GPS EARTH OBSERVATION NETWORK (GEONET) OF JAPAN

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Key words: GEONET, Crustal deformation monitoring, GPS Data Service.

ABSTRACT

Geographical Survey Institute (GSI) established GPS permanent observation station network GEONET covering all over Japanese islands. GEONET is working for the monitoring for crustal deformation. Much information on geodynamics has been obtained from the analysis of GEONET data. GSI is going to extend its ability into the GPS data service for surveying and positioning.

1. INTRODUCTION

GSI (Geographical Survey Institute) started to build a GPS permanent observation network in 1993. Now, we have established GEONET, a nationwide GPS observation network for crustal deformation monitoring, with about 1,000 observation sites. Stations are settled in average spacing of 25km. Data from all stations are downloaded and analyzed everyday to determine three dimensional position of each station. Daily network solution data of GEONET are archived into the database. Those results are reported to the committees, which are responsible to evaluate seismic and volcanic hazard, such as Earthquake Research Committee (ERC).

One of the good examples how these observation results were utilized for hazard mitigation, is the case of Usu Volcano eruption. On March 2000, Usu-san Volcano in Hokkaido, the northeastern island in Japan, started eruption. Another example is the case of Izu islands event including Miyake Island eruption and earthquake swarm around Kodzu and Niijima Island. On June 2000, Oyama volcano in Miyake island, 200km south from Tokyo, started eruption. Seismic activity became also very high at northwest sea of the island. Significant crustal deformations have been observed along the both activities. The data obtained by GEONET will be available to users of various fields in near future.

2. GEONET

GEONET consists from about one thousand GPS observation sites with average distance between two neighboring points being 25-30 km. Data observed by the receivers at those sites are sent to data station in GSI (at Tsukuba) and analyzed once per day.

Observation sites are called "GPS-based control point". Each site equips one GPS receiver, antenna, communication device, backup battery, those are installed in the stainless steel pillar. A pillar is five meters high, standing on the concrete base which is

two meters cube.

Receivers installed in the pillars are dual frequency types. Most of receivers are scheduled to receive dual band carrier phase data and code data every 30 seconds. Receivers have extension memories to keep their data for several days to provide the back up data for data communication failure. Some receivers are scheduled to receive GPS data every one second that could be used for kinematic positioning. But such data is kept in data memories of the receiver temporally for a few days and overwritten by new data if there are no special downloading request.

An antenna is set on the top of the pillar covered with a radome. Communication devices are terminal adapters in most sites where digital telephone line is connected, however modems are used for a part of the sites which only have an analog telephone line.

The central station for controlling the network and data analysis is settled in Tsukuba, at the main office of Geographical Survey Institute. The central station controls the operation of the all observation sites, data communication, data management and archive, analysis, etc.

Data stored by the receivers are downloaded once per day from the central station. Generally the downloading is carried out in midnight. The size of one day data is about 800KB per site. The communication time necessary for downloading is about two or three minute for a site with digital telephone line, besides ten to fifteen minutes for a site with analog telephone line. It takes about two hours to download the data from all stations.

Downloaded data is archived into the database in RINEX(Receiver Independent Exchange) format. One day data set for routine analysis starts from 0h and ends by 24h of JST. The data control unit carries out quality check whether any data is missing, cycle slips exists, etc.

After archiving data, the data processing unit starts network solution process of GPS data. The data processing units consist from eight engineering workstations with UNIX operation system. The main data analyzing software is BERNESE, the product of the Bern University.

The satellite orbit data used for routine processing is "combined ephemeris". This is a combination of IGS (CODE) rapid solution orbit and predicted orbit. IGS rapid solution orbit is a product of International GPS service using a data set from satellite tracking stations and available from CODE(Coordinate Orbit Determination Center in Europe) by the internet. Only the data set for the day before the observation in UT is available. Therefore the orbit data for 0h to 9h of the day is rapid solution besides that of 9h to 24h is predicted orbit which is extrapolation of rapid solution orbit. This combined orbit is more precise than broadcast ephemeris.

