Ishioka Geodetic Observing Station Report

Haruna Furui[1], Kayako Hori[1], Saho Matsumoto[1], Kaho Hashimoto[1],Toshiki Ishii[1],Masafumi Ishigaki[1], Masaki Honda[1], Shinobu Kurihara[1], Hiroyuki Yoshifuji[1], Haruka Ueshiba[1], Akira Suzuki[1], Kensuke Kokado[1], Kentaro Nozawa[2]

Abstract This report summarizes the recent activities of the Ishioka Geodetic Observing Station, which is operated by the Geospatial Information Authority of Japan. In the last two years, it has contributed to both S/X and VGOS observing coordinated by IVS using a broadband receiver. In 2023, it installed a new sampler (DBBC3) and recording server (FlexBuff), and in 2024 it prepared for new observation settings, for example, 1 GHz bandwidth observing, 64 MHz channel width sampling, and 16 channel sampling.

1 General Information

The Ishioka Geodetic Observing Station (Figure 1, hereafter Ishioka station) is located at approximately 70 km to the northeast of Tokyo and 17 km to the northeast of the headquarters of the Geospatial Information Authority of Japan (GSI) in Tsukuba. The Ishioka 13.2-m radio telescope operated by GSI is in Ishioka station (approximately at latitude N 36° 12’ 33”, longitude E 140° 13’ 8”, and altitude 112.8 m). The telescope was constructed in 2014 and started observing in 2015 as a successor of the Tsukuba 32-m telescope, which used to be in Tsukuba. The 13.2-m radio telescope, which fills the VGOS requirements, has participated in S/X sessions coordinated by IVS as well as being involved in VGOS sessions as one of the VGOS stations.

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

Fig. 1: Ishioka Geodetic Observing Station and the Ishioka 13.2-m radio telescope.

2 Component Description

The specifications of the Ishioka 13.2-m radio telescope are summarized in Table 1. Ishioka station has two types of feeds: tri-band feed and QRFH feed. We used to use these two feeds depending on the types of observing by switching the feeds and adjusting the equipment according to the type of observing, which took approximately one week for the adjustment. Nevertheless, since March 2023, Ishioka station has been using only the QRFH feed, which is called a broadband receiver, and has been participating in VGOS observing and also S/X observing as mixed-mode since November of 2023.

The detected signal with the feeds is recorded in the following way for both S/X and VGOS observing. First, the phase calibration signal is added to the received signal and amplified by the LNA (Low Noise

Amplifier). Then, the combined and amplified signal is converted into an optical signal and transferred through an optical fiber to the observation room next to the telescope. The transferred optical signal is re-converted to an electrical signal, downconverted to an intermediate frequency, and finally, digitized by a sampler to be recorded on a recording server. After the observed data are recorded on a recording server, the data are copied once to a storage server and then transferred to correlators via transfer servers.

In 2023, a sampler, recording servers, and the Field System were updated in Ishioka station, which now uses DBBC3 for a sampler, two FlexBuffs for recording servers (Figure 2), and Field System version 10.1.0 for operation. Two FlexBuffs are used alternately for observing; one is for observing and the other one copies the data of previous observations to storage. Regarding the DBBC3 sampler, Ishioka station updated the cabling to increase the number of sampling channels from 8 to 16 per polarization of a band in 2024; thus, Ishioka station is ready to sample and record with 128 channels in a session. Also, the function of 64 MHz bandwidth sampling per channel was tested and succeeded. Now Ishioka station is ready for 16-channel sampling and/or 64-MHz bandwidth sampling using DBBC3 and FlexBuff.

Table 1: Specifications of the Ishioka 13.2-m radio telescope.

