Takaaki Jike et al.: The Antarctic VLBI Experiments During JARE39 and Geodetic Analysis by the Mitaka FX Correlator, IVS 2002 General Meeting Proceedings, p.324–328
http://ivscc.gsfc.nasa.gov/publications/gm2002/jike

The Antarctic VLBI Experiments During JARE39 and Geodetic Analysis by the Mitaka FX Correlator

Takaaki Jike [1], Seiji Manabe [1], Yoshiaki Tamura [1], Kazuo Shibuya [2], Koichiro Doi [2], Teruhito Tanaka [3], Peter McCulloch [4], Marco Costa [4], George Nicolson [5], Jonathan F. H. Quick [5], Katsuhisa Sato [1], Katsunori M. Shibata [6], Yoshihiro Fukuzaki [7], David L. Jauncey [8], John Reynolds [8]

1) *National Astronomical Observatory Mizusawa, Japan*
2) *National Institute of Polar Research, Japan*
3) *NEC Corporation, Japan*
4) *University of Tasmania, Australia*
5) *Hartebeesthoeck Radio Astronomy Observatory, South Africa*
6) *National Astronomical Observatory Mitaka, Japan*
7) *Geographical Survey Institute, Japan*
8) *Australia Telescope National Facility, CSIRO, Australia*

Contact author: Takaaki Jike, e-mail: jike@miz.nao.ac.jp

Abstract

JARE39 started the Antarctic VLBI project at Syowa station. In this project, four regular VLBI observations during the wintering were carried out and the VLBI raw data were correlated by the Mitaka FX correlator. We developed new software and applied it to the geodetic analysis of the Antarctic VLBI data. Main parts of development are the bandwidth synthesis and the time system transformation. By using this software, the position of Syowa VLBI reference point was estimated with standard deviations of 2.9 cm, 2.5 cm and 6.2 cm in x-, y- and z-components in the geocentric Cartesian system. These errors are larger than typical values of recent inter-continental VLBI experiments. To inspect the reliability of our analysis software, we compared performance of ours and GSI's analysis system by using observed delays which were determined from common VLBI data. Then, systematic delay differences with about 2 nanosecond were detected. Now, we are investigating its cause.

1. Introduction

Syowa station is one of the largest earth scientific observation complexes in the world. It is located on bedrock and has several geodetic observation instruments including space geodetic facilities. In 1998, a program for monitoring earth scientific phenomena occurring in the Antarctic plate by those instruments was advancing. As one of the main parts of this program, JARE39 (the Japanese Antarctic Research Expedition 39th, 1998) installed a standard VLBI observation system and started the Antarctic VLBI observation project [1]. In the project, regular VLBI observations throughout a year are planned and carried out during the wintering. Australian, South African and Japanese VLBI stations participated. Furthermore, this project has been continuing thereafter.

Two recording systems, K4 and S2, were used in the Antarctic VLBI project. The Mitaka FX correlator is able to handle both recording systems and, therefore, we adopted the Mitaka FX correlator to carry out correlation processing. However, necessary geodetic analysis tools were not fully implemented in the Mitaka FX correlator. Accordingly, we developed new geodetic analysis tools for reducing the data of the Antarctic VLBI project. It is to be mentioned that the Mitaka FX correlator adopts the geocentric time system, which is different from other correlators used in geodesy previously. Therefore, we adopted and installed a function of time system transformation.

The position of Syowa VLBI reference point was determined from the JARE39 data with the newly developed geodetic analysis system mentioned above and agreed with the result of the observation in 1999 obtained with the use of a usual analysis system.

In this paper, we describe result of regular Antarctic VLBI observations in 1998, result of the correlation by Mitaka FX correlator, constitution of the newly developed geodetic software and result of the geodetic analysis by the software.

2. Result of the Observation and the Correlation

The VLBI experiments were carried out four times in 1998. Summary of the experiments is shown in Table 1. HartRAO, Hobart and Syowa formed a core network of the Antarctic VLBI project.

