# Vienna IGG Special Analysis Center Annual Report 2005

*Harald Schuh, Johannes Boehm, Robert Heinkelmann, Thomas Hobiger, Sonja Todorova, Joerg Wresnik*

**Abstract**

In 2005 the Institute of Geodesy and Geophysics (IGG) at the Vienna University of Technology continued its investigations in atmospheric research for geodetic VLBI: Among other topics, it was dealing with the neutral atmosphere in terms of long time series of tropospheric parameters and with the ionosphere in particular by determining ionospheric parameters from VLBI observations. Furthermore, it started simulation studies which are dedicated to the new VLBI2010 observing system.

## 1. General Information

The Institute of Geodesy and Geophysics (IGG) is part of the Faculty of Mathematics and Geoinformation of the Vienna University of Technology. It is divided into three research units, one of them focusing on advanced geodesy (mathematical and physical geodesy, space geodesy). Within this research unit, one group (out of four) is dealing with geodetic VLBI.

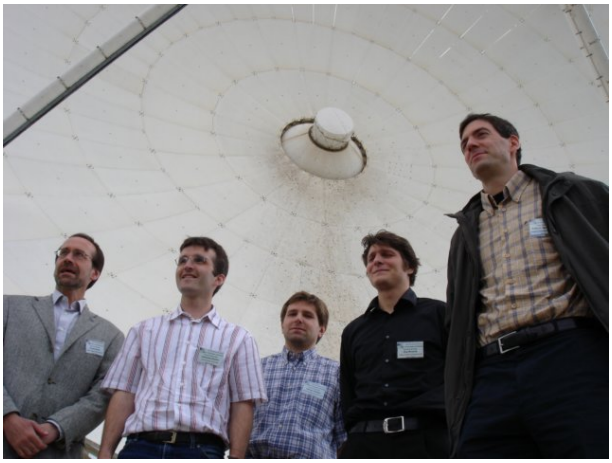

Figure 1. Members of the IVS AC at IGG, Vienna, in front of the Noto telescope at the European VLBI meeting in 2005 . From left: Harald Schuh, Johannes Boehm, Thomas Hobiger, Joerg Wresnik, and Robert Heinkelmann. Sonja Todorova is missing on this picture.

## 2. Staff

Personnel at IGG associated with the IVS Special Analysis Center in Vienna are Harald Schuh (Head of IGG, member of IVS Directing Board), and the scientific staff members Johannes Boehm, Robert Heinkelmann, Thomas Hobiger (until April 2005 at Kashima Space Research Center / NICT, Japan), Sonja Todorova, and Joerg Wresnik. While Johannes Boehm and Robert Heinkelmann are mainly concentrating on tropospheric research, Thomas Hobiger and Sonja Todorova focus on the ionosphere. Joerg Wresnik is taking care of the simulation studies.

## 3. Current Status and Activities

- **Modification of the VLBI software package OCCAM**
  Together with Oleg Titov (Geoscience Australia), chairman of the 'OCCAM Group', and Volker Tesmer (Deutsches Geodätisches Forschungsinstitut, Germany), IGG is involved in the development of the OCCAM software. In 2005, the VMF1 (Boehm et al., 2006) and GMF (Boehm et al., 2006a) have been implemented in OCCAM.

- **Troposphere Mapping Functions**
  The Vienna Mapping Functions VMF have been updated with the VMF1 (Boehm et al., 2006 [1]). Furthermore, the purely empirical Global Mapping Functions GMF have been developed (Boehm et al., 2006a) to be consistent with VMF1. They are based on spherical harmonic expansions and only account for seasonal variations.

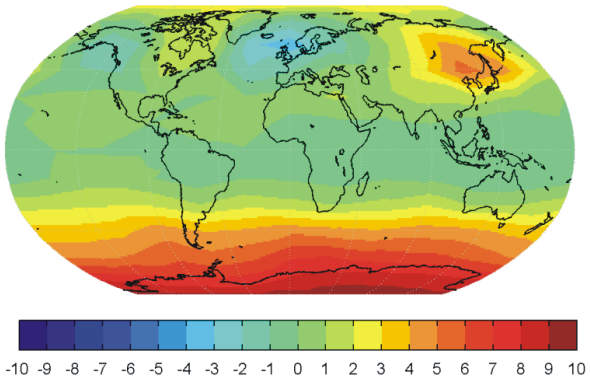


Figure 2. Station height change in mm for January when using GMF instead of NMF.

