the final stages of the amalgamation of the Gondwana supercontinent. We have analysed available reconnaissance scale aeromagnetic data over Peninsular India to understand the magnetic signatures of the Precambrian shield and suture zones there by throwing light on the tectonics of the region. Utilizing a combination of differential reduction to pole map, analytic signal, vertical and tilt derivative and upward continuation maps we are able to identify magnetic source distribution, tectonic elements, terrane boundaries, suture zones and metamorphic history of the region. Processes like metamorphism leave their signatures on the magnetic data; prograde granulites (charnockites) and retrograde eclogites are known to have high susceptibility. We find that mapped charnockites intruded by alkali plutons have higher magnetisation, as they have possibly undergone prograde metamorphism increasing their susceptibility, compared to the retrogressed charnockites. Our analysis is able to identify several West to East trending high amplitude magnetic anomalies with sources extending up to intermediate and deeper levels in the region from Palghat Cauvery shear to Achankovil shear. The magnetic high associated with Palghat Cauvery shear zone may represent the extruded high pressure-ultra high temperature metamorphic belt (granulites at shallow levels and retrogressed eclogites at deeper levels) formed as a result of subduction process. The East West highs within the Madurai block can be related to the linear belts of metamorphosed clastic sediments, BIF and mafic/ultramafic bodies resulting from the process of accretion. Thus the present study supports the subduction and accretionary process related to the formation of the Palghat Cauvery suture zone and Madurai block, respectively.

5.6-6 THE LITHOSPHERIC MAGNETIC FIELD ALONG THE PINGBA-LIJIANG PROFILE, CHINA**Yuan, Jiehao; Gu, Zuowen; Chen, Bin; Wang, Can; Wang, Lie**Institute of Geophysics, China Earthquake Administration; Anhui Earthquake Administration
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In order to research the lithospheric magnetic field and the magnetization structure, the geomagnetic field was surveyed along the Pingba-Lijiang profile with 800 km long in the Yunnan and Guizhou provinces in China. The distance between the adjacent geomagnetic sites is 5 km along the profile. The geomagnetic data were analyzed, and the lithospheric magnetic field was obtained. Using the upward continuation method, the geomagnetic anomalies in different depths were obtained: the basement anomaly, the upper crust anomaly and the superficial anomaly. Basing on these geomagnetic anomalies, the magnetization structure was obtained by using the software of the Model Vision. The preliminary results show: (1) The geomagnetic anomalies have good relationship with the local geological structure. (2) The magnetization structure is related to the RMS, the depth variation of the Curie interface, the values of the magnetic susceptibility, the seismic activity and the tectonic block. (3) There is a good relationship between the magnetization structure and the magneto-electric structure.

5.6-7 CRUSTAL STRUCTURE OF LAXMI RIDGE IN THE ARABIAN SEA**Nair, Nisha; Anand, S.P.; Rajaram, Mita**

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The satellite derived Free Air Gravity (FAG) anomaly map over the Indian offshore region depicts a high over the ridges; however, the Laxmi ridge in the Arabian Sea and the 85 E Ridge in the Bay of Bengal are associated with a low FAG anomaly. Several theories exist to explain this low FAG anomaly. We utilized Satellite derived FAG data and NGDC marine magnetic data constrained by bathymetry, available seismic profiles and isopach maps over the region to throw light on the structure and tectonics of the Laxmi ridge and derived 2D crustal structure of Laxmi Ridge by combined modeling of gravity and magnetic data. From analysis of the FAG and magnetic data and the generated models it is inferred that the gravity low associated with the Laxmi ridge is due to underplating. From a similar analysis of the gravity and magnetic data across 85 E ridge it was found that the gravity low (below 15°N) associated with the 85 E ridge was due to the sagging of the crust.

