VERA 2014 Geodetic Activities

Takaaki Jike, Yoshiaki Tamura, Makoto Shizugami

Abstract The geodetic activities of VERA in the year 2014 are briefly described. The regular geodetic observations are carried out both in K- and S/X-bands. The frequency of regular observations are three times a month—twice for the VERA internal observations in K-band. The networks of the S/X sessions are JADE of GSI and IVS-T2. The raw data of the T2 and JADE sessions are electronically transferred to the Bonn, Haystack, 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 throughout this year. The crustal movements generated by the 11-Mar-2011 earthquake off the Pacific coast of Tohoku continued during 2014, and displacement of VERA-Mizusawa's position by post-seismic creeping continued.

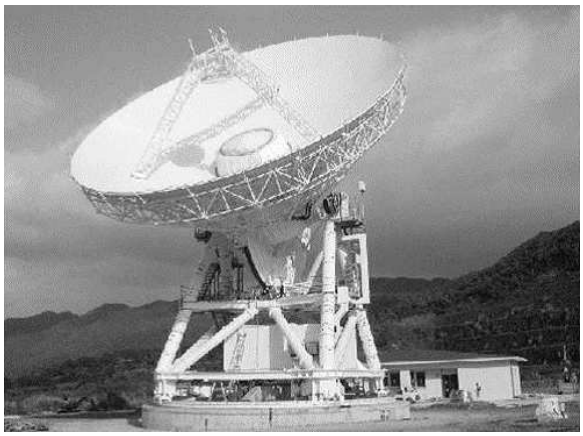

Fig. 1 Complete view of the VERA Ishigakijima 20-m antenna.

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 Ishigakijima 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 and X, C (6.4 GHz), K (22 GHz), and Q (43 GHz). Geodetic observations are made in S/X- and K-bands. Q-band is 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 1,000 km to 2,272 km. The skyline at Ogasawara station ranges from 7° to 18° because it is lo-

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cated at the bottom of an old volcanic crater. The northeast 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 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 station as well as these stations are frequently hit by strong typhoons. The wind speed sometimes reaches up to 60–70 m/s.

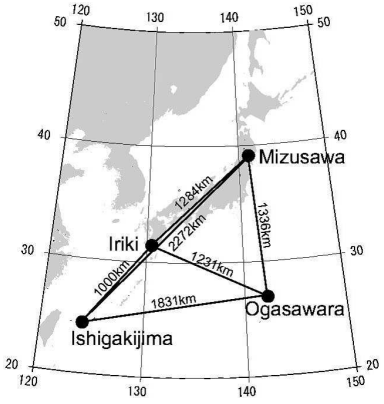

Fig. 2 Distribution of the stations in the VERA Network.

Table 1 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

2 Current Status

The parameters of the antennas and front- and back-ends are summarized in Tables 2 and 3, respectively. Two observing modes are used for geodetic observations. One is the VERA internal observation in K-band with the recording rate of 1 Gbps. The other is the conventional S/X-band observation with K5-VSSP. JADE, which is GSI’s domestic observation project, and IVS-T2 sessions belong to this class. Only Mizusawa and Ishigakijima participated in these sessions.

Table 2 Antenna parameters.

Diameter of main reflector	20m
Mount type	AZ-EL
Surface accuracy	0.2mm (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	T2 and JADE
channels	16	16
Bandwidth/channel	16 MHz	4 MHz
Filter	Digital	Analog video band
Recorder	DIR2000	K5VSSP
Recording rate	1 Gbps	128 Mbps
Deployed station	4 VERA	Mizusawa, Ishigakijima

3 Staff

Noriyuki Kawaguchi is director of Mizusawa VLBI Observatory. The geodesy group consists of Yoshiaki Tamura (scientist), Takaaki Jike (scientist), and Makoto Shizugami (engineer).

4 Activities during the Past Year

VERA observes seven days a week, except for during a maintenance period in June and July. 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 and Ishigakijima participate in JADE by GSI 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 accurate enough for astrometric requirements. The purpose of the S/X sessions is to link the VERA coordinates into the IVS reference frame.

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 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-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 2014, a long maintenance period from the beginning of June to the middle of August was allocated. Except for this period, VERA carried out regular VLBI observations. We participated in six T2 sessions and in four JADE sessions. VERA internal geodetic observations were carried out 17 times. 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 2014. The observing aims at solving the cause of the slow slip event which occurs frequently around the Ishigaki island.

5 State of the Crustal Movement after the 11-Mar-2011 Earthquake at Mizusawa

After the 2011 earthquake off the Pacific coast of Tohoku (Mw=9.0) [Epoch=11 March 2011, 14:16:18 JST], VERA-Mizusawa was displaced by co-seismic crustal movement and post-seismic creeping. Also in 2014, the creeping continued, although the speed declined. According to the newest analysis, the co-seismic steps are X= -2.013 m, Y= -1.380 m, and Z= -1.072 m, and the displacement by creeping during 2014 is X= -0.091 m, Y= -0.061 m, and Z= -0.031 m.

6 Future Plans

Now, the examination of increasing a recording rate to 4 Gbps from 1 Gbps with direct sampling (OCTAD) is being carried out. The reconstruction accompanying this specification change is planned also for the S/X system. The received frequency of X-band will be widened to 8-9 GHz. Furthermore, the examination for changing the recording system from tape recorder to HDD (OCTADISK) is also under enforcement. With these changes, the operation of a new software correlation system (OCTACOR2) is due to become regular. The participation of the Ishigakijima station in IVS sessions will stop after the T2 session in February, 2015. The VERA Network operation office and correlation office will be merged, and the headquarters of the VERA operation team will be assigned to Mizusawa in the 2015 fiscal year.