TECHNICAL DEVELOPMENT CENTER NEWS

COMMUNICATIONS RESEARCH LABORATORY

Serial No. 7 October 1995

CONTENTS

Overview of the Seventh TDC Meeting

The Seventh meeting of the Technical Development Center was held on September 8, 1995 at the conference room of the Communications Research Center.

Attendance

CRL members

Fujinobu Takahashi, Taizoh Yoshino, Michito Imae, Hiroo Kunimori, Shin'ichi Hama, Chihiro Miki, Akihiro Kaneko, Toshimichi Otsubo, Hideyuki Nojiri, Shingo Ohmori(KSRC: Kashima Space Research Center), Yukio Takahashi(KSRC), Takahiro Iwata(KSRC), Hiroshi Takaba(KSRC), Noriyuki Kurihara(KSRC), Ryuichi Ichikawa(KSRC), Mamoru Sekido(KSRC), Yasuhiro Koyama(KSRC), Yuko Hanado(KSRC) Junichi Nakajima(KSRC), Tadahiro Gotoh(KSRC), Tetsuro Kondo(KSRC)

Special members

Takashi Saito(Geographical Survey Institute), Teruo Kanazawa(Hydrographic Department, Maritime Safety Agency), Kazuo Shibuya(National Institute of Polar Research),

Following special members could not attend: Nobuyuki Kawano(National Astronomical Observatory), Noriyuki Kawaguchi(National Astronomical Observatory), Teruyuki Kato(Earthquake Research Institute, University of Tokyo), Hisashi Hirabayashi(Institute of Space and Astronautical Science), Yoshimitsu Okada(National Research Institute for Science and Disaster Prevention)

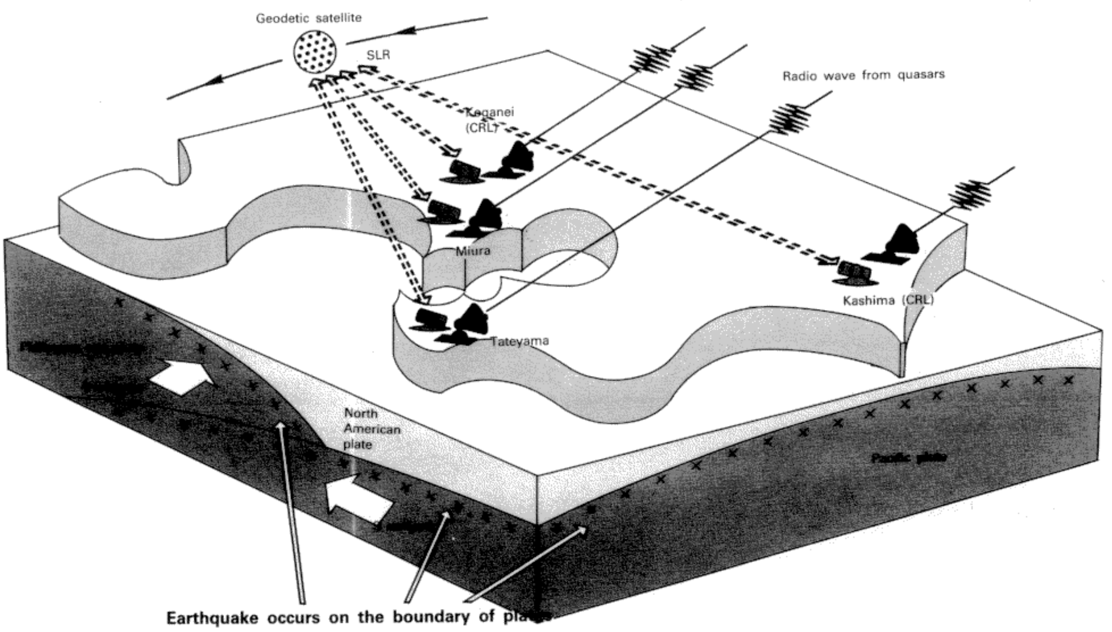
Agenda

1. Opening address by Fujinobu Takahashi, director of the Standards and Measurements Division, CRL
2. Policy of VLBI technical development center at CRL
3. Activity reports by the special members
4. Report of IRIS meeting
5. Technical reports

5.1 Keystone project

5.2 Other technical development activities

6. Proposal of R&D experiments
7. Closing address by Shingo Ohmori, director of the Kashima Space Research Center, CRL



Key Stone Project (see Page 5). The Key Stone Project is named after a Japanese legend in which a keystone in Kashima Shrine holds down the head of a catfish believed to cause earthquakes.

Minutes of the IRIS Subcommission Meeting Held During the IUGG XXI General Assembly

Taizoh Yoshino

Communications Research Laboratory
4-2-1 Nukui-kita, Koganei, Tokyo 184, Japan

Date : July 10, 1995 18:00-19:20

Place: Engineering Center CR1-7, University of Colorado at Boulder

chaired by Taizoh Yoshino (Communications Research Laboratory)

Attendance:

Brent A. Archinal(USNO) John M. Bosworth (NASA/GSFC) James Campbell (Univ. Bonn) William E. Carter (NOAA) M. Cattaneo (University of Genova) Thomas A. Clark (NASA/GSFC) Eva Claudio (University of Genova) Martine Feissel (Obs. Paris) Dennis D. McCarthy (USNO) Douglas S. Robertson (NOAA) Harald Schuh (DGFI) Bob E. Schutz (University of Texas) Yoshiaki Tamura (NAOM) Alan W. Whitney (Haystack Obs.) Shu-Hua Ye (Shanghai Obs.)

1. Status Reports

1.1 NEOS (former IRIS-A) and NEOS Intensive *(D.D. McCarthy)*

New antennas have been set up at Green Bank, Hawaii and recently in Florida. The latter is a replacement for the Richmond antenna destroyed in a hurricane. The clock operations at Richmond will be moved to Colorado Springs.

The correlator at USNO is operated for 5 days a week on two shifts plus a third shift on two days. This is an increase over the previous situation, but the number of VLBI experiments that can be scheduled by USNO is still limited by the available correlation time. The funding by NASA of correlation at Haystack has decreased to a very low level (only for R&D).

The VLBI networks of NEOS (weekly) and NEOS Intensive (daily) are operated for Earth rotation and polar motion as well as for establishing and maintaining the celestial reference frame. The NEOS network is formed by Fairbanks, Green Bank, Richmond, Hawaii, Fortaleza, and Wettzell stations. Algonquin and Onsala occasionally join the NEOS observations. The Intensive operations are continued using the Green Bank-Wettzell baseline.

1.2 IRIS-S *(J. Campbell)*

IRIS-S is operated once a month with Wettzell and Westford/Green Bank including the southern hemisphere stations of Hartebeesthoek (South Africa), Fortaleza (Brazil). Santiago (Chile) took part in IRIS-S from mid 92 to mid 93. The frequency of IRIS-S experiments is low, but they provide high precision data owing to extreme baseline length for the study of long-term effects in Earth orientation.

The correlator at the MPIfR in Bonn is working at the saturation level, the personnel situation being the limitation. The MkIV correlator will supplant the present MkIIIA correlator in 1997 (financial support from IfAG, Geodesy).

1.3 IRIS-P *(Y. Tamura)*

IRIS-P is not in operation since last year because of lack of funding for correlation time in USNO and the problems with operational budgets at several stations.

A K4 type single-baseline correlator is running regularly in Mizusawa. It is mainly used for astrophysical purposes, but it has the capability for geodetic use. A ten-baseline correlator is under construction in the Mitaka headquarters of the National Astronomical Observatory. It is originally designed for space VLBI. Hence it does not have phase calibration. Plans are to modify its hardware for geodetic applications.

A joint project with China will start soon. A K4 type backend system will be installed at Urumqi station in China this year.

Plans to use the Syowa station in Antarctica are still being pursued, although the necessary funding has not yet been secured.

1.4 China *(S. Ye)*

The Status of the Shanghai Observatory was reported with a written memorandum. Several experiments of China-Germany-South Africa-Italy and China-Japan were described. A joint project between China and Japan was explained, and a new IRIS network, named IRIS-E (Eurasia) was proposed. (for more detail, see memorandum by Ye)

1.5 NASA/GSFC *(T. Clark)*

The NASA is conducting global VLBI campaigns for plate motion, celestial and terrestrial reference frames. It carries out R&D work on the further development of the VLBI DAS and correlator systems. The new MkIV correlator is under development with the cooperation of Haystack and the JIVE institute in Europe.

1.6 Other topics

M. Feissel (IERS): One copy of the new MkIV correlator will be built at Dwingeloo within the Europe-Haystack cooperation in MkIV development. It will be used mainly for astrophysics, but a smaller share of geodetic work is also possible. Plans are to schedule some European geodetic experiments on the basis of France's financial contribution to JIVE. The correlator is expected to be operational by the end of 1997.

T. Yoshino: To monitor the crustal deformation, four VLBI observation sites are being built in the Tokyo metropolitan area. The project is named Key Stone Project. The system is operated fully automatically to obtain daily solutions.

H. Schuh: The future of VLBI as a high precision geodetic technique should be ascertained by developing further VLBI technology, aiming at a high degree of automation and a replacement of tape recording by using wide band communications links (prospects of real-time VLBI). European VLBI group has proposed direct data communication by optical fiber network or satellite links.

T. Yoshino: In the Key Stone Project by CRL, real time data processing connecting four stations via optical fiber link is under development.

2. General Discussion

The topic of the optimal size of the radio source catalogue as the realization of the celestial reference system for the geodetic VLBI campaigns was brought up by Dr. Carter who stressed that the source list should not be much larger than the 100 or so core sources, and that other purposes (astronomical research goals on larger samples of geodetically less important sources) should not be supported by geodetic means. Agreement was reached on a set of 100 to 200 core sources to be large enough for geodetic reference frame purposes.

In view of the reorganization of the CSTG under Comm.8, a change in the title of the IRIS-subcommission was discussed. It now seems appropriate to change the title to the "VLBI-Subcommission" in accord with the usage for the other techniques, e.g. SLR-Subcommission.

3. New president

All the participants agreed to accept the nomination of Dr. Thomas A. Clark (NASA/GSFC) as the Chairman of the VLBI subcommission under CSTG for the next four year term.

Current Status of the Key Stone Project

Noriyuki Kurihara

Kashima Space Research Center
Communications Research Laboratory
893-1 Hirai, Kashima, Ibaraki 314-0012, Japan

Development of VLBI stations dedicated to the KSP, which monitors crustal deformation around the Tokyo metropolitan area with a space geodetic technique, started in FY1993. Three of four VLBI stations have already been completed construction. Daily observations on the baseline between Kashima and Koganei have been carried out since January 1995. The last one will be constructed during this fiscal year. Current timetable of development of each KSP station is as follows.

