DGFI Analysis Center Annual Report 2007

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Abstract

This report summarizes the activities of the DGFI Analysis Center in 2007 and outlines the planned activities for the year 2008.

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 2007

1. Common signals in homogeneously reprocessed long-term GPS and VLBI height time series

   The intention was to understand how station position time series improve, if latest high-end models are used in geodetic data analysis. One criteria that can be applied is the similarity of annual harmonic signals estimated from GPS and VLBI height series. We used GPS and VLBI height time series with daily resolution (data from 94-07), computing 2 solution runs:

   - Iteration 1: Both series are fully reprocessed and the a priori models were homogenized in both softwares (GPS: Bernese 5.1 @ GFZ, VLBI: OCCAM 6.1 @ DGFI); Nevertheless, not all models were state-of-the-art (e.g., NMF, constant a priori ZD).
   - Iteration 2: Besides the efforts in iteration 1, all models were updated according to the latest state of knowledge (e.g., VMF1, a priori ZD from ECMWF, thermal deformation for VLBI, the VLBI ZD was estimated in full UTC hours as for GPS).

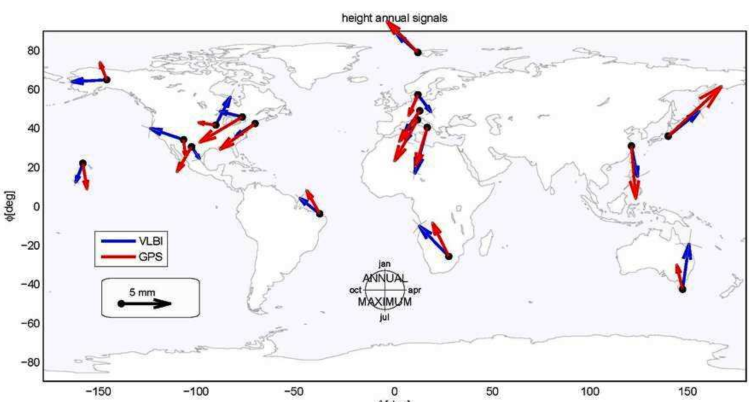

Figure 1. Annual harmonic signals estimated from GPS and VLBI height time series. The arrows illustrate the estimated amplitudes and phases of 17 stations with enough data (dark is VLBI, light grey is GPS). The figure shows the results of iteration 2, which is related to state-of-the-art models.

Figure 1 illustrates the GPS and VLBI annual signals estimated from the iteration 2 data. Considering the WRMS of the VLBI vs GPS differences in phase and amplitude for all stations (iteration 1 / 2: WRMS amplitude 2.2 / 1.7 mm, WRMS phase 44 / 38 deg), one can assume that the iteration 2 modeling is clearly better.

2. Alternative models to estimate nutation and polar motion rates

   In VLBI data analysis, it is common practice to determine the full set of EOP (dUT1 and LOD, polar motion and their rates as well as nutation offsets) for each 24-h VLBI session. For that, we have a mathematical correlation of the nutation offsets and the terrestrial pole rates, as illustrated in Figure 2 (because nutation offsets are equivalent to a retrograde daily oscillation in the terrestrial frame).

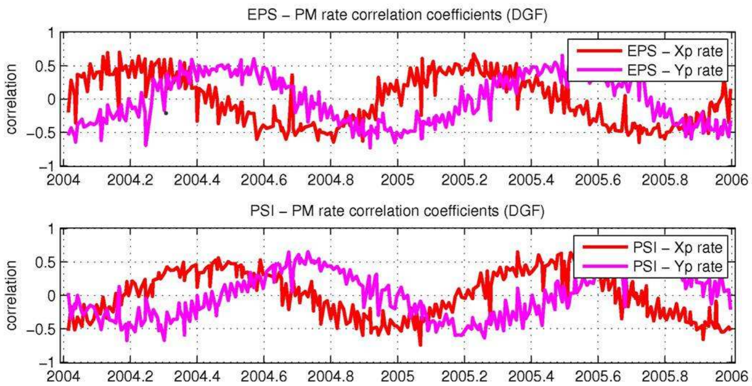

Figure 2. Correlation coefficients between nutation offsets and terrestrial pole rates, estimated from the 2004-2006 session SINEX files, submitted to the IVS by DGFI. The annual variation of the correlation reflects the annual change in phase of the retrograde daily oscillation due to a superposition of the sidereal and the solar day.

   Therefore, efforts were made to estimate nutation parameters not for each session, but for several sessions or even weeks, which would lead to a considerable improvement if the deficiencies of the a priori nutation model are only the free core nutation (FCN, with a period of about 432 days). Like this, we could stabilize the nutation estimates, which thus would help to improve the polar motion rate estimates for each session.

   Preliminary results indicate that the WRMS of the differences between the dX pole rates and the IGS values is getting smaller, the WRMS of the differences of the dY pole rates does not change significantly. An analysis of the daily nutation estimates reveals the reason for the only moderate improvement: the IAU2000A nutation model has small insufficiencies in the shorter periods, like the fortnightly lunar (Mf) 13.661 days period, with residual amplitude of about 0.06 mas. Thus, before repeating these tests, the nutation model has to be improved in the higher frequencies.

3. Effect of analyis options in results from the IVS standard SINEX normal equations

   In close cooperation with the VLBI group of the University of Bonn, the results from two VLBI analysis software packages, OCCAM and Calc/Solve, were compared to detect systematic differences, caused by model differences. The comparisons were carried out with EOP and station position time series calculated from standard normal equations (SINEX files), as used for the official IVS combination (contributions are from DGFI and the NASA Goddard Space Flight Center). In addition, the same comparisons were done with consistent time series generated with all relevant corrections adapted in both software packages (contributions from DGFI and the VLBI group of the University of Bonn, IGGB).

   Comparing the GSFC(IVS)–DGFI(IVS) differences to the IGGB–DGFI differences, systematics became obvious. Many stations had systematic height offsets of about 1 cm in the GSFC(IVS)–DGFI(IVS) case, but not for IGGB–DGFI (horizontal differences were smaller by a factor of 3). These systematic differences turned out to be mainly due to differences in the pole tide model.

4. DGFI contribution to the second realization of the ICRF (ICRF2)

   DGFI takes part in the IVS Working Group for the second realization of the ICRF (ICRF2) by submitting all types of results necessary in this context. The first goal is to identify sources which cannot be assumed to have positions constant in time, by computing and analyzing time series of estimated source positions. DGFI computes such time series using a NNR datum over all sources per session with respect to a homogeneous CRF solution.

   Figure 3 (upper panel) shows the time series of declination components of the source 1741-038, with only NNR conditions applied for each single session. An annual signal can clearly be seen, which is possibly caused by atmospheric mismodeling in data analysis, although the respective source code in OCCAM is fully up-to-date with the latest models in this area of research. If some deformation parameters (see legend of Figure 3) are also estimated (panel in the middle: IERS approach, lower panel: DGFI approach), this signal is absorbed.

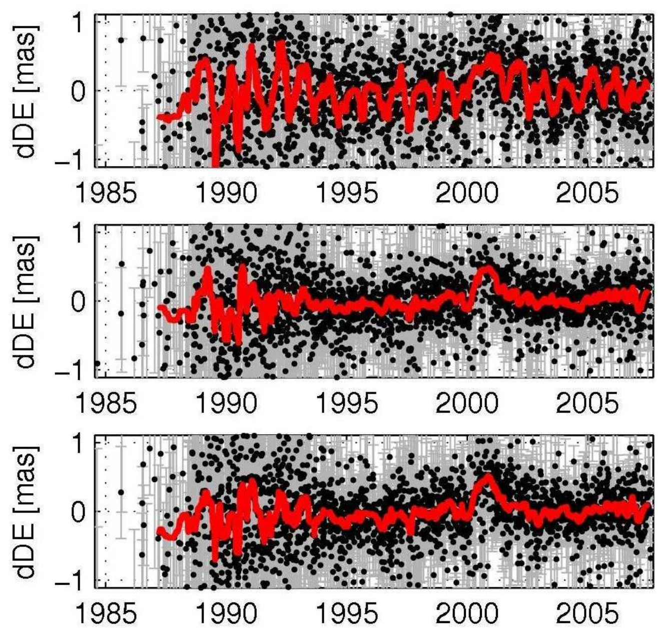

Figure 3. Time series of declination components for the source 1741-038. Upper panel: positions are estimated for each session, with only NNR datum applied. Panel in the middle: with a deformation model also estimated, which is often used in the IERS and the astrometric community (for declination δ: $D_\delta(\delta\text{-}\delta_0) + dz$, for right ascension α:$D_\alpha(\delta\text{-}\delta_0)$). Lower panel: estimated with NNR datum and a simpler but very effective deformation model, developed at DGFI (for declination δ: $dz\cos\delta$). Although still under investigation, the DGFI model fits the data well.