Parameter	Ishioka 13.2-m radio telescope
Radio telescope mount type	Az-El
Antenna optics	Ring focus
Diameter of main reflector	13.2-m
Azimuth range	180° +/- 250°
Elevation range	0–100°
Azimuth drive velocity	12°/sec
Elevation drive velocity	6°/sec
Tsys at zenith (H-pol)[*1]	74 K (S band)
	80 K (3 GHz band)
	93 K (5 GHz band)
	99 K (6 GHz band)
	120 K (X band)
	115 K (10 GHz band)
Tsys at zenith (V-pol)[*1]	86 K (S band)
	80 K (3 GHz band)
	75 K (5 GHz band)
	84 K (6 GHz band)
	97 K (X band)
	115 K (10 GHz band)
SEFD (H-pol)[*1]	2040 Jy (S band)
	2425 Jy (3 GHz band)
	2735 Jy (5 GHz band)
	2707 Jy (6 GHz band)
	2591 Jy (X band)
	3745 Jy (10 GHz band)
SEFD (V-pol)[*1]	1707 Jy (S band)
	2348 Jy (3 GHz band)
	2644 Jy (5 GHz band)
	2830 Jy (6 GHz band)
	2702 Jy (X band)
	3850 Jy (10 GHz band)
RF range (Broadband with BPF)	2–14 GHz
Recording terminal	DBBC3 sampler and FlexBuff recording servers
Storage data capacity	1 PB
Hydrogen maser	VCH-1003M (VREMYA-CH) SD1T03A (Anritsu)

[1]The average value in observing frequency band for recent observations (S band: 2225.99–2365.99 MHz, 3 GHz band: 3016.4–3496.4 MHz, 5 GHz band: 5256.4–5736.4 MHz, 6 GHz band: 6376.4–6856.4 MHz, X band: 8212.99–8932.99 MHz, 10 GHz band: 10216.4–10696.4 MHz).

3 Staff

Ishioka station is operated by seven to eight staff members belonging to the VLBI group of GSI and a contract operation staff. In April 2023 and 2024, there was a personnel change in our group. The list of members is shown in Table 2.

4 Current Status

4.1 Observing

Ishioka station is basically automated and operated remotely from the headquarters of GSI in Tsukuba. The unmanned operation is realized at night on weekdays and all weekends, and error e-mails are sent to operators in case of an emergency. Since the response for COVID-19 has changed from 2021–2022, the operators occasionally work at the headquarters of GSI in Tsukuba and monitor the status of Ishioka station remotely.

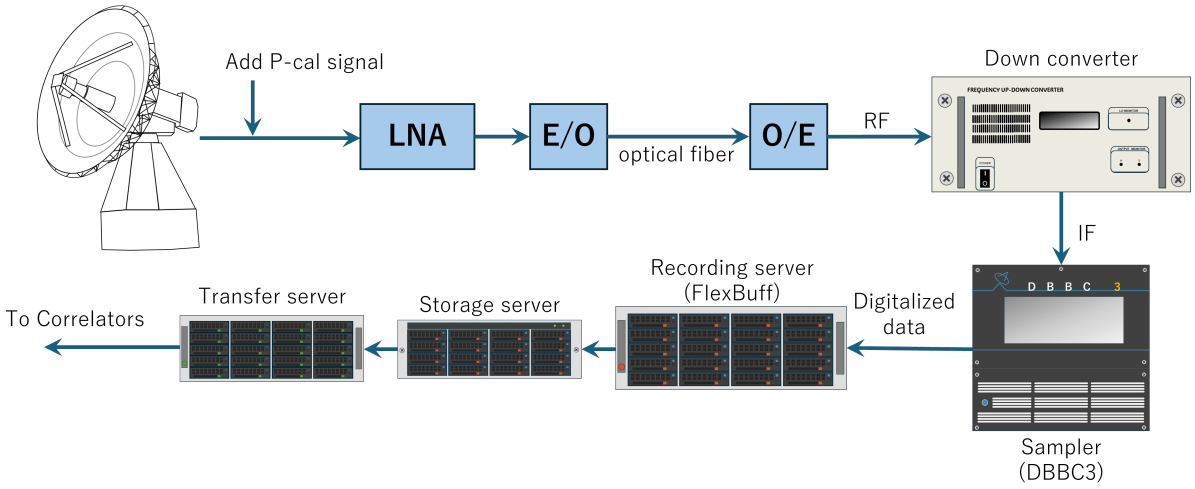

Fig. 2: Signal chain in Ishioka station.

Table 2: Member list of the VLBI group of GSI in 2023 and 2024.

