Activities of GSI on VLBI Observing Operation and Monitoring

Kensuke Kokado[1], Masaki Honda[1], Haruka Ueshiba[1], Hiroyuki Yoshifuji[1], Masafumi Ishigaki[1], Haruna Furui[1], Akira Suzuki[1]

Abstract The Geospatial Information Authority of Japan (GSI) operates the Ishioka Geodetic Observing Station (hereafter the Ishioka Station) and the Tsukuba Correlator/Analysis Center to support geodetic VLBI. The Ishioka Station officially started participating in IVS S/X sessions with a broadband receiver in October 2020, after the introduction of a superconducting filter into the receiver and a series of test observations to evaluate the feasibility of correlation processing in mixed mode. This has made it possible to participate in S/X and VGOS observing sessions without replacing the receiver. The Tsukuba Correlator/Analysis Center has been working on the automation of correlation processing using DiFX/HOPS in order to realize rapid UT1 calculation for VGOS Intensive sessions. In 2023, we were able to automate a series of steps in the correlation process, but we still have some issues in automating the correlation process for short-distance baselines between twin telescopes.

Keywords GSI, VLBI, Tsukuba, rapid UT1

1 Introduction

The Ishioka Station started participating in IVS VLBI observing sessions in 2016 and has participated in both S/X and VGOS observing sessions every year since 2018. In recent years, VGOS observing sessions have gradually increased, but with S/X observing sessions still being conducted at IVS, it was necessary to improve the environment of the Ishioka Station for continued participation in both types of sessions. The Ishioka Station has been participating in both session types by replacing the receiver mounted on the telescope every six months until March 2023. However, replacing the receiver involves safety control risks and lost observation time; therefore we explored the feasibility of conducting both S/X and VGOS sessions with a broadband receiver without replacing the receiver.

The Tsukuba Correlator/Analysis Center mainly processed data of two S/X observing session series, IVS-INT-2 sessions and AOV sessions, and it started processing the data of VGOS-INT-B and C sessions, which are Intensive sessions of the VGOS observing session type. The UT1 value obtained as the result of the VLBI observing sessions is an essential parameter for orbit determination of satellites such as GNSS, and it is desirable to calculate it as quickly as possible after the VLBI observing sessions. The Tsukuba Correlator/Analysis Center has automated the correlation processing and analysis for IVS-INT-2 sessions since 2012 and has been able to calculate UT1 within a few hours after the observing. In VGOS-INT-B and C sessions, which started in 2023, the correlation processing software used is different. Currently, we have been improving the correlation system for VGOS-INT-B and C sessions to automate the processing.

2 Activity of the Ishioka Geodetic Observing Station

2.1 Conventional Observation Systems and Status of Observations

The Ishioka Station has participated in IVS sessions since 2016 and currently participates in both VGOS

1. Geospatial Information Authority of Japan

and S/X observing sessions. Since 2022, we have participated more in VGOS than in S/X for Intensive sessions. Although 24-hour sessions are still more common in S/X, we are working on upgrading our equipment to further increase participation in VGOS observing sessions. Figure 1 shows a time-series plot of the Ishioka Station's position coordinates derived from the analysis of 24-hour sessions in which Ishioka participated. We utilize CALC/SOLVE software in the analysis, with ITRF2020 coordinates serving as the a priori value for station coordinates (Table 1).

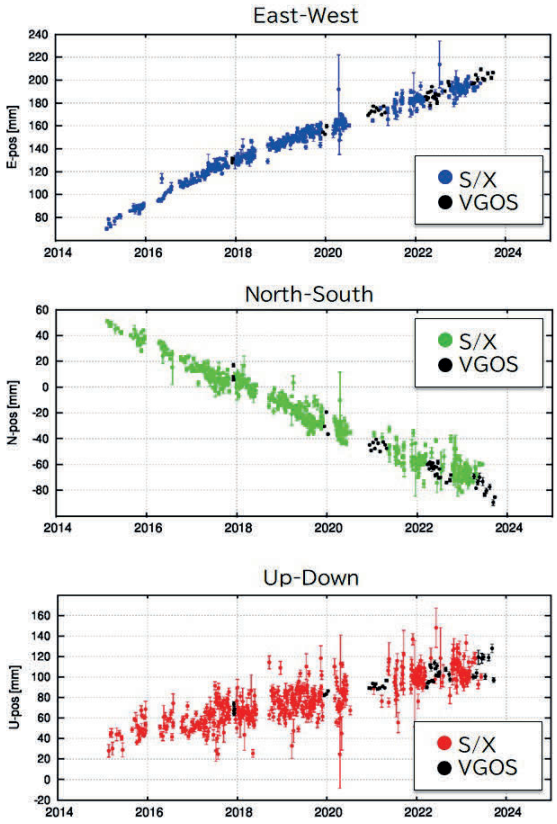

Fig. 1 Coordinate time series of the Ishioka 13.2-m telescope.

