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Tropospheric delays in ground-based GNSS reflectometry – Assessment of ad-hoc models against ray-tracing simulations

Thalia Nikolaidou (1), Felipe Nievinski (2), and Marcelo C. Santos (1)

(1) University of New Brunswick, Fredericton, Canada (msantos@unb.ca), (2) Federal University of Rio Grande do Sul, Brazil

Several studies have demonstrated the utility of GNSS multipath reflectometry (GNSS-MR) for coastal sea level altimetry. GNSS-MR is based on the simultaneous reception of direct propagation and reflections, exploiting the resulting interference pattern as recorded in signal-to-noise ratio (SNR) observations. Recent studies we have provided experimental evidence demonstrating that tropospheric error is proportional to reflector height and leads to the underestimation of tidal amplitudes. Over the last decade, tropospheric delay was accounted for in GNSS-MR to varying degrees. Two simple-to-use formulations have emerged on the basis of angular and linear refraction separately. The first one accounts for the bending angle in Snell's law, leading to a displaced specular reflection point. The second formulation accounts for speed retardation, though it assumes rectilinear propagation in the atmosphere. We have implemented a ray-tracing procedure to solve the reflection three-point boundary value problem, involving the broadcasting satellite, reflecting surface, and receiving antenna. We have also developed a series of ad-hoc models to gain insight about the dependence of delay on surrogate variables, such as bending angle and mean refractivity, as well as independent variables, such as satellite elevation angle, station altitude, and reflector depth/height. We will assess these approximations against ray-tracing simulations (rigorous and pseudo-rectilinear).