Recent activities of IAG working group “Ionosphere Prediction”

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Introduction

Ionospheric disturbances pose, for instance, an increasing risk on navigation, national security, satellite and airline operations, communications networks and the navigation systems. Constructing forecasted ionospheric products with a reliable accuracy is still an ongoing challenge. In this sense, a Working Group (WG) with the title “Ionosphere Prediction” within the International Association of Geodesy (IAG) under Sub-Commission 4.3 “Atmospheric Remote Sensing” of the Commission 4 “Positioning and Applications” has been created and is actively working since 2015 to encourage scientific collaborations on developing models and discussing challenges of the ionosphere prediction problem. Different centers contribute to the WG such as the German Aerospace Center (DLR), Universität Politécnica de Catalunya (UPC), Technical University of Munich (TUM) and GMV. One of the main focus of the WG is to evaluate different ionosphere prediction approaches and products which are highly depending on solar and geomagnetic conditions as well as on data from different measurement techniques (e.g. GNSS) with varying spatial-temporal resolution, sensitivity and latency. In this contribution, the recent progress of the WG on ionosphere prediction studies including individual and cooperated activities will be presented.

DLR

A family of Neustretz Total Electron Content (TEC) models called NTCM has been developed for last two decades at the DLR Institute of Communications and Navigation. Recently the global NTM model has been modified so that it can be driven by the GPS Klobuchar coefficients instead of the solar flux index F10.7. The model can be used as complementary to the GPS Klobuchar model for improving ionospheric corrections up to 40% especially during high solar activity time. Like the GPS Klobuchar model the NTM predicts ionospheric corrections 24 hours ahead.

DGFI-TUM

The DGFI-TUM approach for VTEC modelling is based on a series expansion in terms of products of polynomial B-splines (BS) \( N_i^B(\phi) \) in latitude \( \phi \) and trigonometric B-splines \( T_j^2(\lambda) \) in longitude \( \lambda \), see Eq. (1) and Schmidt et al. (2015). For the forecasting of the VTEC values our approach is based on the extraction of important signal components by using a Fourier series representation of the BS coefficients \( \{a_i^B(r)\} \) established by Kalmann filtering (Erdogan et al. 2017). The approach is extended by an ARMA model to take into account the stochastic part. The unknown coefficients \( a_i^B, a_i^B \) of the Fourier series and the ARMA model parameters (2) for each BS coefficient are computed at the end of every hour. Using the last 5 days data sets. In the current version the Fourier series and the ARMA model are extrapolated to provide the predicted VTEC values.

Comparison among different approaches

Table 1: Comparison of different ionosphere prediction approaches.

<table>
<thead>
<tr>
<th>Approach</th>
<th>Description</th>
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<tr>
<td>DLR</td>
<td>NTM: The presented approach takes benefit of GPS broadcast Klobuchar coefficients. Like the GPS Klobuchar model the NTM predicts ionospheric corrections 24 hours ahead.</td>
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<tr>
<td>UPC</td>
<td>TDMION: linear regression to a temporal window of TEC maps in the Discrete Cosine Transform (DCT) domain.</td>
</tr>
<tr>
<td>DGFI-TUM</td>
<td>B-splines: Fourier series and ARMA model analysis of the BS coefficients using the last 5 days data sets.</td>
</tr>
<tr>
<td>GMV</td>
<td>Ionospheric delay estimated from previous epochs using GNSS data and the main dependence of ionospheric delays on solar and magnetic conditions.</td>
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</tbody>
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Summary & Outlook

Our presented work enables the possibility to compare total electron content (TEC) prediction approaches/results from different centers such as German Aerospace Center (DLR), Universitat Politecnica de Catalunya (UPC), Technische Universität München (TUM) and GMV. Different TEC prediction approaches outlined here will certainly help to learn about forecasting ionospheric ionization. More intensive validation studies using independent TEC data are planned.

Acknowledgements

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References