Analysis Center at Communications Research Laboratory

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Abstract

This report summarizes the activities of the Analysis Center at the Communications Research Laboratory (CRL) for the year 2002. We started to develop the differential VLBI technique to determine the spacecraft orbit. WVR observation in Kashima and an evaluation of atmospheric delay model using ray-tracing through the non-hydrostatic numerical weather model were also performed in this year.

1. General Information

The CRL analysis center is located in Kashima, Ibaraki Japan. It is operated by the Radio Astronomy Applications Group, Kashima Space Research Center of CRL. VLBI analyses at CRL are being mainly concentrated on experimental campaigns for developing new techniques such as differential VLBI (DVLBI) for spacecraft orbit determination and VLBI measurements for real-time EOP determination.

We are also conducting a water vapor radiometer (WVR) observation in Kashima and a numerical simulation of atmospheric parameters (equivalent zenith wet delay and linear horizontal delay gradients) estimated by ray-tracing through the non-hydrostatic numerical weather prediction model (NHM). Our ultimate purpose is to establish a new method for reducing atmospheric effects on geodetic positioning. In addition we determined station coordinates of two new VLBI stations.

2. Staff

The staff members who are contributing to the Analysis Center at the CRL are listed below:

- KONDO Tetsuro, responsible for overall operations and performance.
- KOYAMA Yasuhiro, development of data analysis software for the geodetic experiment.
- SEKIDO Mamoru, development of data analysis software for the DVLBI.
- ICHIKAWA Ryuichi, development of data analysis software for the DVLBI and atmospheric modeling.

3. Current Status and Activities

3.1. Differential VLBI

We performed DVLBI observations with National Astronomical Observatory (NAO) and the Institute of Space and Astronautical Science (ISAS) to determine the precise orbit of the PLANET-B (NOZOMI) spacecraft. Our recent concern is to determine the NOZOMI orbit just before the second swing-by next June [Yoshikawa et al., 2001]. It is significantly important to get the timing to maneuver the spacecraft before the swing-by. However, the usual range and range rate orbit determination will not be available because it will be difficult to point the high-gain antenna

mounted on the spacecraft toward the Earth at that time. So we need a new technique to determine the precise orbit of NOZOMI. An example of source geometry of the NOZOMI spacecraft for each one minute epoch and radio sources on September 17, 2002 are illustrated in Figure 1.

We use eight VLBI antennas which are Kashima 34-m, Kashima 11-m and Koganei 11-m of CRL, Usuda 64-m of ISAS, Mizusawa 20-m of NAO, Gifu 11-m of Gifu University, Tomakomai 11-m of Hokkaido University, and Yamaguchi 32-m of Yamaguchi University in order to carry out the DVLBI observations at X-band (see Figure 2). In addition we equipped the "IP-VLBI system" to these stations, which is designed so that all digital processing from signal sampling and data transmission to real-time correlation processing is performed on multiple personal computers (PCs) [Kondo et al., 2002]. The experimental observation of the NOZOMI spacecraft is also aimed at evaluating the IP-VLBI system.

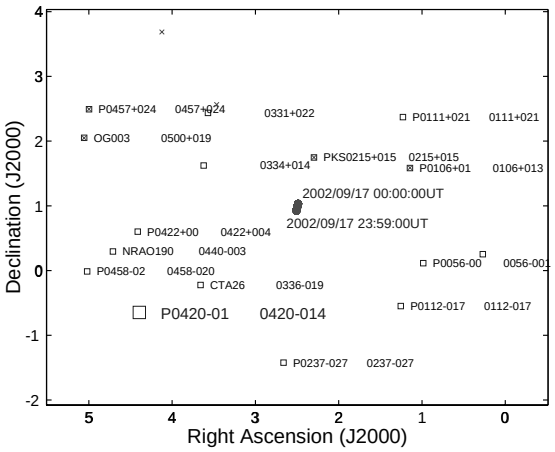

Figure 1. An example of trajectory of the NOZOMI spacecraft (gray circles) and radio sources (open squares) on September 17 2002.

