Investigation of the Quality of a new Regional Model of the Ionospheric Electron Content

N. Magnet, R. Weber

Vienna University of Technology, Institute of Geodesy and Geophysics (IGG), Research Group Advanced Geodesy, Vienna, AUSTRIA

E-mail: nina.magnet@tuwien.ac.at, robert.weber@tuwien.ac.at

1. Introduction

At the Institute of Geodesy and Geophysics (TU Vienna) a new ionospheric model, labeled Multilayer Model, is under development. It consists of nine horizontal equidistant electron layers within the height range of the F2 layer, where the maximum of the ionization can be found. The remaining ionospheric layers are currently not considered. The electron content of each of the nine layers is obtained from a simple model with very few parameters, like the current maximum VTEC and weighting functions to account for the spherical distance between coordinates of the sub-sun point and the points of interest. All parameters are calculated with hourly time resolution from global and regional GNSS observation data.

The final ionospheric TEC grids of IGS (International GNSS Service) and the Global Ionospheric Maps (GIMs) of CODE (Center for Orbit Determination in Europe) have a resolution of 2 hours x 5° Longitude x 2.5° Latitude. They can be downloaded from the respective web pages of IGS (http://www.igs.org/ and CODE (ftp://ftp.unibe.ch/aiub/CODE/) in IONEX format.

In this presentation VTEC values calculated with the Multilayer Model are compared to the results of IGS and CODE in order to evaluate the new model. This research is performed within the project GIOMO (next Generation near real-time IOnospheric Models) which is launched by the Institute of Geodesy and Geophysics (TU Vienna), the TeleConsult Austria company and the Austrian Academy of Sciences and funded by the Austrian Research Promotion Agency (FFG).

2. Multilayer Model

a. Definition

The Multilayer Model consists of nine horizontal equidistant electron layers within the height range of the F2 layer. The electron count of these layers is modelled as a sinus curve with the amplitude A, which describes the maximum electron density of the F2 layer (Fig. 1).

The VTEC at any IPP (Ionospheric Pierce Point) of interest is obtained from the sum of the electron content of each layer at the location of the current electron maximum multiplied by a distance dependent weighting function, which accounts for the spherical distance to the IPP. Furthermore, the STEC along the ray path is derived by introducing nine slightly different IPPs at the corresponding layers.

$$VTEC_i = f_i \cdot q_i \qquad AT = \int_{h_1}^{h_9} A\,dh \qquad f_i = AT \cdot \sin\left((h_i - 300km)\cdot \frac{180°}{150km}\right)$$

b. Amplitude and Weighting Function

With the new model we characterize the electron density (= Amplitude) above the location of the electron maximum (approximately sub-sun point + 30° Longitude). The weighting function describes the decrease of the electron density with increasing distance to this point (Fig. 2).
These three parameters are obtained by a least squares adjustment of the measurements of a regional observation network.

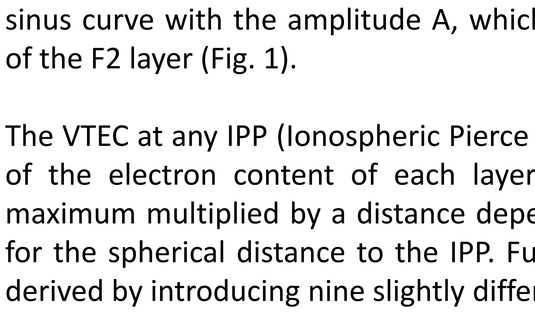

Fig. 1: F2 layer divided up into 9 layers

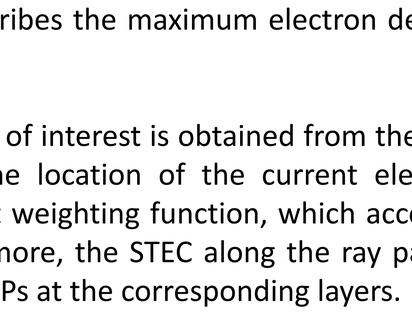

Fig. 2: Weighting Function

3. Comparison

Within the project GIOMO the Multilayer Model was compared with two reference models, the TEC grids of IGS and the GIMs of CODE. All models were evaluated for 05 June 2011 for 24 hours. The observation data required to estimate the parameters of the Multilayer Model was obtained from EPOSA (Echtzeit Positionierung Austria) GNSS network. The data for the two other models was downloaded from their web pages.

