VERA 2019 and 2020 Geodetic Activities

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Abstract The geodetic activities of VERA in the years 2019 and 2020 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-T2. The recorders used are K5-VSSP for IVS-T2 sessions and OCTAD-OCTADISK2 for AOV sessions. The raw data of the T2 and AOV sessions are electronically transferred to the Bonn and GSI correlators via the Internet. Gravimetric observations are carried out at the VERA stations. SGs are installed at Mizusawa and Ishigakijima in order to monitor precise gravity changes, and the observations continued for two years.

Fig. 1 The front view is the Mizusawa 10-m antenna, and the back view is the VERA Mizusawa 20-m antenna.

1 General Information

VERA is a Japanese domestic VLBI network consisting of the Mizusawa, Iriki, Ogasawara, and Ishigakijima stations. Each station is equipped with a 20-m radio telescope and a VLBI backend. The VERA Mizusawa 20-m antenna is shown in Figure 1. The VERA array is controlled from the Array Operation Center (AOC) at Mizusawa via the Internet. The primary scientific goal of VERA is to reveal the structure and the dynamics of our galaxy by determining three-dimensional force fields and mass distribution. Galactic maser sources are used as dynamical probes, the positions and velocities of which can be precisely determined by phase referenced VLBI relative to extragalactic radio sources. The distance is measured as a classical annual trigonometric parallax. The observing frequency bands of VERA are the S-, C-, X-, K-, and Q-bands. Geodetic observations are made in the S/X- and K-bands. The C- and Q-bands 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 ($0.2^\circ <$ separation angle $< 2.2^\circ$) radio sources simultaneously by using the dual-beam platforms.

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

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north-east sky at Ishigakijima station is blocked by a nearby high mountain. However, the majority of the skyline is below 9°. The skylines at Mizusawa and Iriki are low enough to observe sources at low elevations. 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 the K- and Q-bands. The 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.

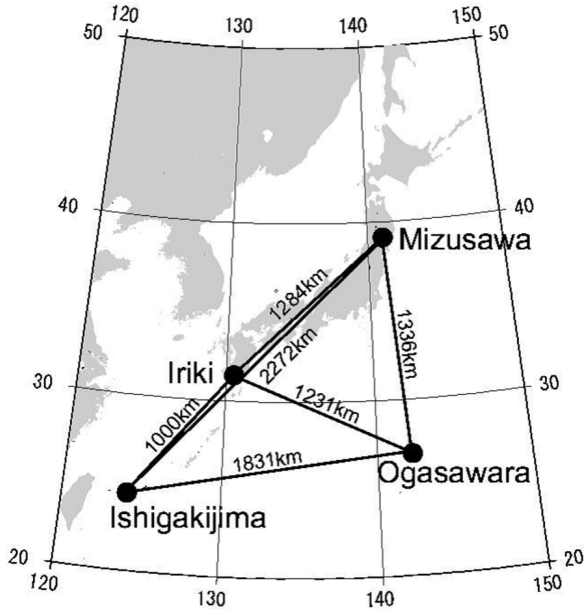

Fig. 2 Distribution of the stations in the VERA network.

Table 1 Locations of the four VERA sites.

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

2 Activities during the Past Years

The parameters of the antennas are summarized in Table 2, and the front and backends are summarized in Table 3. The actual receiver temperature in S-band is much higher than the notation in the table due to the influence of interference. Two observing modes are used for geodetic observations. One is the VERA internal observing in K-band with the recording rate of 1 Gbps or 2 Gbps using OCTADISK. The other is the conventional S/X-band observing with K5-VSSP (128 Mbps) and OCTAD-OCTADISK2 (1 Gbps and 512 Mbps) [1]. AOV, IVS-T2, 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.	T2	T2P	AOV
Sampling [MHz-bit]	32-2 or 1024-2	8-1	16-2	32-2
Channel	16 or 1	16	16	16
Filter	Digital	Analog	Digital	Digital
Recorder	OCD	K5	OCD2	OCD2
Rec. rate [Mbps]	1024 or 2048	128	512	1024
Deployed station	four VERA	Mizusawa		

K5:K5-VSSP, OCD: OCTADISK, OCD2: OCTADISK2

3 Current Status

VERA observes seven days a week, except for during a maintenance period from middle June to middle August. The 24-hour geodetic sessions are allocated two 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 participated in AOV and T2 sessions in the S/X-bands about 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 the S/X-bands to K-band in 2007. The reason for the shift of the observing frequency band from the S/X-bands to K-band is to avoid the strong radio interference from 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 the 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 the S/X-bands.

In 2019 and 2020, a long maintenance period from the middle of June to the middle of August was allocated for each year. Except for this period, VERA carried out internal geodetic VLBI observations 36 times. Mizusawa participated in 16 T2 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. The superconducting gravimeter (SG) installed within the enclosure of the Mizusawa VLBI observatory, in order to accurately monitor gravity change for the purpose of monitoring height change at the VERA Mizusawa station, continued acquisition of gravity data.

An SG was installed also at the VERA Ishigakijima station, and observing started in January 2012. The observing continued also during 2019–2020. The observing aims at solving the cause of the slow slip event which occurs frequently around the Ishigakijima island.

4 Future Plans

VERA will end astrometry observations in a few years and move on to a new project. The examination of increasing the recording rate to 8 Gbps (from 1 Gbps or 2 Gbps) by using OCTAD is being carried out [2] for the purpose of improvement in parameter fitting performance, and we can get the high-precision geodetic solutions, characteristics of wide-band observations, and performance evaluation. It was held several times from 2019 to 2020, and even now, as a preliminary basic experiment for research carried out in the new VLBI project, we plan to continue this basic experiment.

5 Staff

Mareki Honma is the director of Mizusawa VLBI Observatory. The geodesy group consists of Yoshiaki Tamura (scientist) and Takaaki Jike (scientist).

References

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