International Beacon Satellite Symposium BSS-2016
Trieste, Italy

Estimation of Global Ionosphere VTEC Maps by the Combination of Satellite Observation Techniques based on Kalman-Filtering

Eren Erdogan*[1], Michael Schmidt[1], Florian Seitz[1], Denise Dettmering[1], Klaus Börger[2], Sylvia Brandert[2], Barbara Görres[3], Wilhelm F. Kersten[3], Volker Bothmer[4], Johannes Hinrichs[4], Malte Venzmer[4], Niclas Mrotzek[4]

[1] German Geodetic Research Institute of the Technical University of Munich (DGFI-TUM), Munich, GERMANY
(eren.erdogan@tum.de, mg.schmidt@tum.de, florian.seitz@tum.de, denise.dettmering@tum.de)

[2] German Space Situational Awareness Centre (GSSAC), Uedem, GERMANY
(klausboerger@bundeswehr.org, sylviabrandert@bundeswehr.org)

[3] Bundeswehr GeoInformation Centre (BGIC), Euskirchen, GERMANY
(BarbaraGoerres@bundeswehr.org, wilhelmfkersten@bundeswehr.org)

[4] Institute of Astrophysics at the University of Göttingen (IAG), Göttingen GERMANY
(bothmer@astro.physik.uni-goettingen.de, jhinr@astro.physik.uni-goettingen.de, mvenzmer@astro.physik.uni-goettingen.de, nmrotzek@astro.physik.uni-goettingen.de)

ABSTRACT

The project OPTIMAP is a joint initiative by the Bundeswehr GeoInformation Centre (BGIC), the German Space Situational Awareness Centre (GSSAC), the German Geodetic Research Institute of the Technical University of Munich (DGFI-TUM) and the Institute for Astrophysics at the University of Göttingen (IAG). The development of an OPerational Tool for Ionospheric MAPping and prediction (OPTIMAP) constitutes the main concern. The combination of different satellite observation techniques is one of the key features to improve the spatio-temporal data coverage and to analyse the sensitivity for selected target parameters such as the Vertical Total Electron Content (VTEC) and the Electron Density (ED).

Gound-based, i.e. terrestrial GPS and GLONASS observations provide a high-resolution coverage of continental regions and have very high importance to study the variations of the ionospheric VTEC. Due to the very inhomogeneous global distribution of the GNSS observations sites large data gaps exist, especially over the oceans. Thus, additional satellite-based techniques which can mitigate the data gap problem as well as contribute to a data densification on the terrestrial regions are introduced. Over the oceans, the satellite altimetry mission Jason-2 is taken into account to acquire VTEC observations along the satellite tracks. Space-based GPS radio occultation measurements acquired from the Formosat-3/COSMIC mission are exploited for the retrieval of electron density profiles that are

integrated to obtain VTEC observations; see [1], [2]. Jason-2 carrier-phase data tracked by the on-board DORIS receiver are processed to produce further VTEC observations.

All the aforementioned observations are assimilated in a Kalman filter (KF) for modelling the global VTEC distribution. The KF allows for the sequential processing of the measurements where update steps are performed with one-minute sampling in the current configuration. The spatial VTEC distribution is represented by B-spline series expansions see [3], [4]. Therefore, the B-spline coefficients constitute the unknown parameters. Additional technique-dependent unknowns such as Differential Code Biases and Intersystem Biases are also considered to be estimated by the KF.

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.

Currently, a preliminary approach based on a time series analysis of the VTEC product generated by the Kalman filter is implemented to obtain a forecast model for several days. The method uses a Fourier series expansion to compute periodic trend functions which are later on used to provide the forecasted VTEC products.

Key words: Ionosphere, Data Assimilation, Sequential filtering.

References:

[1] Limberger M. (2015): Ionosphere modeling from GPS radio occultations and complementary data based on B-splines. PhD thesis, German Geodetic Commission, Series C 755

[2] Limberger M., W. Liang, M. Schmidt, D. Dettmering, U. Hugentobler (2013), Regional representation of F2 Chapman parameters based on electron density profiles. Annales Geophysicae 31(12): 2215-2227, European Geosciences Union, doi:10.5194/angeo-31-2215-2013 (Open Access)

[3] Schmidt M., D. Dettmering, M. Mößmer , Y. Wang, and J. Zhang (2011), Comparison of spherical harmonic and B spline models for the vertical total electron content. Radio Science, 46, RS0D11, doi:10.1029/2010RS004609

[4] Schmidt M., D. Dettmering, and F. Seitz (2015), Using B-spline expansions for ionosphere modeling. In: Freeden W., Nashed M.Z., Sonar T. (Eds.) Handbook of Geomathematics (Second Edition), 939-983, Springer, doi: 10.1007/978-3-642-54551-1_80