Robert Heinkelmann et al.: Global VLBI Solution IGG05R01, IVS 2006 General Meeting Proceedings, p.42–46
http://ivscc.gsfc.nasa.gov/publications/gm2006/heinkelmann2

Global VLBI Solution IGG05R01

Robert Heinkelmann [1], Johannes Boehm [1], Harald Schuh [1], Volker Tesmer [2]

[1] *Institute of Geodesy and Geophysics/University of Technology, Vienna*
[2] *Deutsches Geodätisches Forschungsinstitut, Munich*
Contact author: Robert Heinkelmann, e-mail: rob@mars.hg.tuwien.ac.at

Abstract

The global solution IGG05R01 includes simultaneously estimated station position, velocity and source coordinate catalogues as well as time series of EOP. It is the first solution of global parameters at the IVS Special Analysis Center Institute of Geodesy and Geophysics (IGG), the first global VLBI solution in Austria, and the second solution using the OCCAM software package with the least-squares method (LSM) together with DOGS-CS. In this paper we introduce the technical details and present results, which show that this solution, in spite of some modelling deficiencies and neglected geophysical model corrections, is already of good quality.

1. Introduction

At the Special Analysis Center IGG, Vienna, a global VLBI solution has been obtained using the OCCAM 6.1 package with the least-squares method (LSM) to determine local parameters and the DOGS-CS software, developed at the DGFI, Munich, for the addition and solution of normal equations to solve for global parameters. With this effort the IGG aims to contribute to future realizations of IVS and IERS combined products, such as ICRF, ITRF, and EOP time series. Investigations are planned on the dependencies between troposphere parameters, meteorological data, station positions and velocities, in particular on the height component, and scale factor and scale rates. In recent studies (Heinkelmann et al., 2005a, [3]) it has been pointed out that deficiencies of the terrestrial reference frame (TRF) significantly influence the troposphere parameters and inherent long-term trends. It was demonstrated that this statement also holds the other way around, because mapping functions and troposphere parameters depend on the input of meteorological data. They also significantly influence the station positions and velocities. Therefore, a homogeneous meteorological data set is indispensable for the determination of a reliable TRF, and a reliable TRF is necessary to obtain consistent troposphere parameters. The meteorological data for IGG05R01 are from the European Center for Medium-Range Weather Forecasts (ECMWF) and from the surface meteorological data recorded at the IVS sites, which were carefully homogenized (Heinkelmann et al., 2005b, [4]).

2. General Characteristics of IGG05R01

To achieve an un-constrained TRF, quasar coordinates, EOP, and station positions and velocities have to be estimated simultaneously (Tesmer et al., 2004, [8]) in a free adjustment applying minimal constraints. The minimal constraints define the origins and axes of the reference frames by forcing the sum of rotations and the sum of translations to be zero. This is due to the fact that - by definition - all overall rotations and translations between the CRF and the TRF are to be expressed by the EOP. In IGG05R01 station positions and linear velocities are modelled and given as coordinates with respect to a reference epoch. The reference epoch of IGG05R01 is the reference epoch of ITRF2000: 1997.0 (1997-01-01). In case of an episodic motion of the antenna two sets of coordinates are reported (before and after the change). While source coordinates are considered constant in time, the EOP are estimated locally session by session and handled as a time series.

2.1. Session Criteria

The global solution IGG05R01 consists of 3,414,325 observations and formal errors from 2702 dual-band sessions in NGS-format between 1984-01-04 and 2005-11-28 taken from the IVS Data Centers. Although Mark III VLBI observations are available from 1979 on, the sessions included in IGG05R01 begin in 1984 with the start of the regular type of session IRIS-A (International Radio Interferometric Surveying, Atlantic), to achieve temporal homogeneity. The total number of geodetic VLBI sessions[1] for almost 22 years of observation is 4490. Although the solution includes only about 60% of the total number of sessions, it nevertheless represents a high amount of significant information. Among the excluded sessions are the intensive sessions and all other sessions which were performed on a single baseline, sessions carried out by small national or regional networks, e.g. JADE (JApanese Dynamic Earth observation by VLBI), and other sessions which are not suitable to determine reliable EOP[2], sessions where the RMS of the postfit residuals exceeds 2 cm, sessions where the fraction of outliers exceeds 3.5%, sessions where the number of parameters exceeds the number of observations[3].