In the region around the Laxmi ridge - basin, we also used a modified form of Energy Spectrum Analysis termed Multi Window Technique where energy decay spectra are calculated over a series of increasingly larger windows centered over point of interest. Depth-Plateaus indicating nearly constant depth values for a range of window size corresponding to the approximate depth to the causative magnetic / gravity interface are thus determined. A horizon-skeleton map, representing depth-plateaus identified as the same interface, form a coarse image of the detected horizon. The Multi Window Technique was applied to satellite derived free air gravity anomaly data over the Laxmi Ridge to understand the crustal structure as well as to generate a 3D model. We have taken around 60 locations (point of interest) along the Laxmi ridge and window length ranging from 20km to 200km with varying window expansion increment. Four different depth-horizons were present at all locations. The horizon-skeleton map thus generated was compared with published seismic reflection / refraction profiles across the Laxmi ridge and it was found that top three horizons matched with the depth to the top of the sedimentary layers with velocity 3km/s, velocity 4km/s and depth to the top of the crust. The fourth and deepest horizon at an average depth of 24 km, is present throughout the axis of the ridge, suggests the thickened nature of the Laxmi ridge and matches with the Moho depth. Further, as we move towards Laxmi basin there is no evidence of underplating. Thus the 3D crustal model developed using Multi Window Technique depicting the structure of the crust and the four horizons is similar to our 2D crustal model of Laxmi Ridge. Results of this analysis will be presented.

5.6-8 HIGH RESOLUTION MAPPING OF MAGNETIC ANOMALIES OVER LA SOUFRIERE OF GUADELOUPE**Bouligand, Claire; Coutant, Olivier; Gibert, Dominique; Barnoud, Anne**

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The andesitic lava dome La Soufrière of Guadeloupe, formed during the 1530 AC eruption, is the most recent volcanic feature of the Guadeloupe Island. It is characterized by a strongly active hydrothermal system which weakens the volcano flanks and can endanger the island population. During the winter 2009, a ground magnetic survey was performed over the dome in order to detect possible magnetic anomalies associated with hydrothermal alteration and use these anomalies to assess the distribution of hydrothermal alteration in the subsurface of the dome. Ground magnetic measurements were performed using two overhauser magnetometers. One magnetometer was left at a fixed station to record diurnal variations of the magnetic intensity. A second magnetometer was used to acquire long magnetic profiles around, across, and at the top of the dome at an elevation of about two meter above the ground. As expected in a volcanic region, this survey displays many short-wavelength and large-amplitude magnetic anomalies, many of which are due to nearby topography of the highly magnetic volcanic terrain. In addition to these short-wavelength anomalies, long-wavelength anomalies are also observed. For instance, pronounced negative anomalies are observed at the top of the dome where pits and craters are located and over a portion of the La Ty fault located south of the dome. These anomalies suggest that volumes of non-magnetic or low-magnetization materials are present at depth. In order to discriminate between magnetic anomalies associated with topography or contrasts of magnetization, we compute magnetic anomalies associated with topography assuming the volcano is characterized by a constant magnetization. The computed magnetic anomalies are strongly correlated with observed anomalies and are used to estimate the magnetic properties within the volcanic dome.

5.6-9 THE 8 MA SUDDEN CHANGE IN SPREADING VELOCITY AT THE MID-ATLANTIC RIDGE**Miranda, Jorge Miguel; Luis, Joaquim; Baptista, Maria Ana**

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We use a new compilation of the magnetic field anomalies for the North Atlantic, between 30N and 70N, to compute two independent sets of finite rotation poles for the plate pairs Eurasia-North America and Nubia-North

America, based on the identification of chrons C2, C2a, C3, C3a, C4, C4a, C5 and C6 and the computation of new collection of finite rotation poles. We select a number of cross sections of the Mid-Atlantic ridge, where magnetic data are dense enough, and we study in detail the time variation of the average spreading velocities for the successive time periods, between C2-C2a and C5-C6, using the Euler finite rotation poles and checking the direct identification of magnetic chrons. We show that spreading velocity along the ridge had two different regimes during the last 20Ma where the spreading velocity was almost stable, separated by a sudden change. This change was larger at 30° N, decreasing in amplitude to the north, being close to zero south of Iceland. This plate wide change in spreading velocity had large influence on the evolution of the Eurasia-Nubia-North America triple junction. We discuss the use of outward displacements in the computation of the finite rotation poles and we show that the spreading velocities for the younger regime agree well with the global geophysical and geodetic models.

