



Estimation of Soil Moisture and Sea Ice Concentration – A GNSS Reflectometry Concept

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Signals of Global Navigation Satellite Systems (GNSS) give the opportunity to investigate new concepts for Earth observation. A prominent example is the exploitation of Earth reflected GNSS signals. Parameters of the signal, like the carrier phase and amplitude, can be used for soil moisture estimation, sea ice detection or sea surface altimetry. A coherent signal processing, using in-phase and quadrature components, is beneficial to increase the precision of the retrieved parameters. Estimates have been based on a coherent processing of data acquired airborne, on ground and from space. In particular observations of ground stations are widely considered already. Further challenges arise when processing data from moving receiver platforms, for example, aircrafts and ships. The here presented concept focuses on a coherent processing of the signal amplitude which is sensitive to the near surface permittivity. It is demonstrated that the general concept can be used for different applications: to invert the moisture near the soil surface and the concentration of sea ice. Right- and left-handed antenna links are used to receive the direct and the reflected GNSS signal with the respective polarization.

A soil moisture experiment with a ground station setup using GNSS front-end hardware (from Syntony) and a software receiver has been realized within the MARCO project (MARine Research at Côte d'Opale). Four stations have been considered with different soil moisture conditions over sand-dominated soil at the Côte d'Opale, Northern France. In-situ measurements provided a reference characterization of the soil moisture and structure for validation.

A sea ice experiment has been realized aboard the Norwegian research vessel Lance using a modified 4-front-end geodetic receiver (GORS type). Data was recorded over 20 days navigating through waters with sea ice in Fram Strait, Arctic Ocean. The conditions during the experiment varied in a range between highest permittivity in ice-free waters and lowest permittivity for a 100% concentration of multiyear ice. The measurements also comprised ancillary data of sea ice concentration for the validation of estimates.

The concept of amplitude estimation, linked to the near-surface permittivity, is applied in a similar way for both experiments. It allows to estimate the state of soil moisture and sea ice concentration with an in-situ data correlation of 98% and 76% for the respective experiments. A future challenge is to apply the concept at higher estimation rates for airborne and satellite receiver platforms.