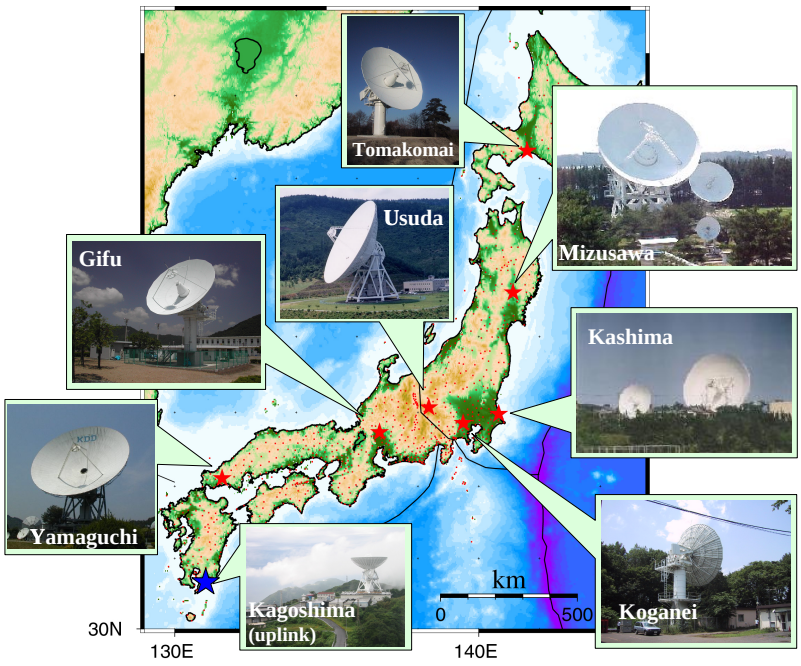

Figure 2. VLBI stations contributing to the NOZOMI DVLBI observations

3.2. Evaluation of Atmospheric Model

We are investigating position change of the Kashima station caused by the horizontal variability of water vapor by means of simulation analysis using ray-tracing techniques. In addition, observation of atmospheric slant delay using water vapor radiometer (WVR) near the Kashima 11-m antenna is also carried out for detecting and characterizing water vapor variations. We are also evaluating atmospheric parameters (equivalent zenith wet delay and linear horizontal delay gradients) and positioning errors derived from slant path delays obtained by ray-tracing through the non-hydrostatic numerical weather prediction model (NHM) with 1.5 km horizontal resolution. Our ultimate purpose is to establish a new method for reducing atmospheric effects on geodetic positioning.

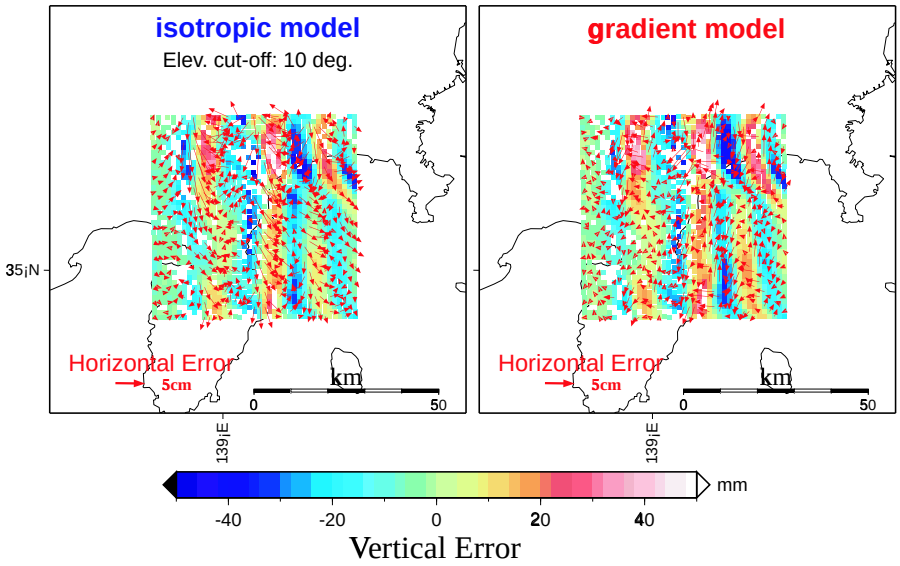

Figure 3. Estimated positioning errors (East, North, and Vertical) obtained at about 1500 grid points using both the isotropic (left) and anisotropic (right) atmospheric models with 10 degrees elevation cut-off. The behavior of those errors under the mountain lee wave phenomena and topographic effect are examined.