Table 1. Summary of the experiments conducted during JARE39.

Experiment Name	Start Epoch (UT)	End Epoch (UT)	Number of Obs.	Station ID
S98040,041	98/Feb/09 08:13	98/Feb/11 08:18	318	Hh,Ho,Sy,Ka
S98131,132	98/May/11 08:00	98/May/13 08:01	347	Hh,Ho,Sy,Ka
S98221	98/Aug/09 08:00	98/Aug/11 08:08	337	Hh,Ho,Sy
SYW984	98/Nov/09 08:00	98/Nov/11 08:12	398	Hh,Ho,Sy,Pk
Hh:HartRAO, Ho:Hobart, Sy:Syowa, Ka:Kashima, Pk:Parkes				

The Mitaka FX correlator started the correlation in April 1999. Various troubles specific to Syowa station that occurred in wintering gave big damage to our observation results. We could not detect fringes in the X-band in February observation. Quality of the data of the May and August experiments was not enough to perform analyses. In the November experiment, the trouble did not occur during observation, thus, good correlation results were obtained for all the baselines. Final result of correlation by the Mitaka FX correlator is shown in Table 2.

Table 2. Result of the correlation by the Mitaka FX correlator.

Exp. Name	Hh-Ho	Hh-Sy	Hh-Ka	Hh-Pk	Ho-Sy	Ho-Ka	Ho-Pk	Sy-Ka	Sy-Pk
S98040	○	S	○	-	S	○	-	S	-
S98041	○	S	-	-	S	-	-	-	-
S98131	-	○	-	-	-	-	-	-	-
S98132	○	×	○	-	×	○	-	×	-
S98221	×	×	-	-	×	-	-	-	-
SYW984	○	○	-	○	○	-	○	-	○
○:Fringes were detected in multiple scans. ×:No fringe was detected. S:Fringes were detected from only S band data.									

3. Outline of the Newly Developed Geodetic Analysis Software

Figure 1 shows the structure of the geodetic analysis system applied to the reduction of the Antarctic VLBI observations. The various steps are necessary before starting geodetic parameter estimation. In these tools, the bandwidth synthesis and time system transformation are mainly developed in this software.

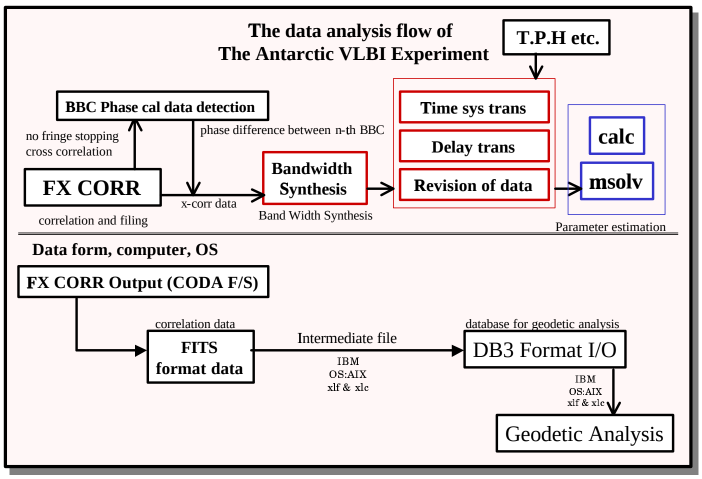

Figure 1. Structure of the geodetic analysis system for the Antarctic VLBI observations.