Name	Main Function
2023	
Kensuke Kokado	Supervisor
Masaki Honda	Management
Akira Suzuki	Observation facility management & Local-tie survey
Haruka Ueshiba	Research & Local-tie survey
Hiroyuki Yoshifuji	Research & Local-tie survey
Masafumi Ishigaki	Operation & Research
Haruna Furui	Operation & Research & Local-tie survey
Kentaro Nozawa	Operation (AES)
2024	
Shinobu Kurihara	Supervisor
Masafumi Ishigaki	Management
Masaki Honda	Observation facility management & Local-tie survey
Saho Matsumoto	Research
Kaho Hashimoto	Research & Local-tie survey
Kayako Hori	Operation & Research
Haruna Furui	Operation & Research & Local-tie survey
Toshiki Ishii	Operation
Kentaro Nozawa	Operation (AES)

4.1.1 S/X Observing

Ishioka station participated in S/X sessions from November 2023, and all the S/X sessions were conducted in mixed-mode (Table 3). It was mainly involved in 24-hour R1 sessions to obtain EOPs and some one-hour INT-1 sessions for determining dUT1, participating instead of the regular station of the session. AOV sessions, which are designed for enhancing positioning accuracy in the Asia-Oceania region, were conducted once a month in 2023 and once every two months in 2024. GSI contributed to all the sessions as an observing station and also about one third of the sessions as a scheduler in cooperation with SHAO and UTAS. Regarding the scheduling software, Sked was used until 2023, and VieSched++ was newly used from 2024.

4.1.2 Broadband Observing

Ishioka station was involved in broadband observing with the QRFH feed from March in 2023. It participated in VGOS-O sessions weekly and observed one-hour Intensive sessions, VGOS-INT-B and VGOS-INT-C, with Onsala (ONSA13NE and ONSA13SW) every Saturday and Sunday as reported last time. In addition to these one-hour Intensive sessions, it participated in VGOS-INT-M sessions with Wettzell (WETTZ13S) and Ny-Ålesund (NYALE13N)

Table 3: Number of regular sessions in 2023 and 2024 in which Ishioka station participated.

	Sessions	2023	2024
S/X	IVS-R1	17	35
	IVS-R4	12	–
	IVS-T2	2	–
	APSG	1	–
	AOV	12	5
	IVS-INT1	–	30
	IVS-INT2	20	–
	IVS-INT3	10	–
	Total	74	70
VGOS	VGOS-OPS	16	23
	VGOS-R&D	1	3
	VGOS-A	4	–
	VGOS-B	56	80
	VGOS-BX	–	–
	VGOS-C	56	80
	VGOS-CX	–	1
	VGOS-M	6	37
	VGOS-G	–	15
	Total	139	239
	Total	**213**	**309**

every Monday from October 2023 and in VGOS-INT-G sessions with Yebes (RAEGYEB), Santa María (RAEGSMAR), and SHAO (SESHAN13) every Friday from February 2024.

Apart from the observing planned by IVS, Ishioka station performed a test session with Hobart and Katherine in August 2024. This test session was aimed at checking the equipment setting for 1 GHz bandwidth observing, because the official test session was conducted as VGOS-R&G done by limited stations, and thus Ishioka station did not have a chance to check its settings. A fringe was successfully found by correlation. A schedule for the test session was created by VieSched++ at GSI and was contributed to Hobart and Katherine.

4.2 Troubles

We briefly report on the troubles which had a large impact on the operation of Ishioka station. The main troubles are listed in Table 4, and details of some troubles are written in subsections.

Table 4: Main troubles that happened in 2023 and 2024.

Date of Occurrence	Outline of trouble
2023-04-17	Network disconnection due to a traffic accident
2023-04-25	Hydrogen maser PLL unlocked
2023-05-16	P-cal signal abnormality due to O/E transmission defect
2023-05-25	Failure of cooling fan for antenna control modules
2023-10-27 etc.	FS10 terminated during sessions due to a program bug
2023-11-17	Antenna emergency stop due to the lid for the manual drive handle attachment loosening and opening
2024-03-09	Antenna control error due to failure of an antenna control module
2024-07-11	Hydrogen maser PLL unlocked
2024-08-05	Failure of a motor encoder
2024-11-11	Receiver became warm due to the failure of the broadband receiver cold-head

4.2.1 Failure of Cooling Fan for Antenna Control Modules

The antenna emergency-stopped on May 25th, 2023, with an error message. After some research, the cooling fan for the antenna control modules turned out to be broken. We decided to use a big floor standing fan instead because it took about three months to get a new genuine fan from the antenna manufacturer. The big floor standing fan could cool the parts needed to be cooled, and thus, Ishioka station did not have to cancel participating observing for too long.

