IONOSPHERIC MODELING BASED ON INTEGER-LEVELED PHASE-AMBIGUITIES

NINA JOLDZIC, ROBERT WEBER
Vienna University of Technology, Department of Geodesy and Geoinformation, Research Group Advanced Geodesy, Vienna, AUSTRIA
E-mail: nina.joldzic@tuwien.ac.at, robert.weber@tuwien.ac.at

I. INTRODUCTION

Within the project Regiomontan (Regional Ionospheric Modeling for Single-Frequency Users) a new and as possible realistic model of the ionosphere is used to calculate GNSS signal delays. These delays will be provided to single-frequency users in real-time in order to increase the positioning accuracy.

As background model the Multi-Layer Model, developed at the Department of Geodesy and Geoinformation (Vienna University of Technology), is used. All parameters are calculated with hourly time resolution from regional GNSS observation data. The Multi-Layer Model focuses on a regional densification of global ionosphere models (e.g. IGS VTEC SH models) by means of a small and easy predictable set of parameters.

So far the parameters of the Multi-Layer Model were only calculated out of smoothed code measurements. For the project Regiomontan our approach is based on integer-leveled phase observations to increase the model accuracy to about a few tenths of a TECU. The SD-ambiguities are fixed to integer values using uncalibrated phase delays, which are calculated by an in-house software from RT-network data streams. Subsequently we derive from the geometric free linear combination regional VTEC maps and satellite specific taylor series for the ionospheric correction. The VTEC maps are compared to IGS ionospheric products.

II. MULTI-LAYER MODEL

A. DEFINITION

The Multi-Layer Model 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 count of these layers is modeled 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.

