Preparatory research on the development of rapid and accurate GNSS routine analysis system

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The Geospatial Information Authority of Japan routinely analyzes GNSS data obtained by GEONET and monitoring crustal deformation all over Japan. The results, crustal deformation data and seismic fault models associated with main shock or postseismic movement, are used to evaluate earthquake activity by the Earthquake Research Committee (ERC) of the Headquarters for Earthquake Research Promotion and the Assessment Committee for Areas under Intensified Measures against Earthquake disaster. Also, the crustal deformation data are used by the Coordinating Committee for Prediction of Volcanic Eruptions as fundamental data for monitoring deformation of mountain body of active volcano and, when eruption occurred, monitoring eruptive activity.
However, even up-to-date routine analysis result sometimes do not have enough rapidness or time resolution. At present, even the result of the most rapid routine analysis, Q3-solution, needs three hours after GEONET data acquisition. In case of the 2016 Kumamoto Earthquake occurring at the night of April 14, crustal deformation information by Q3-solution is obtained on the morning of April 15. Special meeting of the ERC is usually held half a day after the large earthquake occurred. So for the case of the Kumamoto Earthquake, it had possibility that the crustal deformation information offered by GSI would have been late for the meeting and understanding of the earthquake would have got delayed.
Another problem is the time resolution of the solution. For even Q3-solution, which has highest time resolution, the time resolution is six hours. In case of the Kumamoto Earthquake again, three hours after the shock of M6.5 on April 14, an aftershock of almost same magnitude occurred and it also seemed to cause crustal deformation in addition to those caused by the first shock. However, the crustal deformation information using Q3-solution given to the special meeting of the ERC on the afternoon of April 15, cannot distinguish between the crustal deformation caused by the first shock of M6.5 and those caused by the aftershock, which had some difficulties in the understanding of the earthquake. Moreover, present routine analysis do not have enough time resolution for monitoring inflation and deflation of volcanic body before and after eruption. It may have difficulty in evaluating volcanic activity.
These days the GNSS analysis method called Precise Point Positioning (PPP) gains publicity, which is more rapid, has high time resolution and has comparable accuracy to the routine analysis method of GEONET. The principle of PPP is that using precise orbit and clock information of GNSS satellites, GNSS point positioning is performed on each station. The feature of PPP is that the position of the stations in every epoch can be calculated with small calculation load. Moreover, adding corrective information called Fractional Cycle Bias (FCB), which differs for each satellite, enables ambiguity resolution in PPP (called PPP-AR), which is likely to result in the accuracy almost same as GNSS interferometric analysis. In addition, PPP-AR does not need fixed reference station which has advantage when crustal deformation occurs over wide area by large earthquake and it is difficult to find the point that is not subjected to the deformation.
On the background above, GSI has started a three-year research project since the April of 2017. In the project, we will develop more rapid and accurate GNSS analysis method based on PPP-AR and make prototype system implementing this method envisioning future GEONET routine analysis. The goal of this research is routinely and stably obtaining the solution of one-second interval within about two hours after data acquisition with typical repeatability of about 1cm in horizontal component.
In this presentation, I introduce a framework of the system under consideration and the result of the

preparatory research.

Keywords: GNSS, PPP-AR, GEONET routine analysis, GEONET

