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TEC estimation of the topside ionosphere and plasmasphere using GPS sTEC from LEO satellites

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Slant Total Electron Content (sTEC) can be computed from dual frequency GPS/GNSS receivers as they are used on-board several low earth orbiting (LEO) satellites. Over the last years several constellations, including Swarm, GRACE-FO, Sentinel, and COSMIC-2, became operational. Since the altitudes of the different satellites range from 450 km (Swarm A/C) to 815 km (Sentinel 3) their sTEC observations are well suited to obtain key parameters to model the vertical distribution of the electron density, e.g. to separate the topside ionospheric electron content from the plasmaspheric electron content.
We will present an empirical model based on a reference electron density at a defined altitude near the lowest available satellite and variations of scale heights for different locations. Scale heights and reference electron densities are represented using a harmonic expansion. Since the plasmaspheric electron content is expected to have maximum TEC values below 10 TECU, we will level each phase arc in a least squares adjustment of the model parameters to minimize leveling errors. In contrast when using a code-based leveling approach an accuracy of 2-3 TECU can typically be achieved, which may affect the determination of low TEC values expected from the plasmasphere. Each inversion is computed for a 3h time window providing a 3D electron density estimation. For a selected period in 2019 will make use of all the above mentioned satellite constellations and in one inversion and discuss the model behaviour w.r.t to common indices like Kp and F10.7. Our model is available to separate the bottom side TEC from the topside TEC, e.g., when differenced to ground-based CODE TEC maps. Distinguishing between different regions of plasma distributions, e.g., the bottom side ionosphere, the topside ionosphere, and the plasmasphere allow a better investigation of these areas on global scale through the GPS observables.
n addition, the model can be applied to correct higher order ionospheric terms in GNSS observations for LEO satellites and helps evaluating the short time stability of the GNSS receiver code biases and to estimate antenna phase center variations (PCV) for the geometry-free linear combination. By deriving and applying these corrections, we expect a more precise TEC and also a consistent receiver bias estimation for the constellations used in this model adjustment.

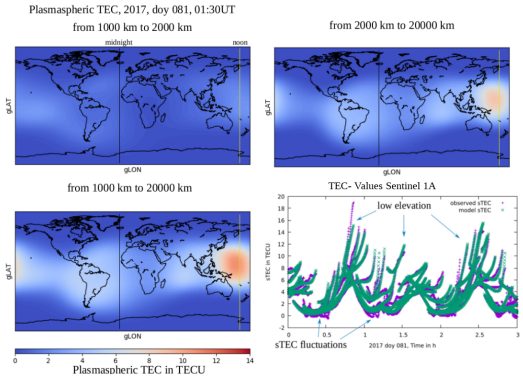

Figure 1. Plasmaspheric TEC maps fo doy 081/2017 and comparison of the modeled and observed sTEC values for Sentinel 1A.