Data processing and analysis system

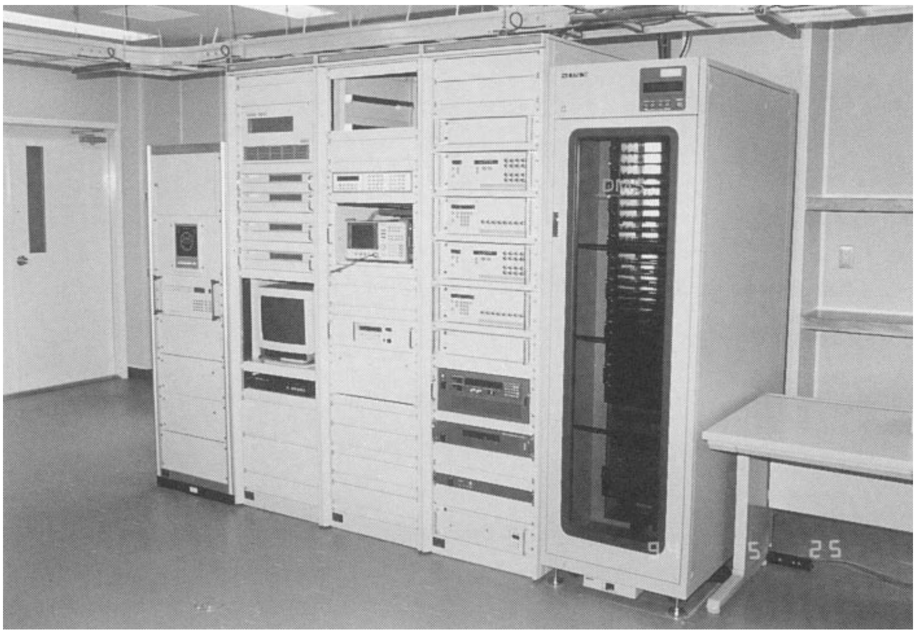
VLBI data are processed and analyzed routinely at Koganei Central station. New correlator dedicated to the KSP is just about ready for the routine processing. Presently careful check out comparing the correlation results between KSP and the conventional one (K3 correlator) tests combining both hardware and software are going on. We will enter the routine operation phase of the correlator by the end of FY1995 (March, 1996).

Future Plans

Real time VLBI, in which digitized data are transferred to the correlator through high speed communication link (optical fiber) instead of tape recording, will be realized on the KSP baselines in near future.

Table 1. Timetable of Each Station's Development

year	KOGANEI Center	KASHIMA Sub-Center	MIURA	TATEYAMA
	Data acquisition	Data acquisition	Data acquisition	
Oct.1995	System monitoring	System monitoring	System monitoring	
Dec.1995	Concentrated controlling	Concentrated controlling		
Mar.1996				Data acquisition System monitoring



KSP/VLBI system at Koganei station. From left: Weather station, antenna front-end control, calibration system, backend terminal, and automatic tape loading unit(DMS24).

The Results in the Daily Observation in the Crustal Deformation Monitoring System in the Tokyo Metropolitan Area

Y.Takahashi[1], N.Kurihara[1], T.Kondo[1], H.Takaba[1], T.Iwata[1], Y.Koyama[1], Y.Hanado[2], M.Sekido[1], J.Nakajima[1], T.Gotou[1], M.Imae[2], T.Yoshino[2], S.Hama[2], H.Kiuchi[2], A.Kaneko[2], H.Kunimori[2], T.Miki[2], J.Amagai[2], T.Ootubo[2], F.Takahashi[2]

[1] *Kashima Space Research Center*
Communications Research Laboratory
893-1 Hirai, Kashima, Ibaraki 314, Japan
[2] *Communications Research Laboratory*
4-2-1 Nukui-kita, Koganei, Tokyo 184, Japan

1. Introduction

We have established the crustal deformation monitoring system in the Tokyo Metropolitan Area (We call this project "KSP"). Both VLBI and SLR equipment are arranged at the four stations (Kashima, Koganei at HQ in Tokyo, Miura, and Tateyama). SLR observations will be conducted always in the clear sky and 5 hour VLBI experiments will be conducted everyday. The VLBI stations of Koganei and Kashima stations were constructed and we started the VLBI observations between Kashima and Koganei. The first 24 test experiment was conducted on 29th August in 1994, and we started 5 hours experiments on every week day since 31th of January in 1995. As it is in the period for test experiments now, we conducted the VLBI observations by 56 Mbps recording mode which is compatible with Mark-III. The regular daily 5 hours experiments will be started since this autumn using 256 Mbps mode on Kashima and Koganei baseline, and the VLBI observations of 3 stations including the Miura stations will be started at the beginning of next year. Figure 1 shows the configuration of stations and the results of baseline length.

The results in the daily test VLBI experiments from 31th January to 6th September (in the period of about 7 months) are described as follows:

(1) The station movement of Koganei against Kashima station,

(2) The change in the correlation amplitude, that is similar to correlated flux density for every quasar,

(3) The comparison of the clock (Hydrogen Maser).

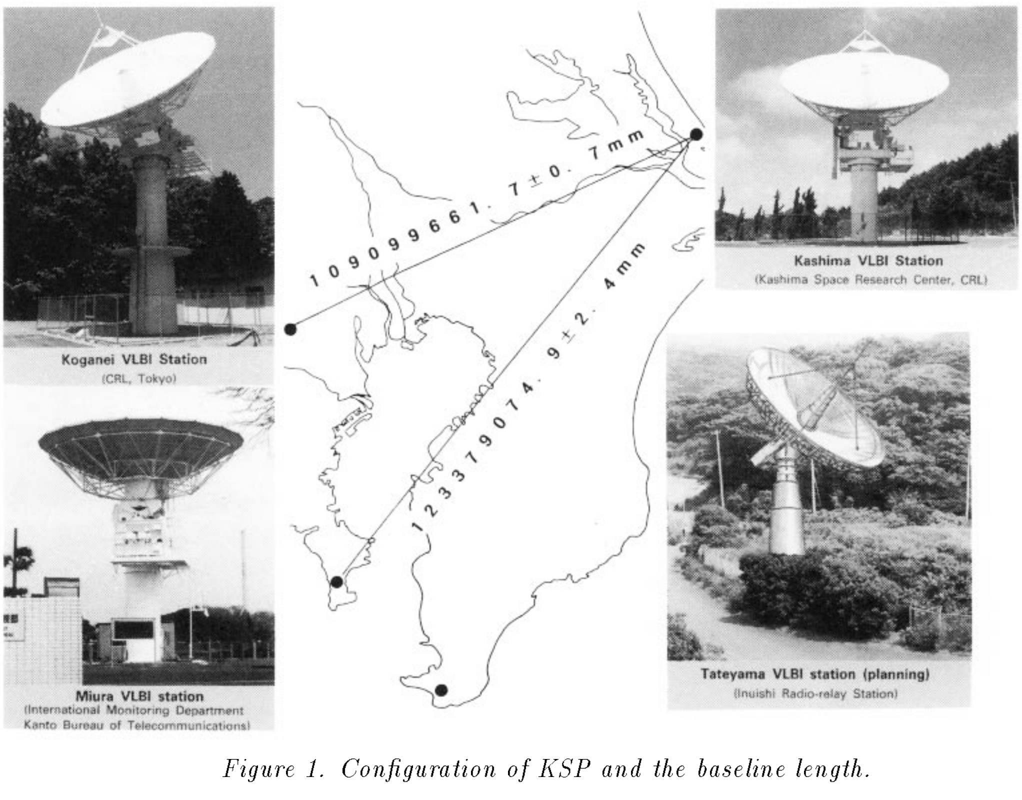


Figure 1. Configuration of KSP and the baseline length.

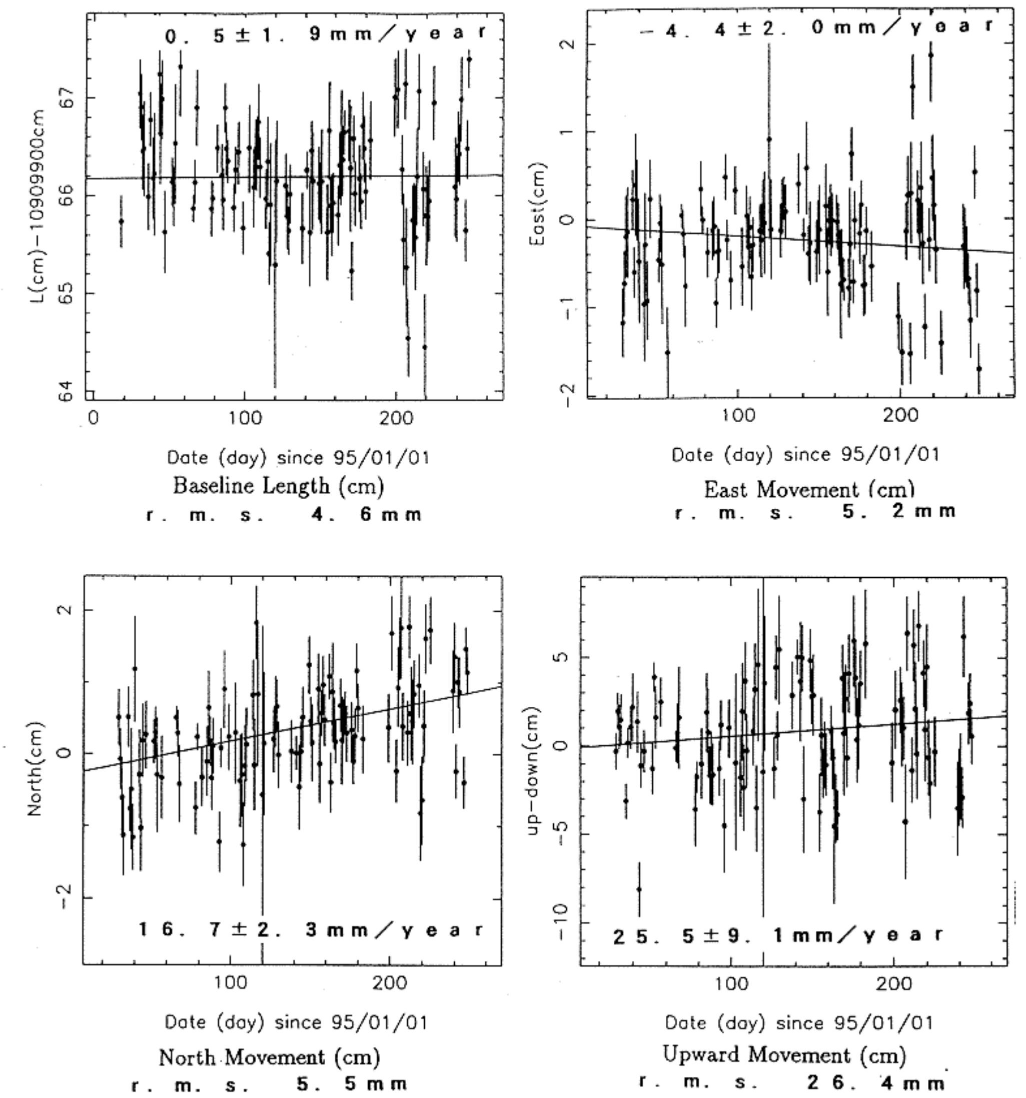


Figure 2. Movement of Koganei station against Kashima.

