DGFI Analysis Center Annual Report 2006

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Abstract

This report summarizes the activities of the DGFI Analysis Center in 2006 and outlines the planned activities for the year 2007.

1. General Information

The German Geodetic Research Institute (Deutsches Geodätisches Forschungsinstitut, DGFI) is an autonomous and independent research institution located in Munich. It is run by the German Geodetic Commission (Deutsche Geodätische Kommission, DGK) at the Bavarian Academy of Sciences. The research covers all fields of geodesy and includes the participation in national and international projects as well as functions in international bodies (see also http://www.dgfi.badw.de).

2. Activities in 2006

1. Effect of various analysis options on estimated TRF and station position parameters

   Geodetic computations offer a variety of analysis options, which are subject of general conventions, like the IERS Conventions, or technique dependent conventions proposed by the technique services. But, neither can all options be objectively judged as right or wrong, nor are the effects of all options on geodetic parameters known in detail.

   For example, VLBI results significantly depend on the chosen tropospheric mapping function (MF), which may cause systematic effects. As illustrated in Figure 1, the station height components of a TRF solution computed from 20 years of data differ by up to 13 mm between solutions computed with the VMF1 (Vienna Mapping Function 1) and the NMF (Niell Mapping Function). Discrepancies between station height time series reveal annual periodical signals with amplitudes up to 5 mm (Figure 2). In terms of station position repeatability, VMF1 is clearly superior: Using VMF1 the overall WRMS of the heights is between 5% and 7% better, for stations between 30° and 50° latitude even by up to 23% than with NMF.
   Using constant a priori ZD (zenith delay) instead of a ZD derived from surface meteorological data may change the station heights of an estimated TRF tremendously, as estimated ZD and station heights are correlated. With the approaches usually used, e.g. in GPS data analysis, the station heights change less than 1 cm. Furthermore, periodic and annual signals in differences of such height position time series can be found up to 4 mm (Figure 3).

   These results and other tested analysis options are described in Tesmer et al. (2006).

2. Effect of various analysis options on VLBI-determined CRF

   The next VLBI-determined realization of the International Celestial Reference System (ICRS) is prepared thoroughly. It will presumably serve as an important link between Earth-oriented and space-oriented sciences via other celestial reference frames (e.g. GAIA) to be created in the next decade. Such satellite-based celestial reference frames are planned to be

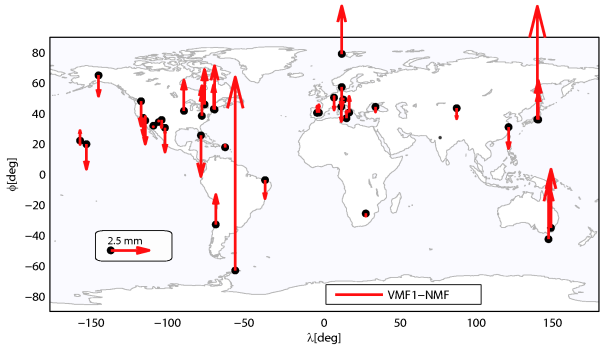

Figure 1. TRF height differences: Comparing solutions with VMF1 and NMF.

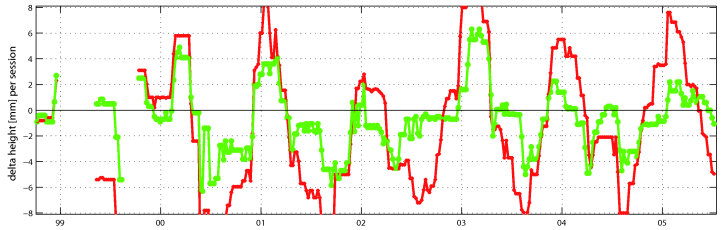

Figure 2. Time series of height differences in Tsukuba (Japan): Solutions VMF1 vs. NMF (dark) and GMF (light), displayed are moving medians computed every 7 days for values of 70 days each.

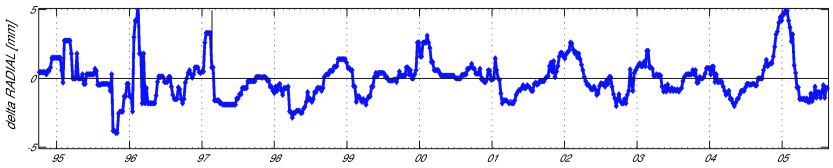

Figure 3. Time series of height differences in Ny-Ålesund (Spitsbergen, Norway): Solution using ZD from surface met data vs. solution using constant apriori ZD. Displayed are moving medians computed every 7 days for values of 70 days each.

of even higher precision than it can be achieved with VLBI observing at the Earth's surface. This connection will be realized by the very stable VLBI station network referred to the International Terrestrial Reference Frame (ITRF). In this context, the effects of various analysis options on VLBI-determined CRF (celestial reference frames) were investigated:

- different troposphere mapping functions and gradient models,
- impact of elevation-dependent weighting (refined stochastic model),
- choice of data set (neglecting 534 sessions before 1990 and 21 astrometric sessions),
- handling of sources that may not be assumed to have time-invariant positions,
- handling of the station network (estimate the station positions per session, as positions and velocities over 20 years, or fix them to a priori values).

The biggest systematic effects in the estimated source positions of up to 0.5 mas were found to be due to different gradient models (see e.g. Figure 4, grey stars indicate the differences

between the declination estimates of the all sources in the solution, solid red lines are median values computed each 0.5° for all values inside a ±12.5° band). The choice of the data set does generally not have a significant influence. This holds also (with exceptions) for different options how to treat sources which are assumed to have time-invariant positions (Figure 5).

