

## The BKG/IGGB VLBI Analysis Center

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### Abstract

In 2012, the activities of the BKG/IGGB VLBI Analysis Center, as in previous years, consisted of routine computations of Earth orientation parameter (EOP) time series and of a number of research topics in geodetic VLBI. The VLBI group at BKG continued its regular submissions of time series of tropospheric parameters and the generation of daily SINEX (Solution INdependent EXchange format) files. Quarterly updated solutions have been computed to produce terrestrial reference frame (TRF) and celestial reference frame (CRF) realizations. Routine computations of the UT1-UTC Intensive observations include all sessions of the Kokee-Wettzell and Tsukuba-Wettzell baselines and the networks Kokee-Svetloe-Wettzell and Ny-Ålesund-Tsukuba-Wettzell. The VLBI group at BKG developed a procedure to get the most probable station positions of Tsukuba after the earthquake on March 11, 2011 for the epochs of the Intensive sessions. The analysis of the Intensive sessions with station Tsukuba could be resumed in February 2012. At IGGB, the emphasis has been placed on individual research topics.

### 1. General Information

The BKG/IGGB VLBI Analysis Center has been established jointly by the analysis groups of the Federal Agency for Cartography and Geodesy (BKG), Leipzig, and the Institute of Geodesy and Geoinformation of the University of Bonn (IGGB). Both institutions cooperate intensely in the field of geodetic VLBI. The responsibilities include both data analysis for generating IVS products and special investigations with the goal of increasing accuracy and reliability. BKG is responsible for the computation of time series of EOP and tropospheric parameters, for the generation of SINEX files for 24-hour VLBI sessions and one-hour Intensive sessions, and for the generation of quarterly updated global solutions for TRF and CRF realizations. Besides data analysis, the BKG group is also responsible for writing schedules for the Tsukuba-Wettzell Int2 UT1-UTC observing sessions. IGGB continues to host the office of the IVS Analysis Coordinator and carries out special investigations within the technique of geodetic and astrometric VLBI. Details of the research topics of IGGB are listed in Section 3.

### 2. Data Analysis at BKG

At BKG, the Mark 5 VLBI data analysis software system Calc/Solve, release 2010.05.21 [1], has been used for VLBI data processing. It is running on a Linux operating system. As in the previous releases, the Vienna Mapping Function (VMF1) has been implemented in a separate Solve version. This modified version was used for all data analysis. The VMF1 data were downloaded daily from the server of the Vienna University of Technology. Additionally, the technological software environment for Calc/Solve has been refined to link the Data Center management with the pre- and post-interactive parts of the EOP series production and to monitor all Analysis and Data Center activities.

- **Processing of correlator output**

The BKG group continued the generation of calibrated databases for the sessions correlated at

the MPIfR/BKG Astro/Geo Correlator at Bonn (e.g., EURO, OHIG, and T2) and submitted them to the IVS Data Centers.

- **Scheduling**

BKG continued scheduling the Int2 Intensive sessions, which are observed on the TSUKUBA-WETTZELL baseline. Altogether 86 schedule files for this baseline were created in 2012. Furthermore 30 schedule files for baseline KOKEE-WETTZELL (Int1 Intensive sessions on weekends) were made available in the first half of the year 2012.

- **BKG EOP time series**

The BKG EOP time series bkg00013 was continued. The main features of this solution were not changed. But three new VLBI stations (HART15M in South Africa, KOGANEI, and UCHINOUR in Japan) could be included successfully in data processing.

Each time after the preprocessing of any new VLBI session (correlator output database version 1), a new global solution with 24-hour sessions since 1984 was computed, and the EOP time series bkg00013 was extracted. Altogether 4391 sessions were processed. The main parameter types in this solution are globally estimated station coordinates and velocities together with radio source positions. The datum definition was realized by applying no-net-rotation and no-net-translation conditions for 25 selected station positions and velocities with respect to VTRF2008a and a no-net-rotation condition for 295 defining sources with respect to ICRF2. The station coordinates of the telescopes AIRA (Japan), CHICHI10 (Japan), CTVASTJ (Canada), DSS13 (USA), HOBART12 (Australia), KASHIM34 (Japan), KATH12M (Australia), PT.REYES (USA), SEST (Chile), SINTOTU3 (Japan), TIGOCONC (Chile), TSUKUB32 (Japan), WIDE85.3 (USA), VERAISGK (Japan), VERAMZSW (Japan), WARK12M (New Zealand), YARRA12M (Australia), and YEBES40M (Spain) were estimated as local parameters in each session. The three new VLBI stations HART15M (South Africa), KOGANEI (Japan), and UCHINOUR (Japan) were modeled in the same way.

- **BKG UT1 Intensive time series**

Regular analysis of the UT1-UTC Intensive time series bkgint09 was continued. The series bkgint09 was generated with fixed TRF (VTRF2008a) and fixed ICRF2. The a priori EOP were taken from finals USNO series [2]. The estimated parameter types were only UT1-TAI, station clock, and zenith troposphere.

A semi-automatic process for handling the Intensive sessions (Int2/3) with station TSUKUBA after the Japan earthquake has been developed. Using the latest global solution with 24-hour sessions, including all available sessions with the station TSUKUBA, a particular a priori coordinate file for each TSUKUBA Intensive session is created by interpolating the values of the 24-hours TSUKUBA sessions. These files are used as input for the session by session TSUKUBA Intensive cycle run. Finally, an IVS formatted EOP list is created and mixed with the non-TSUKUBA IVS EOP list. These algorithms are included in the BKG post\_solve procedure for establishing the IVS EOP solutions.