Table 1. Precision and repeatability in KSP test daily experiments.

	Mean Precision	Repeatability	Koganei	
			Position error	Change
	(mm)	(mm)	(mm)	(mm/year)
Baseline Length	3.2	4.6	±0.7	0.5±1.9
East Movement	3.4	5.2	±0.8	-4.4±2.0
North Movement	4.1	5.5	±1.0	16.7±2.3
Upward Movement	17.0	26.4	±3.3	25.5±9.1

2. Station Movements

We developed the software for the baseline analysis, which are called "Takemikazuchi". The software makes the data base and it makes the baseline analysis automatically. This software also supports making the results publically available using WWW (see Section 7).

Because of the test observations, we make a baseline analysis using the other software "SOLVE" which was developed by GSFC (NASA), and we describe these results since the repeatability of these results is a little better than those by automatic analysis software.

Figure 2 shows the change in the distance on the Kashima-Koganei baseline, and the changes in the position of Koganei (east movement, north movement, upward movement) against Kashima station (when the position of Kashima is fixed). Table 1 shows the summary of the precision. For the horizontal movements and baseline length, the precision and repeatability are about 5mm, and the precision for the vertical movement is about 2.5cm in spite of the test experiments of 56 Mbps mode. For the regular experiments of 256 Mbps mode, the precision will become one third of these results.

The position changes are described in the different methods. At first, one or several stations are fixed using the tectonic model, and the position changes in the other observed stations are obtained against the fixed stations. This method is useful to obtain the deformation of the observation net. Secondly, the movements are described for the international velocity field, such as ITRF (International Terrestrial reference Frame) or the velocity field of GSFC. Finally, the movements are described as the displacement from the plate motion. Figure 3 shows the movements of Koganei and Kashima stations. We also have the results by other experiments, which is call "MDX (Metropolitan Diamond Cross)". These experiments were conducted among Kashima 34m antenna, Koganei 3m antenna, and GSI 5m antenna since 1988 once or twice every year. We show both sets of results. Figure 3 shows these station movements. Figure 3-(a) shows the movement of Koganei station relative to Kashima station. Figures 3-(b),(c) are the movements of Koganei and Kashima stations for the displacement from North American Plate motion in the reference of the GSFC velocity field in 1993, and in the reference of the ITRF velocity field in 1993. Figure 3-(d) shows the movements in the reference of the ITRF velocity fields in 1993. Figure 3-(e) is the plate motion on the plate boundary.

In the Alaska area, the station movements for the displacement from the North American Plate motion are similar to the direction of the Pacific plate motion on the plate boundary. In the Japanese area, the movements of the Kashima and Koganei stations in both KSP and MDX experiments are similar to the direction of the Pacific Plate motion and the Philippine Sea Plate motion shown in Figure 3-(e). It is possible that the deformation is caused by the pressure of the plate motion. The movements obtained from KSP experiments are different from those from MDX experiments. Furthermore, the results appear to differ according to which velocity field is used as a reference.

In Japan, many GPS stations and several VLBI and SLR stations are observed, and the results are collected. The reference of the velocity field may become important.

3. Change in the correlated amplitudes

In KSP experiments, the correlated amplitudes are obtained everyday, and we can monitor the change of the correlated flux density for several quasars. Figures 4,5 show the change in the mean value of correlated amplitudes on the Kashima-Koganei baseline for 12 sources at X band and S band, respectively. The mean value averages the different observations for the resolution and the elevation dependency. In this test period, we do not have the calibration data, but we can estimate approximately that 0.01about 0.3Jy at S band. Different changes for different sources may be caused by changes in the correlated flux density. We can monitor the continuous variation of the source flux density for unresolved center part and the burst change.

4. Comparison of the clock

In KSP experiments, we can monitor the clock. As we have no information concerning the internal delay in the antenna, the absolute difference of clock (Hydrogen Maser) is unknown, but the change in the clock is observed. Figure 6 shows the change in the comparison of the clock and the change in the clock rate. The reasons for the clock jump is known. The rate change means the stability for long periods.

5. Conclusion

We have conducted 5 hour VLBI experiments for every week day since 31 January, 1995. Though these experiments are test experiments in the 56 Mbps mode, we obtain good results and information concerning the practical errors, which are the same as the theoretical errors. From these results, we believe that we can achieve 2mm precision for the horizontal component and baseline length, and 9mm precision for the vertical component in the regular 5 hour VLBI experiments in the 256 Mbps mode, and these precisions are reduced to half for 24 hour VLBI experiments in the case of real time VLBI.

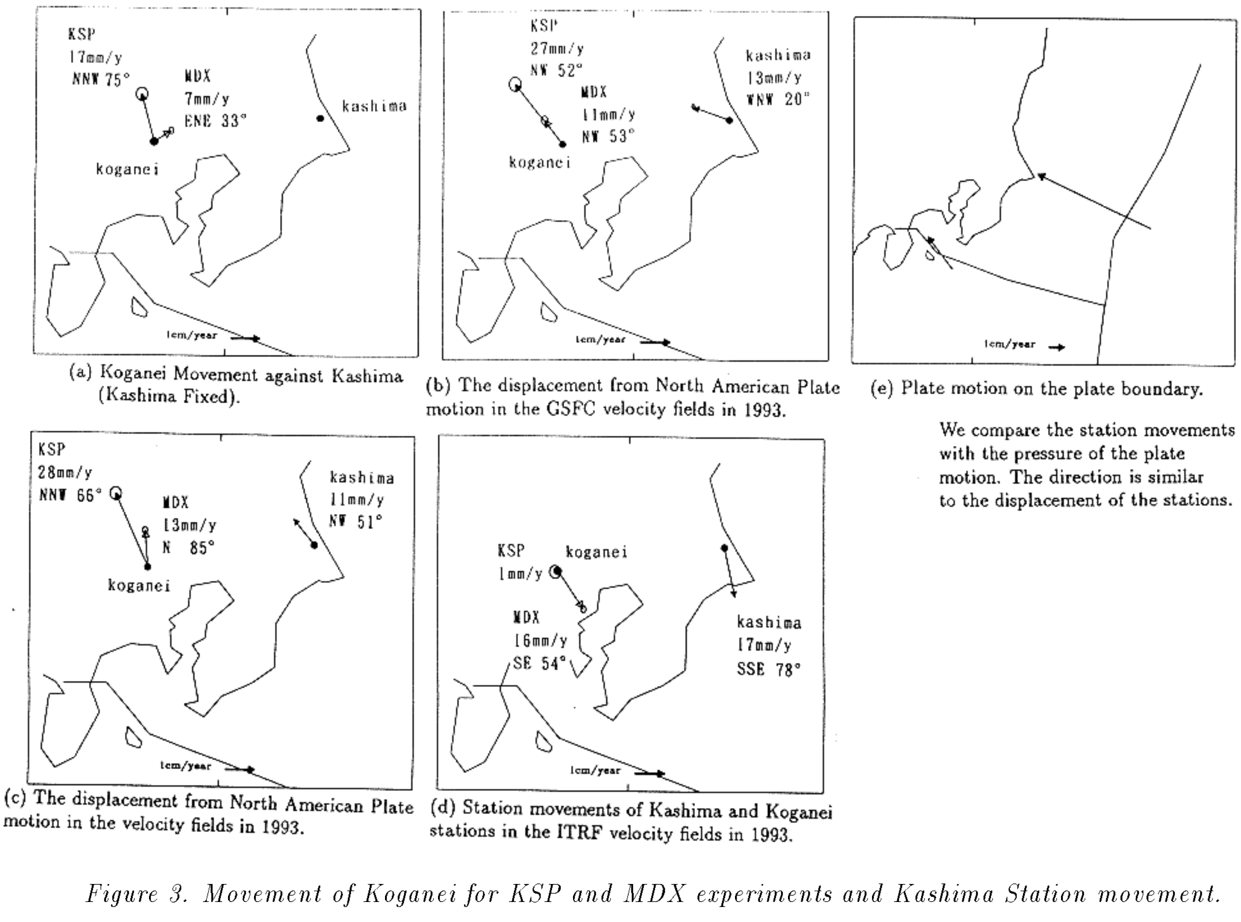
The motion of Koganei station relative to Kashima station are measured. The movements are slightly different from those inferred from MDX VLBI experiments. However, the displacement from the North American Plate motion is similar to the direction of the pressure of the plate motion on the plate boundary. The movements of the other VLBI stations, at Tsukuba and Kanozan, are also the same direction.

The indication of the station movements differens according to the velocity field that is used as a reference. It is important that the reference velocity field should be common since the comparison of the different analyses and different equipment should be not confused. We also obtain the continuous changes in the correlated flux density in KSP experiments. These changes are useful in characterizing the burst changes of the quasar.

The KSP will be completed in next year, and we will obtain the positions of 4 stations with the precision of 2-3mm using daily VLBI and SLR. Furthermore, the real time VLBI using 256 Mbps data transfer by optical fiber cable will be started during the next year.

6. Announcement

The results of KSP experiments, which are the station movements and the correlated amplitudes, are made available using the inter-net "WWW". The station movements are the results by the automatic analysis software. The reference is the position of the Kashima station moved by the latest ITRF. When you want to see the results, URL is "http://kouma.crlgo.jp/" in English and "http://kouma.crl.go.jp/index-j.html." in Japanese. If you have some question about this service, please ask Y.Koyama in CRL (Email koyama@crl.go.jp) or Y.Takahashi (Email takahashi@crl.go.jp).



(a) Koganei Movement against Kashima (Kashima Fixed).

(b) The displacement from North American Plate motion in the GSFC velocity fields in 1993.

(e) Plate motion on the plate boundary.

We compare the station movements with the pressure of the plate motion. The direction is similar to the displacement of the stations.

(c) The displacement from North American Plate motion in the velocity fields in 1993.

(d) Station movements of Kashima and Koganei stations in the ITRF velocity fields in 1993.

Figure 3. Movement of Koganei for KSP and MDX experiments and Kashima Station movement.

