

Analysis Center at National Institute of Information and Communications Technology

Ryuichi Ichikawa, Mamoru Sekido, Thomas Hobiger, Tetsuro Kondo, Yasuhiro Koyama

Abstract

This report summarizes the activities of the Analysis Center at National Institute of Information and Communications Technology (NICT) for the year 2006.

1. General Information

The NICT analysis center is located in Kashima, Ibaraki, Japan. It is operated by the Radio Astronomy Applications Group, Kashima Space Research Center of NICT. Analyses of VLBI experiments and related study fields at NICT are mainly concentrated on experimental campaigns for developing new techniques such as e-VLBI for the real-time EOP determination and compact VLBI system, ionospheric and atmospheric path delay study, and differential VLBI (DVLBI) for spacecraft orbit determination. In addition we carried out monthly IVS-T2 sessions.

2. Staff

The staff members who are contributing to the Analysis Center at the NICT are listed below (in alphabetical order):

- HOBIGER Thomas, Postdoctoral fellowship researcher of the Japan Society for the Promotion of Science (JSPS)/Ionospheric and atmospheric research using VLBI and GPS
- ICHIKAWA Ryuichi, Compact VLBI system development and Atmospheric Modeling
- KONDO Tetsuro, Software Correlator
- KOYAMA Yasuhiro, International e-VLBI
- SEKIDO Mamoru, International e-VLBI and VLBI for spacecraft navigation

3. Current Status and Activities

3.1. CARAVAN2400

The CARAVAN (Compact Antenna of Radio Astronomy VLBI Adapted for Network) is part of a small radio telescope system that is dedicated to mobile e-VLBI measurements. We are now developing a compact geodetic VLBI facility with a 2.4 m diameter dish antenna at Kashima (see Figure 1), which is named CARAVAN2400. A first geodetic VLBI experiment between the CARAVAN2400 and Tsukuba 32m antenna of the Geographical Survey Institute (GSI) was carried out on September 21, 2006. The result of the experiment is summarized in Table 1.

3.2. TID Experiment

Five VLBI experiments dedicated to the detection of traveling ionospheric disturbance (TID) were carried out on Kashima 34 m - Gifu 11 m baseline from March to July of 2006 in cooperation

Table 1. CARAVAN2400 positions derived from first geodetic VLBI experiment.

	X(mm)	Y(mm)	Z(mm)
position	$-3997490991.30 \pm 10.445$	3276829292.16 ± 10.334	3724308240.31 ± 10.394



Figure 1. CARAVAN2400

with the Gifu University. In this experiment, one strong source (e.g. 3C273B) was continuously observed for 1-2 hours split into 5 minute scans. Though a characteristic TID signal could not be detected during the experiments, the acceptable gap length between each scan was assessed in order to obtain phase change during the experiment. In addition, phase change due to the atmospheric disturbance was also investigated.

3.3. Differential VLBI for Spacecraft Tracking

We performed an international differential VLBI experiment in cooperation with China for tracking GEOTAIL spacecraft on December 20, 2006. In this experiment, Kashima, Tsukuba and Aira of GSI, Usuda and Uchinoura of ISAS/JAXA, Mizusawa of NAOJ, Urumqi and Kunming of the Chinese VLBI Network (CVN) of the National Astronomical Observatories of China (NAOC) participated. One of the purposes of the experiment is to evaluate an accuracy of phase delay measurement for tracking.

The bandwidth of the spacecraft's signal is too narrow to achieve enough precision using group delay observables. Thus phase delay is considered as alternative choice to get higher delay resolution, also the ambiguity of phase is an issue to be solved. Phase delay observables are extracted with a special correlation software using the signal around transmitting frequency. In addition, a relativistic delay model for Earth-based VLBI observation of sources at finite distances[1] was implemented in the correlation and processing analysis software.

3.4. Atmospheric Path Delay Study

3.4.1. WVR Observation during CONT05

We compared estimated ZWD time series derived from an independent analysis of simultaneous radiosonde, WVR, GPS and VLBI observations at Tsukuba over the CONT05 period. The

measured ZWDs at Tsukuba are shown in Figure 2. The mean and standard deviation values of the differences between the different techniques such as WVR, GPS, and VLBI (with 10° minimum elevation angle cutoff) are summarized in Table 2. (See Ichikawa et al. [2]). WVR data sets and the related documents are archived on our Web site [3].

