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GEROS-ISS: Innovative GNSS based Remote Sensing aboard the International Space Station for GGOS

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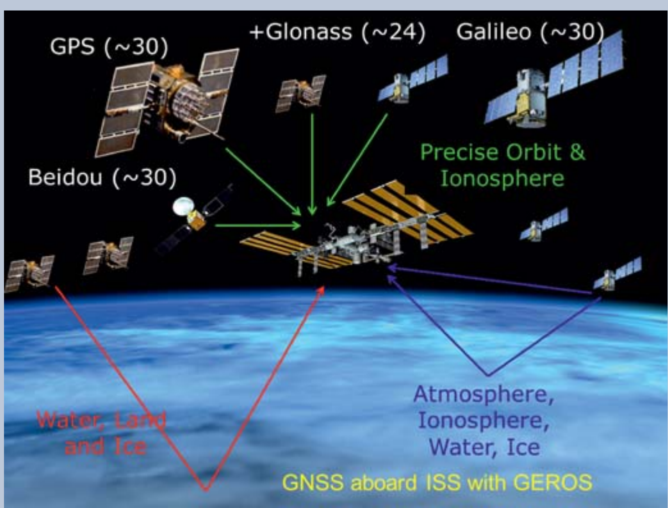
Abstract

GEROS-ISS (GEROS hereafter) stands for GNSS REflectometry, Radio Occultation and Scatterometry onboard the International Space Station [3]. 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 System (GNSS) for remote sensing of the System Earth with focus to Climate Change characterisation. Therefore it will contribute to the Global Geodetic Observing System (GGOS). The GEROS mission idea and the current status are briefly reviewed.

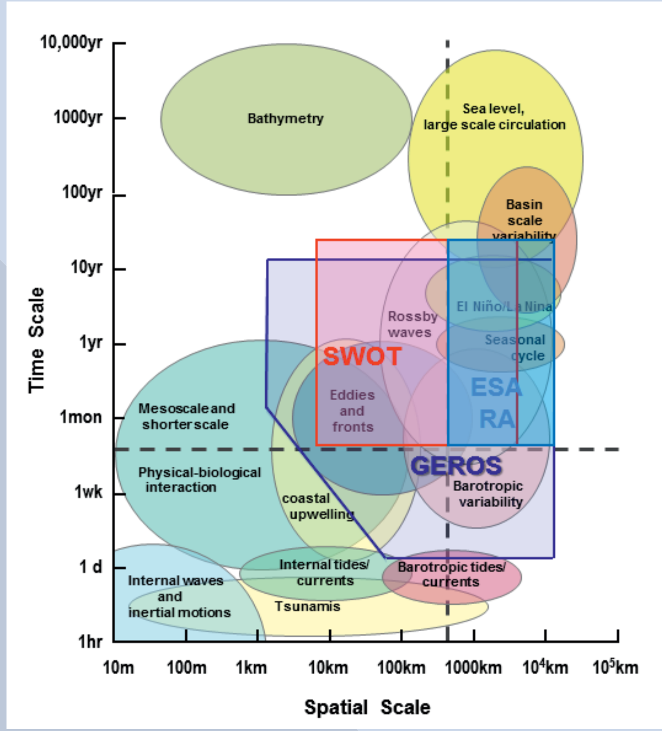


Background

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 was accepted to proceed to Phase A feasibility studies.

Mission Idea

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. above). GEROS will also provide a sensor calibration/validation option for other upcoming satellite missions including, e.g., Sentinel-3, SWOT or FormoSAT-7/COSMIC-II. The GNSS remote sensing data from GEROS will also complement the innovative GNSS scatterometry measurements from the U.S. mission CYGNSS, which is currently foreseen for launch in 2016. [2].



Oceanic observations carry signals of a wide range of related processes. The observed fingerprints of these processes have temporal time scales from 1 hour to tens of thousands of years and spatial scales from ten to tens thousands of kilometres. The figure illustrates the spatial and temporal scales for these processes and indicates phenomena, which can be investigated with GEROS data complementary to and distinct from, the planned NASA SWOT mission and ESA's and NASA's radar altimetry missions (Revised from [4]).

Mission Goals

The primary mission objectives of GEROS are:

(1) to measure the 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 and

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

Secondary mission objectives, which increase the scientific value of the GEROS data, but are not driving the instrument developments, are:

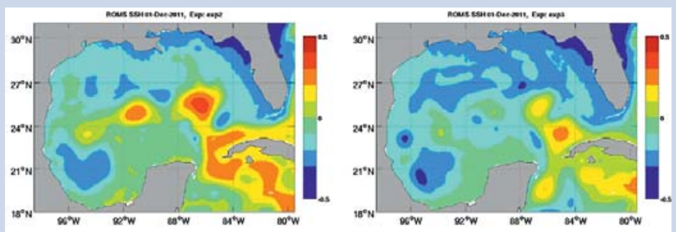
(1) to further explore the potential of GNSS radio occultation data (vertical profiles of atmospheric bending angle, refractivity, temperature, pressure, humidity and electron density), particularly in the Tropics, to detect changes in atmospheric temperature and climate relevant parameters (e.g., tropopause height) and to provide additional information for the analysis of the reflectometry data from GEROS and

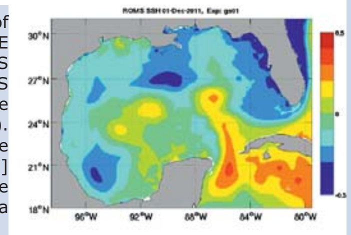
(2) to assess the potential of GNSS scatterometry for land applications and in particular to develop products such as soil moisture, vegetation biomass, and mid-latitudes snow/ice properties to better understand anthropogenic climate change.

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. The begin of two competitive industrial phase A studies for the GEROS mission implementation is foreseen for early 2014. 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 2018.

Scientifc Studies





Sea surface topography of the Gulf of Mexico, reconstructed within an OSSE [1] after one month of artificial GEROS measurements using simulated GPS reflectometry data from the International Space Station (see text). The colors indicate mesoscale variations of the sea surface height [m] related to energetic eddies. The investigation of these phenomena is a major GEROS mission goal.

Part of the preparation of the GEROS mission and the work of the Science Advisory Group are dedicated scientific studies and campaigns. One example is an initial Observation System Simulation Experiment (OSSE), which is described in [1] to investigate the GEROS capability for the observation of highly energetic mesoscale ocean currents (eddies) with changes of <20 cm sea surface within regions of <100 km. Knowledge on these eddies is important for the characterisation of nutrients and/or pollutants with many societal and scientific applications. Presently the tracking and forecasting of eddies is limited due to the capability of the current ocean altimetry missions. The OSSE used artificial GEROS measurements (only GPS, 50 cm accuracy, 1 month) and a regional ocean model. Initial results indicate that GEROS data, even with measurements from only one GNSS and with conservative accuracy assumption, could be used to improve current regional ocean topography forecasting with special focus to highly energetic mesoscale currents. The OSSE investigations will be continued with data from additional GNSS satellites and from classical radar altimetry missions.

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