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Interpretation of VLBI Results in Geodesy, Astrometry and Geophysics

Results from K-band Geodetic VLBI Using VERA

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Abstract. Monitoring the positions and movements of VERA stations is one of the purposes of the VERA internal 1 Gbps geodetic VLBI observations. Regular geodetic VLBI has been carried out for three years to supply coordinates of VERA stations with several millimeters accuracy to support VERA astrometry observations and analysis. The VERA observation system demonstrates best performance at K-band. We started experimental geodetic VLBI observations using K-band in January 2006, aiming at obtaining more precise geodetic solutions and confirming the feasibility of geodetic VLBI using a new frequency band which is capable of replacing S/X bands. From the analysis of these observations, we obtained geodetic solutions with higher precision than S/X band observations.

1. Introduction

VERA (VLBI Exploration of Radio Astrometry) [1] is a project to clarify the three dimensional structure and dynamical motion of our Galaxy. This project aims at the measurement of annual parallax with 10 μas orders accuracy. Four observation sites (Mizusawa, Iriki, Ogasawara, and Ishigakijima) form the VERA network on the Japanese islands operating a 20 m parabolic antenna at each site. Geodetic VLBI observations are crucial to maintain the highly accurate astrometry of VERA. Monitoring the station positions and their time variations within the VERA network is one of the main purposes of the VERA geodetic observations.

VERA-internal geodetic VLBI observations at S/X bands started in Nov. 2004 [2]. These observations regularly use the 1 Gbps recording system DIR2000. Site coordinates and their time variations are obtained with a few mm and 0.1 mm/yr precisions and are used in observation scheduling and analysis of VERA astrometry.

In Jan. 2006, experimental K-band (23 GHz) geodetic VLBI observations were started in the framework of the VERA operations, aiming at obtaining

more precise and more stable geodetic solutions and confirming the feasibility of geodetic VLBI at a new frequency band replacing S/X bands. After an examination period of one year, K-band geodetic VLBI observations were included in a series of the VERA-internal geodetic VLBI observations.

2. Specifications of the K-band Geodetic VLBI System of VERA

Background factors for moving from S/X-band to K-band are as follows. First, the VERA observation system has demonstrated best performance at K-band. Tabl. 1 summarizes the specifications of the VERA observation system at S-, X-, and K-band, respectively. What is evident from this table is that the performance of the K-band observation system is better than that of the S/X-bands most of the times. Next, we expect that simpler source structure at K-band will stabilize the geodetic solutions in the time series. Also, the fringe detection sensitivity improves thanks to 1 Gbps recording.

Table 1. Performance of observation in VERA geodetic VLBI

Specification of observation	S-band	X-band	K-band
Trx, K	300	100	60
Receiver Type	HEMT	HEMT	Cooled HEMT
Polarization	RHCP	RHCP	LHCP
Tau0	0.05	0.05	0.1-0.3
Aperture Efficiency	0.3	0.4	0.6
Receivable Frequency, GHz	2.21-2.37	8.18-8.60	21.5-23.8
Recorded I/F Bandwidth, MHz	128	368	498
Bandwidth, MHz - bit - Stream	16-2-4	16-2-12	16-2-16

The specifications of the observation system at each band are applied in the observation scheduling. The number of scans shown in Tabl. 2 are scheduling results. The number of scans at S/X-bands is typically 500/station/24 hours, while that at K-band is about 800 thanks to the high sensitivity in this band. By the way, the number of scans changes depending on meteorological conditions in the season. The receivable bandwidth of S-band is narrow. And, the interference of cell phones have degraded the sensitivity of the S-band receiving system recently. The fringe detection sensitivity of the VERA-internal geodetic VLBI using S/X-bands is limited by the sensitivity of S-band.

