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**Wickert, Jens; Andersen, Ole Baltazar; Bandejas, J.; Bertino, L.; Cardellach, E.; Camps, A.; Catarino, N.; Chapron, B.; Foti, G. ; Gommenginger, C.**

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# INNOVATIVE SEA SURFACE MONITORING WITH GNSS-REFLECTOMETRY ABOARD ISS: OVERVIEW AND RECENT RESULTS FROM GEROS-ISS

Jens Wickert<sup>1</sup>, O. Andersen<sup>2</sup>, J. Bandejas<sup>3</sup>, L. Bertino<sup>4</sup>, E. Cardellach<sup>5</sup>, A. Camps<sup>6</sup>, N. Catarino<sup>3</sup>,  
B. Chapron<sup>7</sup>, G. Foti<sup>8</sup>, C. Gommenginger<sup>8</sup>, J. Hatton<sup>9</sup>, P. Høeg<sup>2</sup>, A. Jäggi<sup>10</sup>, M. Kern<sup>9</sup>, T. Lee<sup>11</sup>,  
M. Martin-Neira<sup>9</sup>, H. Park<sup>6</sup>, N. Pierdicca<sup>12</sup>, J. Rosello<sup>9</sup>, M. Semmling<sup>1</sup>, C.K. Shum<sup>13</sup>,  
C. Zuffada<sup>11</sup>, F. Soulat<sup>14</sup>, A. Sousa<sup>3</sup>, J. Xi<sup>4</sup>

<sup>1</sup>Helmholtz Centre Potsdam, Germany

<sup>2</sup>Technical University of Denmark

<sup>3</sup>Deimos Engenharia, Portugal

<sup>4</sup>Nansen Environmental and Remote Sensing Centre, NERSC, Norway

<sup>5</sup>IEEC/ICE-CSIC, Institute of Space Sciences, Spain

<sup>6</sup>IEEC/CTE-UPC, Center for Space Technologies, Spain

<sup>7</sup>Fremer, France

<sup>8</sup>National Oceanography Center, Southampton, U.K.

<sup>9</sup>European Space Agency

<sup>10</sup>University Bern, Switzerland,

<sup>11</sup>Jet Propulsion Laboratory, Caltech, USA

<sup>12</sup>Sapienza University of Rome, Italy

<sup>13</sup>Ohio State University, USA

<sup>14</sup>Collecte Localisation Satellites, CLS, France

## ABSTRACT

GEROS-ISS (GEROS hereafter) stands for GNSS Reflectometry, Radio Occultation and Scatterometry onboard the International Space Station. It is a scientific experiment, proposed to the European Space Agency (ESA) in 2011 for installation aboard the ISS. The main focus of GEROS is the dedicated use of signals from the currently available Global Navigation Satellite Systems (GNSS) for remote sensing of the System Earth with focus to Climate Change characterisation. The GEROS mission idea and the current status are briefly reviewed.

**Index Terms**— GNSS, Reflectometry, ISS, Sea Surface Height, Oceanography

## 1. BACKGROUND

The European Space Agency Directorate of Human Space Flight and Operations (HSO) released an announcement of opportunity in July 2011 in coordination with the Directorate of Earth Observation Programmes (EOP) soliciting scientific experiments for the International Space

Station relevant to global climate change studies. 25 Letters of intent were received from 237 science team members. After a peer-review of the received proposals and a scientific and technical evaluation, the GEROS-ISS proposal [1] was accepted to proceed to Phase A feasibility studies.

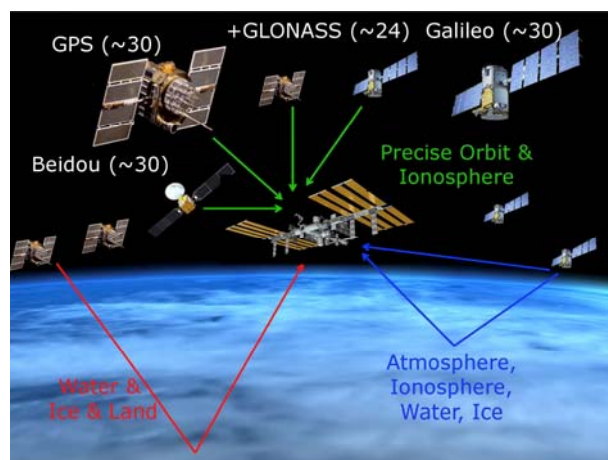


Figure 1. Schematic overview of GEROS-ISS.

