



VLBI Analysis at BKG in the Frame of IVS

Volkmar Thorandt, Gerald Engelhardt, Dieter Ullrich, Reiner Wojdziak

Abstract

The VLBI group of the Federal Agency for Cartography and Geodesy (BKG) in Leipzig is part of the jointly operated IVS Analysis Center of BKG and the Institute for Geodesy and Geoinformation of the University of Bonn (IGGB). BKG is responsible for regular submissions of time series of Earth Orientation Parameters (EOP) and tropospheric parameters, the generation of daily SINEX (Solution INdependent EXchange format) files for 24-hours sessions and Intensive VLBI sessions, quarterly updated solutions to produce terrestrial and celestial reference frame realizations (TRF, CRF), and generating Intensive schedules (mainly Tsukuba-Wettzell).

1. General Information on Data Analysis

At BKG the latest version of the 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 is used for all work of data analysis. The VMF1 data are downloaded daily from the server of the Technical University Vienna.

Additionally an independent technological software environment for the Calc/Solve software is available 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.

2. Processing of Correlator Output

One important task in data analysis at BKG is the generation of calibrated databases for the sessions correlated at the MPIfR/BKG Mark 5 Astro/Geo Correlator at Bonn (e.g. EURO, OHIG, T2) and submitting them to the IVS Data Centers.

3. Scheduling

BKG continued scheduling the INT2 Intensive sessions, which are observed on the baseline TSUKUBA-WETTZELL. Due to the earthquake in Japan in March 2011 scheduling at BKG was extended for the INT1 Intensive sessions on baseline KOKEE-WETTZELL on week-ends. Altogether 153 schedule files were created in 2011.

4. IVS EOP Time Series bkg00013

The solution for generating the EOP series based on a global solution mode with common estimation of all parameter types. The EOP are one part of the arc-parameters, i.e. estimations for each experiment session. The global parameter adjustments refer to the entire data set, e.g. station positions and velocities or source positions. Each new VLBI session issued from correlator as database version 1 is processed and after that a new global solution with 24-hours sessions since 1984 is computed. Then the EOP time series bkg00013 is extracted.

Some topics of solution bkg00013 are:

- number of sessions: more than 4200,
- datum definition is realized by applying no-net-rotation and no-net-translation conditions for 26 selected station positions and velocities with respect to VTRF2008a and no-net-rotation condition for 295 defining sources with respect to ICRF2 [2],
- global parameter types station coordinates and velocities, radio source positions
- local parameter types in each session, e.g. EOP, tropospheric parameters (zenith wet delays at 1 hour intervals), local station coordinates for AIRA (Japan), CHICHII0 (Japan), CTVASTJ (Canada), DSS13 (USA), HOBART12 (Australia), PT-REYES (USA), SEST (Chile), SINTOTU3 (Japan), TIGOCONC (Chile), TSUKUB32 (Japan), WIDE85-3 (USA), VERAISGK (Japan), VERAMZSW (Japan), and YEBES40M (Spain). The three new VLBI stations KATH12M (Australia), WARK12M (New Zealand), and YARRA12M (Australia) were modeled in the same way.

5. IVS UT1 Time Series bkgint09

The UT1-UTC Intensive time series based on independent session solutions. The Intensive sessions include mainly observations of the baselines KOKEE-WETTZELL or TSUKUBA-WETTZELL, but also of the networks KOKEE-SVETLOE-WETTZELL and NYALES20-TSUKUBA-WETTZELL. Series bkgint09 is generated with fixed TRF (VTRF2008a) and fixed ICRF2. The estimated parameter types are only UT1-TAI, station clock, and zenith troposphere. The UT1 Intensive sessions are processed from 1999.01.01 on. The analysis of the INT3 sessions processed at the Bonn correlator every Monday after transferring the raw observations by eTransfer could be finished almost always on the same day. Delays of maximal one day appeared because of problems in data transfer. Due to the Japan earthquake in March 2011 no time series of Intensive sessions (UT1-UTC) with station TSUKUBA were processed. The coordinates of TSUKUBA should be well-known for UT1 estimation, but the earthquake moved TSUKUBA and the motion is still continuing. The VLBI group at BKG developed a procedure to get most probable station positions of TSUKUBA for the epochs of the Intensive sessions. The analysis of the Intensive sessions with station TSUKUBA (Int2/3) could be resumed on February, 2012.