2.2. Station Criteria

The total number of VLBI sites within the ITRF2000 is 136. However, only a small subset (37%) of non-mobile stations takes part in almost all of the geodetic VLBI observations. Thus, the IGG05R01 solution includes only the 50 most frequently used VLBI antennas. The 59 mobile antennas of ITRF2000, except TIGO at Wettzell, and 27 non-mobile antennas which participated in a small number of sessions are excluded. Stations from outside of the ITRF2000 are SVETLOE as well as TIGO at Concepcion. 15 out of the 50 stations were selected for the datum definition (see Table 1). This small subset of stations provides a long observational history, a global temporal and spatial coverage, and it is free of earthquake, rail repairing, and other episodic station motions.

Table 1. The 15 stations used for the TRF datum definition of IGG05R01

ALGOPARK	FORTLEZA	HARTRAO	HOBART26	KASHIMA
KAUAI	KOKEE	MATERA	NRAO20	NYALES20
ONSALA60	RICHMOND	SESHAN25	WESTFORD	WETTZELL

[1] Sessions available in NGS-format from IVS Data Centers on January 6, 2006.

[2] As suggested by the IVS Analysis Coordinator (http://vlbi.geod.uni-bonn.de/IVS-AC/data/exclude.html).

[3] The number of parameters is not constant, it depends on the parameterization, i.e. on the type and resolution of the auxiliary parameters.

2.3. Source Criteria

At least three observations to a source are necessary per session in order to estimate the two source coordinates with minimal redundancy. To ensure reliability the position of a source is only estimated globally, if it participates in at least three sessions. These criteria are fulfilled by 552 radio sources out of the total number of 667 within ICRF-Ext.1 in our solution. For the CRF datum definition no-net-rotation (NNR) with regard to the 199 stable sources defined by Feissel-Vernier (2003, [2]) were applied.

3. Results

3.1. IGG05R01-CRF

The estimated source coordinates do not show systematic differences with regard to the a priori coordinates taken from the ICRF-Ext.1. Considering the reported source position errors of the ICRF-Ext.1 the deviations between the solutions are negligible.

3.2. IGG05R01-TRF

The horizontal and vertical velocities of the stations included in IGG05R01 are compared to the VTRF2005 (Nothnagel, 2005, [6]), a combined TRF obtained from five VLBI solutions. In general, horizontal and vertical velocities agree very well. Small differences in horizontal components occur at KWAJAL26 and SYOWA stations due to the small number of observations. At the VLBA (Very Long Baseline Array) telescopes differences in the vertical components are significant. The sessions of the types VLBA and RDV (Research and Development - VLBA) contain most of the observations of these telescopes. These sessions are currently not included in our solution. The differences in the vertical component of the 15 datum sites are displayed in Figure 1. The interaction of position and velocity becomes more evident by the application of datum transformations of the coordinates from the reference epoch 1997.0 to the beginning (1984.0) and the end (2005.0) of the time span. Then, the vertical components of the TRFs deviate less than 4 cm w.r.t. ITRF2000 and up to 1 cm w.r.t. each other during the whole time span. To get an overall measure of the agreement between the two TRFs the coordinates of the twelve regularly used stations (IVS (2005), [5]) were transformed from IGG05R01 to ITRF2000 for the two epochs 2000 and 2010. The Helmert parameters are given in Table 2.

3.3. IGG05R01-EOP

The IGG05R01 includes time series of nutation offsets, polar motion and $\Delta UT1$ offsets and rates, estimated locally for each single session. The nutation model used is MHB2000, without the free core nutation (FCN) terms. A priori EOP are taken from the IERS-C04 series. Figure 2 shows nutation estimates in longitude $\Delta\psi$ and in obliquity $\Delta\epsilon$ w.r.t. the MHB2000 model.

