Tsukuba VLBI Analysis Center

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Abstract The Tsukuba VLBI Analysis Center has been regularly performing near real-time analysis of the weekend IVS Intensive (INT-2) sessions using *c5++* analysis software. This report summarizes the results of the INT-2 analysis and some activities of the Analysis Center during 2023 and 2024.

1 Introduction

The Tsukuba VLBI Analysis Center, located in Tsukuba, Japan, is operated by the Geospatial Information Authority of Japan (GSI). A major role of the Analysis Center is to regularly analyze the weekend IVS Intensive (INT-2) sessions and deliver the results to the community. The analysis is performed in near real-time, and the estimate of UT1-UTC (= dUT1) is provided to the community rapidly after the end of observing. A dedicated link to the SINET6 operated by the National Institute of Informatics (NII) and several process management programs make it possible to derive the solutions rapidly. Our products are utilized for more accurate dUT1 prediction by the U.S. Naval Observatory (USNO) as the IERS Rapid Service/Prediction Center, which is responsible for providing Earth Orientation Parameters (EOPs) on a rapid turnaround basis, primarily for real-time users and others needing the highest quality of the EOP information sooner than that available in the final EOP series [1][2][3].

1. Geospatial Information Authority of Japan
2. Advanced Engineering Service Co.,Ltd.

2 Component Description

2.1 Analysis Software

Analysis software named *c5++*, which was jointly developed by Hitotsubashi University, the National Institute of Information and Communications Technology (NICT), and the Japan Aerospace Exploration Agency (JAXA) for various space geodetic techniques including SLR, GNSS, and VLBI, is officially used to estimate dUT1 in the regular INT-2 sessions at the Analysis Center [4]. At present, the Analysis Center uses version 0.0.1 (rev 932) of the analysis software.

The correlation and analysis management programs, so-called *rapid_* programs developed by GSI, can execute all the processes from data transfer through analysis and provide the results consecutively and automatically. *Rapid_c5pp* runs *c5++* on outputs of the bandwidth synthesis process and estimates dUT1 to be delivered to the community quickly. Please refer to the report "Tsukuba VLBI Correlator" in this volume for further details of *rapid_* programs.

The Analysis Center creates the version 4 databases to submit to IVS using *νSolve* developed by NASA GSFC [5]. The version of *νSolve* is 0.8.2 as of December 2024.

2.2 Analysis Center Hardware Capabilities

At the Analysis Center, *c5++* and *νSolve* are installed on several general-purpose and commercially produced Linux computers to perform dUT1 analysis. The main analysis server has two 10 TB hard disk drives

where the VLBI databases and necessary a priori files are stored. One is used as main storage and mirrored by the other regularly.

3 Staff

The technical staff members in the Tsukuba VLBI Analysis Center in FY 2023 and FY 2024 are:

FY 2023

- **Haruka Ueshiba**—correlator/analysis chief, management.
- **Hiroyuki Yoshifuji**—correlator/analysis operator, coordination.
- **Tetsuya Hara** (AES)—correlator/analysis operator, software development.

FY 2024

- **Saho Matsumoto**—correlator/analysis chief, management.
- **Kaho Hashimoto**—correlator/analysis operator, coordination.
- **Tetsuya Hara** (AES)—correlator/analysis operator, software development.

4 Analysis Operations

4.1 Updates of the Analysis Environment

- **New ITRF apriori: ITRF2020**

ITRF2020 [6] was released in 2022, and the program was modified to adapt to the new ITRF as a priori. Along with this modification, we updated the EOP file format from gsiint2c.eopi to gsiint2d.eopi. It has been provided in the new file format from the processing of Q23231 on August 19, 2023.

- **File Format Change**

The master file format and the name convention of the database has changed since the beginning of 2023. We have improved our programs so that we can handle these changes.

Table 1 INT-2 sessions analyzed at the Tsukuba Analysis Center in 2023 and 2024. Is, Mk, Wz, and Kk represent ISHIOKA, MK-VLBA, WETTZELL, and KOKEE, respectively.

