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Ionosphere monitoring and forecast activities within the IAG working group "Ionosphere Prediction"

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Ionospheric disturbances can affect technologies in space and on Earth disrupting satellite and airline operations, communications networks, navigation systems. As the world becomes ever more dependent on these technologies, ionospheric disturbances as part of space weather pose an increasing risk to the economic vitality and national security. Therefore, having the knowledge of ionospheric state in advance during space weather events is becoming more and more important. To promote scientific cooperation we recently formed a Working Group (WG) called "Ionosphere Predictions" within the International Association of Geodesy (IAG) under Sub-Commission 4.3 "Atmosphere Remote Sensing" of the Commission 4 "Positioning and Applications". The general objective of the WG is to promote the development of ionosphere prediction algorithm/models based on the dependence of ionospheric characteristics on solar and magnetic conditions combining data from different sensors to improve the spatial and temporal resolution and sensitivity taking advantage of different sounding geometries and latency. Our presented work enables the possibility to compare total electron content (TEC) prediction approaches/results from different centers contributing to this WG such as German Aerospace Center (DLR), Universitat Politècnica de Catalunya (UPC), Technische Universität München (TUM) and GMV.

DLR developed a model-assisted TEC forecast algorithm taking benefit from actual trends of the TEC behavior at each grid point. Since during perturbations, characterized by large TEC fluctuations or ionization fronts, this approach may fail, the trend information is merged with the current background model which provides a stable climatological TEC behavior. The presented solution is a first step to regularly provide forecasted TEC services via SWACI/IMPC by DLR.

UPC forecast model is based on applying linear regression to a temporal window of TEC maps in the Discrete Cosine Transform (DCT) domain. Performance tests are being conducted at the moment in order to improve UPC predicted products for 1-, 2-days ahead. In addition, UPC is working to enable short-term predictions based on UPC real-time GIMs (labelled URTG) and implementing an improved prediction approach.

TUM developed a forecast method based on a time series analysis of TEC products which are either B-spline coefficients estimated by a Kalman filter or TEC grid maps derived from the B-spline coefficients. The forecast method uses a Fourier series expansion to extract the trend functions from the estimated TEC product. Then the trend functions are carried out to provide predicted TEC products.

The forecast algorithm developed by GMV is based on the ionospheric delay estimation from previous epochs using GNSS data and the main dependence of ionospheric delays on solar and magnetic conditions. Since the ionospheric behavior is highly dependent on the region of the Earth, different region-based algorithmic modifications have been implemented in GMV′s magicSBAS ionospheric algorithms to be able to estimate and forecast ionospheric delays worldwide.

Different TEC prediction approaches outlined here will certainly help to learn about forecasting ionospheric ionization.