5.6-10 MAGNETIC SIGNATURE OF DEEP-SEA HYDROTHERMAL SITES

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Since the discovery of hydrothermal vents at mid-ocean ridge at the end of the 70s, detailed deep-sea exploration has been carried out in all oceans, revealing a variety of hydrothermal sites in terms of geological substratum, minerals, emitted fluids and ecosystems. This effort has been recently boosted by the increasing need of metals for the World economy, which makes foreseeable the exploitation of submarine massive sulfide deposits accumulated at hydrothermal sites in a near future. We present high resolution, near seafloor magnetic surveys carried out on several basalt-hosted and ultramafic-hosted hydrothermal sites. To this end, a magnetometer has been installed on deep-sea vehicles such as manned submersible Nautilie, remotely-operated vehicle (ROV) Victor, and autonomous underwater vehicle (AUV) AsterX of Ifremer. These surveys reveal various magnetic signatures. Basalt-hosted hydrothermal sites are characterized by a negative (reduced to the pole) anomaly indicating a reduced magnetization, as observed by previous workers. Two processes are often considered to explain this observation: thermal demagnetization of the basalt or alteration of the magnetic minerals. Our survey of the inactive hydrothermal site Krasnov suggests that the observed magnetic signature survives the end of hydrothermal activity and therefore alteration plays the dominant role. High-temperature ultramafic-hosted hydrothermal sites are characterized by either a positive magnetic anomaly, indicating a stronger magnetization, at the larger sites such as Rainbow and Ashadze 1, or by a lack of significant magnetic signature at the smaller sites, e.g. smoking craters such Logachev and Ashadze 2. Some measurements performed on rock samples suggest that the magnetic bearer is magnetite, which remains unaltered within sulfur-impregnated serpentinized peridotites. To conclude, high-resolution magnetic surveys may play an important role in deep-sea hydrothermal and mineral explorations, to detect and characterize active and fossil hydrothermal sites and evaluate their mining potential.

5.6-11 ROCK MAGNETIC INVESTIGATION OF DEEP SEAFLOOR DRILLING CORE SAMPLES RECOVERED FROM THE PACMANUS HYDROTHERMAL VENT FIELD IN PAPUA NEW GUINEA

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The active PACMANUS hydrothermal vent field in the Eastern Manus back-arc basin, Papua New Guinea, has long been considered as a modern-day analog of massive volcanogenic sulfide deposits within felsic volcanic sequence and was drilled in November-December 2003 by Ocean Drilling Program Leg 193. The recovery was generally low with less than 15% due to fragility of near-surface rocks. Rock magnetic measurements and scanning electron microscope (SEM) observations were performed on samples from three major sites (Sites 1188, 1189 and 1191). Site 1188, a low-temperature diffused venting region also known as the Snow Cap, was drilled to 370 mbsf. Site 1189, a black smoker region referred to as the Roman Ruins, was drilled to a depth of 200 mbsf using rotary core barrel system. The recovered rock samples have inclination close to the present-day Earth field of -7 degrees, but those near the seafloor exhibit much steeper inclination of up to 25 degrees. The upper 35 m of the sites consists of fresh to moderately altered dacite-rhyodacite, which displays moderately high natural remanent magnetization (< 6 A/m). The region below this extrusive layer largely comprises of pervasively altered rocks with little evidence of sulfide deposit and as a whole shows a low magnetization intensity. However, two intervals with extremely high remanent magnetization were discovered below the upper extrusive layer at Site 1188 (135-211 mbsf and 280-370 mbsf) and one interval at Site 1189 (137-190 mbsf). In particular, the samples between 135-211-mbsf interval at Site 1188 have extremely high remanence with intensities ranging up to 300-500 A/m. SEM analysis reveals that the magnetic carriers in these rock samples are composed of moderate-size magnetites which themselves are divided into numerous small grains of a few microns or less in size. It is possible that these individual grains represent single magnetic domain crystals and thus exhibit high magnetization intensity as a collection. Although pockets of magnetite are not uncommon in the ancient hydrothermal ore bodies, they have seldom been documented in modern-day system, and little is known about the physical and chemical condition that allows the magnetite to form

in hydrothermal vent systems. A number of mechanisms of high-intensity magnetite formation are explored including the possibility that: (1) these magnetites precipitated from magnetite-rich fluid as it rapidly cooled from above the Curie temperature (TRM); (2) magnetization was acquired by the growth of magnetite grains below the Curie temperature (CRM); and (3) replacement of certain cations within titanomagnetite or hematite during alterations.