3. Geodetic Solutions at K-band

There is no special item in the analysis of K-band VLBI. We use the Mitaka FX Correlator for correlation processing and the CALC3/MSOLV package

Table 2. Setting of scans in VERA geodetic VLBI scheduling

Parameter Setting	S/X-band	K-band
Integration Time, s	20-240	20-120
Minimum Level of S/N	20-30	35-40
Number of Scans/Site/Session	400-600	600-800

for geodetic analysis, both being VLBI analysis systems developed at NAOJ [3]. ICRF and ITRF catalogs are used for star and site coordinates. Site coordinates, zenith atmosphere delay, and clock offset/rate are solved for simultaneously.

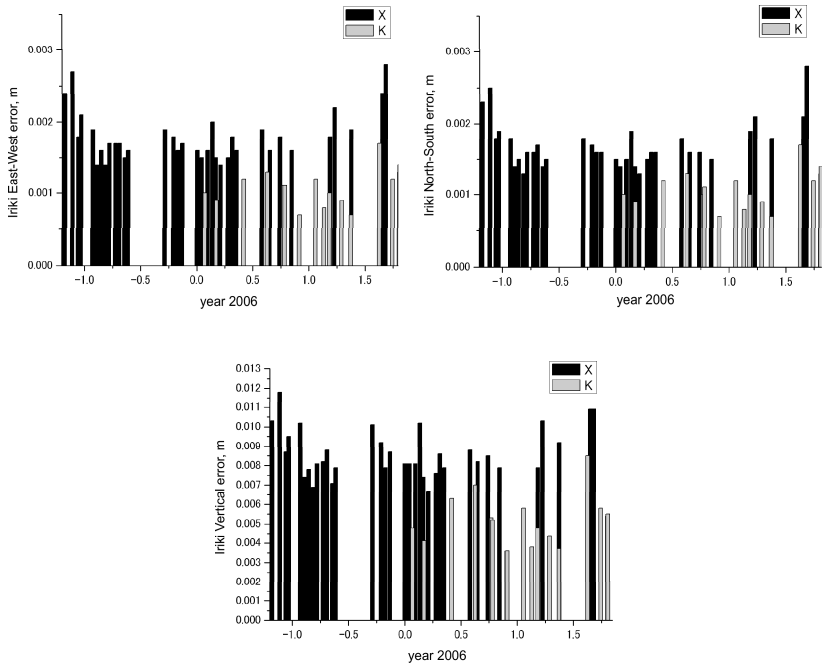

Figure 1. Error size of coordinate solutions. The period is from Nov. 2004 to Oct. 2007

The precision of the site topocentric coordinates in S/X-bands are 1–2 mm and 7–8 mm for the horizontal and vertical components, respectively. Those of K-band observations are better than 1 mm and 4–5 mm in most observations. The errors of K-band are 1.5–2 times smaller as compared with those of S/X-bands, as is evident from Fig. 1. In time series of the coordinates solutions, no significant systematic difference is found in the estimated coordinates between

S/X- and K-band, and K-band solutions look more stable than those for X-band.

4. Summary and Outlook

Experimental K-band geodetic VLBI observations aim at obtaining more precise geodetic solutions and confirming the effectiveness of a new frequency band that can replace S/X-bands. Experimental K-band geodetic VLBI observations started in Jan. 2006 and continues in the framework of the VERA internal geodetic VLBI sessions. High precise geodetic solutions were obtained from these observations. From these results, we recognized that K-band geodetic VLBI will become the main frame of VERA geodetic VLBI observations in the near future.

We try to enhance the K-band geodetic VLBI network for connecting the VERA network to other VLBI networks. VERA has the fifth 1 Gbps recording system for recording at Mitaka Correlation Center. This system in used to record VLBI raw data sent from other antennas linked to Mitaka via optical fiber networks. In Oct. 2007, Gifu University's 11 m antenna joined temporarily in VERA internal K-band geodetic VLBI session. VLBI raw data of Gifu station was transferred to Mitaka via 10 Gbps optical fiber network and recorded in Mitaka. The observation and analysis were both successful.

References

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