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

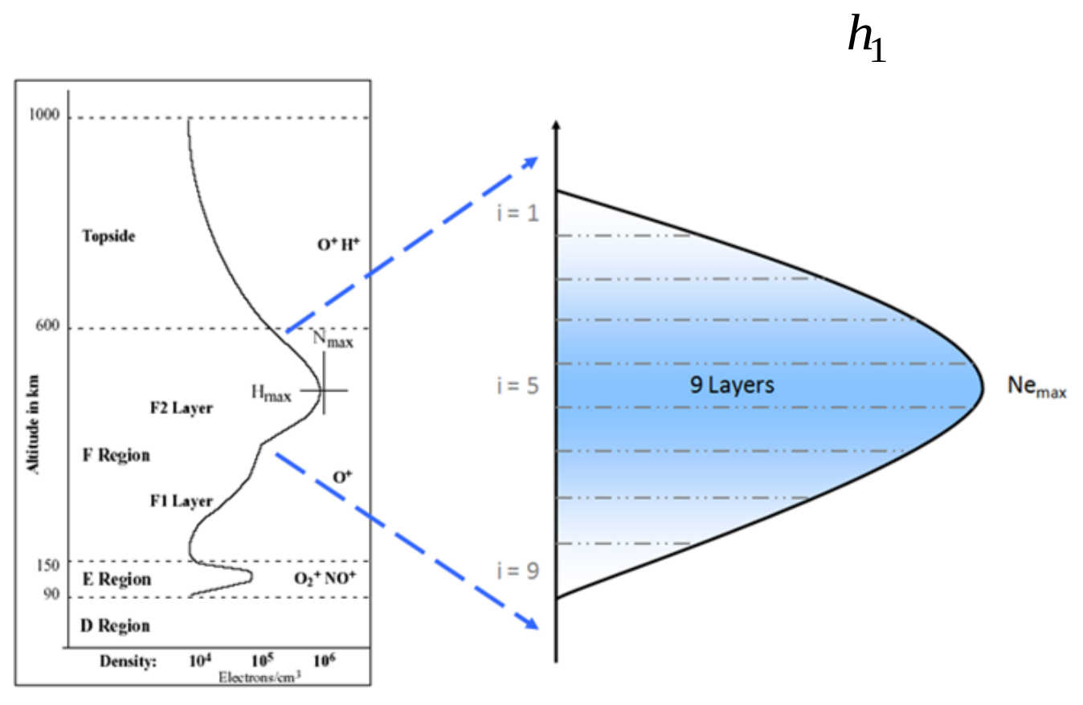

Fig. 1: F2 layer divided up into 9 layers

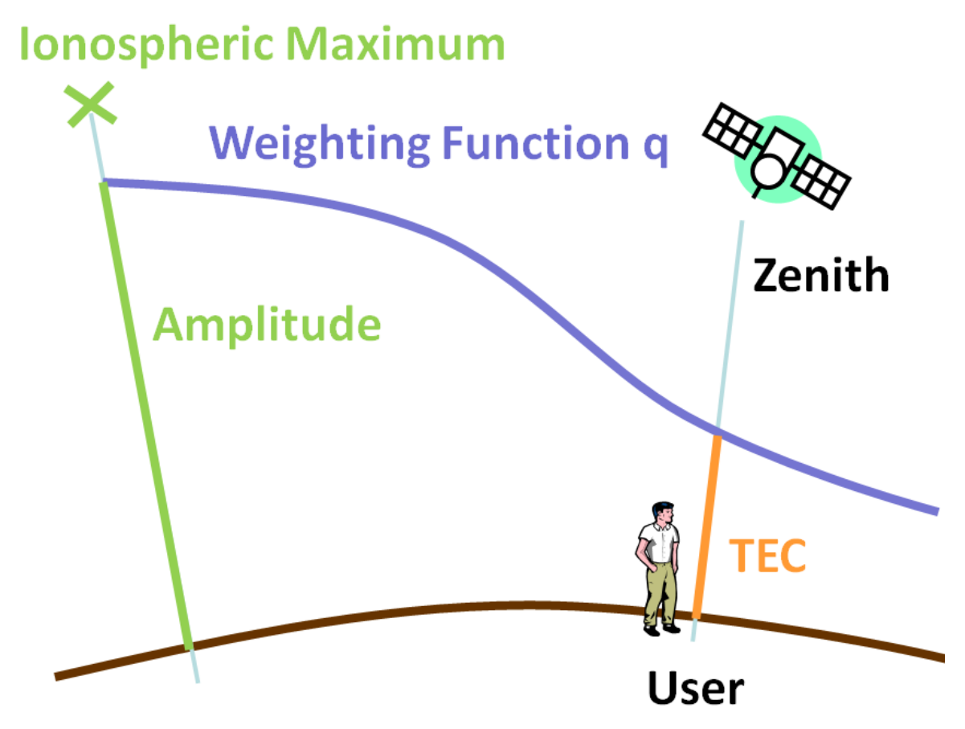

Fig. 2: Weighting Function

B. AMPLITUDE AND WEIGHTING FUNCTION

With the new model we characterize the electron density (= Amplitude) above the location of the electron maximum. The two weighting functions describe the decrease of the electron density with increasing distance to this point (Fig. 2) both in latitude and longitude.

These three parameters are obtained by a least squares adjustment of the dual-frequency measurements of a regional GNSS observation network.

III. INTEGER-LEVELED PHASE-AMBIGUITIES

The geometry-free linear combination (GF) is built to calculate the STEC out of GNSS reference station measurements. Thereby all non-dispersive terms, like the tropospheric delay or the clock errors are eliminated. In case of phase measurements, only an ionospheric term (Ion^j) and the unknown non-integer ambiguities ($\dot{N}$), including receiver- (b_i) and satellite-dependent biases (b_i^j), remain. N_i^j denotes the integer ambiguity:

$$\Phi_{GF}^j = \Phi_1^j - \Phi_2^j = (\mu - 1)\,Ion^j + \lambda_1 \dot{N}_1^j - \lambda_2 \dot{N}_2^j$$

$$\dot{N}_i^j = N_i^j + b_i + b_i^j$$

The satellite-dependent biases (UPDs) are calculated by an in-house software [Fabian Hinterberger] and subsequently we are able to fix the ambiguities of undifferenced observations to integer numbers N [Katrin Huber, TU Graz].

As these integer ambiguities are obtained with respect to a reference satellite, the computed STEC values are only differences to the STEC of the respective satellite. For now the STEC value for the reference satellite is still calculated from code measurements. The observed STEC is subsequently used to provide satellite specific TEC models (Taylor-series) to be interpolated by rover receivers.

IV. FIRST RESULTS AND OUTLOOK

First results were calculated for DOY088 in 2013. Fig. 3 shows the noise behavior of the geometry-free linear combination calculated out of phase measurements of the reference station GRAZ in Austria. The noise level of the derived STEC is as expected less than 0.05 TECU.

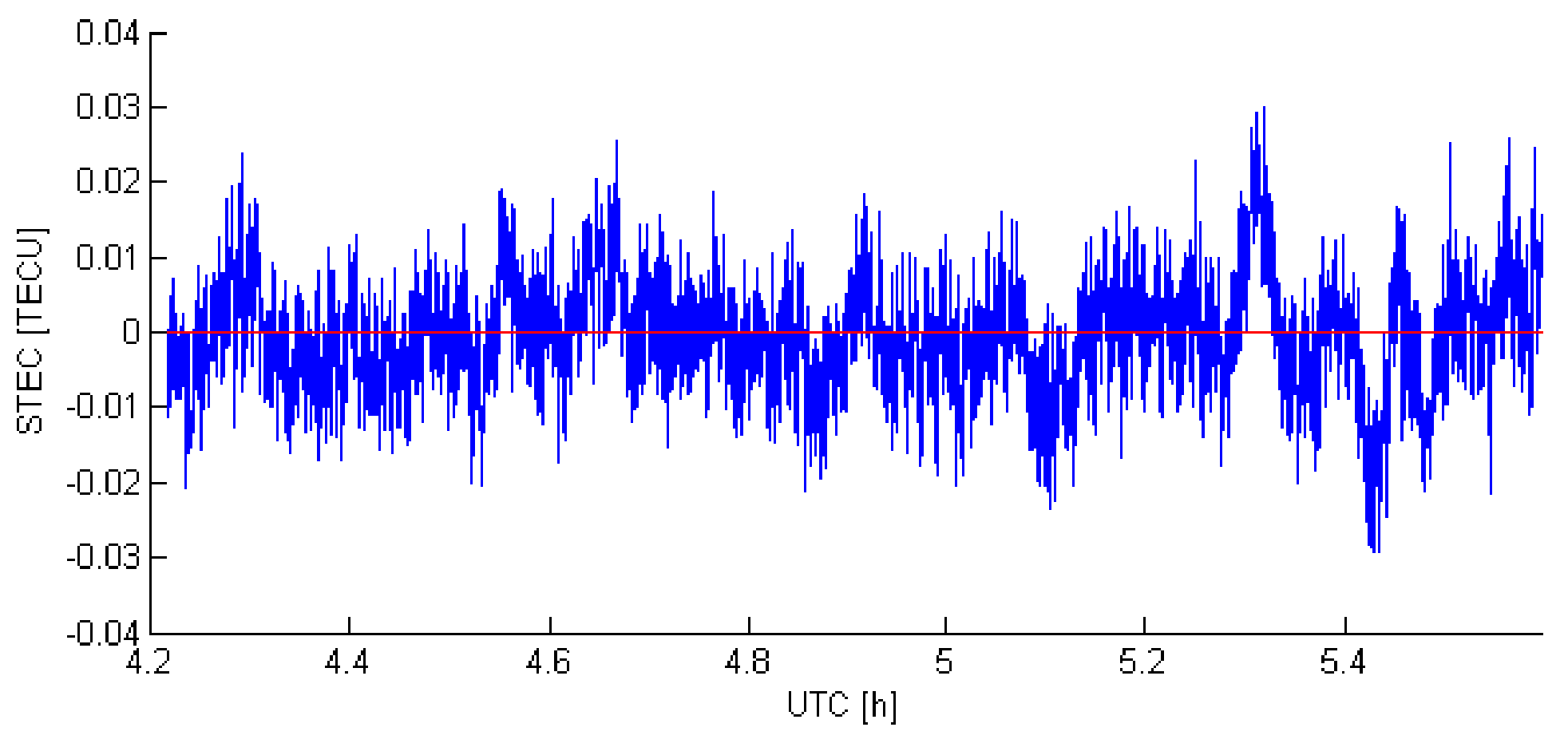

Fig. 3: Noise (GF Linear Combination, λ = 5.4 cm, DOY88 2013, Station GRAZ)