5.6-39p WDMAM VERSION 2: A NEW GLOBAL MAGNETIC ANOMALY MAP OVER THE OCEANS
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In this study we present a candidate model over the oceans for the second version of the World Digital Magnetic Anomaly Map (WDMAM). We complement the existing marine magnetic data by building a realistic model of the magnetic anomalies caused by seafloor spreading. In a first step, we compute magnetization vectors using the age map of the ocean floor, the relative plate motions and apparent geomagnetic path for Africa, a geomagnetic reversal time scale, and simple hypotheses on the magnetized sources - a flat, 1 km-thick layer bearing a 10 A/m magnetization. Adding a present-day geomagnetic field model allows the forward modeling of magnetic anomalies on a spherical Earth at an altitude of 5 km. In a second step, we adjust this model to the existing marine magnetic anomaly data, in order to make it consistent with these data. To do so, we extract synthetic magnetic along the ship tracks for which real data are available, and we compare quantitatively the measured and computed anomalies on 100, 200 or 400 km-long sliding windows (depending the spreading rate). Among the possible comparison criteria, we discard the maximal range - too dependent on local values - and the correlation and coherency - the geographical adjustment between model and data being too approximative - to favor the standard deviation around the mean value. The ratio between the standard deviations of data and model on each sliding window represent an estimate of the magnetization ratio at the origin of the anomalies, i.e. after division by the magnetization of 10 A/m used in the model, an estimate of the equivalent magnetization under the considered magnetized source geometry. Beyond the scientific interest of the obtained equivalent magnetization at global scale, and as a third step, we interpolate the ratio of standard deviations to the whole oceanic domain and multiply it to the magnetic anomaly model in order to adjust it at best to the available data. As a fourth and final step, we superimpose the available data to this realistic model and obtain a global map of magnetic anomalies over the oceans.

5.6-40p MARINE MAGNETIC ANOMALY AND MAGNETIZATION OF SUBDUCTING PACIFIC PLATE AROUND THE JAPAN TRENCH

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We studied marine magnetic anomaly in the northwestern margin of the Pacific Plate off Japan to examine whether the magnetic anomaly varies due to tectonic phenomenon caused by the plate subduction. For the sake of this study, we newly collected magnetic data aboard JAMSTEC cruises in the seaward area where was sparsely surveyed, and made a magnetic anomaly map by compilation of our data, data published by Geological Survey of Japan, and data from NGDC. The seafloor has a series of parallel magnetic anomalies (Japanese Lineation Set) during M11-M7 (135-127 Ma). The anomalies are well lineated and have high-amplitudes of ~500-1000 nT peak-to-trough on the seaward slope of the Japan Trench. The amplitudes of anomalies gradually decay to the landward from the trench axis associated with the plate subduction.

Equivalent magnetization was calculated from the magnetic anomaly to correct for effects of increasing depth of subducting plate and seafloor topography. Densely distributed seismic survey profiles enabled us to constrain the depth of the plate. On the seaward trench slope from the trench axis to a distance of ca. 100 km, horst-graben structure is developed and large steps grow associated with plate bending and normal faulting. At the location, the magnetization is not influenced apparently, however this tectonics is some kind of destruction and mechanical disorganization of the magnetic layer by faulting. The magnetization gradually decreases as the plate subduction proceeded. The apparent decay could reflect destruction and mechanical disorganization and/or chemical demagnetization of the topmost part of the oceanic crust along the plate boundary. The magnetization in reverse polarity decays larger than that in normal polarity. The result is indicative of reduction of remanence in the oceanic crust and induced magnetization possibly due to serpentinized uppermost mantle.

5.6-41p THE TECTONIC FRAMEWORK OF THE AFRICAN PLATE ILLUSTRATED BY POTENTIAL FIELD DATA

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The African continent preserves a diversity of tectonic provinces, from ancient Archaean cratons to recent rifted areas like the East African Rift system, and is surrounded by oceanic crust of Jurassic to Present day ages. Large areas of the African continent are not accessible or simply not mapped in detail, which makes difficult to make regional tectonic interpretations and models. In order to make a consistent first order interpretation of the African's tectonic provinces we assemble a set of multi-scale magnetic data by combining satellite and some available ground and airborne/shipborne data.

