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 2010.

1. General Information

The NICT Analysis Center is operated by the space-time standards group of NICT and is located in Kashima, Ibaraki, Japan as well as at the headquarters in Koganei, Tokyo. Analysis of VLBI experiments and related study fields at NICT are mainly concentrated on experimental campaigns for developing new techniques such as time and frequency transfer, e-VLBI for real-time EOP determination, prototyping of a compact VLBI system, analysis software development, and atmospheric path delay studies.

2. Staff

Members who are contributing to the Analysis Center at the NICT are listed below (in alphabetical order, working locations in parentheses):

- HOBIGER Thomas (Koganei, Tokyo), Atmospheric research, analysis software development
- ICHIKAWA Ryuichi (Kashima), Compact VLBI system and atmospheric modeling
- KONDO Tetsuro (Kashima), Software correlator
- KOYAMA Yasuhiro (Koganei, Tokyo), e-VLBI
- SEKIDO Mamoru (Kashima), International e-VLBI and VLBI for spacecraft navigation
- TAKIGUCHI Hiroshi (Kashima), Time-transfer experiments, e-VLBI and loading effects

3. Current Status and Activities

3.1. Ultra-rapid UT1 Experiments

In cooperation with Geospatial Information Authority of Japan (GSI), Onsala Space Observatory, and Metsähovi Radio Observatory it has become possible [6] to obtain UT1 estimates—which have been proven to be as accurate as the IERS Bulletin-A results—a few minutes after the last observation has been made. This operation mode, called ultra-rapid UT1 determination, has been developed further and extended by a fully automated analysis procedure based on c5++ (Section 3.3). Additionally, results from these low-latency experiments were used by the IERS for test purposes to check the impact of such near-real-time information for their EOP products.

3.2. Time and Frequency Transfer via VLBI

As a new frequency transfer technique which enables the comparison of highly stable frequency standards, we proposed the geodetic VLBI technique using our MARBLE system. NICT is currently developing several T&F transfer techniques besides VLBI such as GPS and two-way satellite time and frequency transfer (TWSTFT). In 2010 we carried out two intercomparison experiments (August and October) on the Kashima 11 m to Koganei 11 m baseline. Thereby we compared results from VLBI, GPS, TWSTFT with a DPN code [7], and time comparison equipment (TCE) on the satellite ETS-8 [8]. Figure 1 shows the result of the August experiment. The October experiment, which aimed at checking if these techniques are able to measure the correct time difference, was conducted by introducing an artificial delay using a coaxial phase shifter which was inserted into the path of the reference signal from the Hydrogen maser to the Kashima 11-m antenna. We are analyzing data in detail now.

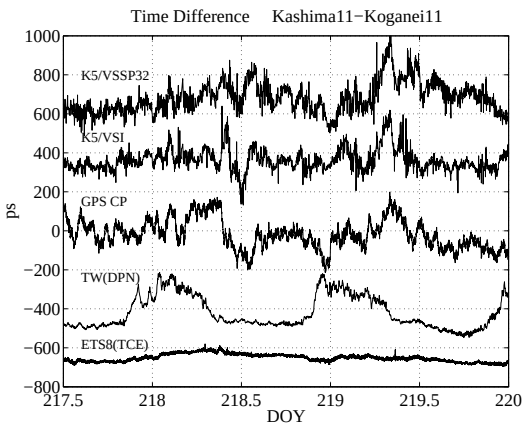

Figure 1. T&F by VLBI using two sampling modes K5/VSSP32 (S/X multi channel) and K5/VSI (S/X broadband) (see TDC report in this issue).

3.3. Development of a Multi-technique Space-geodetic Analysis Software Package

Otsubo et al. (1994, [4]) have developed an analysis software package based on Java named CONCERTO4 which enables the user to consistently process SLR, GPS, and other satellite tracking data. Driven by the need to update the software and to replace the existing Java code, VLBI was added as an additional module to this analysis package, and it was renamed c5++. The software provides state-of-the-art modules for a variety of geodetic, mathematical, and geophysical tasks that can be combined into a stand-alone VLBI application. Although many of these modules can be used for any of the space geodetic techniques, a couple of technique-specific solutions (like relativity, antenna deformation) had to be coded exclusively for VLBI. Thanks to the efforts of the Vienna VLBI group we were able to validate (see Figure 1) our software within the "Comparison Campaign of VLBI Data Analysis Software" [5] before using it for analysis purposes. As our software has the capability to carry out unattended ambiguity resolution of single baseline experiments, the automated analysis procedure of the real-time UT1 experiments has been realized with c5++ [2]. The software is currently under revision to be in agreement with the IERS Conventions 2010 and to become a complete package for multi-baseline experiments. Moreover, further applications including time and frequency transfer and space-craft navigation are being implemented in order to support the research activities of NICT's VLBI project.

