DGFI Analysis Center Annual Report 2005

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Abstract

This report summarizes the activities of the DGFI Analysis Center in 2005 and outlines the planned activities for the year 2006.

1. Introduction

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 2005

1. Consistent Reference Frames

   The parameters of a celestial reference frame (namely spherical coordinates of radio sources) in VLBI solutions are, to a certain extent, always dependent on other parameters such as station positions and velocities (TRF) and the Earth orientation parameters (EOP). This is why much effort was spent on computing a solution, in which VLBI observations are analyzed with all the unknown parameters estimated simultaneously. As a consequence, the TRF, CRF as well as the EOP determined in such a way will be fully consistent with each other. Both, the homogeneity between the frames and the EOP and the homogeneity of all parameters in time are not ensured by today's products of the IERS.

   The actual DGFI VLBI solution 05R02 comprises 2699 sessions between 1984 and 2005, each about 24 h long, including a total of 49 telescopes (of which 46 are part of ITRF2000) observing 1954 sources (of which 562 are part of ICRF-Ext1). Session-wise datum free normal equations were set up with the VLBI software OCCAM 6.0 (modified for estimating source positions) and accumulated to one common equation system with the DGFI software DOGS-CS (see also Tesmer et al. 2004). This equation system can be solved either by fixing station positions and velocities as well as source positions to the values given in ITRF2000 and ICRF-Ext1 (with the EOP estimated), or by applying a non-biasing datum, namely NNR and NNT, e.g. for 25 stable stations w.r.t. ITRF2000 and NNR, e.g. for 199 stable sources w.r.t. ICRF-Ext1. Comparisons between the results of such different approaches confirm the necessity of a solution where TRF, CRF and the EOP are estimated simultaneously:

   - IERS EOP C04 is not consistent to ICRF-Ext1 and the VLBI-part of ITRF2000,
   - ITRF2000 and ICRF-Ext1. were not computed using the same modelling, which can influence the parameters of the respectively other frame systematically,
   - in VLBI solutions, station and source positions can depend significantly on each other, especially in case of weakly determined objects.

2. Combination of space geodetic techniques using CONT02 data

   GPS derived rates of daily terrestrial pole, dUT1 and nutation angles are highly precise. However, the long-term information in dUT1 and nutation series determined with satellite techniques is strongly dependent on the estimation strategy and/or the mathematical formulation of the orbits. Because of its direct link to the CRF, VLBI is capable to determine low frequencies in dUT1 and nutation uniquely stable, whereas the higher frequencies of VLBI-derived EOP (especially of the terrestrial pole) are of lower precision due to technical reasons: Firstly, VLBI observes networks consisting of few stations only, which can easily lead to weakly determined rate-parameters; secondly, VLBI telescopes cannot cover the whole sky by observations in arbitrary high time resolution, thus limiting the separability of topocentric parameters in high temporal resolution such as those necessary to model the influences of the troposphere and the station clocks. Therefore, adequately combined GPS and VLBI observations will give the best EOP results in the whole frequency domain and provide optimal precision, stability and interpretability for the whole set of parameters.

   The benefit of a rigorous combination approach was demonstrated by a combination of VLBI data from 15 days of VLBI observations in October 2002 (CONT02) and the corresponding GPS data, carried out in close cooperation with the Research Establishment Satellite Geodesy (FESG) at the Technical University of Munich. As an example for the effect, Figure 1 compares station repeatabilities of the combined and uncombined VLBI and GPS solutions (see also Thaller et al. 2006). For this, the VLBI and the GPS softwares were prepared in very close cooperation to have identical a priori models and parameterizations.

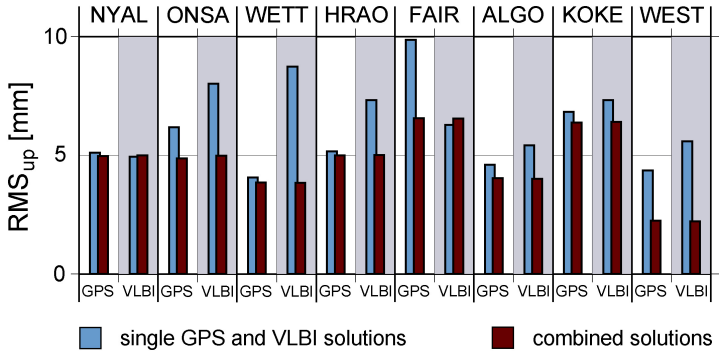

Figure 1. Comparison of the repeatabilities of daily GPS and VLBI height estimates using the data of the CONT02 campaign, estimated in single solutions as well as in a combined solution. It reflects the potential of the combined solution approach to stabilize VLBI as well as GPS.

3. DGFI VLBI SINEX files as a contribution to the IERS Combination Pilot Project

   Another attempt to promote combination efforts is the participation in the IERS Combination Pilot Project, which was started in the beginning of 2004 as a major step towards more consistent, routinely generated IERS products. The corresponding DGFI VLBI contribution were SINEX files of 2666 daily sessions between 1984 and 2005, submitted to the IVS on a quasi operational basis. These files contain the Earth orientation parameters and station positions for each 24-hour session as decomposed normal equations in the SINEX format. The IVS-combined normal equations, compiled from contributions of up to seven IVS Analysis

Centers each, is the VLBI input to the IERS Combination Project, and to the upcoming realization of the International Terrestrial Reference Frame ITRF2005.

4. Towards a new realization of the International Celestial Reference Frame (ICRF)

   The International Celestial Reference System (ICRS) is realized by the coordinates of several hundred radio sources observed by VLBI. The IERS as well as the IVS aims for a new realization of the ICRS in the coming years, which shall, if feasible, be generated by combining several VLBI solutions. The first comparisons of radio source catalog test solutions of several IVS Analysis Centers were presented during the 6th IVS Analysis Workshop, held in Noto, Italy in April 2005. DGFI contributions to these efforts were a CRF solution computed with OCCAM as well as investigations concerning the homogeneity of catalogues computed with different solution setups.

5. Interim VLBI terrestrial reference frame VTRF2005

   Since the ITRF2000 was based only on observation data until the end of 2000, the quality of this TRF deteriorated for the time since then. In order to provide a terrestrial reference frame for operational VLBI determinations of EOP and atmospheric water vapour content, in 2005, TRF realizations of five Analysis Centers were combined by the IVS Analysis Coordinator to the terrestrial VLBI reference frame VTRF2005 (Nothnagel, 2005). One of these contributions was computed by DGFI, using the VLBI software package OCCAM.

6. IVS OCCAM Working Group

   As all work at DGFI related to VLBI is done with the VLBI software OCCAM, the collaboration in the IVS OCCAM Working Group is of particular importance for the DGFI IVS Analysis Center. The general task of the OCCAM Working Group is to regularly improve the OCCAM software. It is chaired by Oleg Titov from Geoscience Australia (Canberra, Australia). Active members are scientists of the Vienna University of Technology (Vienna, Austria), the St. Petersburg University, the Institute of Applied Astronomy (both St. Petersburg, Russia) and DGFI. The current 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 also to estimate source positions. This was done in very close cooperation with the Vienna University of Technology, during several small working meetings, the latest in February and September 2005. An updated, official version of OCCAM will be available soon.

3. Staff

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

4. Plans for 2006

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

- to further improve the VLBI software OCCAM,

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

5. References

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