VERA 2021 and 2022 Geodetic Activities

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Abstract The geodetic activities of VERA in the years 2021 and 2022 are briefly described. The regular geodetic observations were carried out both in K- and S/X-bands. The frequency of regular observations is three times a month—twice for the VERA internal observations in K-band. The networks of the S/X sessions are AOV and IVS-T2P. The sampler/recorder commonly used for IVS-T2P and AOV is OCTAD-OCTADISK2. The raw data of the IVS-T2P and AOV sessions are electronically transferred to the Bonn and Tsukuba correlators via Internet. Gravimetric observations are carried out at the VERA stations. Superconducting gravimeters (SG) are installed at Mizusawa in order to monitor precise gravity changes, and the observations continued for two years.

1 General Information

VERA is a Japanese domestic VLBI network consisting of the Mizusawa, Iriki, Ogasawara, and Ishigaki-jima stations. Each station is equipped with a 20-m radio telescope and a VLBI backend. The VERA array is controlled from the Array Operation Center (AOC) at Mizusawa via Internet. Correlation processing of the data recorded by our VLBI array is performed by the software correlator at Mizusawa. Figure 1 shows the PC group of the software correlator in operation at Mizusawa.

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Fig. 1 View of the Mizusawa Software Correlator and data servers in Mizusawa Correlation Office.

The primary scientific goal of VERA by FY 2021 was to reveal the structure and the dynamics of our galaxy by determining a three-dimensional force field and mass distribution. A project to conduct experimental VLBI observations began in 2022 by widely soliciting proposals for radio astronomy observations. The first proposal was made in August 2022, and observations tentatively started in October.

The observation frequency bands of VERA are listed with the S-, C-, X-, K-, and Q-bands as regular observation bands. S- and X-band are in operation only at Mizusawa. Geodetic observations are made in S/X- and K-bands. C- and Q-band are currently not used for geodesy. Only a single beam is used even in K-band in geodetic observations, although VERA can observe two closely separated radio sources ($0.3^\circ <$ separation angle $< 2.2^\circ$) simultaneously by using the dual beam platforms.

Table 1 Location.

Site name	Longitude	Latitude	Altitude
Mizusawa	141°07′57″.199 E	39°08′00″.726 N	75.7 m
Iriki	130°26′23″.593 E	31°44′52″.437 N	541.6 m
Ogasawara	142°12′59″.809 E	27°05′30″.487 N	223.0 m
Ishigakijima	124°10′15″.578 E	24°24′43″.834 N	38.5 m

General information about the VERA stations is summarized in Table 1, and the geographic locations are shown in Figure 2. The lengths of the baselines range from 1,080 km to 2,272 km. The skyline at Ogasawara station ranges from 7° to 18° because it is located at the bottom of an old volcanic depression. The northeast sky at Ishigakijima station is blocked by a nearby high mountain. But the majority of the skyline is below 9°. The skylines at Mizusawa and Iriki are low enough to observe sources with low elevation. Because Ogasawara and Ishigakijima are small islands in the open sea and their climate is subtropical, the humidity in the summer is very high. This brings about high system temperatures in the summer, in particular in K- and Q-bands. Iriki, Ogasawara, and Ishigakijima stations are frequently hit by strong typhoons. The wind speed sometimes reaches up to 60–70 m/s. Mizusawa often stops operating its antenna due to heavy snow in winter.

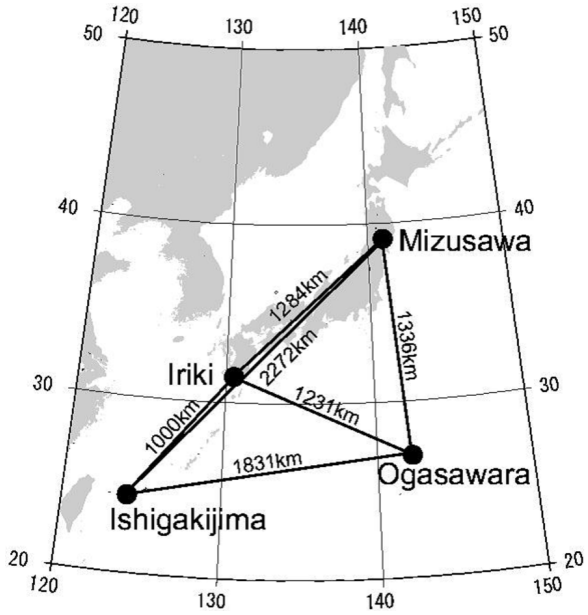

Fig. 2 Distribution of the stations in the VERA Network.