A total of 4048 UT1 Intensive sessions were analyzed for the period from 1999.01.01 to 2012.12.31.

- **Quarterly updated solutions for submission to IVS**

In 2012, one quarterly updated solution was computed for the IVS products TRF and CRF.

There are no differences in the solution strategy compared to the continuously computed EOP time series bkg00013. The results of the radio source positions were submitted to IVS in IERS format. The TRF solution is available in SINEX format, version 2.1, and includes station coordinates, station velocities, and radio source coordinates together with the covariance matrix, information about constraints, and the decomposed normal matrix and vector.

- **Tropospheric parameters**

The VLBI group of BKG continued regular submissions of long time series of tropospheric parameters to the IVS (wet and total zenith delays and horizontal gradients) for all VLBI sessions since 1984. The tropospheric parameters were extracted from the standard global solution bkg00013 and transformed into SINEX format.

- **Daily SINEX files**

The VLBI group of BKG also continued regular submissions of daily SINEX files for all available 24-hour sessions for the IVS combined products and for the IVS time series of baseline lengths. In addition to the global solutions, independent session solutions were computed for the station coordinates, radio source coordinates, and EOP parameters including the X,Y-nutation parameters. The a priori datum for TRF was defined by VTRF2008a, and ICRF2 was used for the a priori CRF information.

- **SINEX files for Intensive sessions**

The parameter types are station coordinates, pole coordinates and their rates, and UT1-TAI and its rate. But only the normal equations stored in the SINEX files are important for further intra-technique combination or combination with other space geodetic techniques.

### 3. Research Topics at IGGB

- **Measurements of paraboloid deformations of the Effelsberg 100-m telescope with a laser scanner**

Variations in the focal length of a radio telescope have a direct effect on the delay observables and on the position estimates. To study this, the paraboloid of the Effelsberg 100-m telescope was scanned with a Leica HDS 6100 terrestrial Laser scanner. The scanner was mounted head-down on an empty prime focus receiver box. Putting the receiver box in place gave the scanner an almost unobstructed view of the main paraboloid. Scans were repeated in various telescope elevation angles down to  $7.5^\circ$  with each data set consisting of 370 million points with three polar components each. This is equivalent to one data point every  $64 \text{ mm}^2$ . Proprietary software of the instrument's manufacturer was not able to handle this large amount of data; thus, a dedicated C++ program running on a computer cluster was developed. As a first result, the estimated focal length variations agree very well with the empirical model for the sub-reflector displacement corrections. Since the accuracy of the individual distance measurements of the scanner is only a few millimeters at a distance of 50-m, the ultimate insight into the deformations cannot be achieved from individual data points but from a surface fitting procedure to the residuals. Figure 1 shows the smoothed surface of the solid part of the paraboloid at  $30^\circ$  elevation after a best fit paraboloid has been subtracted. In the second and third quadrant, two reflector panels can be identified which had been displaced on purpose by plus and minus 3 mm for a holography survey some time ago, validating the

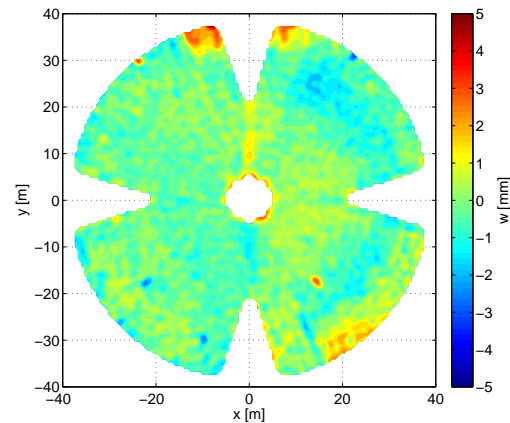


Figure 1. Smoothed surface of the solid part of the paraboloid at  $30^\circ$  elevation after a best fit paraboloid has been subtracted.

correctness of the whole procedure. The second blue spot at the third quadrant persists at other elevation angles as well and must, thus, be a real local deformation.

- **Automatic scheduling based on Singular Value Decomposition**

The automatic scheduling method which selected the observations successively by means of their impact factors has been developed to create schedules for VLBI Intensive sessions replacing the participating single telescopes by twin telescopes successfully. For assessment reasons, observations related to the created schedules have been simulated. The simulation has been adapted for the special features of twin telescopes. However, the simulation has to be improved some more to reach a well-founded evaluation of twin telescope observations in Intensive sessions.

#### 4. Personnel

Table 1. Personnel at BKG/IGGB Analysis Center.

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#### References

- [1] GSFC, NASA (2010): Release of Mark 5 VLBI Analysis Software Calc/Solve from May 21, 2010 (Web reference: <http://gemini.gsfc.nasa.gov/solve>).
- [2] USNO (2011): Earth orientation parameters series from finals USNO series 2011, (Web reference: [http://gemini.gsfc.nasa.gov/500/oper/solve\\_apriori\\_files/usno\\_finals.erp](http://gemini.gsfc.nasa.gov/500/oper/solve_apriori_files/usno_finals.erp)).