Table 1: VTRF2008a station coordinates of TSUKUBA (TSUKUB32) for epochs of Int2/3 sessions after Japan earthquake 2011/03/11

No.	Session	X (m)	Y (m)	Z (m)
1	11MAY07XX	-3.957.409.212	3.310.228.878	3.737.494.699
2	11MAY08XX	-3.957.409.213	3.310.228.879	3.737.494.707
3	11MAY14XX	-3.957.409.213	3.310.228.873	3.737.494.708
4	11MAY15XX	-3.957.409.212	3.310.228.871	3.737.494.706
5	11MAY21XX	-3.957.409.223	3.310.228.868	3.737.494.719
6	11MAY22XX	-3.957.409.225	3.310.228.868	3.737.494.723
7	11MAY28XX	-3.957.409.234	3.310.228.862	3.737.494.714
8	11MAY29XX	-3.957.409.235	3.310.228.860	3.737.494.711
9	11JUN04XX	-3.957.409.229	3.310.228.852	3.737.494.701
10	11JUN05XX	-3.957.409.226	3.310.228.850	3.737.494.700
11	11JUN06XX	-3.957.409.224	3.310.228.849	3.737.494.700
12	11JUN11XX	-3.957.409.234	3.310.228.850	3.737.494.705
13	11JUN12XX	-3.957.409.237	3.310.228.850	3.737.494.706
14	11JUN18XX	-3.957.409.254	3.310.228.859	3.737.494.715
15	11JUN19XX	-3.957.409.257	3.310.228.861	3.737.494.717
16	11JUN25XX	-3.957.409.246	3.310.228.849	3.737.494.705
17	11JUN26XX	-3.957.409.245	3.310.228.847	3.737.494.702
18	11JUN27XX	-3.957.409.244	3.310.228.845	3.737.494.699
19	11JUL02XX	-3.957.409.240	3.310.228.852	3.737.494.685
20	11JUL03XX	-3.957.409.242	3.310.228.851	3.737.494.684
21	11JUL09XX	-3.957.409.248	3.310.228.845	3.737.494.675
22	11JUL10XX	-3.957.409.249	3.310.228.844	3.737.494.673
23	11JUL16XX	-3.957.409.256	3.310.228.851	3.737.494.705
24	11JUL17XX	-3.957.409.253	3.310.228.850	3.737.494.703
25	11JUL18XX	-3.957.409.251	3.310.228.850	3.737.494.701
26	11JUL23XX	-3.957.409.261	3.310.228.839	3.737.494.699
27	11JUL24XX	-3.957.409.263	3.310.228.839	3.737.494.701
28	11JUL25XX	-3.957.409.264	3.310.228.839	3.737.494.703
29	11JUL30XX	-3.957.409.259	3.310.228.835	3.737.494.696
30	11JUL31XX	-3.957.409.258	3.310.228.834	3.737.494.695
31	11AUG01XX	-3.957.409.256	3.310.228.833	3.737.494.693
32	11AUG06XX	-3.957.409.263	3.310.228.838	3.737.494.702
33	11AUG07XX	-3.957.409.265	3.310.228.839	3.737.494.704
34	11AUG08XX	-3.957.409.267	3.310.228.840	3.737.494.706
35	11AUG13XX	-3.957.409.271	3.310.228.846	3.737.494.689
36	11AUG14XX	-3.957.409.271	3.310.228.847	3.737.494.685
37	11AUG15XX	-3.957.409.272	3.310.228.849	3.737.494.681
38	11AUG20XX	-3.957.409.270	3.310.228.830	3.737.494.679
39	11AUG21XX	-3.957.409.269	3.310.228.824	3.737.494.680
40	11AUG27XX	-3.957.409.261	3.310.228.821	3.737.494.676
41	11AUG28XX	-3.957.409.259	3.310.228.821	3.737.494.675
42	11AUG29XX	-3.957.409.258	3.310.228.822	3.737.494.673
43	11SEP03XX	-3.957.409.266	3.310.228.830	3.737.494.683
44	11SEP04XX	-3.957.409.268	3.310.228.832	3.737.494.686
45	11SEP05XX	-3.957.409.270	3.310.228.833	3.737.494.688
46	11SEP10XX	-3.957.409.281	3.310.228.833	3.737.494.689
47	11SEP11XX	-3.957.409.283	3.310.228.833	3.737.494.689
48	11SEP12XX	-3.957.409.285	3.310.228.832	3.737.494.689
49	11OCT01XX	-3.957.409.289	3.310.228.825	3.737.494.700
50	11OCT02XX	-3.957.409.287	3.310.228.821	3.737.494.696
51	11OCT03XX	-3.957.409.286	3.310.228.817	3.737.494.692
52	11OCT08XX	-3.957.409.287	3.310.228.822	3.737.494.694
53	11OCT09XX	-3.957.409.288	3.310.228.823	3.737.494.695
54	11OCT10XX	-3.957.409.288	3.310.228.824	3.737.494.695
55	11OCT16XX	-3.957.409.294	3.310.228.827	3.737.494.703
56	11OCT17XX	-3.957.409.294	3.310.228.829	3.737.494.706
57	11OCT29XX	-3.957.409.306	3.310.228.827	3.737.494.708
58	11OCT30XX	-3.957.409.305	3.310.228.826	3.737.494.707
59	11OCT31XX	-3.957.409.304	3.310.228.826	3.737.494.706
60	11NOV06XX	-3.957.409.300	3.310.228.821	3.737.494.699
61	11NOV07XX	-3.957.409.299	3.310.228.820	3.737.494.698
62	11NOV12XX	-3.957.409.295	3.310.228.817	3.737.494.693
63	11NOV13XX	-3.957.409.294	3.310.228.816	3.737.494.692
64	11NOV14XX	-3.957.409.294	3.310.228.815	3.737.494.691
65	11NOV19XX	-3.957.409.296	3.310.228.815	3.737.494.691
66	11NOV20XX	-3.957.409.294	3.310.228.813	3.737.494.688
67	11NOV21XX	-3.957.409.292	3.310.228.811	3.737.494.686
68	11NOV26XX	-3.957.409.295	3.310.228.815	3.737.494.691
69	11NOV27XX	-3.957.409.295	3.310.228.816	3.737.494.692
70	11NOV28XX	-3.957.409.296	3.310.228.817	3.737.494.693
71	11DEC03XX	-3.957.409.303	3.310.228.817	3.737.494.689
72	11DEC04XX	-3.957.409.304	3.310.228.817	3.737.494.688
73	11DEC05XX	-3.957.409.305	3.310.228.817	3.737.494.687
74	11DEC10XX	-3.957.409.311	3.310.228.819	3.737.494.704
75	11DEC11XX	-3.957.409.312	3.310.228.820	3.737.494.708
76	11DEC12XX	-3.957.409.313	3.310.228.820	3.737.494.712
77	11DEC17XX	-3.957.409.308	3.310.228.815	3.737.494.704
78	11DEC18XX	-3.957.409.308	3.310.228.813	3.737.494.702
79	11DEC19XX	-3.957.409.307	3.310.228.812	3.737.494.700
80	11DEC31XX	-3.957.409.316	3.310.228.810	3.737.494.690
81	12JAN02XX	-3.957.409.319	3.310.228.811	3.737.494.696
82	12JAN07XX	-3.957.409.314	3.310.228.814	3.737.494.696
83	12JAN08XX	-3.957.409.312	3.310.228.814	3.737.494.695
84	12JAN09XX	-3.957.409.310	3.310.228.815	3.737.494.693
85	12JAN14XX	-3.957.409.315	3.310.228.811	3.737.494.697
86	12JAN15XX	-3.957.409.316	3.310.228.810	3.737.494.698
87	12JAN16XX	-3.957.409.317	3.310.228.809	3.737.494.699
88	12JAN1XX	-3.957.409.323	3.310.228.823	3.737.494.691
89	12JAN22XX	-3.957.409.324	3.310.228.821	3.737.494.692
90	12JAN23XX	-3.957.409.324	3.310.228.819	3.737.494.693
91	12JAN28XX	-3.957.409.320	3.310.228.816	3.737.494.690
92	12JAN29XX	-3.957.409.319	3.310.228.816	3.737.494.690
93	12JAN30XX	-3.957.409.318	3.310.228.815	3.737.494.689

