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Evaluation of Different Strategies for Mitigating Azimuthally Asymmetric Tropospheric Delays

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Observations occurring at low elevation angles are beneficial for space geodetic techniques as they improve the observational geometry and redundancy of the estimated solutions. Due to horizontal variations in the Earth's neutral atmosphere, most tropospheric delay mapping functions are not capable of accurately modeling the delay at low elevation angles as they assume the Earth's atmosphere to be azimuthally symmetric. It is possible to estimate tropospheric gradient parameters to account for the bulk of the asymmetric delay, but these gradients account for only a single main direction of asymmetry, and their estimation reduces the redundancy of the solution especially for applications requiring short observation sessions. To help overcome these challenges, ray-tracing through numerical weather models (NWM) is a promising technique to model both the elevation angle- and azimuth-dependence of the tropospheric delay. We evaluate three strategies for mitigating the asymmetric tropospheric delay: (a) unaided GPS estimation; (b) NWM-aided GPS estimation; and (c) NWM-prediction (no GPS estimation).

Strategy (a) consists of employing solely the GPS observations themselves to determine the tropospheric gradient parameters following the standard strategy, recommended in the updated IERS Conventions. In strategy (b) we employ a priori information provided by the NWM to constrain the direction of the delay gradient, needing to estimate only its magnitude from the GPS observations. Finally, in (c)we rely solely on the slant factors (the ratio between slant delays and zenith delay), obtained by ray-tracing in a 3D NWM. Notice that in (a) and (b) we assume the delay exhibits a single dominant direction of azimuthal asymmetry, while in (c) we make no assumptions about the nature of the asymmetries. While this work focuses on azimuthally asymmetric portion of the delay, we evaluate, en passant, the strategy of (d) constraining slant delays (or slant factors) at the observation level, thereby dismissing even the estimation of zenith delays.

Unlike previous studies that have used three dimensional ray-traced slant delays (Hobiger, 2008), we have chosen to parameterize the delay in terms of slant factors. The use of slant factors will prove to be beneficial by allowing for the direct estimation of residual tropospheric delay and could allow the direct use of external troposphere zenith delay measurements in combination with the ray-traced slant factors.

The four strategies for mitigating the asymmetric tropospheric delay are applied to a GPS precise point positioning (PPP) campaign. The tropospheric gradients derived from methods (a) – (c) are compared to determine to what degree they are capable of representing real neutral atmosphere variation. The impact of the four processing strategies are compared based on the estimated parameters and convergence time.