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Potential contributions of GNSS-R towards salinity retrieval in SMOS-like missions

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The concept of GNSS-R (Global Navigation Satellite System-Reflectometry) or PARIS (Passive Reflectometry and Interferometry System) appeared in 1993 as a remote sensing technique based on the analysis of reflected L-band GNSS signals (bistatic radar). This approach has been motivated by the availability of the American GPS, the Russian GLONASS and future European GALILEO, and Chinese COMPASS constellations of navigation satellites. Initially conceived for sea surface altimetry, this approach offers many other potential applications, such as ocean wind speed, sea surface state determination, soil moisture changes and sea ice detection and classification. In the SMOS context, the L-band roughness from both sea and soil surfaces affects the radiometric measurements and its retrieval with reflected GNSS signals would improve the salinity and moisture estimations.

In order to study the science and calibration/validation of the Soil Moisture and Ocean Salinity (SMOS) mission, the experimental campaigns of CAROLS 2009 and 2010 (CNES/ESA) were carried on, comprisin a set of flights over different scenarios: the mouth of Garonne river into the Bay of Biscay, the South of France and Monegros (Zaragoza) and Valencia Anchor Station sites from Spain. Along with a L-band radiometer (CAROLS) and a C-band radar (STORM), a dedicated GNSS reflectometry receiver (GOLD-RTR) was installed in the aircraft. The instrument was designed, developed and tested at the IEEC with the aim of collecting GPS-L1 (C/A) 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 correlation channels, which can be tuned with ancillary Doppler and delay offsets, run in parallel to give an output of ten waveforms every millisecond. The length of these complex waveforms is 64 lags, with a delay resolution of 15 meters. The instrument has been widely used since 2005 for different scientific purposes.

Two different characteristics from the collected GNSS-R dataset will be analyzed: the shape of the waveforms and their polarimetric phase. The L-band roughness, which has an important impact on the retrieval of ocean salinity with SMOS, can be estimated from the first observable. While the peak of the waveform corresponds to the location of the specular reflection over smooth surfaces, the roughness introduces multi-path like contributions at larger delays, shifting the peak in time-delay. In the case of open waters and at a given geometry, the delay between the specular point and the peak has a near-linear relationship with the variance of the slopes of the surface, a parameter also given as MSS (mean square slopes). On the other hand, the second observable (polarimetric phase) is directly related to salinity, due to the fact that presence of this element in the sea modifies its dielectric properties, resulting in different phase for the co- and cross-polar components of the complex Fresnel coefficients. This difference is captured as the POlarimetric Phase Interferometry (POPI), the phase difference between the received co- and cross-polarized fields. Its correct determination would enable an additional mean for the determination of sea surface salinity.

In this work we will show the results obtained with the data collected with GOLD-RTR during CAROLS campaigns towards sea surface remote sensing, including L-band roughness determination and evaluation of the POPI method for the retrieval of salinity.