Tsukuba VLBI Analysis Center

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Abstract

The Tsukuba Analysis Center is funded by the Geospatial Information Authority of Japan (GSI). The *c5++* analysis software is regularly used for the IVS-INT2 analysis and the ultra-rapid EOP experiments.

1. Introduction

The Tsukuba Analysis Center located in Tsukuba, Japan, is operated by the Geospatial Information Authority of Japan (GSI). One of our major roles is to analyze the weekend IVS Intensives (INT2) using the fully automated VLBI analysis software *c5++* developed by the National Institute of Information and Communications Technology (NICT) regularly. It should be noted that the dUT1 solution becomes available within a few minutes after the end of the last scan of the session. A 10 Gbps dedicated link to the SINET4 operated by the National Institute of Informatics (NII) and various process management programs enable the rapid dUT1 derivation. In addition, the ultra-rapid EOP experiments consisting of 23 regular IVS 24-hour sessions and three dedicated experiments were implemented.

2. Component Description

2.1. Fully Automated VLBI Analysis Software C5++

c5++, which is a space-geodetic analysis software that handles SLR, GNSS, and VLBI, has been undergoing several modifications and updates by NICT, and it was installed on some hosts at the Tsukuba Analysis Center in the summer of 2012 [1]. Since before then, the program *c5UT1* that has partial functionality of *c5++* has been used and has provided dUT1 solutions for the regular INT2 sessions. The newly installed *c5++* enables flexible parameterization (X-pole, Y-pole, dUT1, nutation, station clocks, and troposphere) and SINEX input/output with the covariance matrix. Currently only two data formats (NGS and KOMB) are supported for analysis, but the import and export of the new IVS Open DB format will be available in the near future, as well as estimation of station and source coordinates and troposphere gradients. Now the *c5++* solutions have been evaluated, and consistency with the current *c5UT1* solutions has been confirmed. *c5++* will start to be used operationally in place of *c5UT1* at the start of 2013.

2.2. Calc/Solve

Calc/Solve has been in continuous use since the early days of VLBI work at GSI. It is used for the analysis of JADE in its interactive mode and for global analysis in its batch mode, which is reserved for our internal use and is not used to generate IVS Analysis Center products.

2.3. Potential to Use VieVS

VieVS, which has been developed by the Institute of Geodesy and Geophysics (IGG) of the

Vienna University of Technology, has already been installed at the Tsukuba Analysis Center, but it has not been made operational yet [2]. *VieVS* is quite interesting VLBI analysis software, having some unique features that are not seen in other software. We would like to start utilizing the features in 2013.

2.4. Analysis Center Hardware Capabilities

Both *c5++* and *Calc/Solve* are installed on some general purpose and commercially-produced Linux computers (Table 1). MATLAB as a platform for VieVS is also available on a host. Individual RAIDs are mounted on each host for storing a lot of VLBI data files, e.g. Mark III databases.

Table 1. Analysis Center hardware capabilities.

Number of servers	four for VLBI analysis (*c5+*, *Calc/Solve*, and *VieVS*)
Operating System	CentOS version 5.2, 5.4, or 5.5
CPU	Intel Xeon 3.80 GHz quad CPU / Intel Xeon 3.00 GHz quad CPU / Intel Xeon 2.83 GHz quad CPU
Total storage capacity	individual RAIDs: 1.22 Tbytes in total

3. Staff

The technical staff members in the Tsukuba Analysis Center are:

- **Shinobu Kurihara**: correlator/analysis chief, software design and development.
- **Kentaro Nozawa** (AES): correlator/analysis operator, software development.
- **Takashi Nishikawa** (AES): correlator/analysis operator.

Kensuke Kokado, who was correlator/analysis chief until the end of May 2012, moved to another division.

