A supervised learning approach to refining tropospheric delay estimates for grazing-angle altimetry retrievals

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Abstract

We present a method to mitigate uncertainties in estimates of tropospheric delays, which are a major source of error in grazing-angle altimetry retrievals, via an empirical assessment of the GNSS-Reflectometry phase delay altimetry measurements with respect to a reference surface.

As of March 2022, over 1000 multi-GNSS, grazing-angle altimetry profiles, spanning up to 2000 km are generated daily by the Spire RO constellation over polar areas and calm ocean. Changes in the residual phase of these reflections can be used to retrieve altimetry estimates.

The main drawback of grazing-angle altimetry is the high value of the tropospheric delay, which can reach up to 50 meters at the lowest elevation angles due to the path lengths. A typical uncertainty of 10% in this delay is therefore unacceptable for altimetry applications requiring decimeter-level precision. In general, Spire altimetry retrievals match to a reference surface model by about 22 cm of RMS error (n > 300,000 profiles), however height residuals are heavily degraded at lower elevations, largely due to uncertainties in the tropospheric delay estimates.

We use the large number of Spire retrievals as training data to derive an empirical correction to the tropospheric delay estimates. This correction, based on supervised learning via an exponential fit, is shown to be similar when using subsets of residuals collected in different seasons and different areas. We show that applying this correction reduces the RMS of the height residuals. In particular, the RMS of low-elevation (< 10 degrees) height retrievals is reduced by 50%.