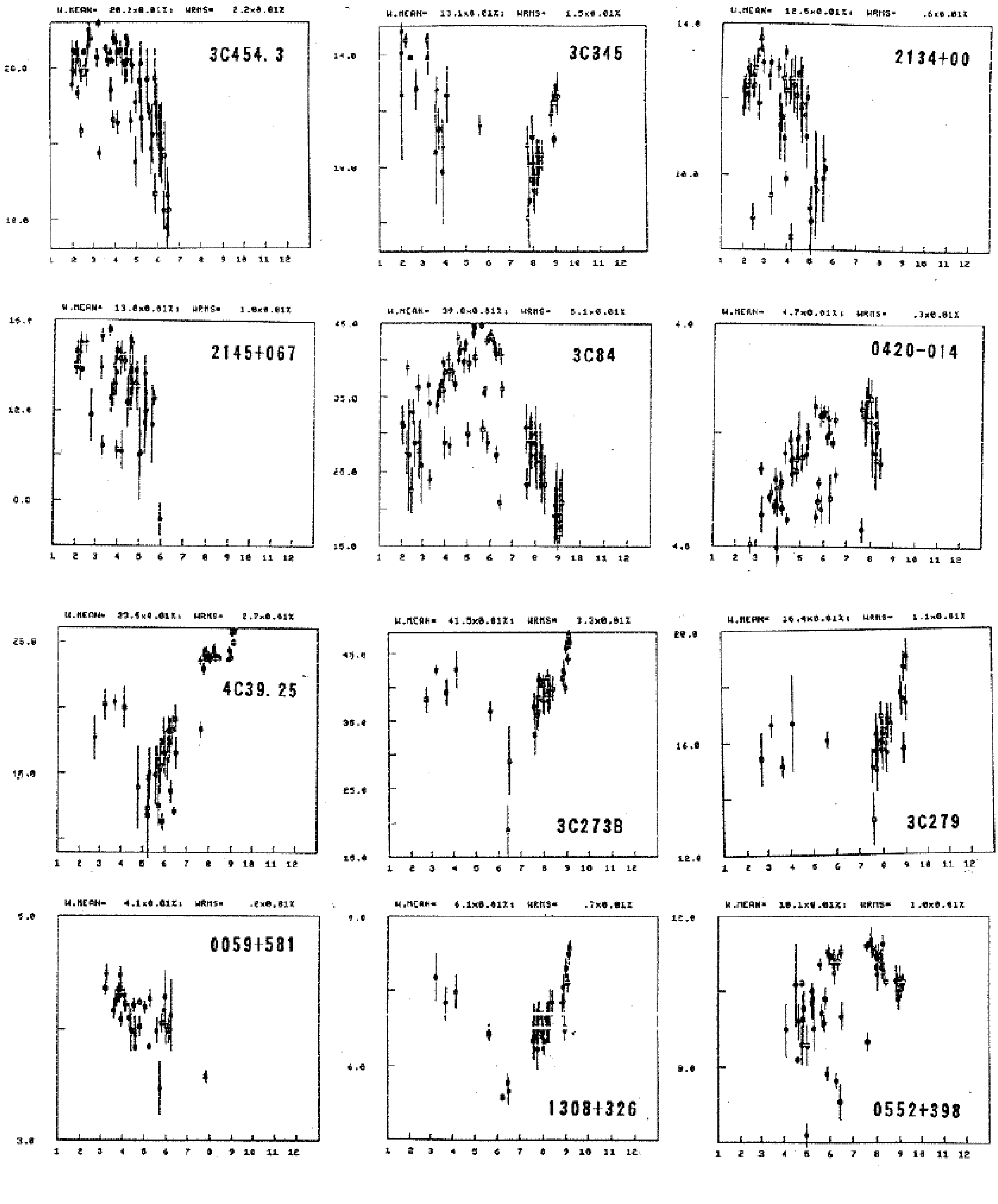


Figure 4. The change in the correlated amplitude at X band on Kashima-Koganei baseline without the correction.

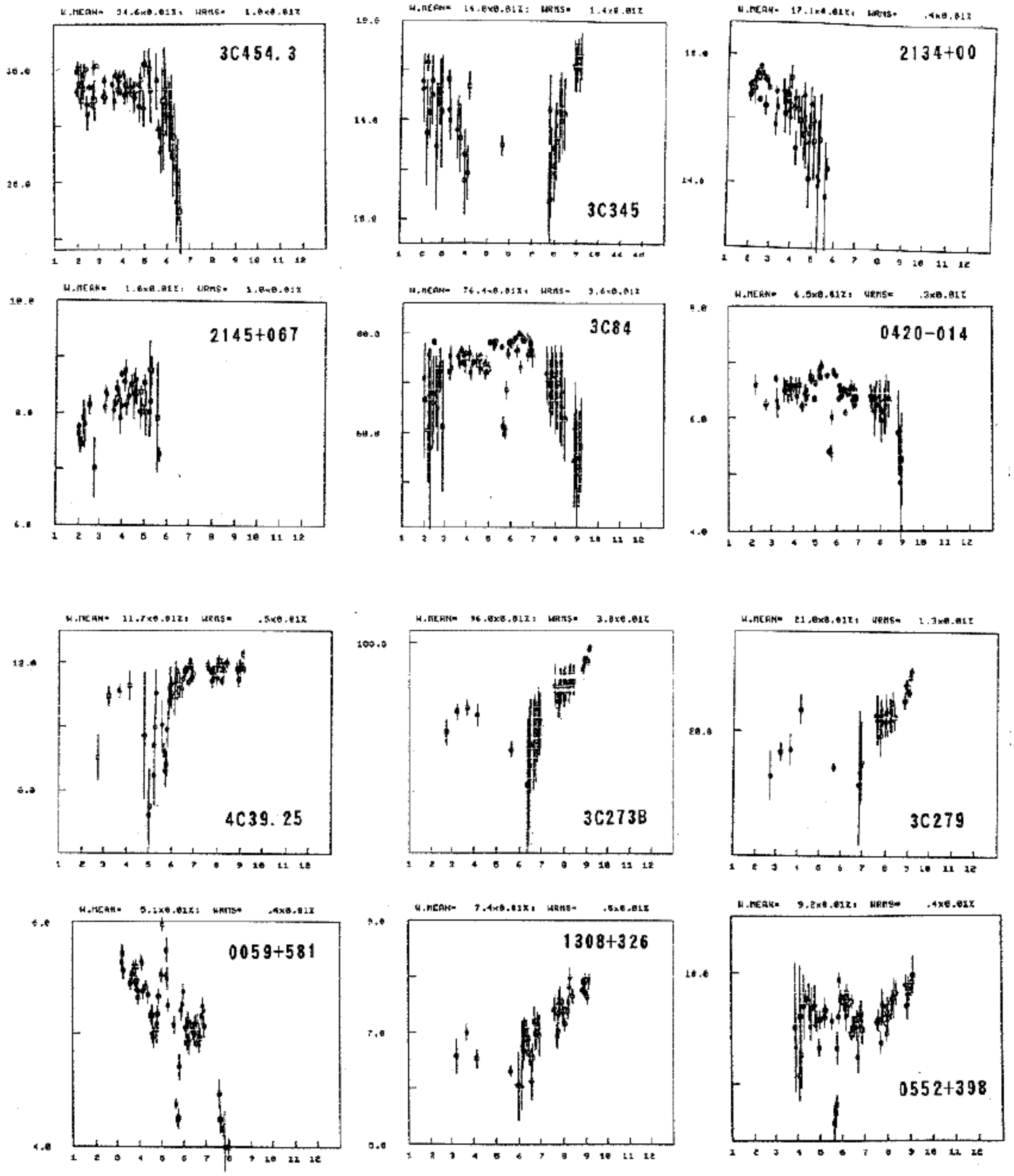


Figure 5. The change in the correlated amplitude at S band on Kashima-Koganei baseline without the correction.

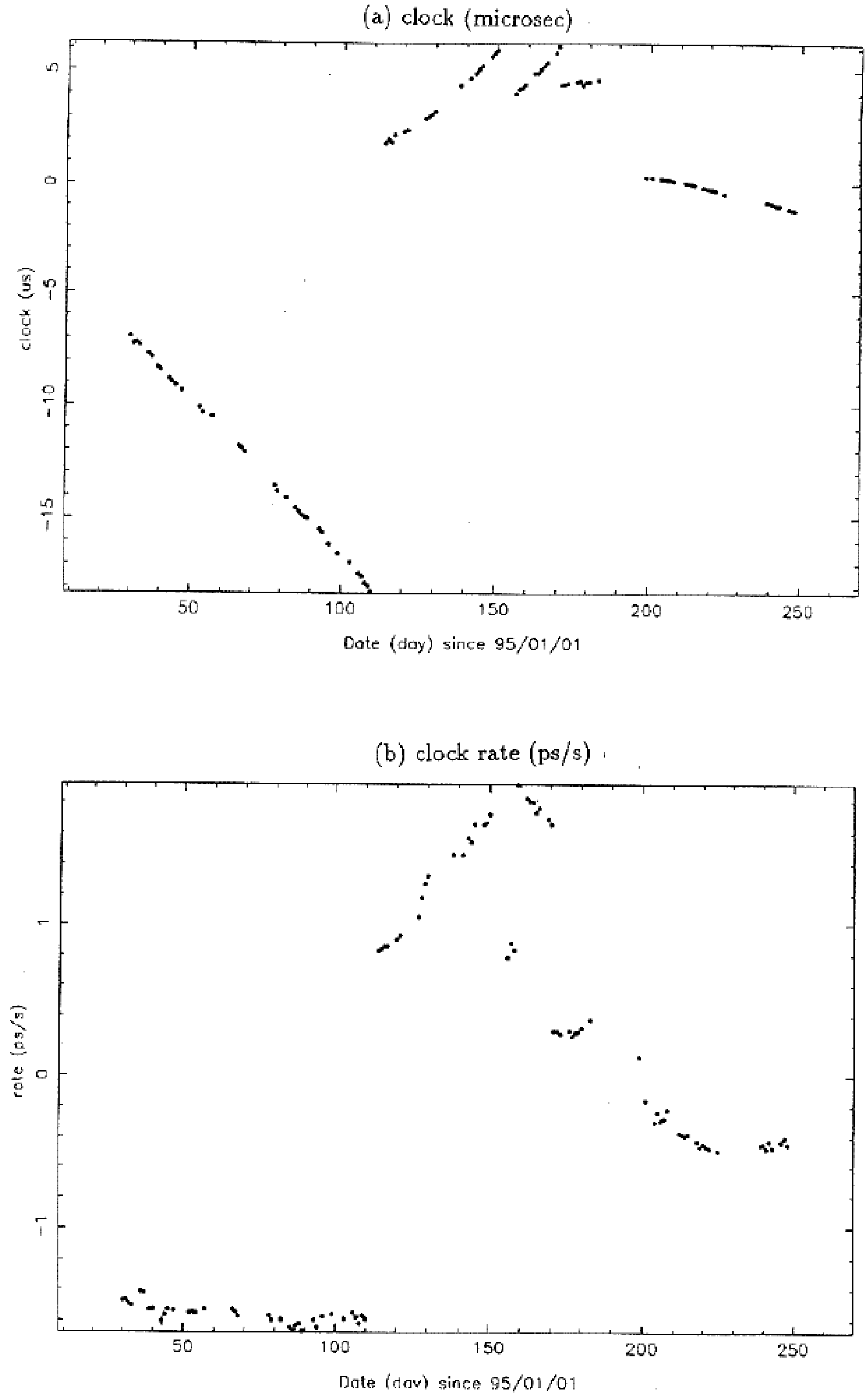


Figure 6.The change in the clock between Kashima and Koganei stations.