2023	Baseline	# of observations	Ave. of dUT1 formal uncertainties
	IsMkWz	12	5.9 μsec
	MkWz	62	9.2 μsec
Intensive 2	IsWz	8	9.8μsec
	KkWz	10	7.5 μsec
Total		92	8.7 μsec

2024	Baseline	# of observations	Ave. of dUT1 formal uncertainties
Intensive 2	MkWz	91	8.9 μsec
Total		91	8.9 μsec

Table 2 Summary of automated processing results.

	2023	2024
# of scheduled sessions	102	100
Success in real-time processing (success rate except cancelled sessions)	70 (76%)	66 (73%)
Failed in real time processing	22	25
– large offset (difference between estimated value and a priori)	5	9
– Data quality (outlier)	7	13
– weak fringe	3	0
– *rapid_* programs failure	0	2
– Station or data transfer failure	7	1
Cancelled	10	9

4.2 Summary of UT1-UTC Results

All the weekend INT-2 sessions were automatically processed at the Analysis Center in near real-time using the *rapid_*programs. The results for INT-2 sessions that were processed at the Analysis Center in 2023 and 2024 are summarized in Table 1. The results were submitted to IVS Data Centers as gsiint2c.eopi (until August 13, 2023) and gsiint2d.eopi. In 2023, the VLBA antenna at Mauna Kea (MK-VLBA) in Hawaii, U.S. and the Wettzell 20-m station (WETTZELL) in Germany mainly participated in the INT-2 sessions. The Ishioka station (ISHIOKA) in Japan also participated in INT-2 sessions while the S/X feed was installed in the antenna in 2023. In March 2023, ISHIOKA shifted to conduct observing only using its VGOS feed, so Q23071 is the last session it participated in. When MK-VLBA and ISHIOKA were unavailable, Kokee Park (KOKEE) in Hawaii, U.S. replaced them. Since

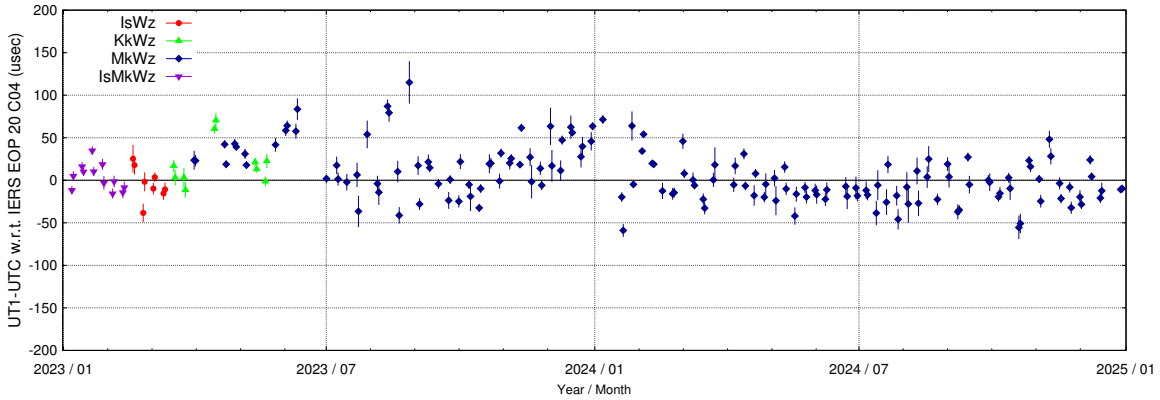

Fig. 1 The time series of UT1-UTC solutions obtained at the Analysis Center with respect to IERS EOP 14 C04 from 2023 to 2024. Error bars represent 1σ formal uncertainties.

