Vienna IGG Special Analysis Center Annual Report 2003

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Abstract

Since July 2003 the combined tropospheric parameters determined at IGG (Schuh and Boehm, 2003 [4]) are regular IVS products provided by the IVS Data Centers one month after the availability of each new session database. Additionally, a forthcoming project within IVS-TROP has been initialized that is dealing with the combination of long time series of tropospheric parameters derived from VLBI for climate studies. The IGG has continued its research on the determination of ionospheric parameters from VLBI data.

1. General Information

The IVS Special Analysis Center at the Department of Advanced Geodesy of the Institute of Geodesy and Geophysics (IGG) is part of the University of Technology, Vienna. It is mainly engaged in atmospheric research (troposphere and ionosphere) and the development of the VLBI software package OCCAM.

Figure 1. **Members of the IVS AC at IGG, Vienna** (from left G. Estermann, S. Todorova, H. Schuh, J. Boehm, and T. Hobiger). The picture was taken at the Working Meeting on European VLBI in Leipzig, Germany.

2. Staff

Personnel at IGG associated with the IVS Special Analysis Center in Vienna are Harald Schuh (Head of Department of Advanced Geodesy, Member of IVS Directing Board) and the research assistants Johannes Boehm and Thomas Hobiger. While Johannes Boehm is mainly concentrating on tropospheric resarches, Thomas Hobiger focuses on the ionosphere. They are supported by several student assistants.

3. Current Status and Activities

- **Modification of the VLBI software package OCCAM**
  Together with Oleg Titov (Geoscience Australia), chairman of the 'OCCAM Group', and several other scientists from various countries, IGG is involved in the development of the OCCAM software. In particular, it is in charge of the classical least-squares approach using the Gauss-Markov model. In 2003, new tropospheric mapping functions based on data from numerical weather models have been implemented (Isobaric Mapping Functions IMF (Niell, 2001 [3]) with a priori hydrostatic gradients, and the Vienna Mapping Functions VMF (Boehm and Schuh, 2004 [1])).

- **IVS Tropospheric Parameters: IVS-TROP**
  Since July 2003 the combined tropospheric parameters determined at IGG (Schuh and Boehm, 2003 [4]) are regular IVS products provided by the IVS Data Centers one month after the availability of each new session database. The combination is done with submissions revceived from seven IVS Analysis Centers and it includes a detailed statistical analysis. Additionally, a forthcoming project within IVS-TROP was initialized that is dealing with the combination of long time series of tropospheric parameters for climate studies. More information about IVS-TROP can be found at the webpage `http://www.hg.tuwien.ac.at/~ivstrop` .

- **Vienna Mapping Functions VMF**

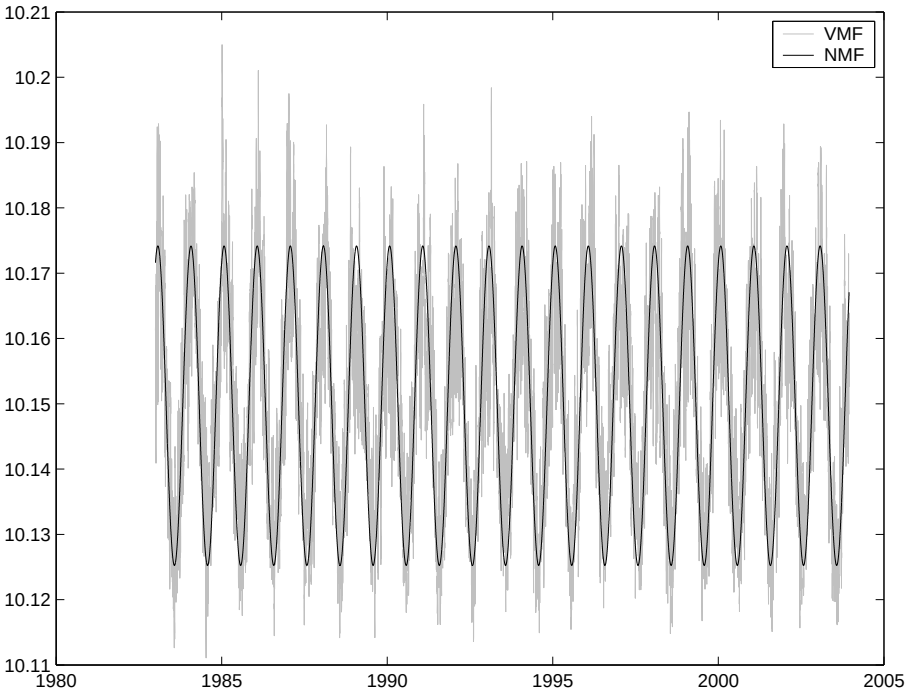

Figure 2. **Hydrostatic mapping functions from NMF and VMF** for an elevation angle of 5 degrees at Wettzell since 1984.

In 2003, much effort was put into the development of new tropospheric mapping functions based on data from numerical weather models. On the one hand data from the ECMWF (European Centre for Medium-Range Weather Forecasts) was used to determine the parameters of the Isobaric Mapping Functions IMF (Niell, 2001 [3]), on the other hand the Vienna Mapping Functions VMF (Boehm and Schuh, 2004 [1]) were developed at IGG. Figure 2 shows the comparison of the VMF with the NMF (Niell, 1996 [2]) at station Wettzell, Germany since 1984. More information about the mapping functions based on data from the ECMWF can be found at `http://www.hg.tuwien.ac.at/~ecmwf` .