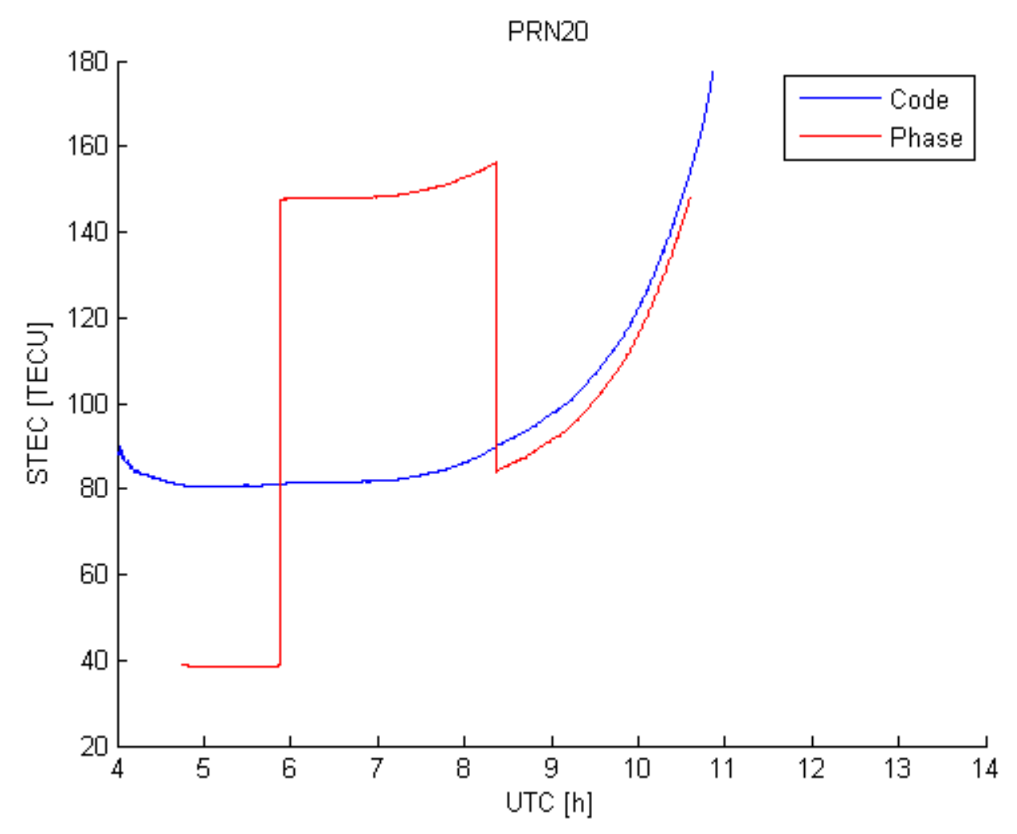

Fig. 4: STEC values for PRN20 to station GRAZ (DOY088, 2013)

As the integer ambiguities are calculated with respect to a reference satellite, the derived STEC values for individual satellites are still biased. This STEC offset is currently obtained from code measurements of the reference satellite. This introduces jumps every time the reference satellite changes (Fig. 4).

OUTLOOK

In the next step our MATLAB processing will be reinvestigated to detect phase jumps. The STEC of the reference satellite will be provided by a common back-ground model to fix the offset problem (Multi-Layer Model). Finally the satellite specific Taylor Series will be obtained.

REFERENCES

- S. BANVILLE, W. ZHANG, R. B. LANGLEY: A Better Way – Monitoring the Ionosphere with Integer-Leveled GPS Measurements. GPS World, March 2013.
- C. ROCKEN, Z. LUKES, L. MERVART, J. JOHNSON, T. IWABUCHI, M. KANZAKI: Ionospheric delay correction for single frequency receivers. ION GNSS, 2006.
- EPOSA (ECHTZEIT POSITIONIERUNG AUSTRIA): www.eposa.at
- N. JOLDZIC: Ionosphärische Korrektur von GNSS-Einfrequenzdaten mittels Multi-Layer Model. Geodetic Week, 2013.
- IGS FINAL IONOSPHERIC TEC GRIDS: http://www.igs.org/

PS07 - IONOSPHERE OBSERVATIONS AND MODELING

IGS WORKSHOP | PASADENA, CA, USA | JUNE 23-27 2014