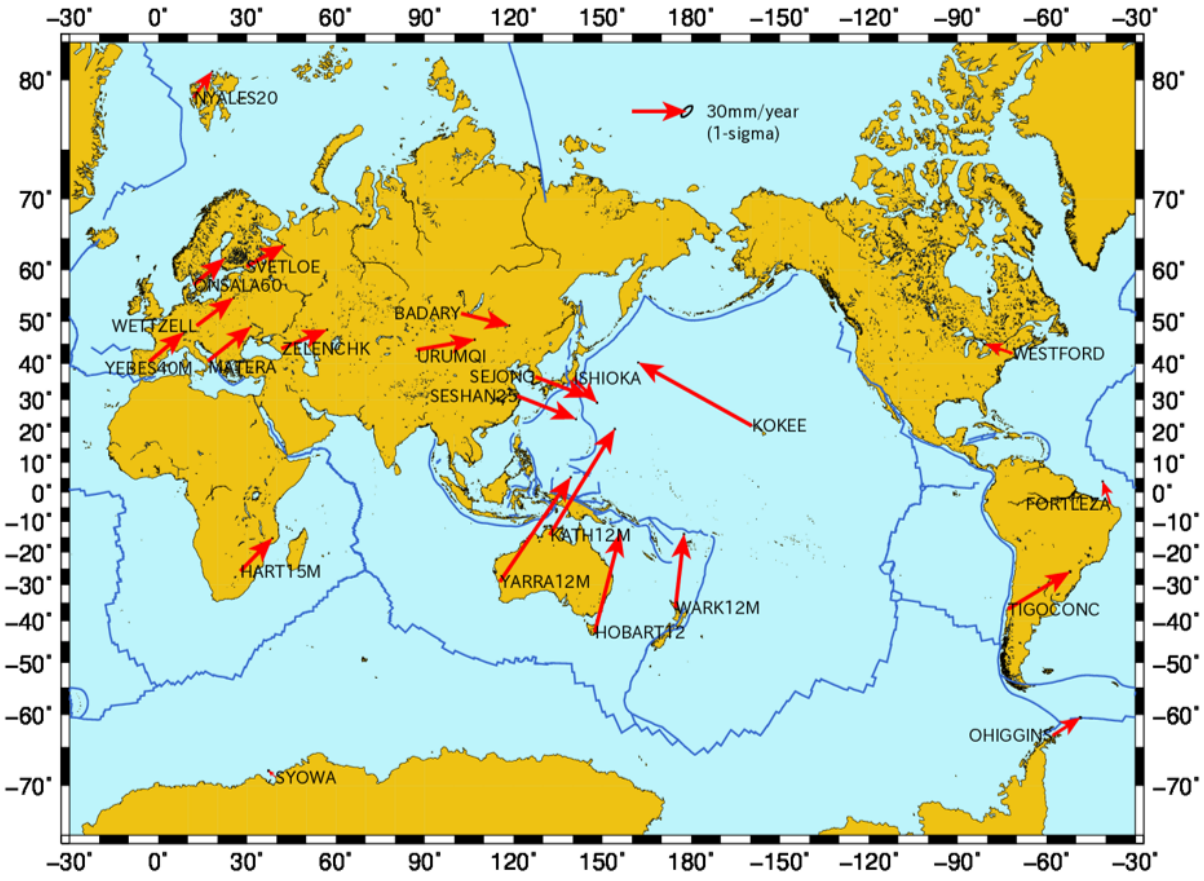

Fig. 2 Rate of change in observation station position.

2024, the baseline has been fixed on MK-VLBA and WETTZELL. The average formal errors for total sessions were about 9 microseconds for 2023 and 2024. Figure 1 shows the difference of estimated dUT1s from the IERS EOP 20 C04 from January 2023 through December 2024.

The results of near real-time processing of INT-2 sessions for 2023 and 2024 are outlined in Table 2. We successfully processed 70 sessions out of 92 sessions in near real-time in 2023, while 66 sessions out of 91 sessions succeeded in real-time processing in 2024. Some of the sessions were cancelled due to station troubles and missing data. The success rate in Table 2 shows the percentage of successfully processed real-time sessions in all the sessions except cancelled ones.

5 Other Activity

At the Analysis Center, we have conducted global analysis using VLBI data regularly since 2002. In the latest analysis, performed in September 2024, we analyzed databases of over 7,000 VLBI observations from 1980 to September 2024. Figure 2 shows the rate of change in observation station positions estimated by GSI. We will continue the regular analysis and study for improving accuracy of solutions.

6 Outlook

We will continue to analyze the IVS S/X Intensive sessions and provide dUT1 products in near real-time. In order to improve the accuracy of dUT1 estimates and to submit more stable products, we will keep updating our automatic processing programs.

References

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