Analysis Center at Communications Research Laboratory

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Abstract

The Key Stone Project was started to obtain precise relative positions of four stations using VLBI, SLR, and GPS on a daily basis by the Communications Research Laboratory. The observations of all KSP systems contribute not only to resolve regional crustal deformation issues but also for the entire field of space geodesy. We carried out research and development such as evaluations of tropospheric path delay and ionospheric electron content, monitoring flux density variations of radio sources and so on. This report summarizes the results from these research fields using the KSP network of the CRL to the end of 2000.

1. Introduction

The KSP has been carried out around Tokyo metropolitan area, Japan by the Communications Research Laboratory (CRL), using VLBI, SLR, and GPS. One of the main objectives of the KSP is to monitor regional deformation and strain accumulation at the plate boundary region of the Kanto district. The KSP is not only aimed for monitoring crustal deformation but also utilized for research and technical development of space geodesy. The KSP system was designed to make frequent observations possible with minimum human operations and to provide analyzed results as fast as possible. In particular this automated design has allowed frequent VLBI experiments to be available. By placing different three techniques close together, one can compare the difference and independently obtained results with each other, improving their individual reliability. We describe some analysis results using the KSP network in this report.

2. Analysis results using the KSP network

2.1. Crustal deformation

Figure 1a plots the estimated lengths of the baseline between Kashima and Tateyama stations using VLBI. In the figure, one can also see evidence of gradual improvements in VLBI data quality with time. The results after September 30, 1997 are remarkable, reflecting the extended duration of each experiment.

Figure 1b shows the observed horizontal site velocities (millimeters per year) using VLBI and GPS at three KSP sites(Koganei, Miura, and Tateyama) relative to Kashima during January 1997 to June 2000. Results from VLBI analysis spanning the last four years indicate that Miura and Tateyama sites are moving with respect to Kashima at velocities of 17.0 and 20.9 mm/year toward the NNW, respectively. The velocities moving toward NNW at Miura and Tateyama suggest the effect of the subducting Philippine Sea plate beneath northern Honshu along the Sagami Trough.

After the end of June 2000 the baseline length between Kashima and Tateyama is shortened by about 5 cm during two months as shown in Figure 1a and Figure 2a. Accumulated displacement at KSP sites toward north-east are presented In Figure 2b. Similar displacement at four GPS sites (Katsuura, Kyonan, Miura, and Tateyama) of GEONET by Geographical Survey Institute (GSI) are also shown in the figure.

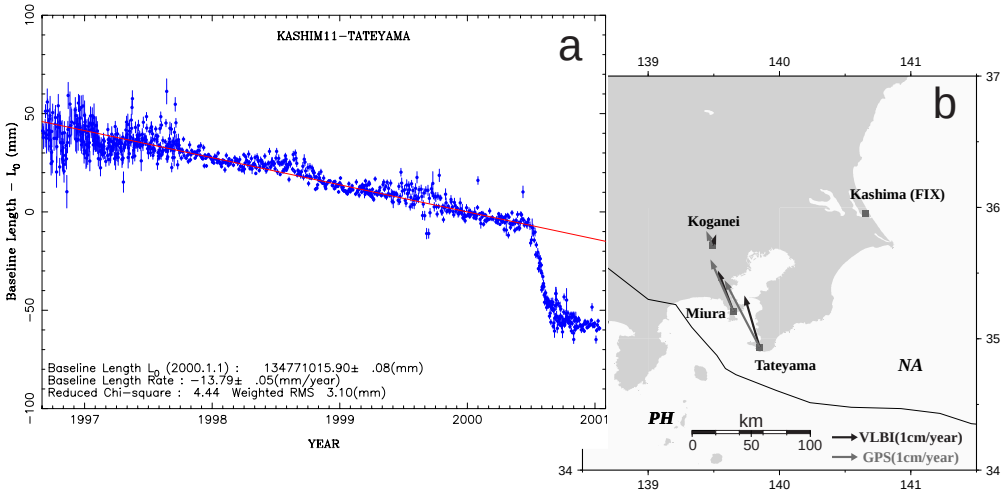

Figure 1. (a) Estimated baseline length between Kashima and Tateyama using VLBI. The formal error of each estimation is shown by a vertical bar in both figures. The variations in baseline length is fitted by linear lines and the best fit line is shown by straight solid lines. (b) Observed horizontal site velocities (centimeter per year) relative to Kashima site. The velocities from VLBI and KSP GPS from January 1997 to June 2000 are shown.