## 2. MISSION GOALS

GEROS-ISS is a new and innovative ISS experiment primarily focused on exploiting reflected signals of opportunity from the GNSS satellites at L-band to measure key parameters of ocean surfaces which are relevant to characterise climate change. Secondary mission goals are global atmosphere and ionosphere observations using the GNSS radio occultation technique and the monitoring of land surface parameters utilizing reflected GNSS signals (see Fig. 1).

The primary mission objective of GEROS is: to measure and map altimetric sea surface height of the ocean using reflected GNSS signals to allow methodology demonstration, establishment of error budget and resolutions and comparison/synergy with results of satellite based nadir-pointing altimeters. This includes Precise Orbit Determination of the GEROS payload.

The secondary mission objective is: to retrieve scalar ocean surface mean square slope (MSS), which is related to sea roughness and wind speed, with a GNSS spaceborne receiver to allow methodology testing, establishment of error budget and resolutions. In addition, 2D MSS (directional MSS, related to wind direction) would be desirable.

Additional goals of GEROS-ISS are (1) the assessment of the potential of GNSS scatterometry for land applications and in particular to develop products such as soil moisture, vegetation biomass, and mid-latitudes snow/ice properties and (2) to further explore the potential of GNSS radio occultation (RO) data (vertical profiles of atmospheric bending angle, refractivity, temperature, pressure, humidity and electron density), particularly in the Tropics, to detect changes in atmospheric temperature and climate relevant parameters (e.g., tropopause height) and to provide additional information for the analysis of the reflectometry data from GEROS. Hereby several new aspects of the GNSS RO technique compared to the recent missions can be covered as precipitation detection (using a polarimetric receiver), radio occultation from low inclination orbit and aspects of Multi-GNSS data, i.e. acquired from different Navigation Satellite Systems.

## 3. STATUS

GEROS was selected in result of a complex review process, initiated by ESA. The review results and decision on further activities was officially announced end of 2012. An interdisciplinary and international Science Advisory Group (SAG) of acknowledged experts in Oceanography, Geodesy, Atmosphere and GNSS Science started to work in June 2013 on details of the preparation of the GEROS

mission. This SAG consists of key members of the proposing GEROS team and additional experts, nominated by ESA. Two competitive industrial phase A studies for the GEROS mission implementation started in the fourth quarter of 2014, the corresponding final presentations are expected for the first half of 2016. In parallel to the industrial studies, a scientific study GARCA (GNSS-R Assessment of Requirements and Consolidation of Retrieval Algorithms) was kicked-off in November 2014, which is also funded by ESA [2]. The main goal of GARCA is to support the assessment and consolidation of scientific requirements and the consolidation of retrieval algorithms for a spaceborne GNSS-R experiment, focusing on the GEROS-ISS concept and its primary and secondary data products (sea surface height and ocean surface roughness). The main work hereby will be the development of an end2end-simulator for the GEROS-ISS measurements (GEROS-SIM), and the evaluation of the expected geophysical data products. A GEROS-SIM version will be executable through a web-server, freely accessible to registered scientists. In addition work packages are included aimed to perform Observing-System Simulation Experiments (OSSE) to assess the oceanographic significance of the expected GEROS-ISS measurements. Initial OSSE results from GARCA related investigations were published in [3]. Scientific experts will support the GARCA project and are involved in the planned work to test the developments and also to initiate the sustainable formation of an interdisciplinary GEROS-ISS user community. According to the current schedule and in case of successful preparative studies and provision of appropriate funding, a launch of GEROS can be expected for late 2019.

In our contribution we review the background and the recent status of the GEROS-ISS mission and also overview recent results of GARCA and related scientific investigations

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