Network solution procedure of GEONET starts 9h of JST just after downloading IGS rapid solution orbit and predicted orbit. Three dimensional positions of all stations are

determined referred to Tsukuba site. The network solution process takes about three to six hours according to the quality of the data. The product of solution is stored into the database in the SINEX(Software INdependent Exchange) format.
This is the routine procedure for quick solution of GEONET data.
Two weeks after the observation, the IGS final orbit becomes available. The final orbit is the most precise ephemeris data available for GPS study. The final solution for GEONET is carried out using this orbit data. In this final network solution, data of all sites are arranged to the 24h data set starting from 0h and ending by 24h of UT, and these data sets are used for the analysis.
Therefore the product of final solution is three-dimensional positions for the day in UT. SINEX file for the final solution is also stored in the database.

The database has a simple data viewer with which users can display and print out the result of the analysis in various formats. For example, time series graph of coordinates of certain site, time series of relative position of two sites or horizontal displacement vector in certain term can be displayed on a screen and printed out by a printer.

The summary of observation result can be seen on our web site. You can see general pattern of crustal deformation of the Japanese islands.
http://mekira.gsi-mc.go.jp/ENGLISH/index.html

3. UTILIZATION OF OBSERVATION RESULTS FOR DISASTER MITIGATION

GPS continuous observation with nationwide network is recognized as a "fundamental observation" by the document of Headquarters for Earthquake Research Promotion, the governmental committee for earthquake research promotion.

Reports compiled from those data are submitted to various committees, such as Earthquake Research Committee (ERC), Earthquake Assessment Committee for the Areas under Intensified Measures against Earthquake Disasters (EAC), Coordinating Committee for Earthquake Prediction (CCEP) and Coordinating Committee for Prediction of Volcanic Eruption (CCPVE), those are organized to investigate current seismic and volcanic activity of Japanese islands.

Crustal deformation data is considered important information for the evaluation of the process of seismic and volcanic activity.

The GPS monitoring data of GSI is accepted as most reliable data for the evaluation of crustal activities along these two events of Usu-zan and Miyake island as described before.

4. GEONET DATA SERVICE

GSI is also planning to supply observation data of GEONET for surveying and navigation through the internet and telephone line in near future. A part of archived observation data of GEONET became available through the internet from the beginning of August 1999. Users can download RINEX format observation data from the

homepage of GSI. However, there are some limitations in this service, now. At first, only the data observed within late three months are provided in the server. Older data should be requested to GSI by e-mail or printed letter. As the data is archived in one file per day, JST 0h to 24h, user should download all 24 hour data even if shorter data is necessary. Finally, only Japanese page is provided for this downloading site. When new servers for data service are available, these limitation should be removed.

Other GPS data service planned by GSI is real time data service for kinematic GPS. There are 22 GPS based control stations in Kanto, Kansai, Tokai and Sapporo regions which serve GPS observation data for RTK(Real Time Kinematic) survey by MCA(Multi Channel Access) radio communication. Users can obtain every one second carrier phase data from GPS-based control point using MCA radio receiver.

GSI is planning to extend this real time data service to other communication media such as a portable telephone, and to establish a data service center, which will control all kinds of GPS data service in various manners.

A new experimental system for real time data service is installed November 2000, and one second epoch data is supplied for RTK-GPS and VRS(Virtual Reference Station) positioning experiment, now.

In near future, it is expected that GPS data observed by GEONET station will be available to many users from such data service center.

5. CONCLUSION

GEONET was established for the monitoring the crustal deformation. It revealed many interesting geodynamic phenomena relating to the plate motion, mechanism of earthquakes and volcanic activity. This network can detect co-seismic movement as well as stationary crustal deformation, which are helpful to the study of geodynamics and earthquake engineering. GSI is planning to maintain and extend this network for more detailed (both in space and time domain) monitoring. The data by GEONET will be served to users of various fields in near future.

6. REFERENCES

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