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

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(A) Introduction and Goals

Earth-reflected signals of Global Navigation Satellite Systems (GNSS) are an opportunity for different geosciences applications. Corresponding studies contribute to the research field of GNSS reflectometry. In a consortium of science partners and industry, we conduct a reflectometry study on altimetric application of observations from small satellites. Here, we use data of the CyGNSS mission, based on earlier work [1], and we look out to PRETTY mission data [2].

A primary goal is the resolution of sea-surface height anomalies by phase-altimetric analysis. A secondary goal is focused on the detection of tropospheric and ionospheric impact that limit the altimetric performance. Variability in sea surface, troposphere and ionosphere conditions on rather small scales within the reflection track lengths (10 to 100 km) is of main interest.

We demonstrate the processing concept (scheme to the right) for a CyGNSS example event in the Caribbean, for implementation see section (B) below.

(B.1) Observation Data and Earth Surface Reference

Fig. 1: signals path in GNSS reflectometry scenarios.

Fig. 3: delay map of CyGNSS example event close to Bahamas. Right: geodetic reference of three CyGNSS reflection events over the Caribbean (the Bahamas event in blue).

Fig. 2: scheme of altimetric processing based on PRETTY mission baseline document.

(B.2) Altimetric Analysis and Atmosphere Reference

Fig. 5: phase altimetric results (upper panel): model-based contribution of neutral atmosphere, ionosphere and sea surface height (lower panel).

Fig. 6: zoom into coherent phase residual (upper panel); observation black and model color code as in Fig. 5.

(B) Example Implementation

Observation Data
- Delay map of event (Fig. 3, left)

Earth Surface Reference
- Reflection track of example close to Bahamas (Fig. 3, right)

Altimetric Analysis Results
- Sea surface height retrieval and atmosphere contribution for event example (Fig. 5)
- Detailed phase and Doppler analysis (Fig. 6)

Atmospheric and Ray Path Reference
- Neutral atmo. Refractivity and iono. electron density along the ray paths (Fig. 7)

(C) Conclusion and Outlook

Sea Surface contributions
- Calm ocean areas, see Fig. 3, or sea-ice cover, see Fig. 4, are favourable for phase altimetry
- Altimetric analysis allows to resolve surface height anomalies, for example, due to geoid undulation, see Fig. 5

Atmospheric contributions
- Modeled delays of neutral atmo. and iono. are large, however rather constant, see Fig. 5
- Phase altimetric results are more sensitive to variations within the track
- Focus on disturbed atmosphere to come

References: