DGFI Analysis Center Annual Report 2004

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Abstract

This report summarizes the activities of the DGFI Analysis Center in 2004 and outlines the planned activities for the year 2005.

1. DGFI Analysis Center, 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 research projects as well as functions in international bodies.

The long-term research programme of DGFI is based on the general theme “Fundamentals of Geodetic Reference Systems”. The definition of geodetic reference systems is studied and methods for their realisation with modern space geodetic techniques are developed. Geodetic observations are analysed, approaches for the data processing are set up, tested and exemplarily applied (see DGFI web server `http://www.dgfi.badw.de`). The major topics of its research in 2004 were:

- Geometric reference systems
- Physical reference surfaces
- Dynamic processes
- International services and projects
- Information systems and scientific transfer

DGFI contributes to the International VLBI Service (IVS) as an Analysis Center to improve the space-geodetic observation technique Very Long Baseline Interferometry (VLBI) and the analysis of its observations, respectively, by participating in pilot projects and by research projects, limited by the available personnel in operational service.

2. Activities in 2004

1. Consistent Reference Frames

   In 2004, a terrestrial reference frame (TRF), the EOP and a celestial reference frame (CRF) were estimated simultaneously in a VLBI solution (as described in e.g. Tesmer et al., 2004). The geodetic datum was realized by applying no-net-rotation (NNR) and no-net-translation (NNT) conditions for the TRF and NNR for the CRF. Such a solution is completely free of biases due to fixing reference frames (which might not be modelled consistently) or other relevant parameters of the observation equations. Due to two reasons, VLBI is especially suitable to perform such a task: Firstly, there are only several million VLBI observations which can very easily be reprocessed in a common solution although they cover more than 20 years. Secondly, the celestial VLBI reference frame consists of quasi pointlike objects (radiosources) and not of dynamic orbits which are difficult to model and valid for several days only. Hence, a major task of VLBI is to provide the link between the celestial and the terrestrial frame, including fully consistent time series of parameters to transform between the frames (pole coordinates and their first derivatives, dUT1 and LOD, as well as daily corrections to a precession-nutation model).

Until now, for 2578 sessions between 1984 and 2004, each about 24h long, normal equations were set up with the VLBI software OCCAM 6.0 (modified to allow for estimating source positions). These data include a total of 49 telescopes (of which 46 are part of ITRF2000) observing 1955 sources (of which 561 are part of ICRF-Ext1). The auxiliary parameters (for troposphere and clocks) are reduced for each session. All prereduced session-wise normal equations are then accumulated to one equation system with the DGFI software DOGS-CS and solved with an appropriate datum, namely NNR and NNT for 25 stable stations w.r.t. ITRF2000 and NNR for 199 stable sources w.r.t. ICRF-Ext1.

Besides a terrestrial (TRF) and a celestial reference frame (CRF), the solution provides time series of the EOP, referenced to the ITRF2000 and the ICRF-Ext1, as well as time series of session-wise station and source positions. Such position series should not directly be interpreted as "real" spatial movements of stations or quasars, but provide the basis for an advanced analysis of shortcomings in the modelling, such as neglected non-linear station motion or apparent motion of the quasars due to jets etc.

2. Advanced Stochastic Model for VLBI Observations

Further refinements of the functional representation of the geometric-physical properties of the VLBI observations mostly need big efforts and are not possible with any precision. Although the stochastic model is an important part of the VLBI observation equations, the stochastic properties of VLBI observations have not been studied in detail so far. The idea is to interpret discrepancies between the functional model and the observations as variances of the observations. In particular, the modelling of station and elevation dependent influences is of limited precision (in general, for present standard VLBI solutions, correlations between observations were found to be negligible).

In contrast to earlier investigations, Tesmer and Kutterer (2004) describe a solution where all of the 57 stochastic properties (station and elevation dependent portions of variance of VLBI observations), determined by means of variance covariance component estimation, were found to be stable and reliable estimates (more data was used). When applying the advanced stochastic model to parameter estimations, care has to be taken regarding indirect effects which are mainly connected with:

- the weights and the respective impact of the pseudo observations for the constraints of auxiliary clock and tropospheric parameters (to be overcome by readjusting the weights of the constraints),
- the power of outlier tests which compare observation residuals with their formal errors (to be overcome by readjusting the criterion for outlier rejection),
- the influence of observations under very low elevations, which can decisively affect the variances of the tropospheric parameters as well as their correlations with station positions, EOP and clock parameters (to be overcome by readjusting the cut off angle).

One of the major motivations for investigating the stochastic VLBI model was to improve VLBI solutions. Tests were carried out concerning the repeatability of estimated station position time series and similarity of EOP from simultaneous NEOS-A and CORE-A sessions. Both tests indicate clearly that by using the advanced stochastic model, many target parameters improve and become more realistic concerning their formal errors. But, it has to considered that further progress in the functional modelling of the VLBI observations (like, e.g., the modelling of tropospheric influences) may have a significant effect on the corresponding stochastic attributes.

3. Reliability Measures for Geodetic VLBI Products

   The reliability of geodetic VLBI products depends essentially on the checkability of the observation data and the reference frame points. First investigations to clarify the potential influence of non-detectable errors in terrestrial and celestial reference frames on VLBI products were done using the CONT02 campaign (Kutterer, 2004). This showed that proper reliability measures for VLBI products can be derived in a rigorous way using statistical test theory as background.

4. CONT02 Rigorous Combination with GPS

   The data of the IVS-initiated VLBI campaign 'CONT02' during 15 days of October 2002 are especially suitable to study the effect of combining normal equations of different space techniques on the stabilty of estimated parameters. In 2004, many investigations were carried out in close cooperation with the Research Establishment Satellite Geodesy (FESG) at the Technical University of Munich, using the CONT02 VLBI data set for advanced combination studies. A detailed description of the strategy and results are given in the paper "Combination Studies Using the CONT02 Campaign", to be found in this IVS annual report's section "Special Reports", as well as in Krügel et al. (2004).

5. IVS OCCAM Working Group

   The goal of the OCCAM working group is to constantly improve the VLBI software OCCAM. The group is chaired by Oleg Titov from Geoscience Australia (Canberra, Australia), its main members are scientists from the Vienna University of Technology (Vienna, Austria), the St. Petersburg University, the Institute of Applied Astronomy (both St. Petersburg, Russia) and DGFI. The version 6.0 of the software was officially released in February 2004 during the IVS General meeting in Ottawa, Canada (Titov et al., 2004). Since then, the software was upgraded in many parts, especially the code that solves the equation systems with the least squares approach, which now allows to also estimate source positions. This was done in very close cooperation with the Vienna University of Technology, during two small working meetings, one in March (Vienna) and one in July 2004 (Munich).

6. OCCAM VLBI SINEX files

   The IERS Combination Pilot Project, underway since the beginning of 2004, can be a major step towards more consistent, routinely generated IERS products. For this, SINEX files for each 24-hour session have to be made available by the IVS containing site coordinates and EOP (possibly quasar coordinates also). DGFI delivered accordant SINEX files to the IVS for more than 2500 sessions between 1984 and 2004, and will continue to do this for forthcoming 24-h sessions on a quasi operational basis.

3. Staff

In April 2004, Hansjörg Kutterer left DGFI to become a full professor at the geodetic institute of the University of Hannover. Manuela Krügel joined the DGFI IVS Analysis Center. The other members of the IVS Analysis Center remain Hermann Drewes and Volker Tesmer.

4. Plans for 2005

Main research goals of the DGFI IVS Analysis Center will be:

- Further improvement of the VLBI software OCCAM,
- Simultaneous and consistent determination of a TRF, a CRF and the EOP in one solution using minimum datum constraints,
- To support IVS TRF and CRF preparation activities, including submission of appropriate solutions computed at DGFI as well as analysis of solutions submitted by other analysis centers,
- To submit SINEX files for forthcoming 24-h sessions to the IVS on a quasi operational basis (as well as for older sessions if recommended),
- Combined estimation and comparative analysis of geodetic target parameters from VLBI and GPS observations.

5. References

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