Detailed studies of the main tectonic structures linked to the southern branch of the East African Rift as well as regions in the Northern and Southern Africa are presented in the light of new magnetic data. Major magnetic field anomalies are compared with gravity anomalies provided by the recently published World Gravity Map. Finally, we discuss how the potential fields reflect the geodynamics of the African plate and its evolution.

5.6-42p MAGNETIC STUDY OF THE CHALCO BASIN INSIDE THE URBAN AREA MEXICO CITY.

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The Instituto de Geofísica of the Universidad Nacional Autónoma de México (UNAM) is performing several studies using potential methods in order to determine the deep of the local basement in the basin of Chalco, this will support a drilling project in order to acquire information about the thickness of the sedimentary sequence for its analysis.

Initially the proposed zone for the acquisition of the data is located southeast of Mexico City between Tlahuac and the municipality of Chalco (Estado de México) in the coordinates -98.977° and -98.956° of longitude and 19.2447° and 19.2572° of latitude.

Gravimetric and magnetometric surveys were carried out during May 19 and 20, 2012. After the proper corrections, a magnetic anomaly map that shows a well defined decrease in the intensity of the magnetic field in the north-northeast direction was obtained. From a physical point of view, this means that the source of the anomaly (in this case the basement of the basin), is shallower in the southern part of the zone.

Secondly these data were processed with a reduction to pole (RTP) filter to build up a map that shows the anomalies directly over the source. This map shows the presence of a body with a positive magnetic susceptibility.

Five profiles were projected over the anomaly and RTP maps to make 2D inversions and determine the deep of the basement based on Talwani (1965). In general the inversions show the deep of the basement ranging from 150 meters in the shallowest parts to about 450 meters in the deepest regions which corresponds to the northeastern part of the zone as mentioned before.

The models obtained from these inversions also show the presence of intrusive bodies causing anomalies in the upper part of the confined aquifer (Campos, 1994).

Two main conclusions were obtained: The basin tends to go deeper to the North-Northeast direction of the area. The shallow bodies extend in the zone between the confined aquifer and the aquitard. This can contribute to establish one or more drilling sites where this kind of obstacles won't represent a problem to obtain the most deep sedimentary sequence.

5.6-43p INTERPRETATION ON DEPTH INTEGRATED MAGNETIZATION OF THE FENNOSCANDIAN AND BRAZILIAN SHIELDS

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The growth and reconstruction of mutual movement of the Fennoscandian and Brazilian shields is outlined between 2200 and 600 Ma ago, based on distribution of the depth integrated magnetization calculated from World Digital Magnetic Anomal Map (WDMAM). The reconstruction supports the SAMBA hypothesis on joint evolution of both shield areas during the Proterozoic Eon.

5.6-44p POST PROCESSING SCHEME FOR MODELING THE LITHOSPHERIC MAGNETIC FIELD FROM SATELLITE DATA

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We derived a model for the noise appearing in lithospheric magnetic field models obtained from satellite data. The noise model is developed for the case where three component vector magnetic data, acquired from a nearly polar orbiting satellite, are used. This case is relevant for e.g CHAMP satellite data. We show that the noise from internal or external origin cannot be distinguished, and that the lithospheric field model is contaminated at all wavelengths. The noise model is non-linear but it requires only few parameters to describe the noise at relatively high spherical harmonic degrees. We used this noise model in a post-processing scheme to improve a lithospheric field model derived

from the full CHAMP satellite data set to SH degree 120. The approach stands as an alternative to the well known along track filtering technique. It can be easily extended to models derived from the three components of magnetic data or from data acquired on other terrestrial planets.

