A NEW 34-M RADIO TELESCOPE AT KASHIMA AND A GEODETIC VLBI NETWORK IN JAPAN

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1. Introduction

The Kashima VLBI station is now working for measurements of global plate motions[1] and regional crustal deformations[2] and for international time services[3] by using a 26-m radio telescope. At the station a new 34-m radio telescope was constructed to make new radio astronomical observations in wide frequency range from 300 MHz to 49 GHz. The antenna is expected to be a fiducial point in Japanese geodetic VLBI network which covers an area in the Eastern Asia. In this article we present characteristics of the new 34-m antenna, medium size antennas and a small transportable antenna involving in the VLBI network, and research objectives expected to be achieved with these antennas.

2. Japanese VLBI network

Japanese islands are separated by four big plates, Pacific, Eurasian, North American and Philippine Sea plates as shown in Figure 1. Relative plate motion of these plates is believed to be a cause of big earthquakes which frequently occurs around Japan.

To measure the plate motion, VLBI stations has been developed on each plate. At Shanghai Observatory on the Eurasian plate, a 25-m radio telescope became operational in 1987. A 34-m radio telescope (Figure 2) on North American plate and two medium size antennas (10-m and 11-m, almost same shape, Figure 3) were constructed at Kashima Space Research Center, Communications research Laboratory in 1988. The 10-m antenna is going to be shipped to Minami-Torishima Island on the Pacific plate and the 11-m antenna is planned to be used at Minami-Daito Island on the Philippine Sea plate. The 10-m antenna has a subreflector of a frequency selective surface which was designed to achieve high efficiency in both frequency bands in 2.3 and 8.4 GHz. A transportable VLBI station with a 3-m antenna (Figure 4) was successfully operated at Koganei, Tokyo and Wakkanai, Hokkaido in September and October, 1988, and at Okinawa Island and Minami Daito Island in February, 1989. A few centimeter precision was achieved in these experiments by receiving signals in twice wider bandwidth with the smallest VLBI antenna in the world. The characteristics of these antennas are summarized in Table 1.

3. 34-m Radio Telescope

As summarized in Table 1, the 34-m radio telescope has eleven receivers, the frequency bands from 330 MHz to 49 GHz. The telescope was constructed at Kashima in 1988 for the research objectives described below.

(1) Pulsar observations in 330 MHz, 610 MHz, 1.5 GHz.

Stably pulsating radio objects called Pulsar were recently found. The stability reaches to 10^{-13} in the Allan standard deviation of the averaging time about 2 years. The long term stability is better than any other clocks ever made by men. The pulsars are expected to be the best clock to keep the UTC in a few years and longer. The 34-m radio telescope is equipped with two hydrogen maser frequency standards and a stable atomic clock, and will be used in pulsar observations to confirm the stability.

(2) Geodetic VLBI Observations in 2.3/8.2 GHz.

A few centimeter precision was successfully demonstrated in VLBI experiments with a pair of a 3-m antenna and a 26-m antenna. The product of diameters, which determines the precision, is 78 m^2. That means we need a base station with an antenna larger than 32-m to keep the same precision for a mobile VLBI station with a 2.5-m antenna. The size is limited by a Japanese traffic regulation. The new 34-m telescope will be used in the mobile VLBI experiments to monitor the crustal deformation in the Tokai district and other regions where a big earthquake is afraid of hitting. The 34-m telescope will be operated as a base station in a geodetic VLBI network in Japan.

(3) Radio astronomical observations in 4.8, 10, 15, 22 GHz

Some of radio stars in our galaxy have been observed as a good reference in calibrating large antennas of an earth station for satellite communications. The power of the celestial radio sources, however, varies with frequency and time as is well known in Cassiopeia-A for the example. The 34-m antenna will be used to observe these radio stars to calibrate the power spectra against thermal radio sources of flat spectrum such as a planet Mars.

(4) Radio astrometric observations in 22 GHz and above.

Celestial maser sources, which selectively emit an electro-magnetic wave in 22, 43 and 49 GHz, will be observed to monitor the change of their positions against a celestial inertia refernce frame formed by many Quasars far away from our galaxy. The rotation speed of our galaxy is expected to be measured from the observations.

