VERA 2017 and 2018 Geodetic Activities

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Abstract The geodetic activities of VERA in the years 2017 and 2018 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 K5VSSP for IVS-T2 and OCTAD-OCTADISK2 for AOV. The raw data of the T2 and AOV sessions are electronically transferred to the Bonn, SHAO, and GSI correlators via 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 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 back-end. 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 Internet. The primary scientific goal of VERA is to reveal the structure and the dynamics of our galaxy by determining three-dimensional force field 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 S-, C-, X-, K-, and Q-bands. 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 ($0.2^\circ <$ 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 crater. 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

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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.

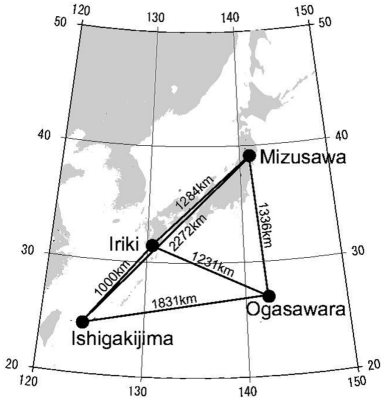

Fig. 2 Distribution of the stations in the VERA Network.

Table 1 VERA station locations.

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 Current Status

The parameters of the antennas and front- and back-ends are summarized in Tables 2 and 3, respectively. The actual receiver temperature at 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 VERA internal observing in K-band with the recording rate of 1- or 2-Gbps using OCTADISK. The other is conventional S/X-band observing with K5-VSSP (128 Mbps) and OCTAD-OCTADISK2 (1 Gbps). The AOV and IVS-T2 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 Front-end and back-end parameters.

Front-end parameters			
Frequency band	S	X	K
Frequency range (GHz)	2.18–2.36	8.18–8.60	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

Back-end parameters			
Observation type	VERA Intl.	T2	AOV
Sampling/ch [MHz-bit]	32-2 or 1024-2	4-1	32-2
Channel	16 or 1	16	16
Filter	Digital	Analog	Digital
Recorder	OCTADISK	K5VSSP	OCTADISK2
Rec. rate [Mbps]	1024 or 2048	128	1024
Deployed station	4 VERA		Mizusawa

3 Activities during the Past Year

VERA observes seven days a week, except during a maintenance period from the middle of June to the middle of 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 per month, and Mizusawa participates in AOV or IVS-T2 sessions in S/X-band on a once-a-month basis. The main purpose of the VERA internal geodetic observations is to

determine relative positions of the VERA antennas accurately 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-band to K-band in 2007. The reason for the shift of the observing frequency band from S/X-band 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 2. 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-band 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-band.

In 2017 and 2018, 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 33 times. Mizusawa participated in eight T2 sessions, and six AOV sessions. The final estimation of the geodetic parameters are 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. Four water level gauges surrounding the SG were used for monitoring the groundwater level. The preliminary results show that gravity variation due to the variation of the water table can be corrected as accurately as the 1 micro gal level. An SG was newly installed also at the VERA Ishigakijima station, and observing started in January 2012. The observing continued also during 2017–2018. The observing aims at solving the cause of the slow slip event which occurs frequently around the Ishigaki island.

4 State of the Crustal Movement after Earthquakes

After the 2011 earthquake off the Pacific coast of Tohoku (Mw=9.0) [Epoch=11 March 2011, 14:16:18 JST], Mizusawa was displaced by co-seismic crustal movement and post-seismic creeping. Also from 2017 to 2018, the post-seismic creeping continued, although the speed declined. According to the newest analysis, the co-seismic steps on March 11, 2011 are X= -2.066 m, Y= -1.407 m, and Z= -1.054 m, and the displacement by creeping during two years, 2017 and 2018, is X= -0.112 m, Y= -0.048 m, and Z= -0.024 m. Due to the 2016 Kumamoto Earthquake (Mw=7.0) [Epoch=14 April 2016, 01:25:05 JST], crustal deformation changed the position and rate of Iriki. Displacement of Iriki by co-seismic step and post-seismic creeping due to the 2016 Kumamoto Earthquake is more than 1 cm toward the south, in total.

5 Future Plans

The examination of increasing a recording rate to 8 Gbps from 1 Gbps by using a high speed sampler (OCTAD) is being carried out. Experimental geodetic VLBI observing was carried out in February 2016 using the high speed sampler. In November 2017, a second experimental session was carried out at all VERA stations for the purpose of improvement of parameter fitting performance, and we can get the geodetic solutions.

VERA installed new frequency band receivers, L- and K(RCP)-band, and performance investigation of these receiving systems is being conducted now.

6 Staff

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