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Generation of global VTEC maps from low latency GNSS observations based on B-spline modelling and Kalman filtering

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In May 2014 DGFI-TUM (the former DGFI) and the German Space Situational Awareness Centre (GSSAC) started to develop an OPerational Tool for Ionospheric Mapping And Prediction (OPTIMAP); since November 2014 the Institute of Astrophysics at the University of Göttingen (IAG) joined the group as the third partner. This project aims on the computation and prediction of maps of the vertical total electron content (VTEC) and the electron density distribution of the ionosphere on a global scale from both various space-geodetic observation techniques such as GNSS and satellite altimetry as well as Sun observations.

In this contribution we present first results, i.e. a near-real time processing framework for generating VTEC maps by assimilating GNSS (GPS, GLONASS) based ionospheric data into a two-dimensional global B-spline approach. To be more specific, the spatial variations of VTEC are modelled by trigonometric B-spline functions in longitude and by endpoint-interpolating polynomial B-spline functions in latitude, respectively. Since B-spline functions are compactly supported and highly localizing our approach can handle large data gaps appropriately and, thus, provides a better approximation of data with heterogeneous density and quality compared to the commonly used spherical harmonics.

The presented method models temporal variations of VTEC inside a Kalman filter. The unknown parameters of the filter state vector are composed of the B-spline coefficients as well as the satellite and receiver DCBs. To approximate the temporal variation of these state vector components as part of the filter the dynamical model has to be set up. The current implementation of the filter allows to select between a random walk process, a Gauss-Markov process and a dynamic process driven by an empirical ionosphere model, e.g. the International Reference Ionosphere (IRI).

For running the model ionospheric input data is acquired from terrestrial GNSS networks through online archive systems (such as IGS) with approximately one hour latency. Before feeding the filter with new hourly data, the raw GNSS observations are downloaded and pre-processed via geometry free linear combinations to provide signal delay information including the ionospheric effects and the differential code biases.

Next steps will implement further space geodetic techniques and will introduce the Sun observations into the procedure. The final destination is to develop a time dependent model of the electron density based on different geodetic and solar observations.