Ishioka Geodetic Observing Station 2021–2022 Report

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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 latest two years, it has contributed to both S/X and VGOS observations coordinated by IVS. In 2021 and 2022, it also participated in several experimental observations, such as a mixed-mode test session, to investigate the possibility for S/X observations with the broadband feed.

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 (Figure 2).

The Ishioka 13.2-m radio telescope started observation in 2015 as a successor of the Tsukuba 32-m telescope which used to be in Tsukuba. Ishioka station is operated by GSI and has the 13.2-m radio telescope which fills VGOS requirements. It has participated in S/X sessions coordinated by the IVS and is also involved in VGOS sessions as one of the VGOS stations.

Fig. 1 The Ishioka 13.2-m radio telescope in the Ishioka Geodetic Observing Station.

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 use these two feeds depending on the types of observation; tri-band feed for legacy S/X observation and QRFH feed for broadband observation. We switch the feeds and adjust the equipment according to the type of

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Fig. 2 Location of Ishioka station.

observation. It usually takes approximately one week for the adjustment.

A signal detected with the feeds is recorded in the following way for both of the S/X and VGOS observation. First, the signal is amplified and converted to an optical signal to be delivered to the observation room next to the telescope through the optical fiber. Then, the electrical signal is reproduced by E/O converters and down-converted to intermediate frequency. Finally it is digitalized and recorded on storage devices. The telescope and other equipment are controlled by Field System ver. 9.10.5 (FS9).

3 Staff

Ishioka station is operated by seven staff members belonging to the GSI VLBI group and is a contracted operation staff as of December 2022. In April 2021 and 2022, there was a personnel change in our group. The member list is shown in Table 2.

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

Parameter	Ishioka 13.2-m radio telescope
Owner and operating agency	GSI
Latitude	N 36°12′33″
Longitude	E 140°13′8″
Altitude	112.8 m
Year of construction	2014
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 (X/S)	50 K / 300 K
Tsys at zenith (Broadband)	H-pol: [*1]
	141 K (3 GHz band)
	191 K (5 GHz band)
	252 K (6 GHz band)
	397 K (10 GHz band)
	V-pol: [*2]
	141 K (3 GHz band)
	181 K (5 GHz band)
	264 K (6 GHz band)
	377 K (10 GHz band)
SEFD (X/S)	1950 Jy / 1750 Jy
SEFD (Broadband)	H-pol: [*1]
	1580 Jy (3 GHz band)
	1978 Jy (5 GHz band)
	2154 Jy (6 GHz band)
	3695 Jy (10 GHz band)
	V-pol: [*2]
	1567 Jy (3 GHz band)
	2083 Jy (5 GHz band)
	2122 Jy (6 GHz band)
	3079 Jy (10 GHz band)
RF range (X)	8192–9104 MHz
RF range (S with BPF)	2170–2425 MHz
RF range (Broadband with BPF)	2–14 GHz
Recording terminal	ADS3000+ sampler & K5/VSI data recording terminals
Data capacity	89 TB
Hydrogen maser	VCH-1003M (VREMYA-CH)

[1]The average value in observing frequency band for VGOS observation (3 GHz band: 3000.4–3480.4 MHz, 5 GHz band: 5240.4–5720.4 MHz, 6 GHz band: 6360.4–6840.4 MHz, 10 GHz band: 10200.4–10680.4 MHz).
[2]Tsys and SEFD of V-polarization had not been measured since January 2020 because of receiver damage. After replacing the LNA in March 2022, it became possible to measure them again. See also Section 4.2.2.

Table 2 Member list of the GSI VLBI group in 2021 and 2022.

Name	Main Function
2021	
Yudai Sato	Supervisor
Toru Yutsudo	Management
Katsuhiro Mori	Observation facility management & Local-tie survey
Yu Takagi	Research
Kyonosuke Hayashi	Research
Haruka Ueshiba	Operation & Local-tie survey
Tomokazu Nakakuki	Operation & Research
Saho Matsumoto	Operation & Research
Kentaro Nozawa	Operation (AES)
2022	
Yudai Sato	Supervisor
Masaki Honda	Management
Katsuhiro Mori	Observation facility management & Local-tie survey
Yu Takagi	Research
Tomokazu Nakakuki	Research
Masafumi Ishigaki	Operation & Research
Hiroyuki Yoshifuji	Operation & Research
Kentaro Nozawa	Operation (AES)

4 Current Status

4.1 Observation

Ishioka is basically automated and operated remotely from the GSI headquarters in Tsukuba. The unmanned operation takes place each weeknight and every weekend, and error e-mails are sent to operators in case of emergency. After the spread of COVID-19, the operators occasionally work from home and monitor the status of Ishioka remotely.