Procedure of the Int2/3 session processing

- Global solution with 24-hours sessions since 1984 including all available sessions with TSUKUBA after Japan earthquake 2011/03/11
- Coordinates of station TSUKUBA estimated as local parameters
- Linear interpolation of successive estimations of TSUKUBA positions to the epochs of Int2/3 sessions (Table 1)
- If epochs of Int2/3 sessions are after the last estimated TSUKUBA position, use coordinates of the last 24-hours session of TSUKUBA.

Comparison of UT1-UTC results of Int2/3 with Int1

The UT1-UTC Intensive series Int2/3 derived from TSUKUBA's post-quake positions were compared with the results of Int1 that does not involve TSUKUBA. The comparison is based on differences to IERS C04 UT1-UTC values. The WRMS of both series computed on the basis of differences to IERS C04 is nearly the same (Figure 1) and no significant difference can be seen between the Int2/3 and Int1 series.

Conclusion

The Int2/3 series derived from the described procedure can be used again for operational UT1 estimation.

6. Quarterly Updated TRF and CRF Solutions for Submission to IVS

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

7. Tropospheric Parameters

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

8. Daily SINEX Files

In addition to the global solutions daily SINEX files for all available 24-hours sessions as base solutions for the IVS time series of baseline lengths and for combination techniques are submitted. Independent session solutions are computed for the parameter types station coordinates, radio source coordinates, and EOP including the X,Y-nutation parameters. The a priori datum for TRF is defined by the VTRF2008a, and ICRF2 is used for the a priori CRF information.

