VERA Geodetic Activities

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Abstract

Geodetic activities of VERA in the year 2009 are briefly described. The regular geodetic observations are carried out both in K- and S/X-bands. The frequency of regular observations is three times a month—that is, twice for the VERA internal observations in K-band and once in S/X-band. The S/X sessions are GSI's JADE sessions until August and IVS-T2 sessions starting in September, whenever the IVS-T2 sessions are scheduled. The raw data of the T2 sessions are electronically transferred to the Bonn and Haystack correlators via the Internet using the Tsunami protocol.

Delays, delay rates, and other relevant data of the S/X sessions through the end of 2009 were disclosed and submitted to IVS.

Gravimetric observations are carried out at the VERA stations. The super conducting gravimeter previously installed at Esashi Earth Tides Station was moved to Mizusawa and placed in the vicinity of the VERA antenna in order to monitor vertical displacement at the end of 2008, and observations continued throughout 2009.

1. General Description

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 Ishigakijima antenna is shown in figure 1. The VERA array is controlled from the Array Operation Center at Mizusawa via the Internet.

The primary scientific goal of VERA is to reveal the structure and the dynamics of our galaxy by determining its three-dimensional force field and its distribution of mass. Galactic maser sources are used as dynamical probes, whose positions and velocities 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, K (22 GHz) and Q (43 GHz). Geodetic observations are made in S/X- and K-bands. Q-band is currenttly not used for geodesy. Only a single beam is used even in K-band in geodetic observations, although VERA can simultaneously observe two closely separated radio sources ($0.2^\circ <$ separation angle $< 2.2^\circ$) by using the dual beam platforms.

General information about the VERA stations is summarized in Table 1, and their geographic locations are shown in Figure 2. The lengths of their baselines range from 1000 km to 2272 km. The horizon west of at the Ogasawara station ranges from 7° to 18° because it is located at the bottom of an old volcanic crater. The northeast sky at the Ishigakijima station is blocked by a nearby high mountain. However, most of the sky is visible to below 9°. The horizon at Mizusawa and Iriki are low enough to observe sources with low elevation. Since Ogasawara and Ishigakijima are small islands in the open sea and their climate is subtropical, the humidity in the summer is very high. This causes a high system temperature in the summer, in particular in the K and Q bands. The Iriki station, as well as the other stations, is frequently hit by strong typhoons. The wind speed sometimes reaches 60–70m/s.

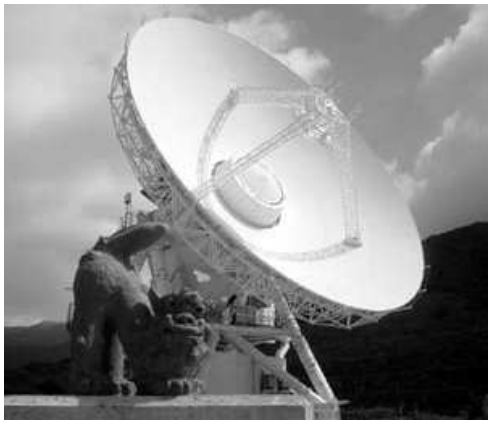

Figure 1. VERA Ishigakijima antenna

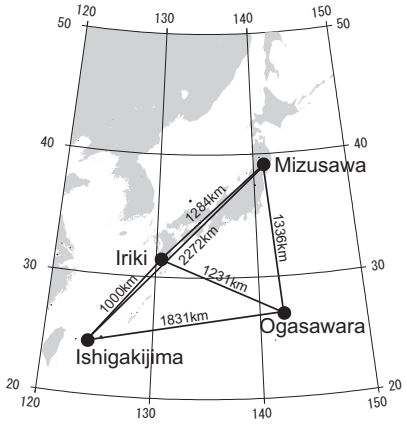

Figure 2. Location of the VERA stations

Table 1. General information

Sponsoring agency	Mizusawa VLBI Observatory, National Astronomical Observatory of Japan	
Contributing type	Network observing station	
Location	Mizusawa	141° 07' 57".199E, 39° 08' 00".726N, 75.7m (sea level)
	Iriki	130° 26' 23".593E, 31° 44' 52".437N, 541.6m (sea level)
	Ogasawara	142° 12' 59".809E, 27° 05' 30".487N, 223.0m (sea level)
	Ishigakijima	124° 10' 15".578E, 24° 24' 43".834N, 38.5m (sea level)