4.1.1 S/X Observation

Ishioka station participated in S/X sessions from May 2021 to March 2022 and also from October to December in 2022 (Table 3). It was mainly involved in one-hour sessions for determining dUT1 and 24-hour sessions for obtaining EOPs. AOV sessions were conducted once a month in mixed-mode, which are designed for enhancing positioning accuracy in the Asia-Oceania region. 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.

In September 2022, Ishioka also participated in a mixed-mode test session. In this session, some of the VGOS stations including Ishioka joined the S/X session to investigate the feasibility of cross-correlation between circular and H-V polarizations. If the mixed-mode observation becomes feasible, it is quite beneficial for Ishioka because we do not have to switch the feed between S/X observation and VGOS observation periods. A fringe was not detected in the test session, so it is necessary to investigate the cause for further progress.

4.1.2 Broadband Observation

Ishioka station was involved in the broadband observation with the QRFH feed from January to April in 2021 and from April to September in 2022. It participated in VGOS-O sessions weekly and also observed one-hour Intensive sessions, INT-B and INT-C, with Onsala (ONSA13NE and ONSA13SW) every Saturday and Sunday.

Table 3 Number of regular sessions in 2021 and 2022 Ishioka participated in.

	Sessions	2021	2022
S/X	IVS-R1	14	21
	IVS-R4	16	20
	IVS-T2	3	2
	APSG	1	–
	AOV	5	11
	AUA	–	1
	IVS-CRF	2	1
	IVS-INT1	15	9
	IVS-INT2	28	40
	IVS-INT3	15	18
	IVS-R&D	2	4
	Total	101	127
VGOS	VGOS-O	11	24
	VGOS-B	5	42
	VGOS-C	4	38
	VGOS-W	–	4
	VGOS-R	–	3
	Total	20	111
	Total	**121**	**238**

4.2 Troubles

We briefly report on the troubles which had a large impact on the operation of Ishioka station. See [1] for more details of the troubles.

4.2.1 Trouble in Motor Encoder

From May through November 2021, Ishioka didn't participate in many of the sessions due to antenna troubles. The antenna suddenly stopped during observation because of an error of the servo amplifier for the elevation drive motor. It was caused by contact failure of the motor encoder. During investigation of the encoder, we had participated in observation as much as possible with slow slew speed (EL 3 deg/sec). It stopped frequently in spite of the slow speed, so it was necessary to monitor the telescope during the observation. We restarted the observation with normal slew speed (EL 6 deg/sec) in November 2021, so it took more than five months to return to normal operations.

4.2.2 Internal Noise due to LNA

Noise in the V-polarization had caused a serious problem in Ishioka station since January 2020. Detailed investigation revealed that the LNA on the VGOS receiver was broken and generated the noise. After replacing the LNA, we successfully detected a clear fringe in a test session between Onsala and Ishioka in March 2022.

4.3 Local-tie Survey

At 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 antenna and the GNSS antenna (Figure 3), which contribute 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. In 2021 and 2022, we adopted the *Inside method* in the local-tie survey. In the *Inside method*, we set a total station inside the azimuth cabin and measure the distance between the total station and mirrors attached on the wall of the cabin. See [2] for more details of the method.

We submitted the result of the local-tie surveys to IERS. Ishioka was registered as one of the IERS stations for the first time in 2021.

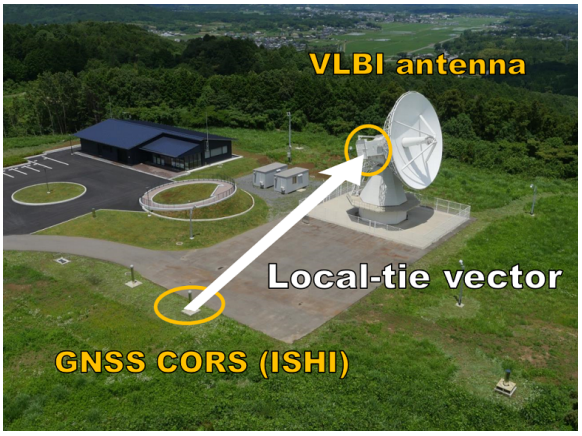

Fig. 3 VLBI-GNSS local-tie in Ishioka station.

4.4 Update of Backends in Ishioka

We are planning to update backend recorders and storage servers in Ishioka. As described in Section 2, we have used an ADS3000+ sampler and a K5/VSI data recording system. They have been used for many years, and some parts of the system need to be renovated. In addition to that, a recording system with larger storage is required because the cadence of VGOS observation has been increased recently. We are preparing for introducing a DBBC3, Flexbuff, and new storage as a replacement for the current system. The new storage has 1.5 PB, which is three times larger than the present one. They will be installed in the spring of 2023.

5 Outlook

Ishioka station will continue to participate in the S/X and the VGOS observation coordinated by IVS. We will install a new sampler DBBC3, recording system

Flexbuff, and new large-volume storage for our operating system. In addition, we will continue to conduct local-tie surveys regularly.

References

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2. 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.