A standard algorithm is used in the bandwidth synthesis. However, the observed delay that the software outputs is expressed in geocentric time system that differs from the geodetic analysis specification. It is following the specification of the Mitaka FX correlator which adopts the geocenter as a time reference station common to all the ground stations. In processing of the Mitaka FX correlator, a delay is defined as a difference of epochs when the same wave-front from a celestial body passes the geocenter and a ground station, respectively, while observed delay is the difference in the time when this wave front passes two ground stations. The geometrical delay between two ground stations is computed as a difference of the delays between the geocenter and individual ground stations. On the other hand, the reference time of a priori delay used in geodetic analyses is the time when the wave-front from a celestial body reaches the time reference station on the ground. Figure 2 shows difference of two time system and delays. The magnitude of the delay due to the difference of the time systems is at most 1–10 nanoseconds and changes with time. Therefore the time system transformation is necessary to compensate the influence of the difference of time system between the observed and a priori delays. In figure 2, if the same wave front is observed with both time systems, the relation of two time systems is able to be expressed as $t_x = t_0 + \tau_x$.

In order to convert the delay following this transformation method, twice the atmosphere propagation delay must be added. By these processing, comparison of observed delay obtained

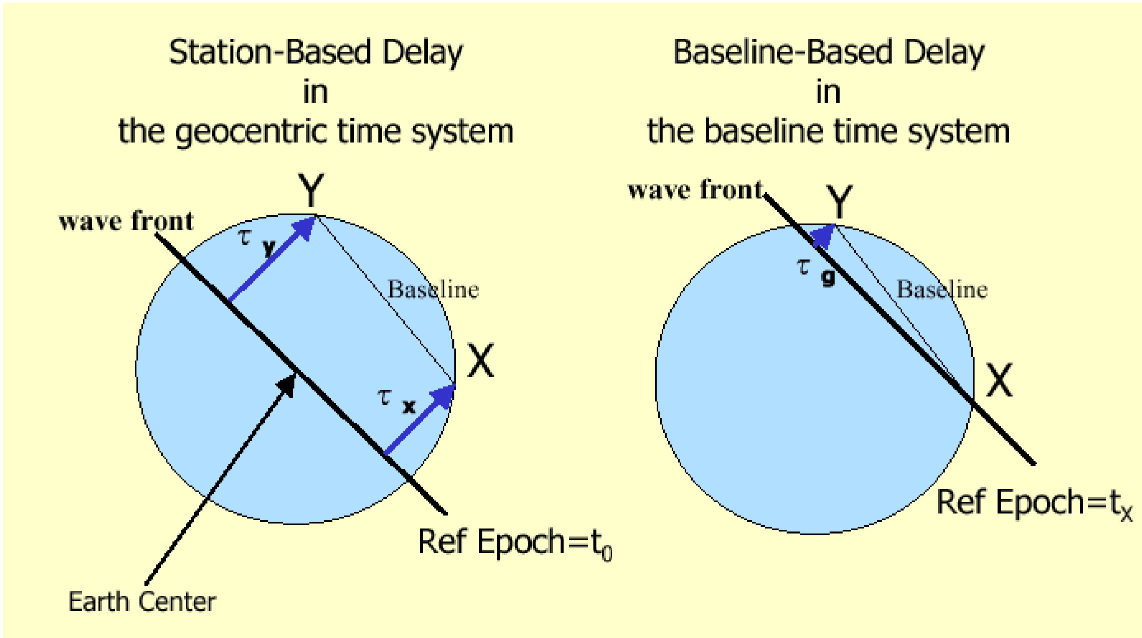

Figure 2. Delays in the geocentric time system and in the baseline time system.

from the Mitaka FX correlator and a priori delay computed with CALC3 became possible.

4. Result of the Analysis

The parameter estimation was performed for the data in November, 1998 by using "msolv". By the processing, the position of the Syowa VLBI point was estimated with differences in -0.3 cm, -1.6 cm and 2.1 cm to the position predicted from ITRF2000 and with standard deviations of 2.9 cm, 2.5 cm and 6.2 cm in x-, y- and z-components in the geocentric Cartesian system. An error ellipsoid is shown in figure 3. Form of this ellipsoid dose not contradict the error estimation of the VLBI position measurement reported by Takahashi [2]. In addition, standard deviations of the post-fit residual delays for the individual baselines are about 300 picoseconds. These errors were larger than typical values of recent inter-continental VLBI experiments.