4. Conclusions and Outlook

The global solution IGG05R01 is already of good quality. It can be improved by extending the number of stations, the number of sources, and the included session types, modelling non-linear post-seismic and other station motions, acounting for thermal telescope deformation and

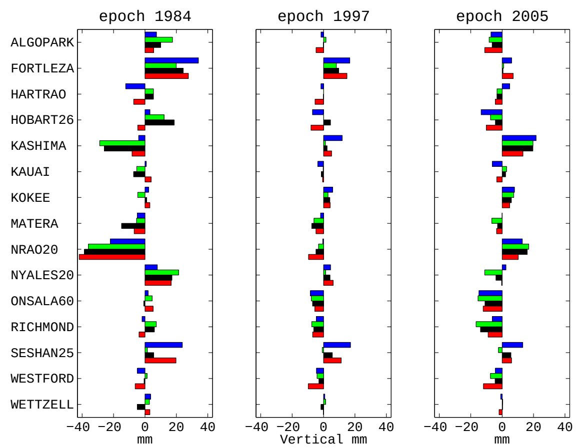

Figure 1. Comparison of the vertical components of the 15 datum stations at three epochs w.r.t. ITRF2000. Compared solutions from top to bottom: IGG05R01-TRF in blue (grey 80%), VTRF2003 (Nothnagel, 2003, [7]) in green (grey 30%), VTRF2005 in black, and the current VLBI solution of DGFI, 05R02 in red (grey 50%).

Table 2. Parameters of a Helmert transformation of twelve regularly used stations (IVS 2005, [5]) from IGG05R01-TRF to ITRF2000. * at Earth radius

epoch		**2000**		**2010**	
α	$[\mu as]$	**-37.4**	$\pm$151	**112**	$\pm$240
β	$[\mu as]$	**-66.6**	$\pm$155	**-238**	$\pm$247
γ	$[\mu as]$	**-51.4**	$\pm$148	**-82.4**	$\pm$236
ΔX	$[mm]$	**1.5**	$\pm$4.0	**-2.1**	$\pm$6.3
ΔY	$[mm]$	**-2.6**	$\pm$3.9	**-1.5**	$\pm$6.2
ΔZ	$[mm]$	**1.0**	$\pm$3.8	**-0.9**	$\pm$6.0
scale	$[ppb]$	**0.81**	$\pm$0.59	**0.84**	$\pm$0.94
scale	$[mm^*]$	**5.2**		**5.4**	

atmospheric loading corrections, applying the new Vienna mapping functions VMF1 (Boehm et al., 2006, [1]) and a priori non-zero atmospheric gradients, and optimizing inherent soft and hard constraints.

References

[1] Boehm J., B. Werl, H. Schuh: Troposphere mapping functions for GPS and VLBI from ECMWF operational analysis data, J. Geophys. Res., in press, 2006

[2] Feissel-Vernier M.: Selecting stable extragalactic compact radio sources from the permanent astrogeodetic VLBI program. Astronomy and Astrophysics, 403, 105-110, 2003

[3] Heinkelmann R., J. Boehm, H. Schuh: IVS long-term series of Tropospheric Parameters. In: Vennebusch M., Nothnagel A. (Eds.): Proceedings of the 17^{th} Working Meeting on European VLBI for Geodesy and Astrometry, Noto, Italy, 69-73, 2005