2. Technical Parameters

Parameters of the antennas and their front- and back-ends are summarized in Tables 2 and 3, respectively. Two observing modes are used in geodetic observing. One is the VERA internal K-band observing mode with a recording rate of 1 Gbps. The other is the conventional S/X-band observing mode 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	20m	Slew	Azimuth	Elevation
Mount	Az-El	range	-90° – 450°	5° – 85°
Surface accuracy	0.2mm (rms)	speed	2°.1/sec	2°.1/sec
Pointing accuracy	<12" (rms)	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					
Frequency band	Frequency range (GHz)	Receiver temperature	Polarization	Receiver type	Feed
S	2.18–2.36	100°K	RHC	HEMT	Helical array
X	8.18–8.60	100°K	RHC	HEMT	Helical array
K	21.5–24.5	39±8°K	LHC	HEMT(cooled)	Horn
Back-end					
Type	channels	BW/channel	Filter	Recorder	Deployed station
VERA	16	16 MHz	Digital	DIR2000	4 VERA
K5-VSSP	16	4 MHz	VC	HDD	Miuzsawa Ishigakijima

3. Organizational Change and Staff Members

The Mizusawa VERA Observatory of NAOJ was reorganized as the Mizusawa VLBI Observatory in April, 2009. VERA and VSOP-2 were integrated into a unified project. The director is Hideyuki Kobayashi. The geodesy group consists of S. Manabe (chief, scientist), Y. Tamura (scientist), T. Jike (scientist), and M. Shizugami (software technician).

4. Current Status and Activities

4.1. VLBI

VERA observes six days a week, except for a maintenance period in the summer. The nominal frequency of geodetic observations is three days a month. Among these three days, VERA internal geodetic observations in K-band are performed twice a month, and Mizusawa and Ishigakijima participate in GSI's JADE sessions or in the IVS-T2 sessions in S/X-band once a month. The main purpose of the VERA internal geodetic observations is to determine the relative positions of the VERA antennas accurately enough for astrometric requirements. The purpose of the S/X sessions is to integrate VERA's coordinates into the global reference frame. The reason for shifting the observing frequency band from S/X-band to K-band is to avoid strong radio interference created in S-band by cellular phones, particularly at Mizusawa. Interfering signals, which have line spectra, are filtered out. However, this filtering considerably degrades the system noise temperature. It is likely that S-band observations 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 750 per station every 24 hours, while that in S/X-band is at most 500. It has been confirmed that the K-band observations are far more precise, although no correction is made for the ionospheric delay. 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.

The error ellipsoid is fairly elongated in the vertical direction due to the insufficient network

size for separating the vertical displacement from the zenith atmospheric delay variation. No significant systematic differences between the estimated coordinates in S/X-band and the estimated coordinates in K-band seem to exist. This means that most of the ionospheric effect can be eliminated in the course of estimating the tropospheric delay, at least for the VERA network, whose typical size is around 2300 km. However, the number of observations are not enough to derive a definite conclusion.

In order to link the VERA network to the international reference frame VERA started participation in the IVS-T2 sessions by using the Mizusawa and the Ishigakijima stations. The observations at Ishigakijima were conducted by GSI. In September, 2009, we successfully made a test of observing and transferring the data electronically to the Haystack correlator via the Tsunami protocol. Since October, we participated in the T2 sessions twice. The T2 sessions replace the JADE sessions whenever the T2 sessions take place.

The final estimation of the geodetic parameters is performed by using software developed by the VERA team.

From December 2004 to July 2008, 54 S/X-band data sets were submitted to IVS in the form of PIVEX.

4.2. Other Activities

Continuous GPS observations were carried out at each VERA station throughout the year. The observation of gravity tides with a LaCoste-Romberg gravimeter at Ogasawara has been completed, and that at Ishigakijima is underway. The provisional result shows that there is no large discrepancy between the observed tidal amplitude and phase and the tidal amplitude and phase predicted by ocean models.

The superconducting gravimeter was moved from the Esashi Earth Tides Station to Mizusawa in order to accurately monitor gravity change for the purpose of monitoring height change at VERA Mizusawa station. Four water table gauges surrounding the SCG were used for monitorig the water table height. The preliminary results show that gravity variation due to the variation of the water table can be corrected to 1μgal level accuracy.

5. Future Plans

The internal K-band VLBI and the participation in the IVS-T2 sessions will be continued. Continuous GPS and gravimentric observations will also be carried out. Reconfirmation of local ties between GPS and VLBI has become an urgent task.

The possibility of optical fiber links between Mitaka and the VERA stations is being pursued. Widening of the receiving and recording bandwidth is planned.