2 Current Status

The parameters of the antennas are summarized in Table 2, and front- and backends are summarized in Table 3, respectively. The actual receiver temperature of S-band is much higher than in the notation of the table due to the influence of interference. Two observing modes are used for geodetic observations. One is the VERA internal observation in K-band with the recording rate of 1 or 2 Gbps using OCTADISK. The other is the conventional S/X-band observation with OCTAD-OCTADISK2 (1 Gbps and 512 Mbps) [1]. The AOV and T2P sessions belong to this class. Only Mizusawa participated in these sessions.

Table 2 Antenna parameters.

Diameter of main reflector		20 m	
Mount type		AZ-EL	
Surface accuracy		0.2 mm (rms)	
Pointing accuracy		<12” (rms)	
	Azimuth	Elevation	
Slew range	−90° – 450°	5° – 85°	
Slew speed	2.1°/sec	2.1°/sec	
Acceleration	2.1°/sec^2	2.1°/sec^2	
	S	X	K
HPBW	1550″	400″	150″
Aperture efficiency	0.25	0.4	0.47

Table 3 Frontend and backend parameters.

Frontend parameters			
Frequency band	S	X	K
Frequency range (GHz)	2.18–2.36	8.18–9.00	21.5–24.5
Receiver temperature	>100 °K	100 °K	39±8 °K
Polarization	RHC	RHC	LHC
Receiver type	HEMT	HEMT	cooled HEMT
Feed type	Helical array		Horn

Backend parameters			
Observation type	VERA Intl.	T2P	AOV
Sampling [MHz-bit]	32-2 or 1024-2	16-2	32-2
Channel	16 or 1	16	16
Sampler	ADS1000	DBBC	DBBC
Recorder	OCD	OCD2	OCD2
Rec. rate [Mbps]	1024 or 2048	512	1024
Deployed station	4 VERA	Mizusawa	

OCD: OCTADISK, OCD2: OCTADISK2
DBBC: OCTAD Digital Baseband Converter

3 Activities during the Past Years

VERA observes seven days a week, except for during a maintenance period from mid-June to mid-August. The 24-hour geodetic sessions are allocated twice or three times in a month. Among these geodetic sessions, VERA internal geodetic observations in K-band are performed once or twice in a month, and Mizusawa participates in AOV and T2P sessions in S/X-bands six to eight times a year in total. The main purpose of the VERA internal geodetic observations is to determine relative positions of the VERA antennas accurate enough for astrometric requirements. The purpose of the S/X sessions is to link the VERA coordinates into the reference frame built by VLBI.

In the VERA internal geodetic sessions, the regularly used frequency changed from S/X-bands to K-band in 2007. The reason for the shift of the observing frequency band from S/X-bands to K-band is to avoid the strong radio interference by mobile phones in S-band, particularly at Mizusawa. The interfering signal, which has line spectra, is filtered out. But this filtering considerably degrades the system noise temperature. The interference zone is increasing, so it is likely that S-band observing will become almost impossible in the near future. On the other hand, VERA has the highest sensitivity in K-band, as shown in Table 3. Thanks to the high sensitivity in this band, the maximum number of scans in K-band is 800/station/24-hours, while that in S/X-bands is 500 at most. It has been confirmed that the K-band observations are far more precise. In fact, standard deviations of the individual determinations of the antenna positions in K-band are less than half of those in S/X-bands.

In 2021 and 2022, there was a long annual maintenance period from early June to mid-August in each year. Then, there were temporary maintenance periods from September 2021 to March 2022, resulting in a significant decrease in the number of observations. With the exception of this period, VERA carried out internal geodetic VLBI observations 18 times. Mizusawa participated in ten T2P and AOV sessions. The final estimation of the geodetic parameters is derived by using the software developed by the VERA team.

Continuous GPS observations were carried out at each VERA station throughout the year. In order to accurately monitor gravity change for the purpose of monitoring height change at VERA Misuzawa station, the superconducting gravimeter (SG) was installed to continue the acquisition of gravity data. Gravity-continuous measurement by the SG on Ishigaki-jima was completed in FY 2021.

4 Future Plans

The SKA sub-project will be established under the Mizusawa VLBI observatory in FY 2023. At the request of SKA Japan, VERA will provide a testing field to conduct basic experiments. An experiment of relativistic geodetic observation using an optical lattice clock is also planned.

5 Staff

Mareki Honma is the director of Mizusawa VLBI Observatory. The geodesy group consists of Yoshiaki Tamura (scientist) and Takaaki Jike (scientist). Jike is also responsible for the operation of the Mizusawa Correlation Office.

References

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