4. Analysis Operations

4.1. IVS-INT2

In 2012, 107 IVS-INT2 sessions were correlated at the Tsukuba VLBI Correlator that is also operated by GSI. 83 of them observed the Tsukuba-Wettzell baseline. The observed data at Wettzell is transferred to the correlator in real-time with the VDIF/SUDP protocol. The correlated data is rapidly analyzed by *c5++* as soon as all of the correlator output becomes available, and then a dUT1 solution is derived. Figure 1 shows in how many sessions their analyses are completed within a short latency. Due to some sort of trouble on the station's side, nine sessions are excluded from the total number of sessions. 90% of the total sessions derived dUT1 solutions within four minutes after the end of the last scan, and 50% were within two minutes. The ending time of the IVS-INT2 sessions is 8:30 UT on every Saturday and Sunday. Thus, the dUT1 solution becomes available at 8:40 UT at the latest. This is really an advantage of the Tsukuba Analysis Center.

The eopi file that is a product of the Intensives from the Analysis Center is submitted immediately after the analysis and becomes accessible as an IVS product. The U.S. Naval Observatory (USNO) operates as the IERS Rapid Service/Prediction Center, which is responsible for providing earth orientation parameters on a rapid turnaround basis, primarily for real-time users and others needing the highest quality EOP information sooner than that available in the final EOP series.

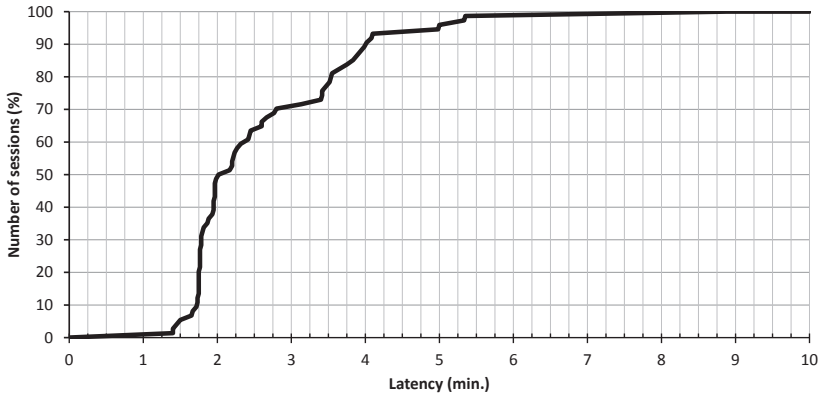

Figure 1. Latency vs. percentage of sessions (out of 74 sessions, excluding nine sessions with some sort of trouble during these sessions).

4.2. Ultra-rapid EOP Sessions

This session type started in 2007 as a joint project of Japan (Tsukuba and Kashima) and Fennoscandia (Onsala and Metsähovi). It aims to derive consecutive time series of EOP as soon as possible taking advantage of the strategy which is that the observed data is sent in real-time via the international optical fiber backbone to Tsukuba, where the data is correlated and analyzed in near real-time. *c5++* is used in the whole analysis (see section 2.1).

Nowadays four countries — Japan, Sweden, Australia, and South Africa — are involved in association with Hobart and HartRAO, which recently joined in 2012. 23 regular IVS 24-hour sessions that involved at least two stations from Hobart, HartRAO, Onsala, and Tsukuba were operated with the ultra-rapid strategy. Eight which were originally scheduled with HartRAO, Onsala, and Tsukuba added Hobart as the fourth station by using the tag-along function of SKED and performed with a four-station/six-baseline network in order to derive not only dUT1 but also two polar motion parameters more accurately with a very low latency by better network geometry.

However, since the regular IVS 24-hour session schedule is optimized for networks consisting of the originally involved stations, the network geometry throughout the whole duration of the experiment does not improve obviously even if Hobart is added. Therefore we planned three dedicated experiments and carried out them from November to December (Table 2).

In particular, the ultra-rapid processing in UR1203, which had a duration of 35 hours, worked very well for most of the time except the periods when some sort of trouble on the station's side happened. Figure 2 presents time series of EOP derived from this experiment. You can see some points with a large error bar and gaps, which might be caused by failure in the analyses in this period.

