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Boundary Layer Ducting of Low-elevation GNSS Ocean Reflected Signals

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GNSS reflected signals are able to derive parameters as sea surface roughness, winds, waves, and heights from the spectral measurements. Coming satellite missions as, CYGNSS and GEROS, are focusing on GNSS ocean reflected measurements. Thus, simulation studies, highlighting the assumptions for the data retrievals and the precision and the accuracy, are of interest for assessing the observational data content.

Simulations of the low-elevation ocean reflected GNSS signal reveal a ducting of the signal when applying a model of the boundary layer. This effect is presented during varying conditions of the sea surface roughness, ocean wind and temperature, density and gradient of the water vapor profile in the boundary layer.

The model for the sea surface roughness impedance, wind speed, and rms ocean wave-height show a stronger signal damping for a smoother ocean surfaces (sea state 0) compared to a rough sea (sea state 4). While the real part of the signal shows the reverse effect. At the same time the reflection zone enhances for rough sea states. Simulations, including a standard atmosphere and a boundary layer, give a significant ducting of the received signal, leading to a much larger reflection zone (and broader received power spectra).

The spectral analysis of the simulated surface reflected signals shows spectral structures that could be used for the extraction of parameters as, boundary layer height and atmosphere water vapor density, sea surface roughness, ocean wave heights, and surface wind speed. The presented simulations will quantify how these parameters are derived from the observations.

Our simulator uses a finite difference solution to the parabolic wave equation using the split-step sine transformation. The ocean surface is modeled through the use of an impedance model, which gives an accurate lower boundary condition in the determination of the electromagnetic field. A semi-isotropic Philips spectrum is used to represent the air-sea interaction.