Real Time VLBI Plan in the Key Stone Project

Michito Imae[1], Hitoshi Kiuchi[1], Tadahiro Goto[2], Shin'ichi Hama[1], Yukio Takahashi[2], Taizoh Yoshino[1], Hiroyuki Hara[3], Hisao Uose[3]

[1] *Communications Research Laboratory*
4-2-1 Nukui-kita, Koganei, Tokyo 184, Japan
[2] *Kashima Space Research Center*
Communications Research Laboratory
893-1 Hirai, Kashima, Ibaraki 314, Japan
[3] *NTT*

1. Introduction

CRL has been constructing the precise crustal deformation measuring system in the Tokyo Metropolitan Area using the space geodetic technique, such as VLBI and SLR, which is called "Key Stone Project" (KSP) from 1993.

The main target of this project is monitoring the crustal deformation in mm order level daily for the study of earthquakes.

For this purpose the real time VLBI, real time received data transmission and quick data processing, is being planned in cooperation with NTT (Nippon Telephone and Telegraph Co.), with high rate digital data transmission links among the KSP stations.

This report describes the concept of the real time VLBI which is now under construction.

2. Limit of Recorder Base VLBI and Real Time VLBI

Development of the VLBI system was made possible by progress in highly stable frequency standards, such as the hydrogen maser, and high speed digital data recorder. But due mainly to the recording rate of the data recorder, there are several limitations in the VLBI system.

Some of them are

1. receiving band width which is limited by the recorder's recording rate. In the case of K-4 system, 256 Mbps is the maximum recording rate of the data recorder.

2. time delay to obtain the analyzed data from observation, mainly the need for tape transportation after the observation.

On the other hand, nowadays high rate digital data transmission links using optical fiber cable are available or under development which have the transmission rate of several hundred Mbps or exceed 1 Gbps.

The real time VLBI using such a high rate digital communication link will be one of the "breakthroughs" of VLBI to improve the performance and to shorten the duration to output the final data.

3. Real Time VLBI Plan in the KSP

Figure 1 shows the block diagram of the real time VLBI in the KSP project.

The received signal is digitized by the acquisition system at each station and transmitted to the correlation station by using high rate ATM (Asynchronous Transfer Mode) link through the ATM transmitter.

The transmitted data from each station are combined at the ATM cross-connector at NTT Mitaka and transmitted to the correlation center located at CRL Koganei. The ATM receiver placed at the correlation center absorbs the jitter of the ATM cells and transmission delays using memories.

Each ATM link has the ability of 2.4Gbps transmission rate, but we use the VLBI sampling rate of 256Mbps to keep the compatibility to the recorder base VLBI experiments.

The correlator which is used in the real time VLBI is basically a same as the tape-based one, and it has the processing rate up to 512Mbps. After the real time VLBI using 256Mbps sampling rate technology will be confirmed, we will challenge higher rate data sampling for the next step.

4. The Future of Real Time VLBI

The real time VLBI will be a very powerful solution to improve the VLBI's capabilities. But it is not the all-round tool, because

1. high rate digital link cost is very expensive,

2. the raw data will be missing without any backup recording system.

So it is important to consider the real time VLBI's application field.

5. Conclusion

The real time VLBI facilities are now under construction for the KSP project, and its first fringes will be detected early in 1996.

But the regular base real time VLBI operations will be started after careful comparison with the recorder base VLBI experiments. The preliminary data will be presented in the next TDC's news.

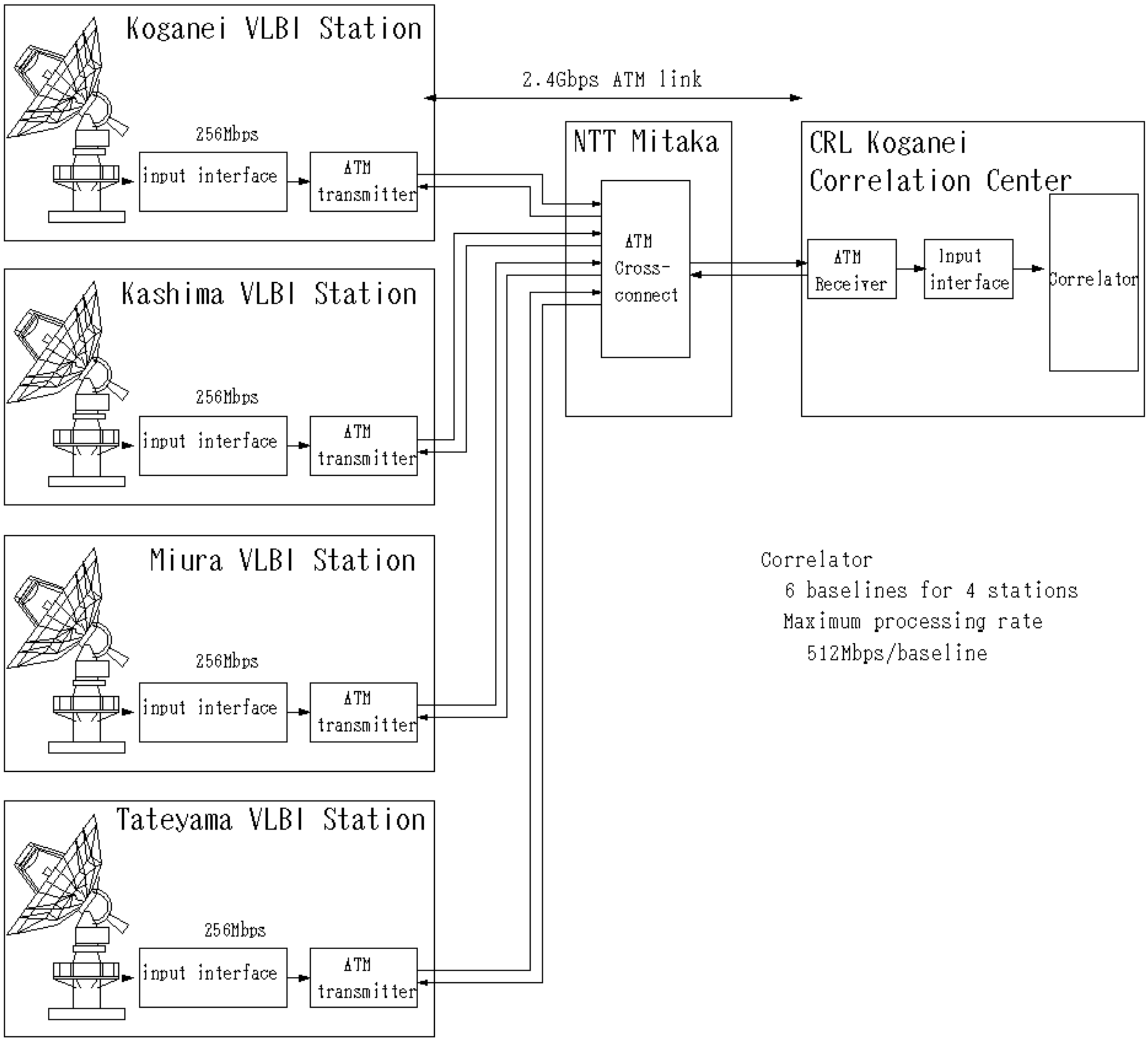


Figure 1. Block diagram of the realtime VLBI in KSP project.

Status Report of the CRL 34 m Antenna at Kashima

Hiroshi Takaba

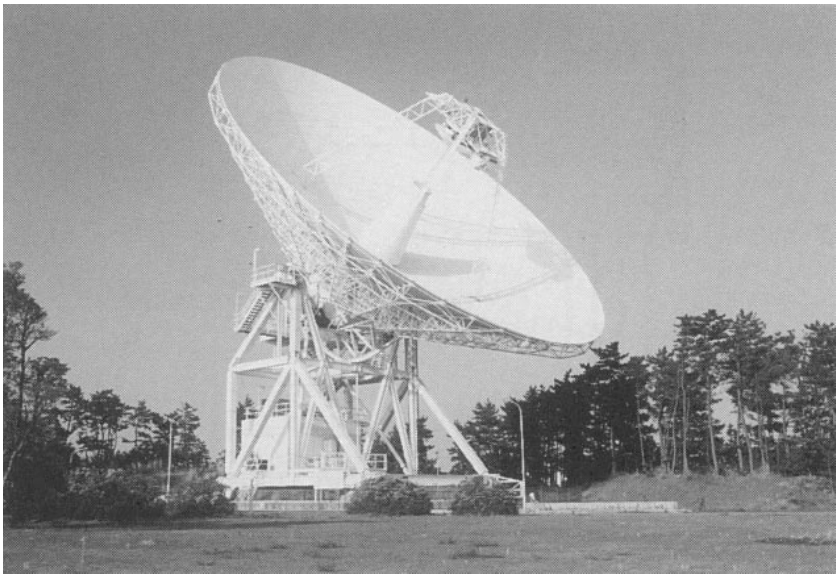
Kashima Space Research Center
Communications Research Laboratory
893-1 Hirai, Kashima, Ibaraki 314-0012, Japan

1. Antenna Control System

Antenna control unit (ACU) and receive band interchange computer will be replaced to new models in 1995.

2. Receiver System

1.5 GHz Receiving Syetem	Good
2/8 GHz Receiving Syetem	Good
5/10 GHz Receiving Syetem	Problem on the vacuum of the Dewar. Not available. A new room temperature LNA is considered to use for the space VLBI experiment (VSOP).
15/22 GHz Receiving Syetem	The receiver noise temperature of the 22 GHz system increases twice.
43 GHz Receiving Syetem	A new system using an SIS mixer was being tested.



34 m antenna at Kashima

The Next Generation Giga-bit VLBI Terminal

Junichi Nakajima[1], Hitoshi Kiuchi[2], Sachiko Okumura[3], Kazuyoshi Sunada[3], Hideyuki Kobayashi[4], Yoshihiro Chikada [3] and Noriyuki Kawaguchi[3]

[1] *Kashima Space Research Center*
Communications Research Laboratory
893-1 Hirai, Kashima, Ibaraki 314, Japan
[2] *Communications Research Laboratory*
4-2-1 Nukui-kita, Koganei, Tokyo 184, Japan
[3] *National Astronomical Observatory*
[4] *Institute of Space and Aeronautic Science*

Joint Japanese group (NRO, ISAS and CRL) have started to develop new VLBI terminals. This system will standardize surprisingly high speed aquisition (1024M-bits per second) in the near future. To establish high sensitivity in VLBI observations, which enables observations of the weak distant QSO, we must make better use of the receiver bandwidth. Ground based VLBI is limited by the radio telescope aperture size and the integration time due to the atmosphere. Development of both the High Speed Sampler and the High Speed Data Storage has started. This equipment will be employed as the next Japanese VLBI standard terminal (Fig.1). We will name the system brand new "J-1" or something which indicate the difference from the K-4 series.