5.6-45p THE ACCURACY AND APPLICATION OF EMM2010 IN CHINA

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In order to research the application of the Enhanced Magnetic Model for 2010 (EMM2010) in China, the accurate data of 1334 groups are analyzed quantitatively, including the geomagnetic total intensity, the geomagnetic declination and the geomagnetic inclination at 1302 sites and 32 observatories in China. Through analyzing and comparing the geomagnetic 7 elements, the differences between the geomagnetic observation values and the corresponding EMM2010 calculation values in China, and the standard deviation are obtained. The results show that while the truncation order for EMM2010 increases, the corresponding decreases. When $n=720$, the ΔT , ΔD , ΔI is 10.44%, 7.83%, 126.89 respectively. Among the various regions in China, ΔT is larger in the Northeast China, the North China and the Xinjiang autonomous regions of China; The mean value of ΔT for $n=720$ in these three regions is 13.07%, 8.90%, 139.57 respectively. While ΔD is smaller in the South China, Tibet plateau and its east regions; The mean value of ΔD for $n=720$ is 7.07%, 6.65% and 82.43 respectively. The standard deviation of these differences is the estimated value of the errors for application of the EMM2010 in China. The errors of the EMM2010 are caused by the factors of the limited truncation order of the EMM2010, the geomagnetic anomaly condition in various regions of China, the errors of the geomagnetic observation data and so on. The results of comparing the EMM2010, the WMM2010 and the IGRF-11 show that the corresponding of the EMM2010 is the smallest. The main reason is that the EMM2010 includes not only the main geomagnetic field, but also the crust magnetic field and the lithospheric magnetic field. The example of the EMM2010 used in China shows that it can be used by a certain degree, but is limited. The EMM2010 can not calculate the geomagnetic field in China accurately. Therefore, it is necessary to study the geomagnetic field model with high accuracy for practical application.

5.6-46p A CANDIDATE FOR THE WDMAM VERSION 2

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We compiled a new version of the World Digital Magnetic Anomaly Map taking a particular care of the oceanic domains (see Choi *et al.*, this session). The data set has been completed by new marine and aeromagnetic data made available to the project by various institutions and scientists. The long-wavelengths have been adjusted to match models derived from satellite data. Two maps will be presented, one displaying the total field anomaly, the other one showing the origin of the data.

5.6-47p 3D SPACED 3 COMPONENT MAGNETIZATIONS USING VECTOR ANOMALIES MEASURED BY HPMS

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We have developed a High Precision Magnetic survey System (HPMS). HPMS can measure the Three Components of Geomagnetic Anomaly (TCGA) fields with high precision and reliability. The TCGA surveys have been conducted since 1970's, because the Total Intensity Anomaly (TIA) field, which has been used as common magnetic data, does not fit neither the Laplace's nor the Biot Savart's laws. This means that the analytical/physical form describing the relation between TIA and magnetization cannot be built (Isezaki and Matsuo, 2009). HPMS consists of high accuracy devices such as gyroscope, magnetometer, transponder for positioning, and so on. Furthermore, HPMS can be used on ATCM (Airborne Three Component Magnetometer), STCM (Shipboard Three Component Magnetometer), DTCM (Deep-tow Three Component Magnetometer) and VTCM (automatic underwater Vehicle Three Component Magnetometer). Therefore, the HPMS can be mounted on multi-platforms. We succeeded to measure the vector magnetic anomaly fields using DTCM, and also using VTCM despite the severe magnetic noises around the magnetometer sensors. The method of Isezaki(1984) works good to eliminate these noises. We got the very precise magnetization structure in the Bayonnaise submarine caldera area at the southern end of Izu island arc. Generally the magnetization changes very smoothly in each layer, however, intensity of 3 component magnetization decreases from the 1st layer to the 4th layer. The horizontal directions of magnetization show that they direct in various directions in the 1st layer, however, they are reorganized in some directions suggesting the influence of tectonic history in the 2nd and 3rd layers. The induced magnetization directed northward increases in deeper part of this region. The inversion method must be improved. we are starting to take care of the maximum likelihood method

using the Basian rule. We strongly recommend to carry out the magnetic survey using a three component magnetometer to get TF and TA which have many advantages for magnetic analyses (magnetization, upward continuation etc.) which cannot be done using scalar TIA.