a. Final Ionospheric TEC Grids (IGS) and Global Ionospheric Maps (CODE)

Fig. 3 shows the VTEC-differences between the Multilayer Model and the final ionospheric TEC grid of IGS over the area of Austria. The obtained results are very consistent, so they differ by not more than 2 TECU. The most visible difference is at approximately 8:00 UTC. The comparison with the GIMs provided by CODE show a similar picture, so there are again no significant differences.

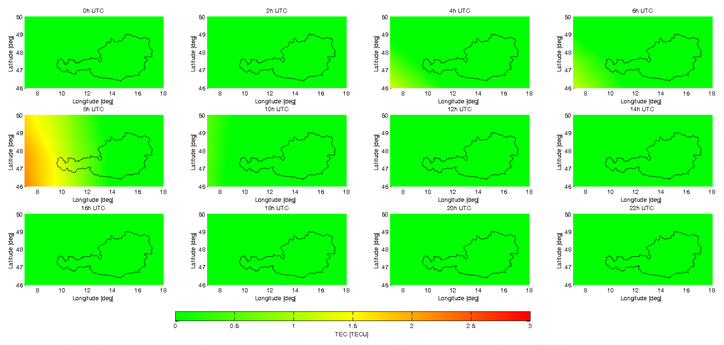

Fig. 3: Multilayer Model compared with TEC grids of IGS (VTEC over Austria)

b. Static 48h - Measurement

To further evaluate the Multilayer Model a reference site has been occupied with a single-frequency receiver over a period of 48 hours. The site coordinates established by means of different ionospheric models are compared in Fig. 4.

	OLG Model (Spherical Harmonics)	NeQuick Model	Multilayer Model
Standard deviation latitude (m)	0.88	1.15	0.88
Standard deviation longitude (m)	0.59	0.85	0.60
Standard deviation height (m)	1.85	2.93	1.83

Fig. 4: Statistic analysis, 48h static measurement

This table shows, that the accuracy of the Multilayer Model and the regional spherical harmonics model provided by OLG (Observatory Lustbühel Graz) is almost equal, so the results confirm the quality of the new model.

4. Summary

The VTEC calculated by means of the Multilayer Model is comparable to the corresponding results obtained from the final ionospheric TEC grids of IGS and the Global Ionospheric Maps of CODE. Both models differ by less than 2 TECU from the new model during the investigated period.
The new model requires only a few input parameters, which are furthermore easily to predict over a few hours. So the model can serve for real-time applications aiming at 1m positioning accuracy with single-frequency receivers.

In a planned collaboration with the DGFI (Deutsches Geodätisches Forschungsinstitut) the Multilayer Model will be compared to the B-Spline Model proposed by (Schmidt et al).

The Multilayer Model is still under development, so there are some suggestions for improvement. For example the F2 layer should be fitted by a Chapman function, and it should be tested if the number of 9 sub-layers is appropriate.

References

- TeleConsult Austria GmbH, Austrian Academy of Sciences, Vienna University of Technology: GIOMO – Next Generation near real-time Ionospheric Models. TN2000, 2012.
- Eposa (Echtzeit Positionierung Austria): *www.eposa.at*
- Rolf Dach, Urs Hugentobler, Pierre Fridez, Michael Meindl: Bernese GPS Software Version 5.0, January 2007
- Michael Schmidt: Wavelet modeling in support of IRI. Advances in Space Research , Volume 39, Issue 5, 2007.
- IRI 2007 online: http://omniweb.gsfc.nasa.gov/vitmo/iri_vitmo.html
- CODE GIMs: ftp://ftp.unibe.ch/aiub/CODE/
- IGS final ionospheric TEC grids: http://www.igs.org/