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Cosmic Ray induced aerosol Formation in Earth's aAmosphere

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Cosmic rays penetrating Earth's atmosphere produces ions which can enhance nucleation as shown by theory, observations, and experiments, but the exact mechanism still remains to be determined. In particular nucleation of the dipolar sulfuric acid - water system has been investigated since ion-induced nucleation is expected to increase the nucleation rate at the critical cluster size, where the charge makes the small clusters more thermodynamically stable than their neutral counterparts and thus reduces the energy barrier to nucleation.

Also the initial growth rates of small ion clusters are found to be enhanced by the dipole-charge interaction between the core ion and the strongly dipolar condensing sulfuric acid and/or water molecules. In the initial phase these ion-molecule interactions greatly accelerate the kinetics of molecular association. During the later stages of aerosol growth (from 2-3 nm and larger) the effect of the ion is expected to become small and the growth rate will be dominated by the vapor pressure of the condensing species.

We have studied ion-induced nucleation of the sulfuric acid - water system under a variety of conditions from an ultra-low background radiation environment 1100 meter underground to ionization densities far above the natural levels found in the atmosphere using a particle accelerator. Together with recent advances in modeling this has increased our understanding of the nucleation mechanism and the role of ions.

Testing a Link between cosmic Rays and Cloudiness over daily Timescales

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Much debate still remains regarding a hypothesized link between the solar-modulated cosmic ray (CR) flux and the Earth's cloud properties influencing the climate. Recently, it was shown that numerous long-term studies of satellite-based cloud observations are limited by non-trivial disadvantages, such as: satellite data intercalibration issues, view-angle biases, and the influences of factors on cloud cover like ENSO and volcanic eruptions interfering with the analyses. Consequently, the reported studies have failed to present compelling evidence of a CR-cloud link. The satellite-data limitations can be resolved by focusing on short-term (daily) timescales using Forbush decrease events and epoch-superpositional (composite) methods. Unfortunately, these studies have also arrived at a range of conflicting conclusions. It may be the case, that for the short-timescale studies, a hypothesized CR induced signal in clouds may be drowned in the meteorological noise, and noise may even be mixed with the (likely far smaller) hypothesized signal. Using extensive Monte Carlo simulation techniques and two most widely used satellite cloud datasets (ISCCP and MODIS), we quantitatively demonstrate how the high noise levels present in composites of small sample sizes, or for overly isolated sample areas, may predominately account for the inconsistent results obtained. Furthermore, we find that assumptions made by classical statistical tests (like the Student's T-test) are frequently violated by both the restricted samples and methods frequently employed in the literature (such as normalization to an averaging period). We conclude that such tests should be avoided, in favor of MC simulations, which offer a far more robust method of assessing significance and enabled us to correctly assess the significance of some recent short-term studies purporting to identify evidence of a CR-cloud link.

Response of the fair weather electrical Current to geomagnetic Substorms at a desert Station in southern Israel

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The global electrical circuit (GEC) postulates a constant downward flowing conductance current (Jz) equal to ~2 pA m-2 (Williams, 2009). Continued measurements of the vertical fair-weather atmospheric electrical current have been carried out from May 2011 continuously at Tel-Aviv University's Wise astronomical observatory in the Negev desert, Israel (30° 35' 45" N, 34° 45iä 48" E, altitude 875m above sea level). The instrument we used is a modified version of the GDACCS design described by Bennet and Harrison (2008) which is capable of measuring the fair-weather current density with an accuracy of 0.4 pA m-2. The sensors are placed on a flat 1.5m x 1.5m concrete surface 150m away from the observatory. The signal is passed in a differential mode to the computer at the observatory, sampled at 250Hz by the data acquisition program (LabView) and saved to 1 minute files with a GPS time stamp every 1 second. In addition to the Jz we collect ELF data in the Schumann Resonance band, and record the vertical component of the electrical field and the NS and EW magnetic field components with an accuracy better than 0.1 pT.