Table 2. The ultra-rapid EOP experiments with dedicated schedules that are optimized for all involved stations in 2012.

Experiment	Date	Time	Duration	Stations	#obs. (skd)	#obs. (cor)
UR1201	NOV29	18:00	24	HbHtTs	822	382
UR1202	DEC06	18:00	24	HbHtTs	482	363
UR1203	DEC17	07:30	35	HbHtOnTs	1033	846

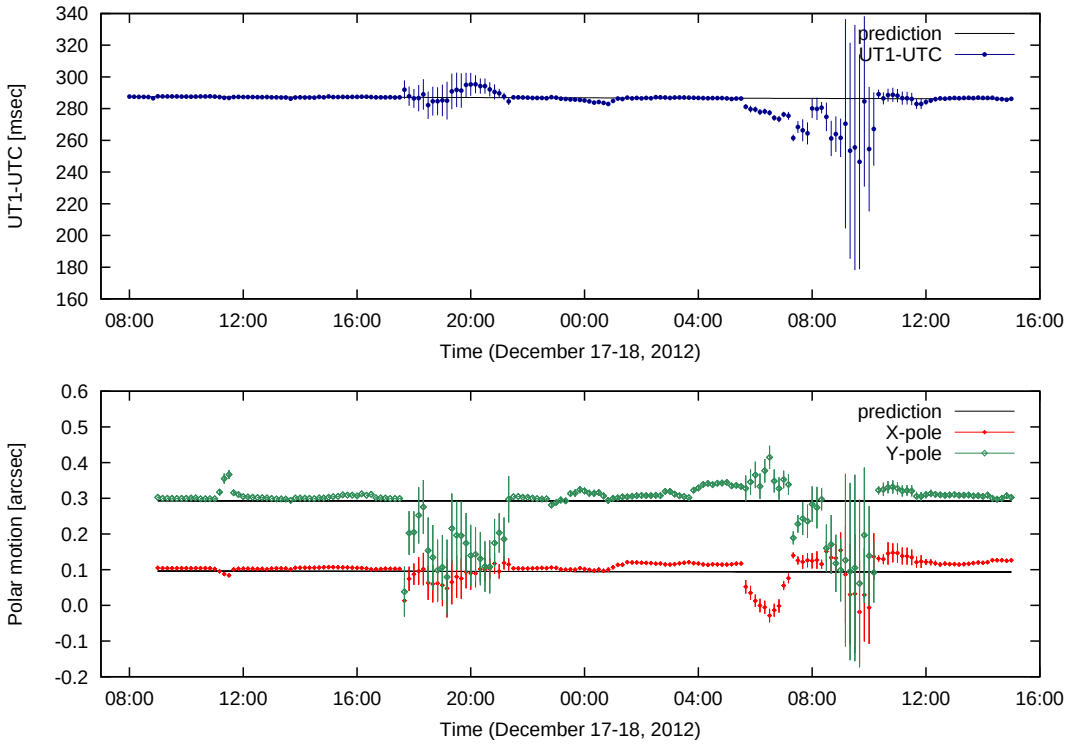

Figure 2. The time series of EOP estimation derived from the UR1203 experiment with the prediction (Rapid Service/Prediction of Earth Orientation, finals2000A.daily).

5. Outlook

Analyses of all INT2 sessions are being performed as in 2011, and dUT1 solutions will be produced with a low latency. In addition, the ultra-rapid EOP experiments will be continued.

References

[1] Hobiger, T., et al.: Fully automated VLBI analysis with c5++ for ultra-rapid determination of UT1, *Earth Planets Space*, **62**, 933-937, 2010.

[2] Böhm, J., et al.: The New Vienna VLBI Software VieVS, In Proceedings of IAG Scientific Assembly 2009, *International Association of Geodesy Symposia Series*, **136**, edited by S. Kenyon, M. C. Pacino, and U. Marti, doi: 10.1007/978-3-642-20338-1_126, 1007-1011, 2012.