REFERENCES

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[2] N. Kawaguchi, Effect of the earthquake east off Chiba on a Kashima-Tsukuba baseline, to be published in Jour. Geod. Soc. Japan, vol.35, No.2, June 1989

[3] S. Hama et al., Japan-US time comparison experiment for realizing better than 1 nano-second accuracy by using a radio interferometric technique, ibid. in [1].

34-m Antenna at the Kashima Space Research Center

BAND	Frequency	Tsys[c]	HPBW[e]
330MHz[a]	312 - 342 MHz	150K	1°.8
610MHz[a]	580 - 640 MHz	150K	1°.0
1.5GHz[b]	1.35 - 1.75GHz	55K	24′
2.3GHz[b]	2.15 - 2.35GHz	60K	16′
4.8GHz[b]	4.60 - 5.10GHz	60K	7′.5
8.2GHz[b]	7.86 - 8.68GHz	60K	4′.4
10GHz[b]	10.2 - 10.7GHz	90K	3′.6
15GHz[b]	14.4 - 15.4GHz	105K	2′.4
22GHz[b]	21.8 - 24.0GHz	160K	1′.6
43GHz[b]	42.3 - 43.5GHz	500K	51″
49GHz[b]	48.8 - 49.2GHz	500K[d]	44″

a)Front feed, room temperature receiver

b)Cassegrain feed, 15K cooled receiver

c)SSB system noise temperature(except for the 49GHz band)

d)DSB system noise temperature

e)HPBW~1.2λ/D

10-m Antenna at Minamitorishima

BAND	Frequency	Tsys
2.3GHz	2.20 - 2.32GHz	100K
8.4GHz	8.28 - 8.60GHz	170K

3-m Antenna (Mobile Station)

BAND	Frequency	Tsys
8.4GHz	7.86 - 8.60GHz	120K

Table 1. Characteristics of antennas involving in a Japanese geodetic VLBI network.

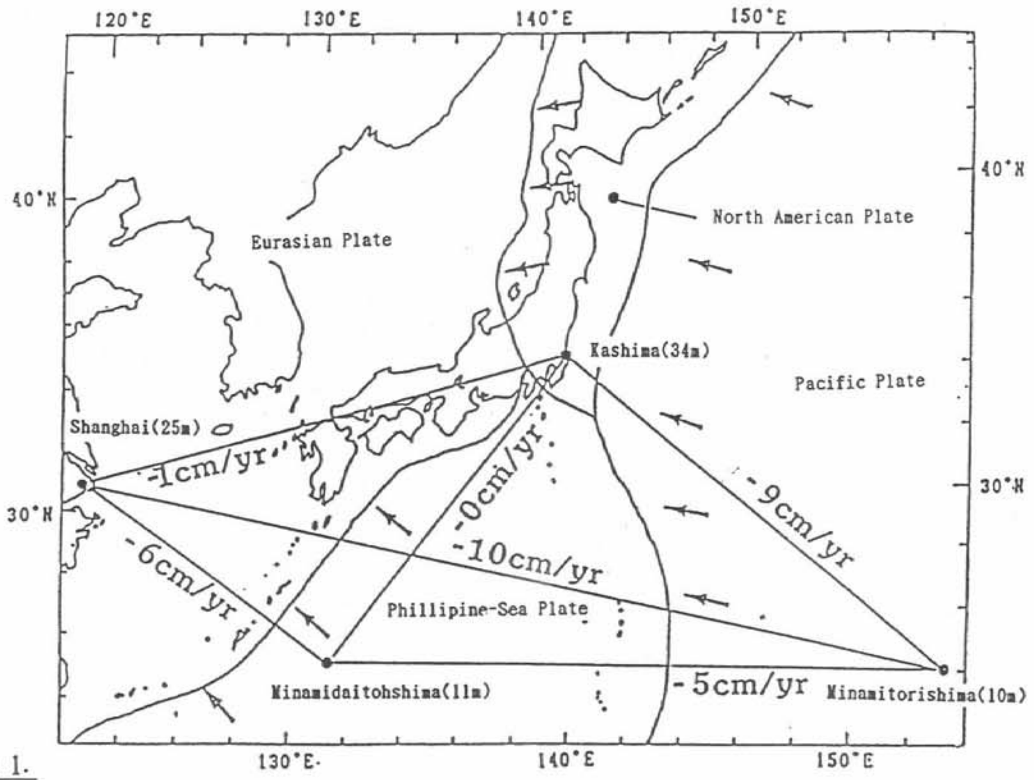

Figure 1.
Plate boundary distribution in and arround Japan, and the geodetic VLBI network of CRL. Shanghai Astronomical Observatory will cooperate at the experiments. Arrows denotes the direction of the plate motion. Calculated changing rates of the baseline length are shown.