- **Determination of ionospheric parameters - Vienna TEC Model (VTM)**
  In March 2003 a project entitled "VLBIonos", funded by the Austrian Science Fund (FWF) was launched. The project aims at the determination of ionospheric parameters by VLBI and comparsion with other techniques like GPS or Topex/Poseiden.
  It is a well known fact that in geodetic VLBI the observations are performed at two distinct frequencies (2.3 and 8.4 GHz) in order to determine ionospheric delay corrections. This allows us to gain information from VLBI observables about the sum of electrons (total electron content - TEC) along the ray path through the ionosphere. Because VLBI is a differential technique only the differences in the behavior of the propagation media over the stations determine the leading signs and the absolute values of the observed ionospheric delays. However, there is an instrumental delay offset per baseline that shifts the measurements by a constant value. This offset is thought to be independent of the azimuth and elevation in which the antennas point and this allows us to separate the ionospheric parameters for each station from the ionospheric offsets per baseline in a least-squares adjustment process. First tests using Fourier coefficients up to 4th order plus a constant value and a linear trend representing the vertical TEC (VTEC) were already made by Kondo (1991, [5]). Slant TEC (STEC) values are converted into VTEC values by a mapping function. The disadvantage of this approach is the assumption that these values are assigned to the station coordinates but not to the geographical coordinates of the intersection point of the ray path and the infinite thin ionospheric layer. Some problems may occur due to the apparent negative TEC values corresponding to the trigonometric approach. This effect can be avoided by a second approach developed at IGG using piecewise-linear functions having only positive values. This functional model was improved further to an adaptive piecewise-linear approach which fits the length of each time interval to the density of the observations. Figure 3 shows a comparison between the results obtained by VLBI and by different GPS analysis centers for 24 hours at Fortaleza, Brasil. In addition to the functional model a stochastical model was developed, that takes the elevation angle of each observation into account. The precision of the estimated values is about 2-3 TEC units (TECU). These results agree within 3-10 TECU with other techniques like GPS (Hobiger, 2003 [6]).

4. Future Plans

For the year 2004 the plans of the IVS Special Analysis Center at IGG include:

- Further development of OCCAM, e.g. the estimation of radio source coordinates,
- Research on new tropospheric gradient models that are based on numerical weather data,
- Participation in the new IVS Pilot Project - Baseline Lengths,

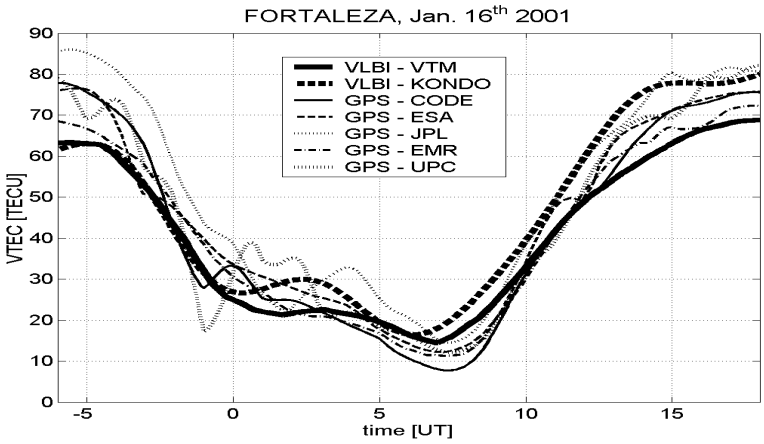

Figure 3. VTEC over the station Fortaleza, Brasil, comparison between VLBI (Vienna TEC Model - thick line; Kondo approach - thick dotted line) and individual GPS solutions (from IGS).

- Combination and analysis of long time series of tropospheric parameters with respect to climate variations,
- Determination of total electron content (TEC) maps from VLBI.

References

[1] Boehm, J., and H. Schuh: Vienna Mapping Functions in VLBI analyses, Geophys. Res. Lett., 31, L01603, doi:10.1029/2003GL018984, 2004.

[2] Niell, A.E.: Global mapping functions for the atmosphere delay at radio wavelengths, J. Geophys. Res., 101B2, 3227-3246, 1996.

[3] Niell, A.E.: Preliminary evaluation of atmospheric mapping functions based on numerical weather models, Phys. Chem. Earth, 26, 475-480, 2001.

[4] Schuh, H., and J. Boehm: Determination of Tropospheric Parameters Within the new IVS Pilot Project, In: Proceedings of the 16th Working Meeting on European VLBI for Geodesy and Astrometry, held at Leipzig, May 9-10, 2003, edited by W. Schwegmann and V. Thorandt, Bundesamt für Kartographie und Geodäsie, Frankfurt/Leipzig, 257 - 264, 2003.

[5] Kondo T.: Application of VLBI data to measurements of ionospheric total electron content, Journal of the Communications Research Laboratory, Vol. 38, No. 3, 613-622, Tokyo, Japan, 1991.

[6] Hobiger T., J. Boehm, S. Todorava, and H. Schuh: The project "VLBIonos" - how VLBI contributes to ionospheric research In: Proceedings of the 16th Working Meeting on European VLBI for Geodesy and Astrometry, held at Leipzig, May 9-10, 2003, edited by W. Schwegmann and V. Thorandt, Bundesamt für Kartographie und Geodäsie, Frankfurt/Leipzig, 291 - 298, 2003.