The High Speed Sampler is designed to sample the data rate of 1024/512/256MHz 1/2/4ch 1/2bit selection. The baseband signal is supplied from the NRO wide-band video converter which receive 5 to 7GHz IF optical transmission. The sampler is equipped with the external time code input. When the correlation system needs the time code, it can insert a user programmable one. We will use the DSO (Digital Storage Oscilloscope) AD-aquisition module for the sampler. The continuous sampling DSO provides the function of selection of various rates and channels. Hence we are using the DSO, this sampler can monitor the input signals directly. This is convenient to adjust the signal level. The sampler applications to the interferometer and the digital spectrometer components are possible.

The High Speed Storage System will reach the 1024Mbits/sec recording. To achieve the first ever performance in VLBI, we are modifying the HDTV-VCR (High Definition TV Video Cassette Recorder). This recorder is designed for multi-HDTV-formats. VLBI raw data is recorded as the part of HDTV frame data. Error rate is better than 10^{-10}. The recorder time sequence is controlled by the newly designed VLBI interface. The interface is arranged to record the data without time code. Playback speeds of 1/2 to 1/32 are possible for the low-data rate correlation system. Some of the initial specifications of the VCR did not reach our targets, and we are trying to increase the performance.

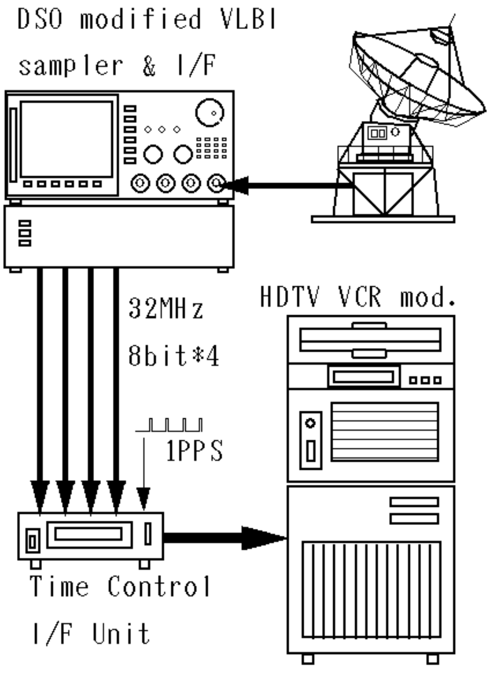


Figure 1. 1024Mbps VLBI terminal.

Pulsar VLBI Kashima(Japan)-Kalyazin(Russia) Pulsar VLBI Experiment in 1995

M. Sekido[1], Y. Hanado[2], M. Imae[2], Y. Takahashi[1], Y. Koyama[1], Yu. P. Ilyasov[3], A. E. Rodin[3], A. E. Avramenko[3], V. V. Oreshiko[3], and B. A. Poperchenko[4]

[1]*Kashima Space Research Center*
Communications Research Laboratory
893-1 Hirai, Kashima, Ibaraki 314, Japan
[2]*Communications Research Laboratory*
4-2-1 Nukui-kita, Koganei, Tokyo 184, Japan
[3]*Astro Space Center P.N. Lebedev Physical Institute, Russia*
[4]*Special Research Bureau of the Moscow Power Engineering Institute, Russia*

1. Introduction

Pulsars are high-velocity objects (Lyne 1994) and their positions and proper motions are important for our understanding of the formation and evolution of pulsars. Accurate astrometric measurements by inter-continental VLBI observation will determine the positions and proper motions of pulsars in several years interval observations.

2. Observation and data acquisition

A VLBI experiment observing pulsars and reference sources was carried out by Kashima(Japan)-Kalyazin(Russia) baseline in March of 1995. This experiment was organized by collaboration between Communications Research Laboratory (CRL) and Lebedev Physical Institute of Russian Academy of Science (LPI). The antenna diameter and efficiency of Kashima and Kalyazin are 34m, 60%, and 64m, 60% respectively. Observation frequency band 1.4GHz was down converted to video band and divided into 16 channels with each 2MHz width. Data of each channel are sampled with 4Mbps sampling rate and recorded by K-4 VLBI recorder. This was the first VLBI experiment between Kashima and Kalyazin, therefore making sure of the direction of circular polarization, as well as of the coordinates of Kalyazin station was main purpose of this experiment.

3. Data processing

The K3 correlator, developed by CRL, was used for cross correlation processing. First fringes were successfully detected. K3 correlator has a gating function, which enhance the Signal to Noise Ratio (SNR) of pulsar data by accumulating only a part of the pulsar's signal. Initially we processed the pulsar data without the gating function. Correlation processing with gating function will be done soon. By using the gating function, weak pulsars, which have not yet been observed with interferometric methods, will become observable.

4. Preliminary result

A MkIII database, which is used for ordinary geodetic analysis data storage, was made for pulsar VLBI data. The analysis software Solve, which is widely used for geodetic analysis, was used to analyze the position of pulsars. In Fig.1, mark • shows the result of this experiment and shows the position from Taylor's catalog (J.H.Taylor 1993). The discrepancies between the results and catalog position may be due to several reasons. The main reason is ionospheric delay: ionospheric delay compensation cannot be done with single band (1.4GHz) data. Another reason may be the difference of coordinate systems. Timing positions are relative to a reference frame defined by an ephemeris of Solar system motions, whereas interferometric positions are relative to equatorial frame defined by the rotation of the Earth to background extragalactic sources.

5. Future

By applying the pulsar gating function of K3 correlator, SNR will be enhanced and accuracy of the position will be improved.

This experiment had been organized to analyze the difference of delay between pulsars and closest reference sources (Differential VLBI). By applying this method, calibration of ionospheric delay will be improved.

We are planning to equip K4 backend system at Kalyazin station for a few years. Then we will be able to organize pulsar VLBI experiments frequently.

Investigation for how we should compensate the ionospheric delay will be necessary. We are considering of using GPS observation for this purpose.

References

Taylor,J.H., Manchester,R.N., and Lyne,A.G., (1993) Astrophys.J .Suppl., 88, 529-568. "Catalog of 558 Pulsars"

Lyne,A.G., and Lorimer,D.R. (1994). Nature 369, pp.127-129., "High birth velocities of radio pulsars"

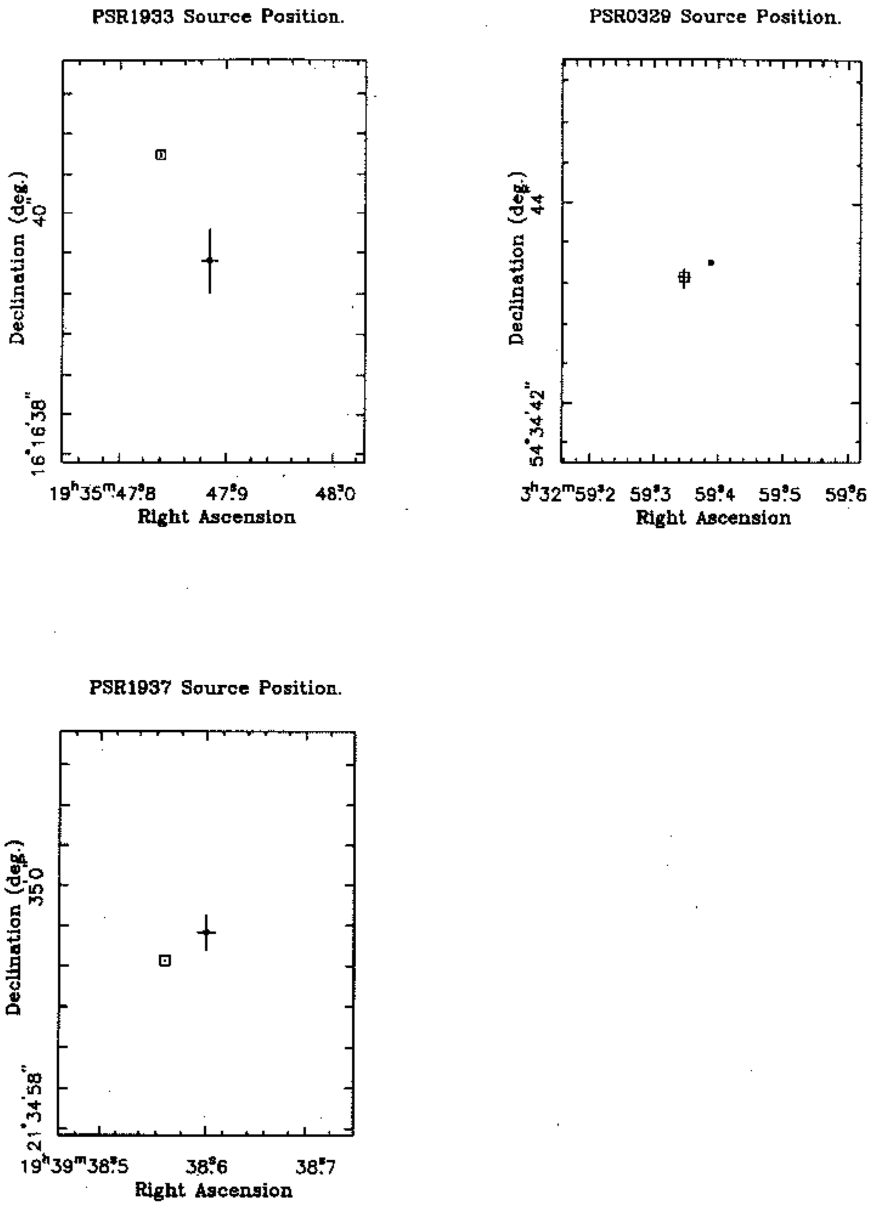


Figure 1. Mark • shows the result of this experiment and shows the position from Taylor's catalog (J.H.Taylor 1993). The discrepancies between the results and catalog position may be caused from some reasons. Main reason may be caused from ionospheric delay because ionospheric delay compensation cannot be done with single band (1.4GHz) data. Other reason may be the difference of coordinate . Timing positions are relative to a reference frame defined by an ephemeris of Solar system motions, whereas interferometric positions are relative to equatorial frame defined by the rotation of the Earth to background extragaractic sources.