Figure 3 shows the positioning errors numerically estimated from the slant delays through the NHM, assuming single point positioning. The behavior of the positioning errors under the atmospheric disturbance in local scale, the relation between the slant delay errors and the vertical positioning errors, and the efficiency of the reduction of the azimuthal anisotropy of the atmosphere using the anisotropic mapping function are examined.

3.3. Geodetic VLBI experiments

The VLBI system that was used at the KSP Tateyama station until the end of 2001 was moved to Gifu University's new station Gifu. The three geodetic VLBI experiments with the Tomakomai (another new station which was installed in 2002), Kashima 11-m, Kashima 34-m antennas and two or three VLBI stations of Geographical Survey Institute (GSI) were successfully performed in 2002. The Gifu and Tomakomai VLBI station locations in the experiments are shown in Figure 2. The determined station coordinates of Gifu and Tomakomai are summarized in Table 1.

Table 1. Determined station coordinates

Experiment	Date		Tomakomai (mm)	GIFU (mm)
HOKT01	21/11/2001	x	-3680586317.93 ± 13.3	
		y	2917515761.37 ± 11.4	no observation
		z	4300987681.65 ± 13.9	
HOKT02	21/05/2002	x	-3680586338.06 ± 7.9	
		y	2917515779.22 ± 6.6	no observation
		z	4300987690.10 ± 7.6	
CUTE01	19/06/2002	x	-3680586301.7 ± 15.3	-3787123360.8 ± 9.0
		y	2917515745.6 ± 12.7	3564181693.8 ± 8.3
		z	4300987652.7 ± 15.1	3680274907.4 ± 8.0
CUTE02	11/11/2002	x	-3680586294.2 ± 13.4	-3787123418.3 ± 10.2
		y	2917515754.7 ± 11.5	3564181732.0 ± 9.3
		z	4300987636.2 ± 13.8	3680274950.5 ± 9.5
CUTE03	16/12/2002	x	-3680586346.9 ± 19.7	-3787123442.0 ± 7.5
		y	2917515812.2 ± 16.6	3564181710.2 ± 7.3
		z	4300987636.4 ± 21.1	3680274953.9 ± 7.1

4. Future Plans

During the year 2003 the plans of the Analysis Center at CRL include:

- Several international and domestic VLBI experiments for developing the Internet VLBI system, the Gbps VLBI system and PC-VSI system.
- Domestic experiments for the ITRF collocation with GSI, ISAS, Hokkaido University and Gifu University.
- Comparisons of the tropospheric parameters derived from VLBI, GPS, WVR and non-hydrostatic numerical weather prediction data.

In addition KSP data sets are still available at the URL http://ksp.crl.go.jp/index.html. General information about VLBI activities at the CRL is provided at
http://www2.crl.go.jp/ka/radioastro/index.html.

References

[1] Kondo et al., Real-time Gigabit VLBI System and Internet VLBI System, IVS 2002 General Meeting Proceedings, 0.142-146, 2002.

[2] Yoshikawa M., Sekido M., Kawaguchi N., Fujisawa K., Hanada H., Kono Y., Hirabayashi H., Murata Y., Sawada-Satoh S., Wajima K., Asaki Y., Kawaguchi J., Yamakawa H., Kato T., Ichikawa T., and Ohnishi T., Present status and future problems of the orbit determination for Nozomi spacecraft, IVS Technical Development Center News, No. 19, p.37-40, 2001.