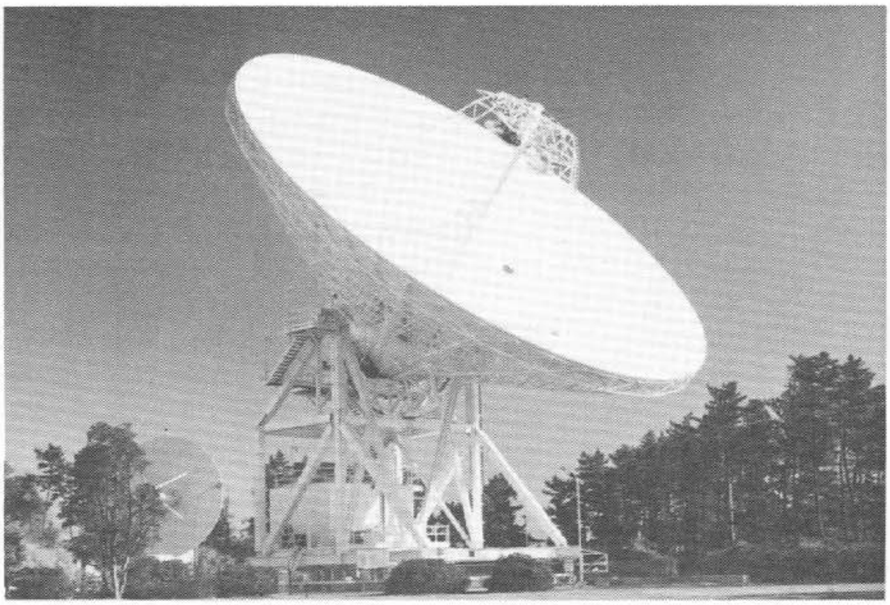

Figure 2.
The 34-m antenna at the Kashima Space Research Center, CRL. Receiving frequencies are from 300MHz to 50GHz. The 10-m antenna for Minamitorishima station was temporarily constructed(left).

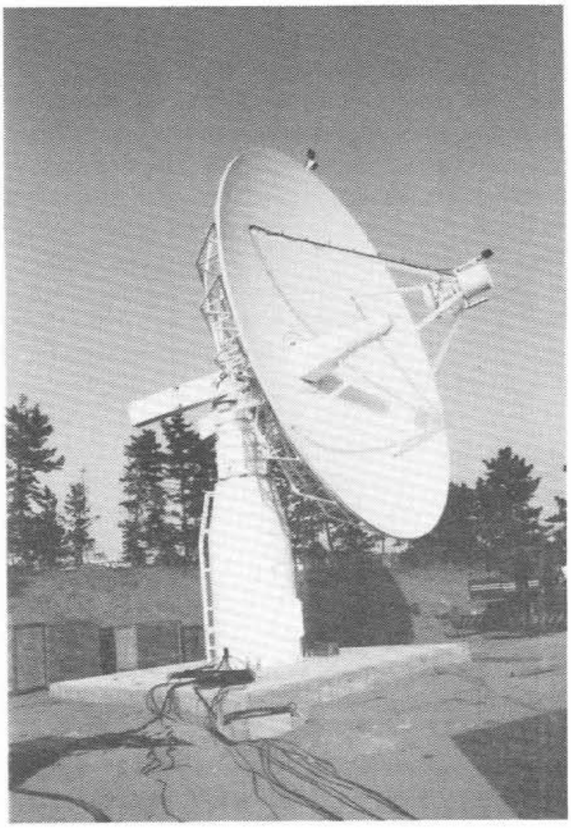

Figure 3.
The 10-m antenna for Minamitorishima (Marcus Island) station. A frequency selective sub-reflector (FSS) is used for S/X band simultaneous observations.

Figure 4.
3-m mobile antenna, the smallest geodetic VLBI station, is operated for domestic experiments with the K-4 VLBI backend system developed by CRL.