9. SINEX Files for Intensive Sessions

IVS SINEX files for Intensive sessions are created and submitted to IVS. The parameter types are station coordinates, pole coordinates and their rates, and UT1-TAI and its rate. Only the normal equations stored in the SINEX files are important for further combination with other space geodetic techniques.

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] Ma Chopo et al (2009) IERS Technical Note No. 35: The Second Realization of the International Celestial Reference Frame by Very Long Baseline Interferometry; Presented on behalf of the IERS/IVS Working Group, edited by Alan L. Fey, David Gordon, Christopher S. Jacobs.

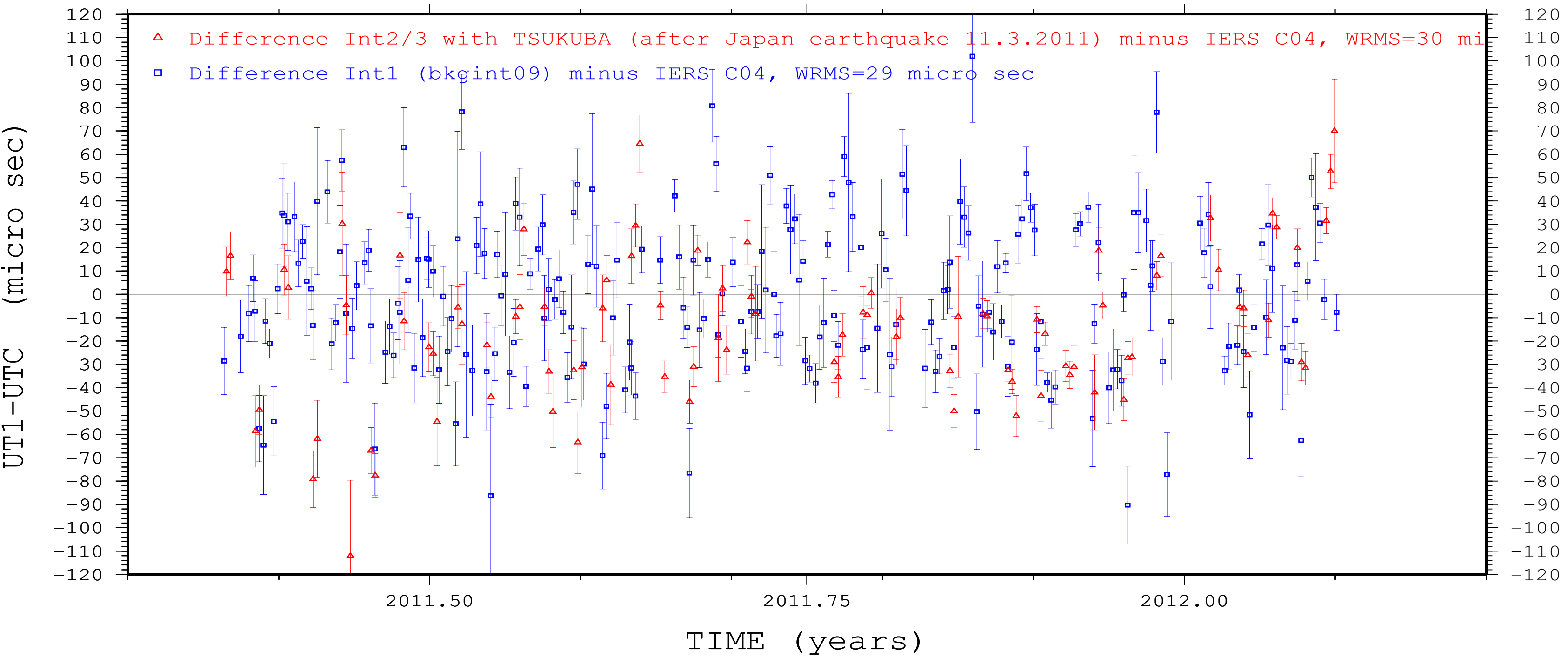


Figure 1: Differences of Int1 and Int2/3 series to IERS C04 in UT1-UTC

Further Information

Volkmar Thorandt (volkmar.thorandt@bkg.bund.de), Gerald Engelhardt (gerald.engelhardt@bkg.bund.de), Dieter Ullrich (dieter.ullrich@bkg.bund.de), Reiner Wojdziak (reiner.wojdziaak@bkg.bund.de)
Federal Agency for Cartography and Geodesy • Branch Leipzig • Karl-Rothe-Str. 10-14 • D-04105 Leipzig • www.bkg.bund.de