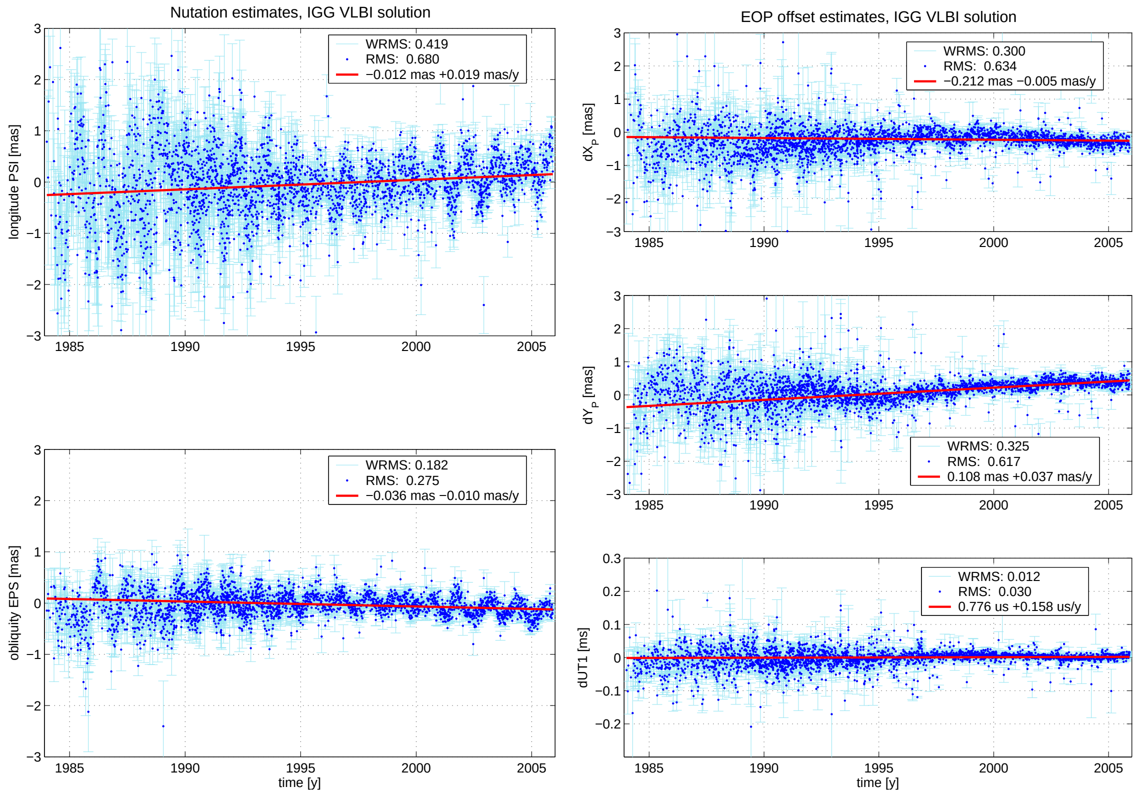

Figure 2. IGG05R01 nutation series w.r.t. MHB2000 model without FCN (left) and IGG05R01 Earth rotation parameters w.r.t. IERS-C04 (right). The nutation series are dominated by a quasi-harmonic signal with a period of about 430 days (FCN). The small trend in the Y-Pole component is probably due to a small inconsistency in the IERS-C04 series stemming from a constrained determination independently of the TRF and CRF solutions.

[4] Heinkelmann R., J. Boehm, H. Schuh: Homogenization of surface pressure recordings and its impact on long-term series of VLBI tropospheric parameters. In: Vennebusch M., Nothnagel A. (Eds.): Proceedings of the 17^{th} Working Meeting on European VLBI for Geodesy and Astrometry, Noto, Italy, 74-78, 2005

[5] IVS (2005): International VLBI Service for Geodesy and Astrometry: Annual Report 2004, D. Behrend, K. Baver (Eds.), NASA/TP-2005-212772, 2005

[6] Nothnagel A.: VTRF2005 - A combined VLBI Terrestrial Reference Frame. In: Vennebusch M., Nothnagel A. (Eds.): Proceedings of the 17^{th} Working Meeting on European VLBI for Geodesy and Astrometry, Noto, Italy, 118-124, 2005

[7] Nothnagel A.: VTRF2003: A Conventional VLBI Terrestrial Reference Frame. In: Schwegmann W., Thorandt V. (Eds.): Proceedings of the 16^{th} Working Meeting on European VLBI for Geodesy and Astrometry, Leipzig, Germany, 195-205, 2003

[8] Tesmer V., H. Kutterer, H. Drewes: Simultaneous Estimation of a TRF, the EOP and a CRF. In: Vandenberg, N., K. Baver (Eds.): IVS 2004 General Meeting Proceedings, NASA/CP-2004-212255, 311-314, 2004