UT1 Prediction Improvement Using AAM Data for Daily VLBI Baseline Analysis

Jun Amagai[1], Yukio Takahashi[2], Taizoh Yoshino[1], and Guo Wei[3]

[1] *Communications Research Laboratory 4-2-1 Nukui-kita, Koganei, Tokyo 184, Japan*
[2] *Kashima Space Research Center Communications Research Laboratory 893-1 Hirai, Kashima, Ibaraki 314, Japan*
[3] *Shaanxi Observatory, Chinese Academy of Sciences*

Crustal deformation monitoring network is under development in Tokyo metropolitan area by Communications Research Laboratory using VLBI and SLR techniques. The observation network consists of four stations which are connected by high speed data transmission network using ATM switch for the real time VLBI. Precise Earth's rotation parameters, in particular UT1, are needed in time to determine the baseline vector. The simple method to predict UT1 from AAM (Atmospheric Angular Momentum) data was investigated and the precision of the predicted value was evaluated.

The error of the UT1 predicted by IERS and that calculated from AAM data are shown in Fig.1 (a) and Fig.1 (b) respectively. Predicted UT1 is compared with IERS Bulletin-B final value. The UT1 prediction derived from AAM data is twice better than that of IERS Bulletin-A. In this study, the oldest value in the latest cycle of IERS rapid data was used for the initial value of integration. We may have a possibility to improve the precision of prediction by introducing a more skillful method such as Kalman filter.

Recently AAM data are calculated by Japan Meteorological Agency within 6 hours. Because the amount of AAM data is very small, it is easy to introduce AAM data by FTP for quasi-real time analysis of KSP.

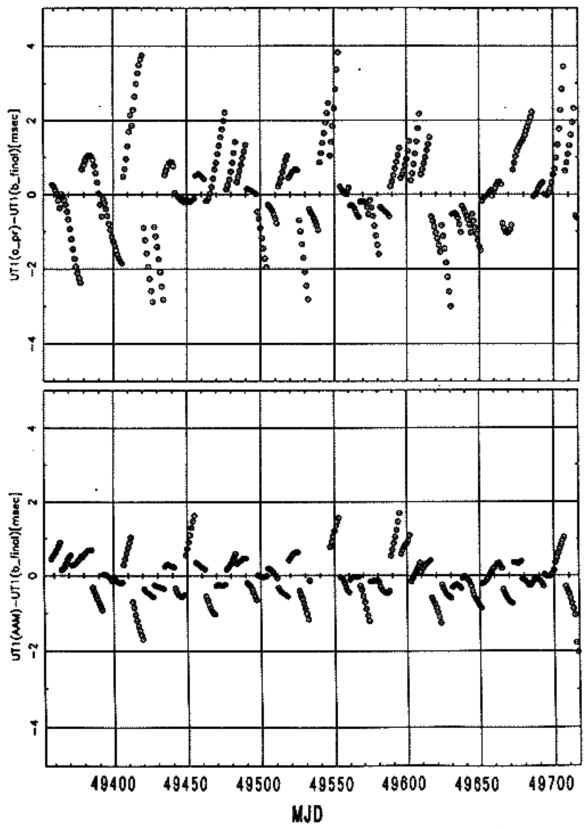


Figure 1. The error of the UT1 predicted by IERS Bulletin-A (a) above and that calculated from AAM data (b) bellow respectively (Comparison with IERS final value).

Atmospheric Path Delay Correction Based on The Numerical Prediction Data

ICHIKAWA, Ryuichi

Kashima Space Research Center
Communications Research Laboratory
893-1 Hirai, Kashima, Ibaraki 314-0012, Japan

1. Introduction

Atmospheric path delay is a serious error source in measurements by very long baseline interferometry (VLBI) both through ray path bending and the modification of the electromagnetic wave velocity. The delay has been separately discussed because of its causes; one is the "wet delay" due to the dipole component of water vapor and the other is the "hydrostatic delay" due to the nondipole components of atmospheric constituents. Geodesists have especially focused their attention on devising techniques for estimating the wet delay because of the significant variability of water vapor. Conventionally, the wet delay for each site has been estimated from a "zenith delay" and a "mapping function", with the latter function describing the elevation angle behavior of the atmospheric path delay (e.g. Chao, 1972; Davis et al., 1985). The zenith wet delay is estimated from (1) a model relating surface meteorological conditions to this delay (e.g. Saastamoinen, 1972), (2) observation by using a ground-based water vapor radiometer (WVR) (e.g. Hogg et al., 1983), and (3) parametric estimation by using a stochastic process such as the Kalman filtering techniques (e.g. Herring et al., 1990; Tralli et al., 1992). The mapping functions are constructed for a spherically symmetric atmosphere. On the contrary, the atmospheric water vapor, temperature, and pressure vary in various temporal scales and spatial dimensions. Consequently, we exactly require an effective method to correct the azimuthal asymmetry of the wet delay to attain sub-millimeter accuracy.

2. Atmospheric Path Delay Estimated by Numerical Prediction Data

Recently, the numerical weather prediction model has been successfully used for the purpose of the operational weather prediction. The three-dimensional grid point data set is produced from the numerical weather prediction model can be applied to estimate the wet delay. Figure 1 shows a schematic figure of the global analysis (GANL) data set by the Japan Meteorological Agency (JMA) (JMA, 1993). The GANL data are given four times a day to a 1.875-degree latitude-longitude grid system with 16 layers (surface and 15 standard pressure levels, i.e., 1000, 850, 700, 500, 400, 300, 250, 200, 150, 100, 70, 50, 30, 20, and 10 hPa). At each grid point meteorological elements, geopotential height, temperature, dewpoint depression, and wind vector are computed from the data obtained by radiosonde, aircraft, maritime and satellite observations, using a multi-variate optimum interpolation method (Lorenc, 1981) together with the forecast values. Figure 2 shows the temporal variations of the zenith wet delay based on the GANL data set and that from radiosonde observation at Tateno near Tsukuba and Hachijo-jima in the West Pacific during the period from April 1988 to February 1989. At both sites the zenith wet delay computed from radiosonde data varies from 5 to 20 cm in winter (January), and from 20 to 40 cm in summer (July). Moreover, the amplitude of delay variation within the period of several days reaches more than 10 cm during all seasons. The zenith wet delay based on the GANL data set is well consistent with that from radiosonde observations in both amplitude and phase through the period. It is clear that the GANL data set exhibits a good recovery of the observed meteorological conditions. JMA developed finer mesh

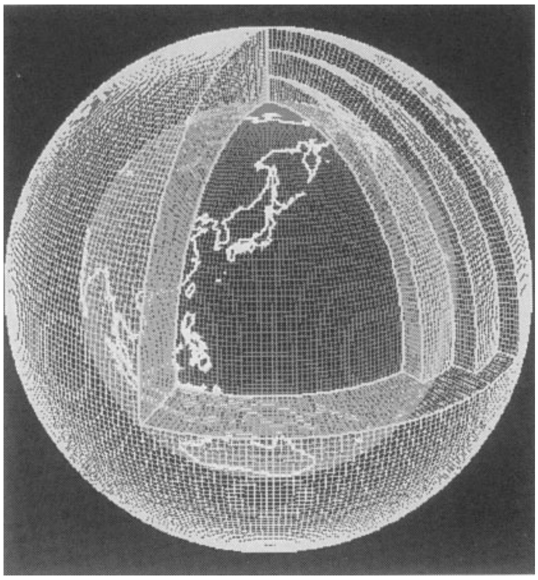


Figure 1. Grid system of the JMA (Japan Meteorological Agency) global analysis data. (after JMA(1995))

model, named the 10 km spectral model to forecast mesoscale phenomena accurately as shown in Figure 3. The 10 km data are given on a 97 × 97 latitude-longitude grid system with 10 km intervals (at 60 degrees N) and 12 layers (surface and 11 significant pressure levels, i.e., 1000, 900, 850, 700, 500, 400, 300, 250, 200, 150, and 100 hPa) for the purpose of the numerical prediction of mesoscale phenomena of the order of 20-200 km, such as squall lines, cloud clusters and so on. The outputs from the model can be available to correct the azimuthal asymmetry of the wet delay. Figure 4 shows an example of positioning errors due to the azimuthal asymmetry of the wet delay numerically estimated by 10 km spectral model (Ichikawa et al., 1994). Minimum elevation angle of 15 degrees is assumed. According to the figure, uncertainties of baseline vectors are up to several centimeters in horizontal and more than one centimeter in vertical.

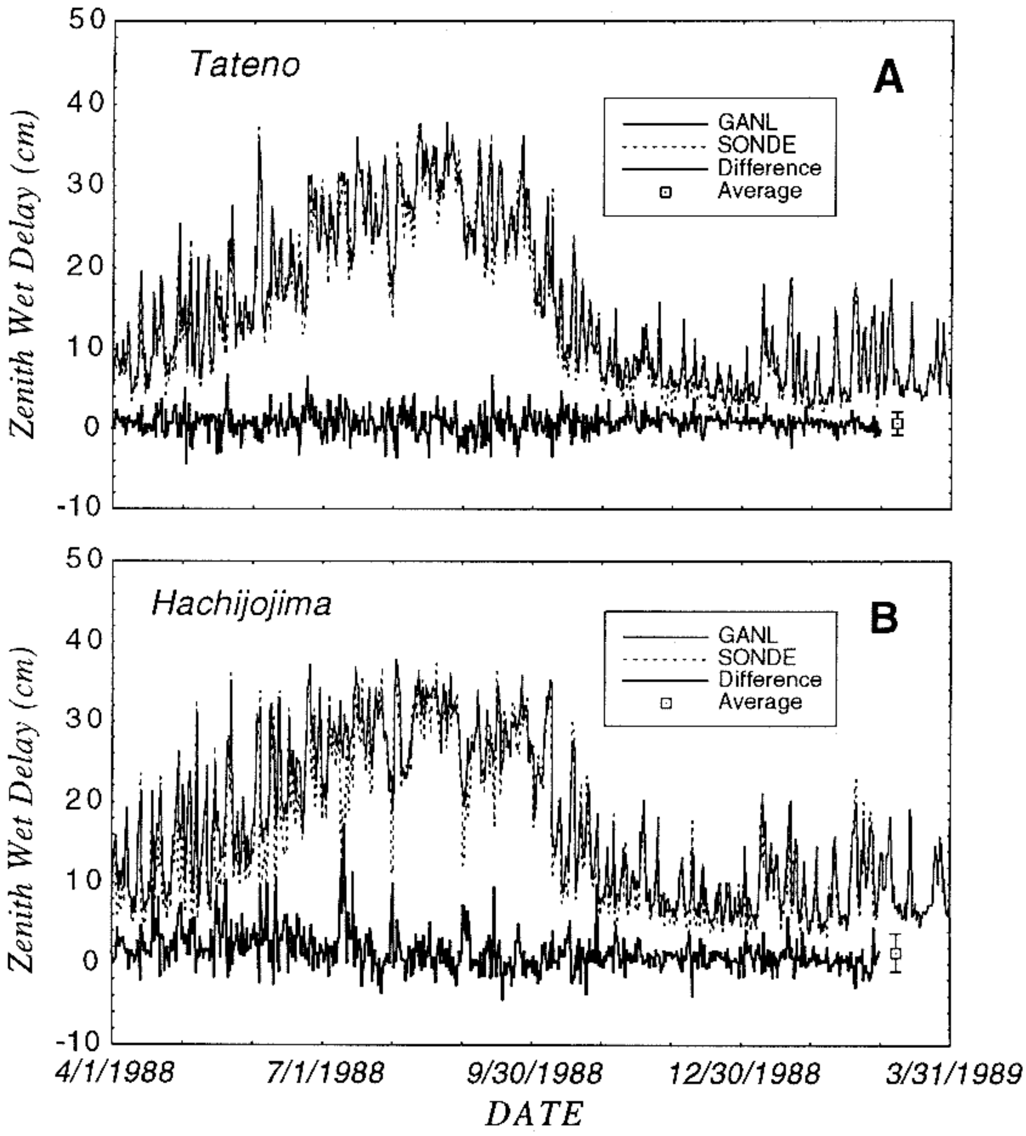


Figure 2. Daily variation of the zenith wet delay based on the global analysis data set (solid line) and that from radiosonde observation (broken line) during the period from April 1988 to February 1989 at Tateno (upper) and Hachijojima (lower).