5. IVS Operational Analysis Center at DGFI

   The IVS updated its approach to determine the operational IVS Earth Orientation Parameters (EOP) series from averaging solutions submitted by the different Analysis Centers (which all used inhomogeneous solution setups, different reference frames etc), to computing them from normal equations, which were derived by adding the SINEX files submitted to the IVS by the different Analysis Centers (ACs). These files contain the EOP and station positions for each 24-hour session as SINEX normal equations, which provides a direct relation of the EOP to one definite TRF throughout the whole series (e.g., the ITRF2005). This approach also allows to analyze the input data in a much better way than before and is especially suitable to rigorously reprocess the combination, if necessary. The DGFI IVS AC contributed to this new operational series from its beginning in December 2006 with a recomputed series of datum-free normal equations in SINEX format for VLBI sessions back to 1984 (3050 sessions at the end of 2007).

6. IVS OCCAM Working Group

   Most important for DGFI as IVS AC is to maintain and refine the VLBI software OCCAM to current requirements in close collaboration within the IVS OCCAM Working Group, chaired by Oleg Titov, Geoscience Australia (Canberra, Australia). Other leading members are scientists from the Vienna University of Technology, Austria, the St. Petersburg University, the Institute of Applied Astronomy, both Russia, and DGFI. The latest updates of the software package are related to an optional homogenization effort with the Bernese GPS Software and post-fit analysis tools to analyze station and radio source position time series.

3. Staff

Members of the DGFI IVS AC are Volker Tesmer, Manuela Krügel, and Hermann Drewes.

4. Plans for 2008

In 2008, it is planned to further improve the VLBI software OCCAM, support IVS TRF and CRF preparation activities (submit solutions computed at DGFI and analyze different contributions), and to submit SINEX files for all 24-h sessions to the IVS on an operational basis.

5. Selected Publications

Artz, T., S. Böckmann, A. Nothnagel, V. Tesmer: ERP time series with daily and sub-daily resolution determined from CONT05. J. Boehm, A. Pany, H. Schuh (Eds.): Proc. of the 18th EVGA Working Meeting, 12-13 April 2007, Geowiss. Mitteilungen, Heft Nr. 79, TU Wien, ISSN 1811-8330, 69-74, 2007

Böckmann, S., T. Artz, A. Nothnagel, V. Tesmer: Comparison and combination of consistent VLBI solutions. J. Boehm, A. Pany, H. Schuh (Eds.): Proc. of the 18th EVGA Working Meeting, 12-13 April 2007, Geowiss. Mitteilungen, Heft Nr. 79, TU Wien, ISSN 1811-8330, 82-87, 2007

Heinkelmann, R., J. Boehm, S. Bolotin, G. Engelhardt, D. MacMillan, H. Schuh, E. Skurikhina, V. Tesmer, O. Titov, P. Tomasi: Combination of long time series of troposphere zenith delays observed by VLBI. In: Schuh, H., A. Nothnagel, C. Ma (Eds.): VLBI special issue. Journal of Geodesy, DOI 10.1007/s00190-007-0147-z, 2007

Schuh, H., R. Heinkelmann, J. Sokolova, V. Tesmer: Sub-Commission 1.4 Interaction of Celestial and Terrestrial Reference Frames. IAG Commission 1 Reference Frames, Report 2003-2007, Bulletin No. 20, ed. By H. Drewes and H. Hornik, DGFI, Munich, pp. 46-51, 2007

Tesmer, V.: Celestial Reference Frames and Interaction with Terrestrial Reference Frames. In: Müller, J., H. Hornik (Eds.): National Report of the Federal Republic of Germany on the Geodetic Activities in the years 2003-2007. Deutsche Geodätische Kommission, Reihe B, Nr. 315, München, 11-13, 2007

Tesmer, V.: Effect of various analysis options on VLBI-determined CRF. J. Boehm, A. Pany, H. Schuh (Eds.): Proc. of the 18th EVGA Working Meeting, 12-13 April 2007, Geowiss. Mitteilungen, Heft Nr. 79, TU Wien, ISSN 1811-8330, 103-110, 2007