Detection of High-rate surface displacements induced by 2007 Noto Hanto Earthquake with 1 Hz GEONET data and GPS PPP strategy

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Instantaneous positioning with high-rate GPS observation (1Hz or higher sampling rate) has considered as a complementary information for strong motion instruments (accelerometer) in strong earthquakes because low frequency noise of the accelerometer leads a divergence (or saturation) of displacements through double integration of the acceleration. The GPS solutions would help an urgent modeling of mechanism of earthquake and validation of accelerometer records if real-time estimation is available with the similar precision with post processing.

We have developed RTNet software which processes both real-time streaming and archived data in a variety strategies. We focused on precise point positioning (PPP) strategy for the processing of high-rate surface displacements to avoid errors came from a reference station. Several satellite orbit and clock products from IGS (International GNSS service) and CODE (Center for Orbit Determination in Europe, AIUB, Switzerland) were used to check if a solution from real-time processing shows similar surface displacements with those from post-processing.

The 1 Hz data for 45 stations close to an epicenter of Noto Hanto Earthquake (Mj 6.9) occurred on March 25, 2007, were estimated using RTNet software.

The coordinate estimates show very similar pattern depending on satellite clock products in the local network. We thus set about 10 stations which locate more than 150 km and less than 200 km from the epicenter of the earthquake as reference stations to compute common in-phase coordinate errors due to satellite clock errors. The coordinate estimates for the reference stations were stacked and the resulting time-series were subtracted from original time-series. We assumed the difference of satellite clock errors due to the difference of sampling time can be neglected. We call the method a PPP satellite clock error mitigation (PSCM) filter.

The PSCM filter helped to reduce common drifts in PPP single epoch (1Hz) solutions. The seismic motion after the filter application is much clear than those in original solution, and the solutions showed a propagation of seismic motion horizontally in GEONET stations. The detectable seismic motion is about 10 mm and 25 mm for horizontal component and vertical component, respectively.

The predicted part of IGU (IGS Ultra-rapid) products are available with real-time (without latency). The coordinate solution from the IGU predicted products sometimes showed meter order offset, but seismic motions similar with those estimated with observed satellite clock could be seen after applying PSCM filter. It suggests that true real-time monitoring of seismic motion is possible with GPS PPP strategy in the network with an infrastructure of real-time data streaming such as GEONET.

There are data missing in some GEONET stations which locate near epicenter. To reduce the missing observation and improve communication in the disaster is one of the issue to be improved if we need to use GEONET for monitoring seismic motions (and tropospheric delays in severe weather condition).