4.2.2 Failure of the Broadband Receiver Cold-head

On November 11th, 2024, an abnormal large noise and a rise in receiver temperature occurred, and we stopped the helium compressor. Its broadband receiver ran warm until December 21st, 2024, and Ishioka station could not participate in many sessions in this period. The repairs were carried out December 17 – 19, 2024 and revealed that the piston shaft fixture of the cold-head was broken, and thus, the piston shaft was free in the cold-head cylinder. The cause of this failure is thought to be gas contamination which might happen over time and lead to causing extra torque on the shaft.

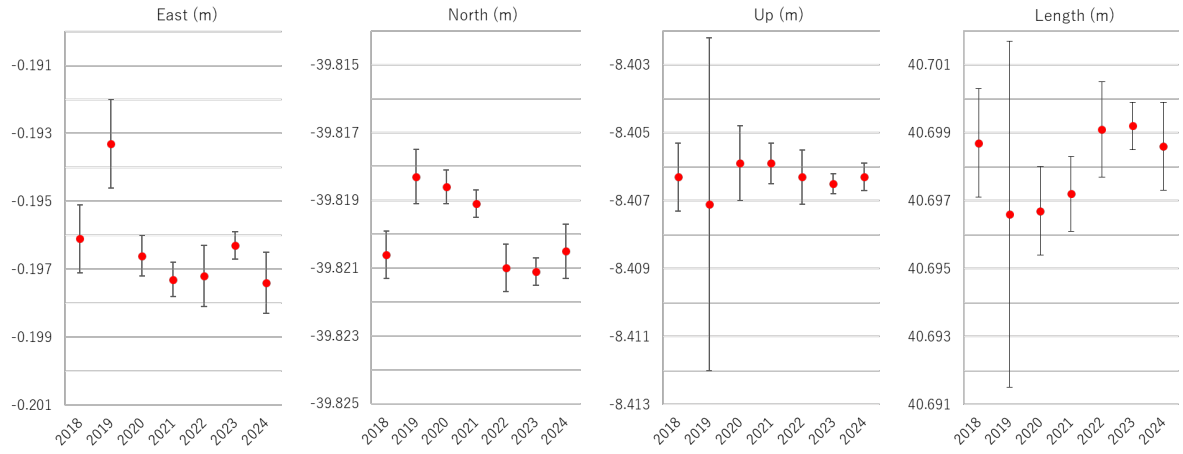

Fig. 3: Local-tie vector between VLBI and GNSS in Ishioka station.

The cold-head was replaced with a spare one, and the receiver returned to being cold.

4.3 Local-tie Survey

In Ishioka station, GNSS Continuously Operating Reference Stations (GNSS CORSs) are also operated, and one of them is registered as an IGS station. We regularly conduct local-tie surveys to determine the local-tie vector between the VLBI telescope and the GNSS antenna, which is contributed to the ITRF construction. The first local-tie survey in Ishioka station was conducted in 2016, and it has been done once a year since 2018 (Figure 3). Through repeated trial and error every year, we aim to consistently keep the standard deviation of the calculated vectors below 1 mm. To estimate the position of the telescope invariant point, the *Inside method* [1] was used in 2023 and 2024 as in 2022. It took approximately two weeks for surveying, and a total of about 15 people participated in each year. We will submit the results of the local-tie surveys from 2021 to 2024 to IERS by April 2025.

4.4 Update Plan in Ishioka Station

As described in Section 2, we are now using DBBC3 as a sampler, and it has a function to measure Tsys during each scan. The DBBC3 using the Tsys measurement system is planned to be installed at Ishioka station in 2025.

5 Outlook

Ishioka station will continue to participate in the S/X and the VGOS observing coordinated by IVS. We will install a new DBBC3 using the Tsys measurement system. In addition, we will continue to conduct local-tie surveys regularly.

References

1. Matsumoto, S., H. Ueshiba, T. Nakakuki, Y. Takagi, K Hayashi, T. Yutsudo, K. Mori, Y. Sato, T. Kobayashi, An effective approach for accurate estimation of VLBI–GNSS local-tie vectors, Earth, Planets and Space volume 74, article number 147, 2022.