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Error Assessment of Global Ionosphere Models for the Vertical Electron Content

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The Total Electron Content (TEC) is a key parameter in ionosphere modeling. It has the major impact on the propagation of radio waves in the ionized atmosphere, which is crucial for terrestrial and Earth-space communications including navigation satellite systems such as GNSS.

Most existing TEC models assume all free electrons condensed in one thin layer and neglect the vertical distribution (single-layer approach); those called Global Ionosphere Models (GIM) describe the Vertical Electron Content (VTEC) in dependency of latitude, longitude and time.
The most common GIMs are computed by the International GNSS Service (IGS) and are based on GNSS measurements mapped from slant TEC to the vertical by simple mapping functions. Five analysis centers compute solutions which are combined to one final IGS product. In addition, global VTEC values from climatology ionosphere models such as IRI2007 and NIC09 are available. All these models have no (ore only sparse) input data over the oceans and show poorer accuracy in these regions.
To overcome these disadvantages, the use of measurement data sets distributed uniformly over continents and open oceans is conducive. At DGFI, an approach has been developed using B-spline functions to model the VTEC in three dimensions. In addition to terrestrial GNSS measurements, data from satellite altimetry and radio occultation from Low Earth Orbiters (LEO) are used as input to ensure a more uniform data distribution.

The accuracy of the different GIMs depends on the quality and quantity of the input data as well as the quality of the model approach and the actual ionosphere conditions. Most models provide RMS values together with the VTEC; however most of these values are only precisions and not meaningful for realistic error assessment. In order to get an impression on the absolute accuracy of the models in different regions, this contribution compares different GIMs (IGS, CODE, JPL, DGFI, IRI2007, and NIC09) to each other and to actual measurements. To cover different ionosphere conditions, two time periods of about two weeks are used, one in May 2002 with high solar activity and one in December 2008 with moderate activity. This procedure will provide more reasonable error estimates for the GIMs under investigation.