The upper, middle, and lower figures in Figure 1 show the coordinate time series in the east-west, north-south, and vertical directions, respectively. The black plots show the results of the VGOS observing sessions, exhibiting smaller errors compared to S/X observing sessions. There is no significant difference in the coordinate values between the VGOS and S/X observing sessions.

Table 1 A priori files for CALC/SOLVE analysis.

CRF	ICRF3
TRF	ITRF2020
UT1, Polar motion	usno_finals.erp
Nutation	IAU2006/2000
Antenna Axis Offset	2019a.axo

2.2 S/X Observations with Wideband Receiver

The Ishioka 13.2-m telescope had been using a broadband receiver with a QRFH for VGOS observing sessions and a tri-band feed receiver for S/X observing sessions. We had participated in both types of sessions by replacing the receiver once every six months. However, because it takes one to two weeks to replace the receiver and because there is a risk of failure during the replacement, we are investigating the possibility of supporting both S/X and VGOS observing sessions using only a broadband receiver. During the period from 2020 to 2021, we had developed and installed the superconducting filter necessary to conduct S/X observations with the broadband receiver. From 2022 to 2023, some tests of mixed-mode correlation processing of observation data by the wideband receiver were conducted. Fringes were detected in the R session in April 2023. As the result of these equipment improvements and data processing tests, we officially started participating in S/X observing sessions with the broadband receiver in October 2023. S/X and VGOS observations can now be performed without receiver replacement, and we have been participating in S/X and VGOS observing sessions in parallel since then (Figure 2).

3 Activity of Tsukuba Correlator/Analysis Center

3.1 Correlation Software in Tsukuba Correlator

The Tsukuba correlator has conducted correlation processing for two S/X observing session series, IVS-INT-2 and AOV sessions, since 2012 and two VGOS observing session series, VGOS-INT-B and C sessions, since 2022. The correlation processing software used

