Analysis Center at National Institute of Information and Communications Technology

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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 field 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 Teturo, Software Correlator
- KOYAMA Yasuhiro, International e-VLBI
- SEKIDO Mamoru, Internationa 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 the series of the small radio telescope system that is dedicated to mobile e-VLBI measurements. We are now developing a compact and 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 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.

	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 hour split up in 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 corporation 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 thought as alternative choice to get higher delay resolution, even 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 during 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 another report in detail[2]). WVR data sets and the related documents are archived in our web site[3].

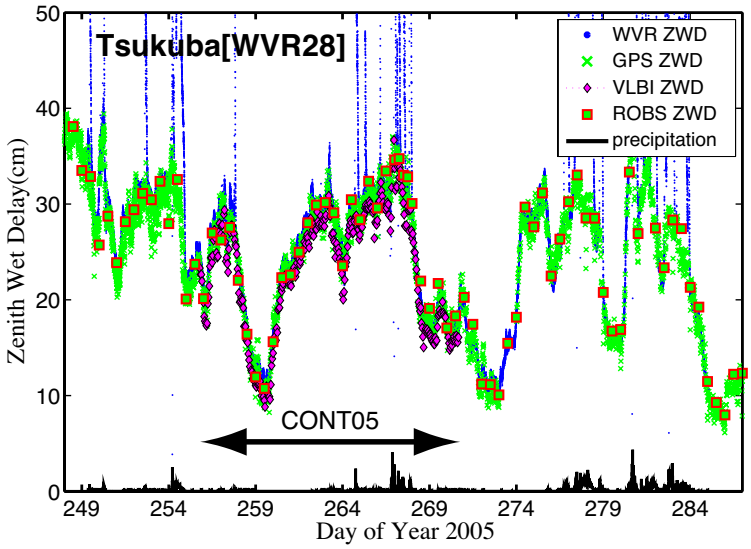

Figure 2. Time series of ZWD derived from the collocated techniques VLBI, WVR, GPS and radiosonde at Tsukuba during September 6 - October 12, 2005. The arrows indicate the period of the CONT05 campaign for which VLBI data were compared.

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 through the Recent High Resolution Numerical Weather Model

Japan Meteorological Agency (JMA) provides a meso-scale analysis data over Japan islands 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.

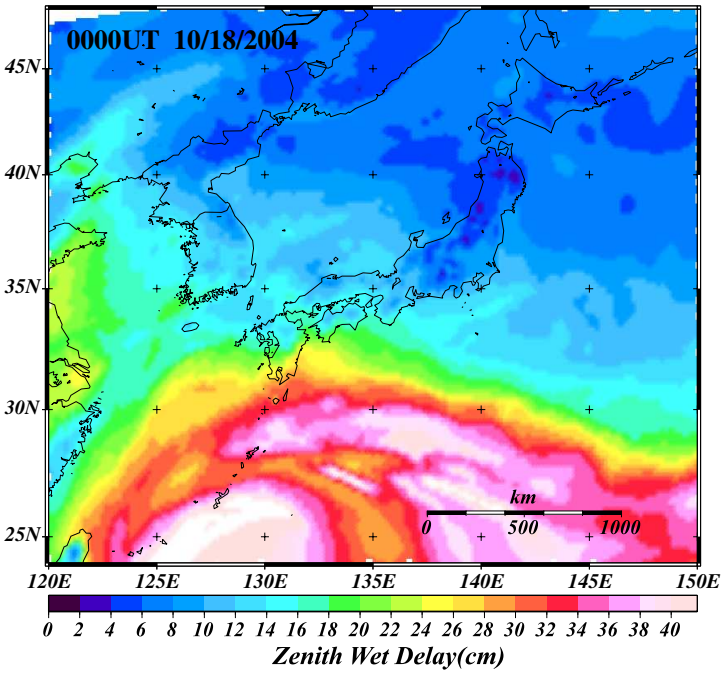

Figure 3. Zenith wet delay retrieved by the JMA meso-scale analysis data at the 0000UT of October 18, 2004.

4. Future Plans

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

- Several international and domestic VLBI experiments for the real-time EOP determinations using the e-VLBI and K5 system (both VSSP system and PC/VSI system).
- Differential VLBI experiments for spacecraft tracking and its analysis
- Development of the analysis software for the spacecraft positioning using phase delay observables
- Improvement of processing speed and efficiency for the VLBI data correlation using multiprocessor and high speed network
- Evaluation of simulated positioning errors due to the 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/*