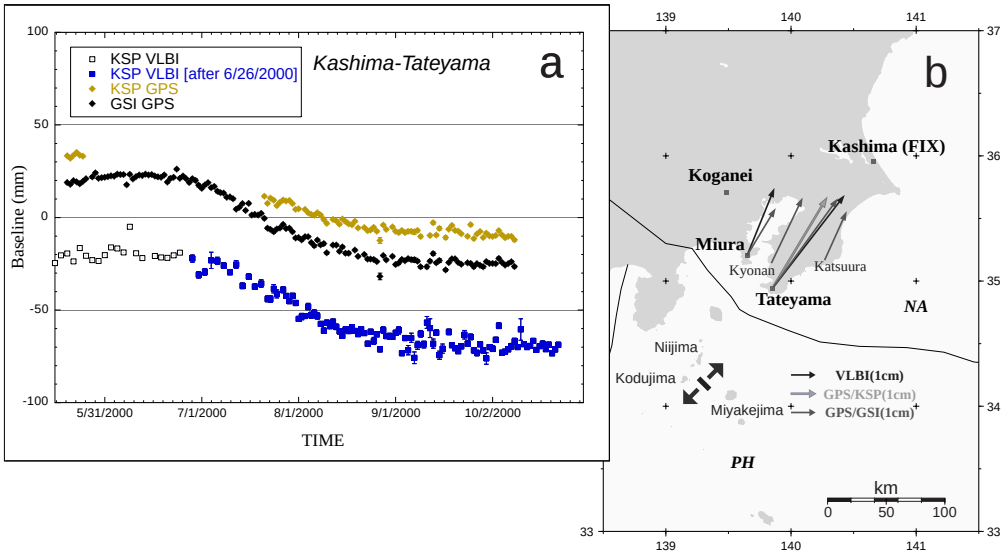

Figure 2. (a) Estimated baseline length between Kashima and Tateyama using VLBI and GPS of the KSP network. GPS results of the GEONET by Geographical Survey Institute (GSI) are also shown. (b) Accumulated displacements from VLBI, KSP GPS and GEONET GPS sites from July to September 2000

Following the magma intrusion event at Izu Islands about 150km south of Tokyo during 26 and 27 in June 2000, the crater subsidence and volcanic eruption events continued in July and August

at Miyakejima which is one of the Izu islands. In addition, high seismic activity and significant crustal deformation has continued around Miyakejima and Niijima-Kodushima since the end of June. According to the inversion using half-infinite elastic model it can be explained that the crustal deformation at Tateyama, where is located about 100 km north-east from Kodushima island, is caused by the dike intrusion at about 6km depth and co-seismic offsets between the islands [1]. The strike of the simulated dike is N140E, which is almost perpendicular to the azimuth from Kodushima toward Tateyama. This geometric setting is efficient to move Tateyama site toward north-east by the deformation due to the simulated dike.

2.2. Evaluation of tropospheric path delay

A repeatability of baseline length of the KSP VLBI tends to be degraded in summertime. A correlation analysis between measured baseline lengths and surface meteorological data was made and it was suggested that an apparent position change of Kashima station occurred according to the change of temperature[2].

In June 1998, we initiated a field experiment for detecting and characterizing water vapor variations using water vapor radiometers(WVRs) at KSP Kashima site and Tsukuba. A WVR at Tsukuba is deployed by the Meteorological Research Institute (MRI) of the Japan Meteorological Agency (JMA). Time series of atmospheric gradients estimated by WVR slant delays at Tsukuba and Kashima are compared each other.

In spite of relatively short distance between Tsukuba and Kashima (about 54 km) the atmospheric gradients solutions are significantly different. This result suggests that the mesoscale weather pattern caused large differences. We are now analyzing the output of high resolution numerical weather prediction models in order to investigate these results more deeply.

2.3. Evaluation of ionospheric electron content

Ionospheric delay correction with GPS-based Earth ionosphere total electron content (TEC measurement is useful for single band VLBI application, for example pulsar astrometry and geodetic VLBI with single band receiver. To investigate the accuracy of GPS-based ionospheric TEC measurement, a GPS-based TEC measurement was compared with TEC derived from dual band VLBI observation on Kashima-Koganei baseline of KSP VLBI system[3]. This comparison study indicated the GPS-based TEC measurement has potential to enable ionospheric delay correction to VLBI observation in almost the same accuracy with S/X dual band VLBI. This result is encouraging to apply GPS derived TEC to single band astrometric VLBI observation. Also realizing single band geodetic VLBI benefit at lower cost single band receiver instead of dual band receiver and more data channels can be used for X band signal.

2.4. Monitoring flux density variations of radio sources

Compact and strong radio sources are repeatedly observed in regular geodetic VLBI experiments under the KSP[4]. The two main purposes of the KSP VLBI network are to precisely measure relative site positions and to monitor their variations with a minimum delay of processing time. For these purposes, time delays between signals received at two sites and their rates of change are obtained through data correlation and bandwidth synthesis processing performed in real-time. From about five years of the observed data, irregular variations in the flux densities

were detected for several radio sources using the source 2134+004 as the calibrator.

3. Staff

The staff members who are contributing to KSP Analysis Center at the CRL are listed below:

- Kondo Tetsuro, Responsible for overall operations and performance.
- Koyama Yasuhiro, Development of data analysis software.
- Ichikawa Ryuichi, Research for crustal deformation and atmospheric modeling.
- Amagai Jun, Maintenance of data analysis system.

4. Current Status and Future Plans

As of mid-September 2000, the crustal deformation around Izu islands almost decayed according to the results from continuous GPS measurements of GEONET at the Izu islands by GSI. However, it is very important to monitor a postseismic stage in order to understand the tectonic process of the recent event around the islands. Thus, we made a decision to continue the KSP observations at least for one year regularly though we had a plan to close the KSP in the Spring 2001.

At present, the atmospheric gradient models[5][6] are not used in the operational analysis of the KSP VLBI. We are now modifying the VLBI analysis software to improve the accuracy of the position determination using atmospheric gradient model.

The web server for the Analysis Center is provided by CRL. The URL address is

`http://ksp.crl.go.jp/index.html`

The KSP web site holds all the data obtained by the KSP VLBI network. Baseline lengths, site positions, flux densities of observed radio sources, estimated earth orientation parameters are available on our web site. Our analysis results of the site positions have been generated using SINEX format.

References

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