- **IVS Tropospheric Combination and Long Time Series of Tropospheric Parameters**
  In 2005 the IGG combined weekly solutions of wet and total zenith delays from eight IVS Analysis Centers. The combined solution undergoes several quality checks before it is provided to the user community via the webpage http://mars.hg.tuwien.ac.at/~ivstrop/, maintained at IGG (Heinkelmann et al., 2005). Combination reports are available as tables; the most recent ten combinations and statistics are also provided graphically. The IVS combined tropospheric parameters are used for comparison by individuals and institutions. Since May 2005 north-south and east-west gradients are compared, too, showing systematic differences in the range of a few millimetres between individual ACs. The long time series of tropospheric parameters provided by six Analysis Centers have been combined using the BIBER estimator for outlier elimination and variance component estimation to determine the weights for the combination process on the level of results.

- **IVS-MET: Meteorological Surface Instrumentation and Data**
  During 2005 several efforts to get the missing meta-data about the IVS meteorological surface instrumentation were launched, but with low success. Important information necessary

for a reliable climate analysis is still missing. The time series of surface pressure measurements of all VLBI sites were homogenized statistically using the SNHT (Heinkelmann et al., 2005a) method. The analysis revealed jumps ranging from 1hPa to about 17hPa in almost every time series significantly distorting the determination of wet zenith delays, if ignored. The role of meteorological data for the VLBI analysis was assessed comparing long time series of tropospheric parameters using surface pressure and temperature data from surface instrumentation and from the European Centre of Medium-Range Weather Forecast (ECMWF). For the exchange of knowledge and up-to-date data the IVS-MET web page http://mars.hg.tuwien.ac.at/~ivstrop/ivsmet.html was set up.

- **VLBI as a tool to probe the ionosphere**
  Within project VLBIonos at the IGG, Vienna a method has been developed which enables estimation of vertical total electron content values from VLBI measurements (Hobiger et al., 2006). As VLBI observations cover more than two complete solar cycles, longer than all other space geodetic techniques using radio signals, the relation to space weather indices on long time scales can be demonstrated. Additionally, the results obtained from VLBI can be cross-validated against GPS, satellite altimetry data, and theoretical models like IRI. It can be stated that the overall agreement between VLBI and GPS is within the formal error of each technique and that both systems detect the same periods of ionospheric variations. But only VLBI is able to reveal long period signals like the (~11 year) solar cycle, since it covers a sufficiently long time span. Systematic biases of the techniques can be investigated and deficiencies of theoretical models can be revealed.

- **Detection of short period ionosphere variations by VLBI**
  The usage of fringe phase information from VLBI measurements is a new and challenging field of research, which can be applied for the detection of short period variations (scintillations) of the ionosphere. Short period ionosphere variations can be detected very precisely, if the signal-to-noise ratio of the VLBI data is high enough. A method for the extraction of such disturbances was developed and dispersive influences could be separated from intra-scan delay variations. Possible physical origins of the disturbances were investigated and the results obtained from VLBI were validated against GPS measurements to verify the outcomes.

- **Simulation studies**
  Simulations for VLBI2010 were started to propose new observing strategies and schedules, to improve troposphere and clock modeling, to find the best antenna configuration and to optimize the network geometry. The simulation studies are realized by a sequence of three software programs. After scheduling the observations with SKED, the fake observations (Monte Carlo simulation) are transformed to NGS format. These files are the input for the VLBI analysis software package OCCAM, which will be adapted for the simulations. The covariance and correlation matrices from OCCAM will be available in SINEX format and will be the input for a Matlab program called VV-SIM (Vienna VLBI-Simulation), which allows the interpretation of the results with distinct numbers and figures to deliver objective criteria for comparison.

## 4. Future Plans

For the year 2006 the plans of the IVS Special Analysis Center at IGG include:

- Further development of OCCAM, e.g., the implementation of high resolution, a priori gradients from numerical weather models
- Homogeneous recombination of the weekly combined tropospheric parameters
- Combination of tropospheric parameters on the level of normal equations
- Further investigations of the influence of various meteorological data on the global and local parameters of the VLBI analysis
- Investigations of the ionosphere by means of VLBI
- Development of a multi-technique global ionosphere model
- Further development of a software correlator based on Matlab (Hobiger and Kondo, 2005)
- Further simulation studies for VLBI2010

## 5. Acknowledgements

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