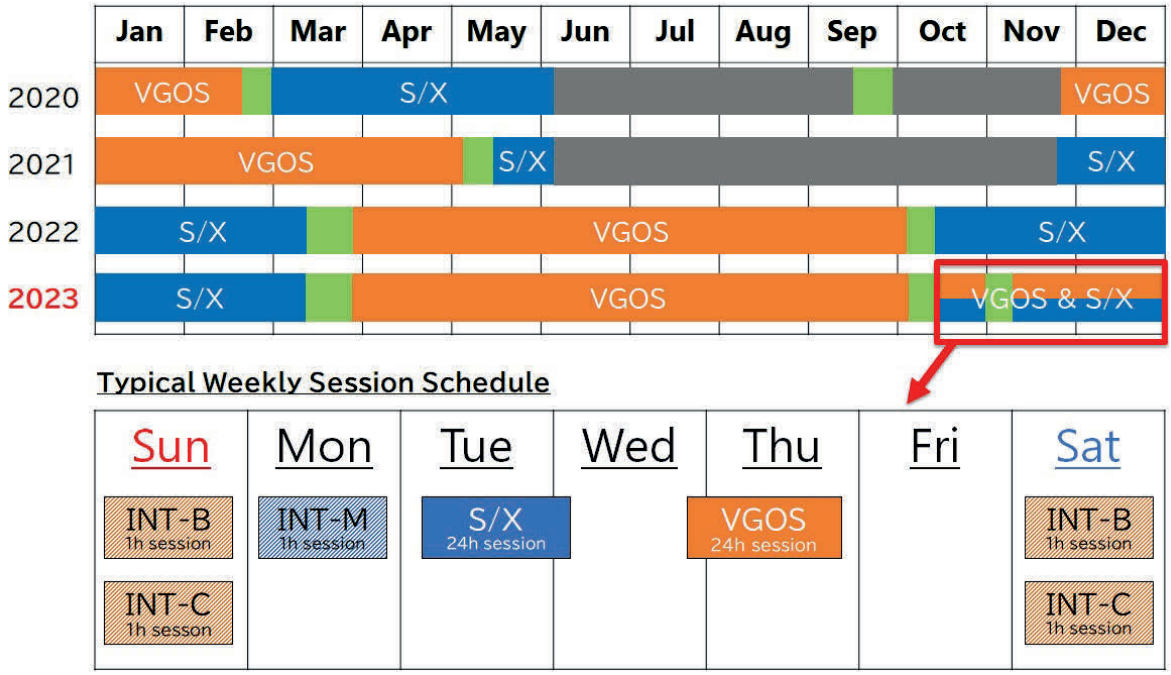

Fig. 2 Parallel participation in VGOS and S/X sessions.

are K5/VSSP and DiFX/HOPS, and the correlation processing of IVS-INT-2 sessions is automatically processed using K5/VSSP.

3.2 Rapid UT1 Calculation for IVS-INT-2 Sessions

Figure 3 shows the flow of automatic correlation processing for IVS-INT-2 sessions. The entire sequence of data conversion, processing, and UT1 analysis after the VLBI observing is done automatically, and once all data is stored on the data servers at the Tsukuba correlator, the entire process can be completed within one hour.

Table 2 shows the summary of the rapid UT1 calculation from 2021 to 2023. Although the automatic processing sometimes failed due to missing observation data or poor data quality, the automatic processing was completed for approximately 80% of the sessions in 2023. The average of latency for calculating UT1 was within two hours in 2021, but the calculation time has been longer since 2022. It was about three hours in 2023. The main reason for the delay of data processing is that it takes time for data transfer, and the start time of data processing has become later. If good quality data can be obtained quickly, processing can be done within one hour after the end of a session.

3.3 Automation of the Correlation Process of the VGOS-INT-B/C Sessions

The correlation processing for the VGOS-INT-B and VGOS-INT-C sessions is performed with DiFX/HOPS instead of K5/VSSP, because K5/VSSP does not support the data processing of VGOS observation data. We are in the process of automating the processing of DiFX/HOPS as well.

Figure 4 shows the flow of the data processing with DiFX/HOPS. The red frame indicates the tools that we have built for automated processing. It has become possible to automatically process a series of flows by introducing these tools. However, the correlation processing of short baselines, such as the baseline between twin telescopes, is difficult to process automatically, and improvements are needed to automatically process short baselines.

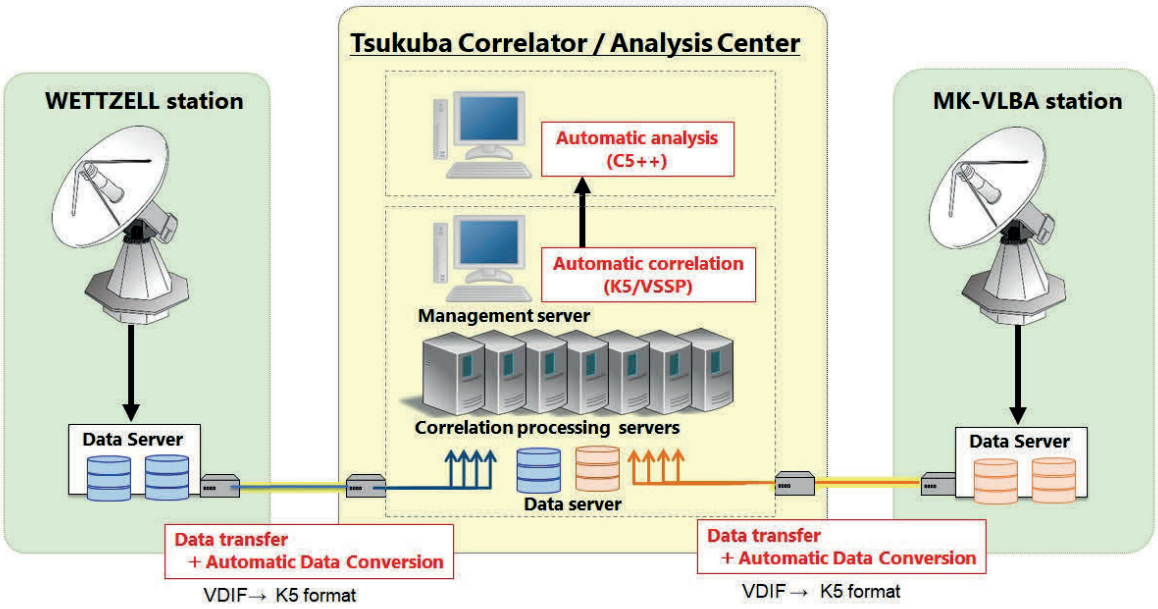

Fig. 3 Rapid UT1 measurements with IVS-INT-2 sessions.