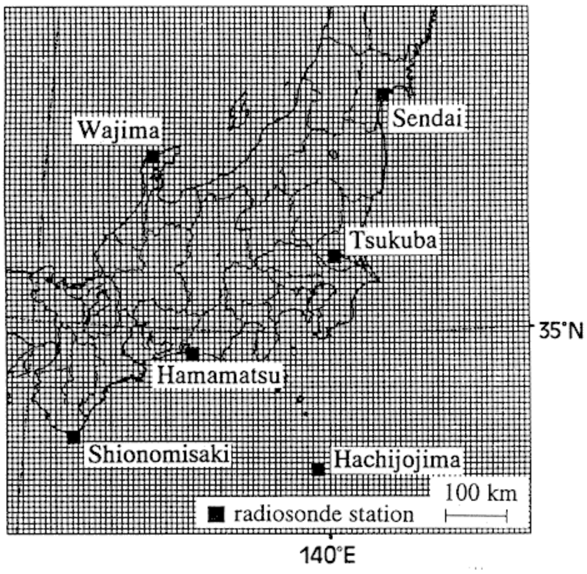


Figure 3. Forecast area of the JMA 10 km spectral model.

3. Proposal of New Correction Method

The estimations of the wet delay by the numerical prediction data can be easily applied to the correction of VLBI measurements considering the azimuthal asymmetry. In the field of numerical weather prediction, there has been much effort recently in developing more accurate models. These new models are devised to take account of modeling the real atmospheric motion and new meteorological observations such as satellite microwave radiometry. These model data sets always keep the three-dimensional scheme. Therefore, once an estimation system of the wet delay is established, we can easily obtain more accurate estimates of the delay when the numerical prediction model data set is up to date. This new correction method has two advantages. First, the equally-weighted correction to the delay is available wherever the VLBI measurements are conducted. Second, re-examination and re-correction of the delay for the past geodetic observations are always available by using the updated model data in the future. It is expected that this will become a powerful correction method. At present, I plan feasibility studies to evaluate the availability of the numerical prediction data for correcting VLBI measurements.

References

Chao, C. C. (1972): A model for tropospheric calibration from daily surface and radiosonde balloon measurements, Tech. Memo. 391-350, Jet Propul. Lab., Pasadena, Calif.

Davis, J. L., T. A. Herring, I. I. Shapiro, A. E. E. Rogers, and G. Elgered (1985): Geodesy by radio interferometry: Effects of atmospheric modeling errors on estimates of baseline length, Radio Sci., 20, 1593-1607.

Hogg, D. C., F. O. Guiraud, J. B. Snider, M. T. Decker, and E. R. Westwater (1983): A steerable dual-channel microwave radiometer for measurement of water vapor and liquid in the troposphere, J. Clim. Appl. Meteor., 22, 789-806.

Herring, T. A., J. L. Davis, and I. I. Shapiro (1990): Geodesy by radio interferometry: The application of Kalman filtering to the analysis of very long baseline interferometry data, J. Geophys. Res., 95, 12561-12581.

Ichikawa, R., M. Kasahara, N. Mannoji, and I. Naito (1994a): An evaluation of positioning error for space geodetic technique due to azimuthal asymmetry of wet troposphere delay based on JMA 10 km spectral model data, Proceedings of The Eighth International Symposium on Recent Crustal Movements (CRCM '93), pp. 181-187.

Japan Meteorological Agency (1993): Outline of operational numerical weather prediction at Japan Meteorological Agency, Appendix to Progress Report on Numerical Prediction Division.

Japan Meteorological Agency (1995): http://www.goin.nasda.go.jp/GOIN/JMA/htdocs/NPD/goin_npd.html

Lorenc, A. C. (1981): A global three-dimensional multivariate statistical interpolation scheme, Mon. Wea. Rev., 109, 701-721.

Saastamoinen, J. (1972): Contributions to the theory of atmospheric refraction, part 2, Bull. Geodesique, 107, 13-34, 1972.

Tralli, D. M., S. M. Lichten, and T. A. Herring (1992): Comparison of Kalman filter estimates of zenith atmospheric path delays using the global positioning system and very long baseline interferometry, Radio Sci., 27, 999-1007.

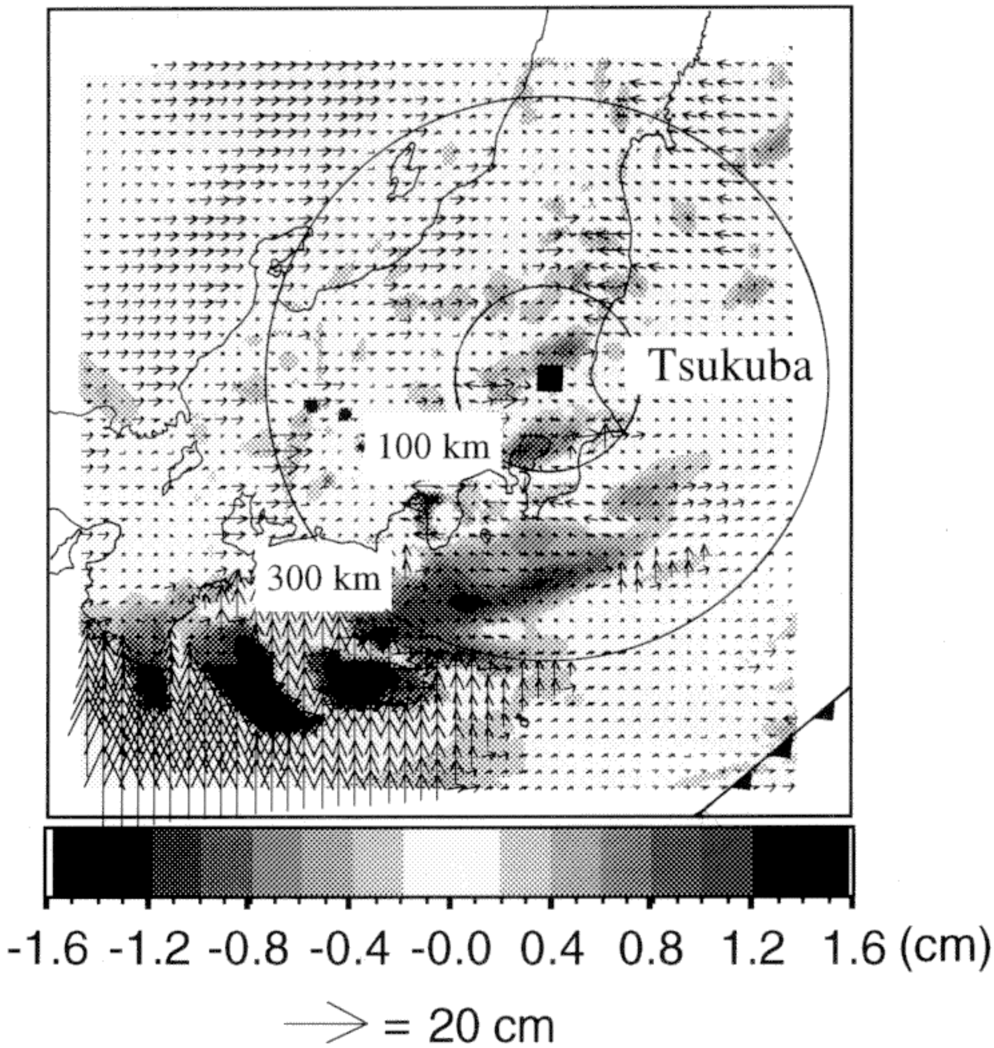


Figure 4. Estimated horizontal vectors and vertical components of the apparent displacement vectors caused by the wet delay error due to the azimuthal asymmetry of atmosphere. These apparent displacement vectors are considered to be the relative positioning errors in measurements by VLBI. Minimum elevation angles of radio sources are assumed to be 5 degrees. Frontal position is obtained from JMA operational surface analysis.

In October 1990, the International Earth Rotation Service (IERS) designated the Communications Research Laboratory (CRL) and Haystack Observatory, USA, as the Technical Development Centers (TDC). These centers are supposed to do

1) the development of new observation techniques and new systems for advanced Earth's rotation observations by VLBI and other space techniques,

2) the promotion of research in Earth rotation by advanced methods in VLBI,

3) the distribution of new VLBI technology.

The TDC meeting, attended by the ordinary members from inside the CRL and the special members from the outside, is held twice a year. The special members advise the committee, concerning the plan of technical developments. The TDC newsletter is published biannually by CRL to inform the IERS community its current activities.

This news was edited by Tetsuro Kondo, Kashima Space Research Center, who is the current representative of TDC at the Communications Research Laboratory, Japan. The editor wishes to thank Dr. O. J. Sovers for his kind help in the correction of the news translated from Japanese to English.

Inquires on this issue should be addressed to:


```
T. Kondo
Kashima Space Research Center
Communications Research Laboratory
893-1 Hirai, Kashima, Ibaraki 314, Japan

TEL    : +81-299-84-7137
FAX    : +81-299-84-7159
e-mail : kondo@crl.go.jp
```


Summaries of VLBI and related activities at the Communications Research Laboratory are available from the home page of the Radio Astronomy Applications Section of the Kashima Space Research Center on the World Wide Web (WWW). The URL to view the home page is : *http://apollo.crl.go.jp/*

TECHNICAL DEVELOPMENT CENTER NEWS No.7, October, 1995
International Earth Rotation Service - VLBI Technical Development Center News
published by
Communications Research Laboratory, 4-2-1 Nukui-kita, Koganei, Tokyo 184, Japan