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VTEC Modelling using Space Geodetic Techniques with different latencies and Sun Observations

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ABSTRACT

Nowadays, space geodetic techniques such as GNSS or satellite altimetry provide valuable information with high spatial-temporal coverage and different latencies which pave the way of detailed investigations of atmospheric constitutes, for instance, the vertical total electron content or the electron density of the ionosphere, and their coupling with space weather events.

Fully operational GNSS systems, namely GPS and GLONASS, allow to obtain ionospheric observations with different latencies: IGS, for instance, provides real time GPS observations as well as GPS and GLONASS observations with one hour latency. Satellite altimetry data from the Jason-2 mission is characterized by a latency of about 3 hours and GPS occultation data from the Formosat-3/COSMIC mission is available with a latency of about 1 day. Other techniques such as the DORIS system deliver data with even a higher latency of, for example, a few days.

In this context, an ongoing project, named OPTIMAP (Operational Tool for Ionosphere Mapping and Prediction) was set up; 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 Göttingen (IAG). The project is dealing with the combination of the observations from the space geodetic measurement techniques mentioned before and Sun observations to improve the spatio-temporal data coverage, the sensitivity for the selected target parameters to obtain high quality estimated and forecasted ionosphere products; the final goal is to develop a time dependent model of either VTEC or the electron density based on different space geodetic and solar observations.

For VTEC modelling, we present a processing framework which is capable of running with different latencies and utilizing different space geodetic techniques for generating estimated and forecasted VTEC products. Here, 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, they provide a flexible approximation approach to handle the inhomogeneous data distribution. All the observations are assimilated in a Kalman filter which providing a recursive filtering approach which allows (near)-real time processing.

The Sun provides a significant amount of energy responsible for the motion of atmospheric constitutes and the coupling mechanisms between the magnetosphere, the ionosphere and the thermosphere. An incoming radiation causes variations (e.g. diurnal and solar weather event, for instance solar flares, related variations) in the ionosphere plasma including electrons and ions. Predictions of these effects due to solar weather events, e.g. solar flares, play an important role for VTEC forecasting and product quality. These events can be monitored from Sun observation techniques. Additionally, unusual changes on the observations obtained from space geodetic techniques and displayed in VTEC maps can also provide very useful information. In this context, relations between the Sun and the space geodetic observations as well as the computed VTEC products are investigated.

Key words: Ionosphere, Space geodetic Techniques, Sun observations, VTEC.