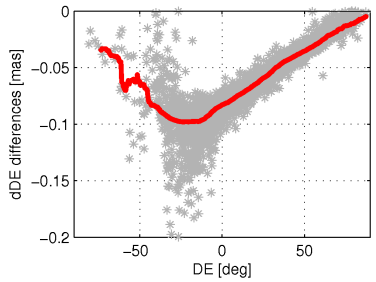

Figure 4. Differences between 2769 declination estimates of two CRF solutions: using constant a priori gradient values (mean of 1990-1995) - using 0 a priori values.

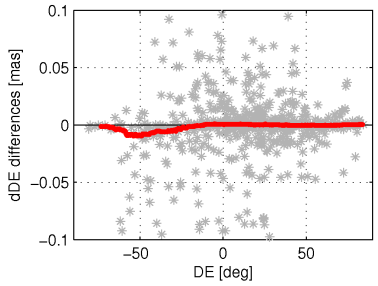

Figure 5. Differences between 669 declination estimates of two CRF solutions: without using the 21 sessions of the VCS (VLBA Calibrator Survey) - with using the VCS sessions.

3. IVS VLBI contribution to the ITRF2005

   The release of the ITRF2005 in October 2006 is a major step towards more consistent IERS products. The DGFI IVS Analysis Center contributed to this effort in two different ways:

   Firstly, SINEX files for 2666 daily sessions between 1984 and 2005 were submitted to the IVS, containing the EOP (Earth orientation parameters) and station positions for each 24-hour session as unconstrained normal equations. As the IVS moved to generate its operational products using a comparable procedure (not combining results but datum free normal equations) at the beginning of 2006, DGFI continues to submit these files as operational analysis center, which is the only non CALC/SOLVE contribution to this IVS product.

   Secondly, the two independent solutions of the ITRF2005, computed by DGFI and the IGN (Institut Geographique National, France) were validated. This enabled to compare geodetic results computed with OCCAM (EOP, station position time series) using the two indenpendent ITRF2005 solutions as a reference. It turned out that the VLBI parts of both ITRF2005 solutions were well adapted to VLBI-only results and did not differ significantly.

4. IVS Working Group on a new realization of the ICRS

   DGFI actively takes part in the corresponding IAU and IVS Working Groups by contributing solutions, as well as doing research, especially to better understand expected systematic differences and to optimize the homogeneity of the celestial and the terrestrial reference frames under the umbrella of the IERS (see also 2.2 of this report).

5. IVS OCCAM Working Group

   The VLBI software OCCAM is the central tool for DGFI′s work in IVS. It is maintained, refined and adapted to the current requirements in close collaboration within the IVS OCCAM Working Group, chaired by Oleg Titov, Geoscience Australia (Canberra, Australia). Leading members are scientists from the Vienna University of Technology, Austria, the St.

Petersburg University and the Institute of Applied Astronomy, Russia, and DGFI. During the last year, the code solving the equation systems with the least squares approach was updated in many parts, in very close cooperation with the Vienna University of Technology.

3. Staff

In 2006, members of the DGFI IVS Analysis Center were Volker Tesmer, Manuela Krügel and Hermann Drewes.

4. Plans for 2007

- Further improve the VLBI software OCCAM,
- support IVS TRF and CRF preparation activities, including submission of appropriate solutions computed at DGFI as well as analysis of different contributions,
- submit SINEX files for all 24-h sessions to the IVS on an operational basis,
- intensify the work related to a combined estimation of geodetic target parameters from VLBI and observations of other space geodetic techniques.

5. Selected Publications

Krügel, M., D. Thaller, V. Tesmer, M. Rothacher, D. Angermann, R. Schmid: Tropospheric Parameters: Combination studies based on homogeneous VLBI and GPS data. In: Schuh, H., A. Nothnagel, C. Ma (Eds.): VLBI issue. J. of Geod., DOI 10.1007/s00190-006-0127-8, 2006

Steigenberger, P., V. Tesmer, M. Krügel, D. Thaller, R. Schmid, S. Vey, M. Rothacher: Comparisons of homogeneously reprocessed GPS and VLBI long time series of troposphere zenith delays and gradients. In: Schuh, H., A. Nothnagel, C. Ma (Eds.): VLBI issue. J. of Geod., DOI 10.1007/s00190-006-1024-y, 2006

Tesmer, V.: Konsistente Realisierung von Referenzrahmen mit dem Verfahren VLBI. DGFI-Report No. 78, 2006

Tesmer, V., J. Boehm, R. Heinkelmann, H. Schuh: Impact of Analysis Options on the TRF, CRF and Position Time Series Estimated from VLBI. In: Behrend, D., K. Baver (Eds.): IVS 2006 GM Proceedings. NASA/CP-2006-214140, 243-251, 2006

Tesmer, V., J. Boehm, R. Heinkelmann, H. Schuh: Effect of different tropospheric mapping functions on the TRF, CRF and position time series estimated from VLBI. In: Schuh, H., A. Nothnagel, C. Ma (Eds.): VLBI issue. J. of Geod., DOI 10.1007/s00190-006-0126-9, 2006

Thaller, D., M. Krügel, M. Rothacher, V. Tesmer, R. Schmid, D. Angermann: Combined Earth orientation Parameters based on homogeneous and continuous VLBI and GPS data. In: Schuh, H., A. Nothnagel, C. Ma (Eds.): VLBI issue. J. of Geod., DOI 10.1007/s00190-006-0115-z, 2006