3.4. MARBLE

We have developed two prototypes of a compact VLBI system with a 1.6 m diameter aperture dish in order to provide reference baseline lengths for calibration purposes. The reference

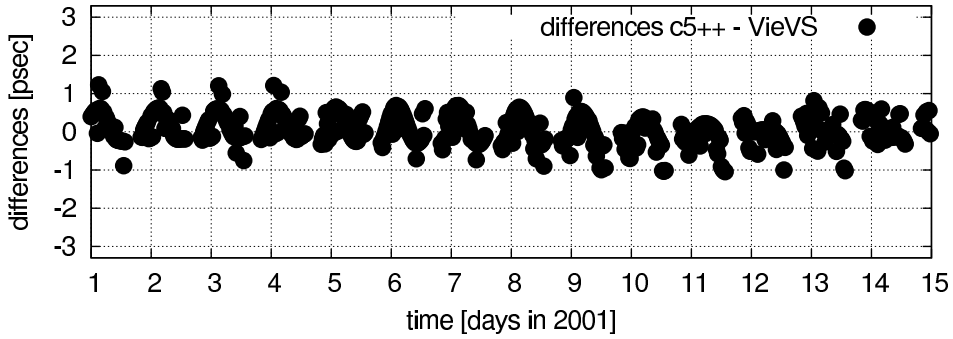

Figure 2. Differences of total theoretical delay for the baseline Westford-Wettzell between c5++ and VieVS as obtained within the "Comparison Campaign of VLBI Data Analysis Software" [5].

baseline is maintained by GSI. We named the system "Multiple Antenna Radio-interferometry for Baseline Length Evaluation (MARBLE)" [3]. We have carried out six geodetic VLBI experiments between Kashima and Tsukuba (about 54 km) during the fiscal year of 2010. The baseline length repeatability is 2.4 mm.

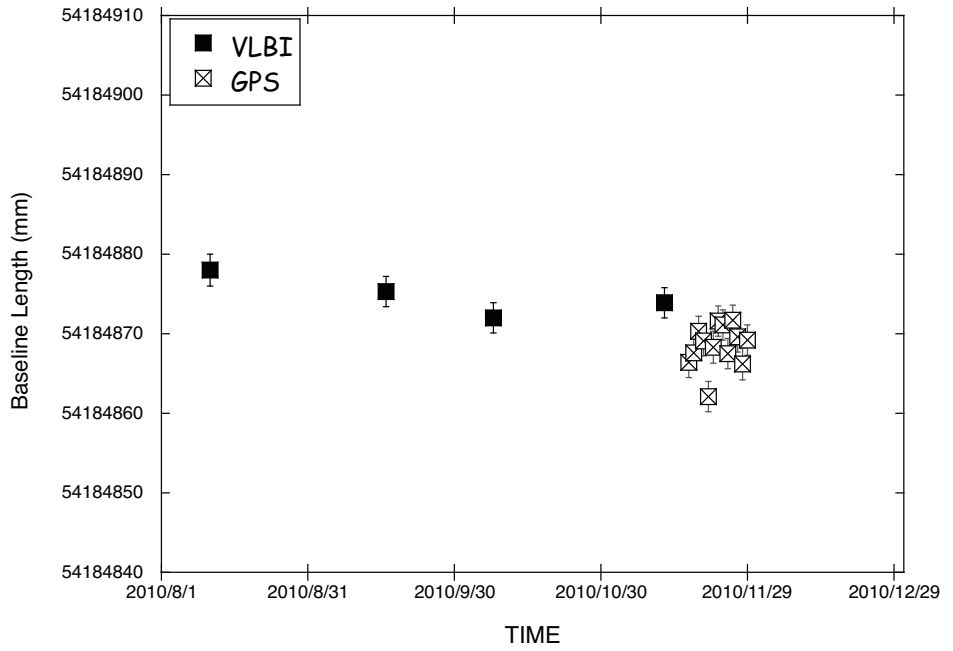

Figure 3. Baseline lengths between Kashima and Tsukuba as obtained by MARBLE and GPS.

3.5. Ray-traced Troposphere Slant Delay Correction for Space Geodesy

A software package, called Kashima Ray-tracing Tools (KARAT), has been developed which is capable of transforming numerical weather model data sets to geodetic reference frames, computing fast and accurate ray-traced slant delays, and correcting geodetic data on the observation level.

Besides other space-geodetic techniques like GPS or InSAR, the impact of such corrections on UT1 estimates from VLBI has been investigated by Böhm et al. [1]. A thorough comparison of ray-traced troposphere delays with results from other space-geodetic techniques during CONT08 has been made by Teke et al. (2011, [9]). Moreover, the usage of such corrections for other VLBI applications is currently under investigation.

4. Future Plans

For the year 2011 the plans of the Analysis Center at NICT include:

- Time and frequency transfer experiments by VLBI
- Further improvement of the multi-technique space-geodetic analysis software c5++
- Extension of the concept of ultra-rapid UT1 experiments to a multi-baseline network which allows the determination of all three EOPs
- Improvement of processing speed and efficiency for the VLBI data correlation using multi-processors/multi-cores and high-speed networks
- VLBI experiments for spacecraft tracking and its analysis

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