The BKG/GIUB VLBI Analysis Center

Volkmar Thorandt, Axel Nothnagel, Gerald Engelhardt, Markus Vennebusch,
Dorothee Fischer, Dieter Ullrich

Abstract

In 2005 the activities at the BKG/GIUB VLBI Analysis Center, as in previous years, consisted of routine computations of Earth orientation parameter (EOP) time series and 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 were 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. At BKG a set of antenna axis offsets was estimated as a prerequisite for issuing the official list of VLBI antenna axis offsets by the IVS Analysis Coordinator. At the same time first steps to investigate the long-term stability of radio sources in the VLBI analysis were done. At GIUB the emphasis was placed on individual research topics.

1. General Information

The BKG/GIUB VLBI Analysis Center has been established jointly by the Bundesamt für Kartographie und Geodäsie (BKG), Leipzig, and the Geodetic Institute of the University of Bonn (GIUB). Both institutions maintain their own analysis groups in Leipzig and Bonn but cooperate intensively in the field of geodetic VLBI. The responsibilities include data analysis for generating of the IVS products and special investigations with the goal of increasing the accuracy and reliability. BKG is responsible for the computation of time series of EOP and tropospheric parameters, the generation of daily SINEX files, and quarterly updated global solutions for TRF and CRF realizations. In fall 2005 the BKG group took over responsibility for the scheduling of the Tsukuba - Wettzell INT2 UT1 - UTC observing sessions. Details of the research topics of BKG/GIUB are listed in section 3.

2. Data Analysis

At BKG the Mark 5 VLBI data analysis software system Calc/Solve, release of March 18, 2004 (ref. [3]), is currently still used for VLBI data processing. Work was started to install the update to release of August 16, 2005 (ref. [4]) and the LINUX test version of Calc/Solve. In addition, an independent technological software environment for the Calc/Solve software is available. The latter is used for linking up the Data Center management with the pre- and post-interactive part of the EOP series production and to monitor all Analysis and Data Center activities (Data Center topics are described in the BKG Data Center report in this issue). The Mark 5 software is running under Fortran 90 on a HP workstation with an HP-UX11.00 operating system.

- **Processing of correlator output**
  The BKG group continued the generation of calibrated databases for the sessions correlated at the MPIfR/BKG Mark 5 Astro/Geo Correlator at Bonn (e.g. R1, T2, OHIG, EURO) and submitted them to the IVS Data Centers.

- **Creating of schedule files**
  BKG has taken over a new task with regard to VLBI session scheduling. The schedule files for the Intensive observation sessions of the baseline TSUKUBA-WETTZELL have been created since August 2005.

- **IVS EOP time series**
  The new EOP time series bkg00007 differs from the previous bkg00006 by the implementation of the official list of the VLBI antenna axis offsets (ref. [2]). Bkg00007 was extracted from a global solution with 24 hour VLBI sessions since 1984. Altogether 3213 sessions were processed. The main parameter types in this solution are globally estimated station coordinates and velocities together with radio source positions. Minimal constraints for the datum definition were applied to get zero net rotation and net translation for 26 selected station positions and velocities with respect to the VTRF2003 (ref. [7]) and zero net rotation for 212 defining sources with respect to ICRF-Ext.1 (ref. [5]). The station coordinates of the stations TIGOCONC (Chile), SVETLOE (Russia), CTVASTJ (Canada), and METSAHOV (Finland) were estimated as local parameters in each session.

  The UT1 time series bkgint03 was replaced by bkgint04. Again the official list of the VLBI antenna axis offsets (ref. [2]) was used. The observations of both baselines KOKEE-WETTZELL and TSUKUBA-WETTZELL each with a duration of about 1-hour were processed regularly. Series bkgint04 was generated with fixed TRF (VTRF2003) and fixed CRF derived from the global BKG solution for EOP determination. The estimated parameter types were only UT1, station clock, and zenith troposphere. A total of 1723 UT1 Intensive sessions were analyzed for the period between 1999.01.01 and 2006.01.15.

- **Quarterly updated solutions for submission to IVS**
  For the IVS products TRF and CRF quarterly updated solutions were computed. There are no differences in the solution strategy compared to the continuously computed EOP time series bkg00007. 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, but now with station coordinates, 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, horizontal gradients) for all VLBI sessions since 1984. The tropospheric parameters are directly extracted and transformed into SINEX for tropospheric estimates from the results of the standard global solution for the EOP time series bkg00007.

- **Daily SINEX files**
  The VLBI group of BKG also continued the regular submissions of daily SINEX files for all available 24 hours sessions as base solutions for the IVS time series of baseline lengths and for combination techniques. In addition to the global solutions independent session solutions were computed for the parameter types station coordinates, EOP, and nutation parameters. The a priori datum for TRF is defined by the VTRF2003 and the fixed CRF derived from the global complete BKG solution for EOP determination is used for the a priori CRF information.

