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Ionospheric Filtering: Improving Swarm Orbits and Studying Ionospheric Fluctuations

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With three near-polar low earth orbiter satellites, the Swarm mission contributes to bridge the gap between Earth gravity field missions. However, GPS-based kinematic orbits of Swarm satellites were shown to be degraded by ionospheric scintillations due to random electron density fluctuations. Indeed, the receivers perform worthier and strong artefacts are observed in GPS phase observations, when the Swarm satellites fly above the geomagnetic equator or above polar regions.
Besides a pure elimination of contaminated parts, an alternative approach is presented in this contribution using a physically based filtering of the corresponding GPS observations. Starting point is a stochastic modeling of the ionospheric effects using a Matérn covariance function. Apriori knowledge of the spectral density of GPS phase observations under strong scintillations allow to derive optimal parameters for the this covariance function that is used to mitigate ionospheric effects from the GPS observation time series under consideration. We consider a smoothness of 1 and a correlation factor of 1.5 as physically plausible and show that this set provides an adequate filtering of the ionospheric noise. Noisy parts of the observation time series are detected as a block thanks to a simple algorithm with a fixed threshold, then filtered and reintegrated in the original time series. Therefore, the proposed methodology is independent of the observation type used (double differences or raw phase observations for PPP). The filtered time series exhibit a homogeneous standard deviation and a spectral slope at high frequencies corresponding to the one of a time series of reference, free from ionospheric noise. The orbit solution computed with filtering is smoother with respect to the non-filtered solution and a 18% decrease of the rms with respect to the non-filtered solution holds for days of low-middle ionospheric noise increase. Furthermore, spectral properties of the time series can be used to characterise the ionospheric fluctuations.