SEA-ICE REMOTE SENSING WITH GNSS REFLECTIONS

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GNSS-R is a remote sensing technique that first appeared in 1993 (PARIS concept). The availability of the GPS, GLONASS and future GALILEO constellations of navigation satellites motivated this approach, which is based on the analysis of reflected L-band GNSS signals (bistatic radar). Despite being initially conceived for sea surface altimetry, this technique has many other potential applications, such as ocean wind speed, soil moisture changes, sea surface state determination, and sea ice detection and classification.

IEEC, jointly with GFZ and DMI, has carried on ESA's experimental campaign GPS-SI during the last polar winter. From October 2008 until May 2009, a set of GNSS reflected signals have been gathered at Godhavn (Qeqertarsuaq), Greenland. To do so, the GPS Open Loop Differential Real-Time Receiver (GOLD-RTR) have been employed. Placed on top of a cliff (fixed position) with around 700 m of altitude, the instrument has monitored the formation/evolution/melting of the Sea-Ice at the area during a continuous period of 7 months.

The GOLD-RTR was designed, developed and tested at the IEEC with the aim of collecting the GNSS signals reflected off the Earth's surface. Three different radio front-ends generate the complex cross-correlation function (waveform) in real-time. Input 1 is fed by an up-looking antenna for reference signal (direct), and either one or two other antennas (down-looking for reflected signals, either polarization) fed inputs 2 and 3. Ten configurable correlation channels running in parallel give an output of ten waveforms every millisecond. They can be tuned with ancillary Doppler and delay offsets. The length of these complex waveforms is 64 lags, with a delay resolution of 15 meters. To reduce the storage size, non-coherent integration is allowed (up to 1 second). The GOLD-RTR has been widely used since 2005, and nowadays it has been replicated (3 GOLD-RTR available).

During the campaign, non-coherent integrated data (1 second) have been stored, allowing measurements of total reflected GPS power, which relates to the surface emissivity at L-band; and study of the surface roughness by means of the shape of the reflected waveform. Complex waveforms at 1 msec coherent integration have also been gathered, both with Left- and Right-Hand Circular Polarization (LHCP and RHCP). These permit to look into phase and polarimetric observables, either to relate them with changes in the ice freeboard level (accurate altimetry with phase-delay), or changes in its complex permittivity (POlarimetric Phase Interferometry). A combination of GPS-based estimates of parameters such as roughness and permittivity could help classifying the sea ice type. Due to storage size limitations, coherent waveforms were restricted to a few hours per day, whereas non-coherent data have been continuously stored, summing up to 1.4 TB.

The campaign, its analysis strategies, processing algorithms and results will be presented.

17 YEARS OF EUROPEAN ALTIMETRIC MISSIONS AND THEIR CALIBRATION

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ESA has a long history on altimetric missions: from the European Remote Sensing Satellite (ERS-1), launched in 1991, with EnviSat launched in 2002, to the future missions of CryoSat-2 and Sentinel-3.

Different calibrations have been performed over these years to these altimeters, driven by the current scientific needs. The ERS-1 altimeter range was absolutely calibrated over the Venice tower (Francis, 1993). The ERS-2 altimeter was cross-calibrated against ERS-1 and TOPEX/Poseidon altimeters (Benveniste et al. 1997). The EnviSat RA-2 was calibrated in absolute terms for both: its range over the Mediterranean sea with a regional calibration (Roca et al. 2002) and, for the first time in altimetry, its backcatter using an ESA transponder (Roca et al. 2002).

CryoSat mission will determine fluctuations in the mass of the Earth's land and the marine ice fields. The primary scientific objectives for the CryoSat mission (Wingham et al. 2004) are to improve the accuracy of measurements of ice sheet elevation and sea-ice thickness and thus enhance understanding of cryospheric dynamics. Over sea-ice this is to be achieved by the use of a radar altimeter with synthetic aperture forming capability to improve the along track resolution. In addition, over ice-sheet margins the direction (along and across track) of the leading edge of an echo is retrieved through the use of a second receiving antenna recording chain allowing interferometric capability. This new design of an altimeter also implies that new calibrations shall be performed.

Its primary payload is a radar altimeter (SIRAL) that will operate in different modes optimised depending on the kind of surface: Low resolution mode (LRM), SAR mode (SAR) and SAR inteferometric mode (SARin).

A transponder can be seen by a radar as a point target. Transponders are commonly used to calibrate absolute range from conventional altimeter waveforms. As a uniquely defined terrestrial reflection surface, a transponder is deployed within the footprint of the radar altimeter. The waveforms corresponding to the transponder distinguish themselves from the other waveforms resulting from natural targets in power and shape. One transponder will be available for the CryoSat project, that will be deployed in the ESA Svalbard station.

We will be using the ESA CryoSat transponder to calibrate SIRAL's absolute range, datation, angle of arrival and sigma-0. In these calibrations, we will retrieve the biases in two ways: using the stack beams, before multi-looked (calibration stack data) and using the single multi-looked echo (L1b data).

During CryoSat Commissioning phase, these data will be retrieved during several passes over the transponder. The developed algorithms are currently being tested with simulated data from the CRYMPS simulator, generated by overflying a transponder point target in different geometrical and instrumental configurations. We will show the method, its performance, and the results obtained with these simulated data.