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Global VTEC-modelling in near real-time based on space geodetic techniques, adapted B-spline expansions and Kalman-filtering including observations of the Sun's radiation

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Today, the observations of space geodetic techniques are usually available with a rather low latency which applies to space missions observing the solar terrestrial environment, too. Therefore, we can use all these measurements in near real-time to compute and to provide ionosphere information, e.g. the vertical total electron content (VTEC).

GSSAC and BGIC support a project aiming at a service for providing ionosphere information. This project is called OPTIMAP, meaning "Operational Tool for Ionosphere Mapping and Prediction"; the scientific work is mainly done by the German Geodetic Research Institute of the Technical University Munich (DGFI-TUM) and the Institute for Astrophysics of the University of Goettingen (IAG). The OPTIMAP strategy for providing ionosphere target quantities of high quality, such as VTEC or the electron density, includes mathematical approaches and tools allowing for the model adaptation to the real observational scenario as a significant improvement w.r.t. the traditional well-established methods. For example, OPTIMAP combines different observation types such as GNSS (GPS, GLONASS), Satellite Altimetry (Jason-2), DORIS as well as radio-occultation measurements (FORMOSAT#3/COSMIC). All these observations run into a Kalman-filter to compute global ionosphere maps, i.e. VTEC, for the current instant of time and as a forecast for a couple of subsequent days.

Mathematically, the global VTEC is set up as a series expansion in terms of two-dimensional basis functions defined as tensor products of trigonometric B-splines for longitude and polynomial B-splines for latitude. Compared to the classical spherical harmonics, B-splines have a localizing character and, therefore, can handle an inhomogeneous data distribution properly. Finally, B-splines enable a so-called multi-resolution-representation (MRR) enabling the combination of global and regional modelling approaches.

In addition to the geodetic measurements, Sun observations are pre-processed and integrated in the data analysis. Sun observations provide very important and useful information that is passed into the Kalman-filter to improve the ionosphere predictions.