3. Research Topics

- **Estimation of VLBI antenna axis offsets**
  The BKG group participated in the coordinated effort to generate reliable VLBI antenna axis offsets. A complete set of axis offsets was estimated from all available geodetic VLBI data to verify and update the values used so far. This data set was used as one of the input series to create an official list of VLBI antenna axis offsets by the IVS Analysis Coordinator.

- **Radio source stability**
  First steps to investigate long-term stability of radio sources in the VLBI analysis were made at BKG. So time series for all radio sources were computed with nearly no change in datum definition. The a priori datum for CRF is defined by zero net rotation of 199 stable sources detected by M. FEISSEL-VERNIER (ref. [1]) with respect to ICRF (ref. [5]). Based on these time series of radio source positions residuals to the weighted mean of a radio source component can be tested for normal distribution for the purpose of uncovering systematic errors. Presently the normal distribution was not rejected for 121 radio sources in both components (right ascension, declination).

- **Analysis of the Tsukuba - Wettzell INT2 Series**
  At GIUB a detailed analysis of the Tsukuba - Wettzell INT2 series for the determination of UT1 - UTC is being completed for a consistent integration into the results of the R1 and R4 network sessions as well as the INT1 (Wettzell - Kokee Park) series. The results will be published in a Ph.D. thesis in 2006.

- **Analysis of water vapour radiometer data**
  Investigations in the use of water vapour radiometer data (WVR) in VLBI data analysis were continued. A comparison campaign for atmospheric sensors at Wettzell was analyzed leading to the detection of severe deficits of the ETHZ radiometer.

- **IERS Combination Pilot Project and ITRF2005 input generation**
  Within the IERS Combination Pilot Project and the ITRF2005 initiative SINEX files from seven IVS Analysis Centers have been combined into the official IVS submission to the IERS. A number of consistency issues had to be solved before a rigorous combination could be achieved. Final tasks are still being completed.

- **Phase and cable cal investigations**
  Motivated by the investigations of MacMillan (ref. [6]) in the azimuth dependence of the phase calibration at Onsala a project was launched searching for azimuth and/or elevation dependencies also at other telescopes. The results will be published in 2006.

- **Simulations of cluster-to-cluster VLBI sessions**
  A setup of several radio telescopes at individual sites observing in different directions at the same time can be used for cluster-to-cluster observing sessions. Observation schedules were generated for a few test setups of multi-station network sessions and single baseline UT1 - UTC intensive sessions using the SKED program. In simulation studies the schedules were analyzed with the Calc/Solve program and the results intercompared. The results of these investigations will be published in 2006.

4. Personnel

Table 1. Personnel at BKG/GIUB Analysis Center

Thomas Artz (from Jan 1, 2006)	GIUB	++49-228-733570	thomas.artz@uni-bonn.de
Gerald Engelhardt	BKG	++49-341-5634438	gerald.engelhardt@bkg.bund.de
Dorothee Fischer (until Dec 31, 2005)	GIUB	++49-228-732623	dorothee.fischer@uni-bonn.de
Axel Nothnagel	GIUB	++49-228-733574	nothnagel@uni-bonn.de
Volkmar Thorandt	BKG	++49-341-5634285	volkmar.thorandt@bkg.bund.de
Dieter Ullrich	BKG	++49-341-5634328	dieter.ullrich@bkg.bund.de
Markus Vennebusch	GIUB	++49-228-733565	vennebusch@uni-bonn.de
Reiner Wojdziak	BKG	++49-341-5634286	reiner.wojdziak@bkg.bund.de

References

[1] Feissel-Vernier M. (2003): Selecting stable extragalactic compact radio sources from the permanent astrogeodetic VLBI program, In: Astronomy and Astrophysics, 403, 105-110, 2003.

[2] GIUB, Bonn (2005): Official list of VLBI antenna axis offsets, (web reference: http://vlbi.geod.uni-bonn.de/IVS-AC/data/axis-offsets.html).

[3] GSFC, NASA (2004): Release of Mark 5 VLBI Analysis Software Calc/Solve from March 18, 2004 (web reference: http://gemini.gsfc.nasa.gov/solve).

[4] GSFC, NASA (2005): Release of Mark 5 VLBI Analysis Software Calc/Solve from August 16, 2005 (web reference: http://gemini.gsfc.nasa.gov/solve).

[5] ICRF-Ext.1 (http://hpiers.obspm.fr/webiers/results/Icrf)

[6] MacMillan D.S., Bjerkeli P. (2002): Modeling phase/cable-cal position dependence at Onsala 20m antenna, (web reference: http://ivscc.gsfc.nasa.gov/bjerkeli/report).

[7] VTRF2003: A Conventional VLBI Reference Frame, Jun. 30, 2003 (web reference: http://vlbi.geod.uni-bonn.de/IVS-AC/vtrf2003/vtrf2003.html).