5.6-48p LITHOSPHERE MAGNETIC ANOMALOUS AREAS AND EARTHQUAKE

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According to twice geomagnetic data at 215 survey sites measured in eastern area of Qinghai-Tibet plateau during 2011-2012, which its diurnal and secular variation be corrected by China's geomagnetic stations data, we established the geomagnetic internal field model by Surface Spline method, respectively. Each of lithosphere magnetic fields and its variation can be obtained by separating main field in the region. Meanwhile, the charts of lithosphere magnetic field distribution and its change can also be drawn. The change chart includes component and vector change chart.

Based on analysis of the lithosphere field component and vector charts, the vector change charts of H, Z provide foundation anomalous areas and the component change charts of D, I, H, F, Z to confirm anomalous situation at the same areas, we found several anomalous areas of different component and vector change charts overlapped each other, and these overlapped regions be considered as lithosphere magnetic anomalous areas. These areas would become earthquake risk region within the next year on the authority of geomagnetic data. For instance, There were two earthquakes had occurred in and near the areas during 2012-2013, YiLiang Ms5.7 and ErYuan Ms5.5.

This study and analysis process can provide a new idea and method for us to achieve earthquake forecast using geomagnetic data. However, before we use the method attempted to forecast earthquake, we need some more data and earthquake case.

SESSION 5.7

REPORTER REVIEWS - DIVISION V

5.7-1 ADVANCES THE IN GLOBAL GEOMAGNETIC OBSERVATORY NETWORK

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A considerable part of geomagnetic and space physics research is linked directly or indirectly to geomagnetic observatory data. Observatories provide magnetic vector time series that are of special value because of their homogeneity, continuity, and long period accuracy. This talk deals with advancements in observatory technology as well as the progress made with the global network of geomagnetic observatories. The talk will cover observational techniques, operational procedures and data processing, including quality control and distribution. Special emphasis will be given to initiatives that bring historic data, near real time data, increased time resolution data (1 Hz) and readily available, high quality data (quasi-definitive) to scientists.

5.7-2 RECENT MAGNETIC SURVEYS FOR REGIONAL AND GLOBAL CHARACTERIZATION OF THE GEOMAGNETIC FIELD

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Over the past decades, geophysical surveys of the Earth's magnetic field have been significantly advanced through the use of satellite technology permitting global field characterization. Large-scale airborne, land and marine geomagnetic surveys remain an important source for detailed regional near surface data. The combination of remote sensing and ground survey measurements through generation of seamless digital grids has resulted in new data sets describing crustal magnetic anomalies across many regions of the globe.

This talk is a review of the studies presented during the session 5.2. It focuses on applications and case studies of geomagnetic surveys providing surface (land and marine) and airborne magnetic data, as well as the interpretation of this data with respect to the spatial and temporal evolution of the Earth's magnetic field.

5.7-3 REPORTER REVIEW OF SESSION 5.3

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Session 5.3 deals with the observations of the geomagnetic field and their application in monitoring the conditions of the near-Earth space, and thereby the solar wind and the Sun, over short time scales (space weather) as

well as long time scales (space climate). In this Reporter review we will review the main developments in this field, especially those included in the contributions to this Session, setting them into a wider perspective, e.g., in terms of the development of changing Sun.

5.7-4 POLAR CAP GEOMAGNETIC INDICES: MEANING DERIVATION AND USES

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Clarification of PC index derivation issues is a key issue to achieve a definition of the PC index that gains consensus within the scientific community. At first, the derivation scheme submitted by the DTU Space and AARI teams in view of IAGA endorsement of the PC index and the Task Force report will be presented.

PC index derivation issues will then be reviewed in the light of recently published papers and of communications presented during the session.

5.7-5 THE USE OF GEOMAGNETIC OBSERVATIONS IN CONJUNCTION WITH LIDAR, RADAR AND OTHER MEASUREMENTS FOR IONOSPHERIC STUDIES

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5.7-6 MAGNETIC ANOMALIES - A REVIEW

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Magnetic anomalies remain an essential tool to investigate the Earth crust and lithosphere at all scales, from global to regional to local. This presentation will summarize the 15 presentations given in session 5.7. Two aspects will be emphasized: (1) the role of marine magnetic anomaly studies fifty years after the seminal paper of Vine and Matthews, and (2) the importance of past, current and future efforts to build and refine the World Digital Magnetic Anomaly Map (WDMAM) and the scientific outputs we can expect from such a map.



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