Table 2 Summary of rapid UT1 measurements in 2021–2023.

Session	IVS-INT-2	AOV	VGOS-INT-B & VGOS-INT-C
Frequency	S/X	S/X	VGOS
Duration	1 hour	24 hours	1 hour
Networks	WETTZELL, MK-VLBA (ISHIOKA *until Jan. 2023)	Stations of AOV (HOBART12,ISHIOKA, KATH12M,KOGANEI, SEJONG,SESHAN25, URUMQI,VERAMZSW, YARRA12M, etc.)	ISHIOKA,ONSA13NE, ONSA13SW
Day	Every Saturday and Sunday	Once a month	Every Saturday and Sunday
Software	K5/VSSP	DiFX/HOPS	DiFX/HOPS

4 Summary

The Ishioka Station has improved its broadband receiver system in order to continuously and stably participate in S/X and VGOS observing sessions. With the installation of a superconducting filter in the broadband receiver of the Ishioka 13.2-m telescope and the introduction of mixed-mode processing at the correlation station, S/X observations with the broadband receiver have been possible since October 2023. As the result of the improvement, S/X and VGOS observing sessions are scheduled to be performed weekly from 2024 onward. The Tsukuba Correlator/Analysis Center has been developing an automatic processing system using DiFX/HOPS for rapid UT1 calculation in VGOS-INT-B and VGOS-INT-C sessions. Currently, we still have some issues in the correlation processing of short baselines. Therefore, we will continue to improve the system and conduct implementation tests of automatic processing with DiFX/HOPS in the future.

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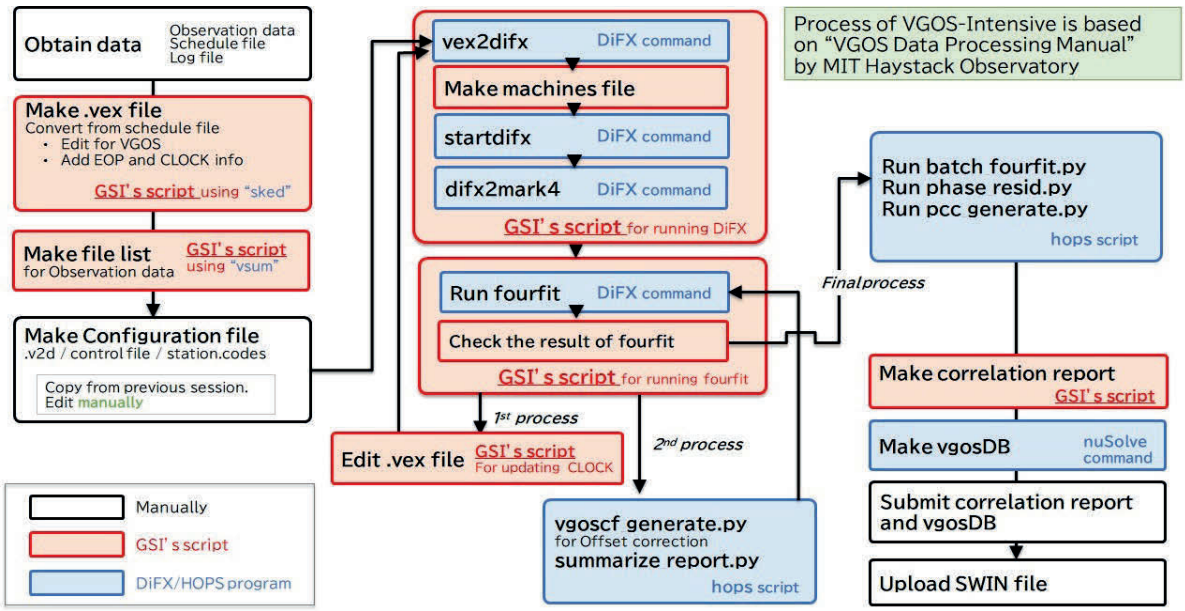

Fig. 4 Process flow and tools for VGOS Intensives.

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