Building a comprehensive picture of sea surface, troposphere and ionosphere contributions in precise GNSS reflectometry from space

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Signals of Global Navigation Satellite Systems (GNSS) are subjected to propagation effects, like reflection, refraction and scintillation. Twenty years ago, a first dedicated payload has been launched on a satellite mission (UK-DMC) to study Earth-reflected GNSS signals and their potential for Earth observations. It was a milestone in the research field of satellite-based reflectometry. The altimetric use of reflectometry is of particular interest for the geoscience community. The permanent and global availability of GNSS signals, exploited in an altimetric reflectometry concept, can help to improve the rather sparse coverage of today’s altimetric products.

Studies on altimetric reflectometry concepts started already thirty years ago. However, the sea surface roughness, the limited GNSS signal bandwidth, orbit uncertainties and the sub-mesoscale variability (we assume here a horizontal scale < 50 km) of troposphere and ionosphere pose a persistent challenge for the altimetric interpretation and application of reflectometry data.

The ESA nano-satellite mission PRETTY (Passive REflecTometry and dosimeTrY) will investigate the altimetric application of reflectometry. It concentrates on a grazing-angle geometry. A mitigation of roughness-induced signal disturbance can be expected under these angles. On the other hand, at grazing angles tropospheric and ionospheric variability will rise in importance. The PRETTY satellite and payload have been developed by an Austrian consortium and successfully launched on 9\textsuperscript{th} October 2023 into the dedicated polar orbit (roughly 550 km in orbit height). We formed a science consortium (among the here listed partners) to merge competences in the field of altimetry and GNSS signal propagation effects.

Based on the mission’s ATBD (Algorithm Theoretical Baseline Document), we conducted simulations and case studies of existing satellite data. They allow a first quantification of expected roughness and sea surface topography effects, as well as, tropospheric and ionospheric biases in grazing-angle geometry. The preliminary results show that, for calm ocean areas (significant wave height < 1 m) and over sea ice, altimetric retrievals reach centimeter level precision. In these
specific cases, the residual Doppler shift is small (mHz range) which indicates moderate variability of tropospheric and ionospheric contributions. New observation data of the PRETTY mission is expected early in 2024. Then, we will extend our picture for a more general altimetric use of precise reflectometry data.