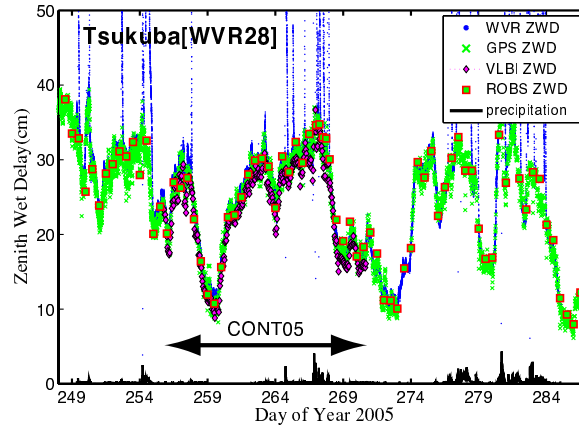


Figure 2. Time series of ZWD derived from the co-located techniques VLBI, WVR, GPS and radiosondes at Tsukuba during September 6 – October 12, 2005. The arrows indicate the period of the CONT05 campaign for which VLBI data were compared.

Table 2. Mean and scatter (standard deviation) values in millimeter between ZWDs derived from different techniques at Tsukuba.

	GPS	VLBI
WVR26	12.3 ± 16.5	23.6 ± 13.5
WVR28	6.5 ± 15.2	17.2 ± 12.1
VLBI	-12.1 ± 12.6	—

3.4.2. Atmospheric Path Delay Estimation using a Recent High Resolution Numerical Weather Model

Japan Meteorological Agency (JMA) provides a meso-scale analysis model over Japan and Eastern Eurasia with about 10 kilometer horizontal resolution (see Figure 3). We are now modifying a ray tracing tool for estimating atmospheric slant delay through the recent numerical weather model of JMA. This tool will enable to evaluate horizontal and vertical positioning errors associated with horizontal water vapor inhomogeneity.

4. Future Plans

For the year 2007 the plans of the Analysis Center at NICT include:

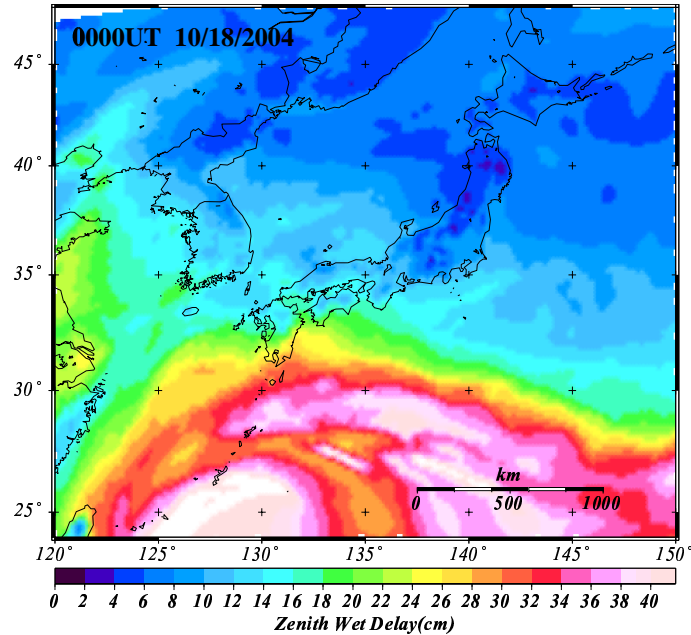


Figure 3. Zenith wet delay retrieved by the JMA meso-scale analysis model at 00:00 UT October 18, 2004.

- Several international and domestic VLBI experiments for real-time EOP determination using e-VLBI and the K5 system (both VSSP system and PC/VSI system)
- Differential VLBI experiments for spacecraft tracking and its analysis
- Development of the analysis software for spacecraft positioning using phase delay observables
- Improvement of processing speed and efficiency for the VLBI data correlation using multi-processor and high speed network
- Evaluation of simulated positioning errors due to tropospheric parameters (VLBI, GPS, WVR and the numerical weather prediction model)

References

- [1] Sekido, M. and T.Fukushima, A VLBI delay model for radio sources at a finite distance, *Journal of Geodesy*, DOI10.1007/s00190-006-0035-y, **Vol.80**, No.3, pp.137-149.
- [2] Ichikawa, R., H. Kuboki, M. Tsutsumi, and Y. Koyama, Zenith wet delay comparisons at Tsukuba and Kashima VLBI stations during the CONT05 VLBI campaign, *IVS NICT-TDC News*, **No.27**, pp. 19-22.
- [3] http://www2.nict.go.jp/w/w114/stsi/CONT05_WVR/