The causes of the large standard deviation must be researched to confirm the reliability of the newly developed analysis system and the analysis result. Thereupon, we compared the accuracy of delay determination with our newly developed analysis system and GSI's analysis system. In the comparison, the differences were obtained in two observed delay sets which were individually determined with two systems mentioned above. Furthermore, the common VLBI data used in the comparison is SYW997, which was obtained with the Antarctic VLBI observation in 1999. As the result, the systematic delay differences of about 2 nanoseconds were detected, when the delays were discerned with the individual observed radio sources. Now, in order to resolve the problem, we are investigating the influences which are bases to the special processing of the Mitaka FX correlator.

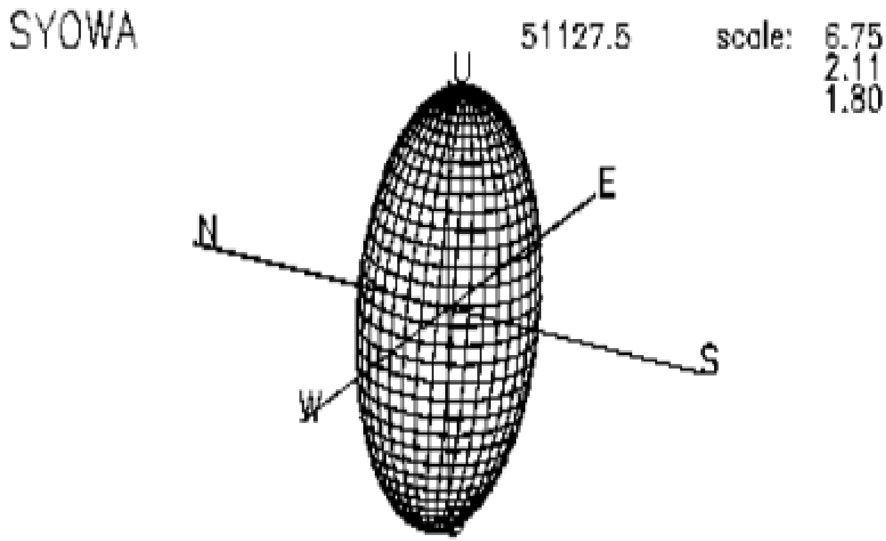

Figure 3. Error ellipsoid of the estimated position of Syowa.

4.1. Future Plan of Software Development

The main part of the geodetic analysis system for the Mitaka FX correlator is considered to be usable as one of the core parts of a VERA analysis system and a large contribution is expected in the VERA project. Accordingly, the improvement of the reliability is indispensable. Furthermore, the reconstruction of the software will be continued along with the future activity of other VLBI analysis software and global models.

5. Acknowledgements

The VLBI experiments at Syowa station are supported by many people and many institutes at various stages. The authors would like to express their thanks to K. Kashiwabara (Anritsu Corporation, JARE39), S. Kuji, N. Kawaguchi, T. Miyaji (NAO), M. Tobita, T. Kawahara, S. Ogi, K. Takashima (GSI), Y. Takahashi, N. Kurihara (CRL) and members of JARE39.

References

[1] Jike, T., T. Tanaka, K. Shibuya, S. Manabe, Y. Tamura, K. Sato, P. McCulloch, M. Costa, G. Nicolson, J. F. H. Guick, K. M. Shibata, K. Doi, Y. Fukuzaki, D. L. Jauncey, J. Reynolds, VLBI Experiments at Syowa Station, Antarctica, In: Proceedings of the International Workshop on GEodetic Measurements by the collocation of Space Techniques ON Earth, Jan. 25-28, 1999, CRL, Koganei, Tokyo.

[2] Takahashi, Y., Estimation of errors in VLBI data and position, In: J. Geod. Soc., Japan, 40, 309-332.