Ability of 1-Hz GPS to Infer the Source Process of a Medium-Sized Earthquake: The 2008 Iwate-Miyagi Nairiku, Japan, Earthquake

Yusuke Yokota[1]; Kazuki Koketsu[1]; Kazuhito Hikima[1]; Shin'ichi Miyazaki[2]

[1] Earthq. Res. Inst., Univ. Tokyo; [2] Kyoto Univ.

We demonstrated the ability of 1-Hz GPS data to infer a medium-sized earthquake source process through the case of the 2008 Iwate-Miyagi Nairiku, Japan, earthquake. In the last few years, high-rate GPS (1 Hz or higher) has been used to research over many topics. The capability of high-rate GPS to represent seismic wave fields for large magnitude earthquakes has been demonstrated by Larson et al. [2003]. Recent studies have demonstrated the ability of 1-Hz GPS data to infer earthquake source processes in cases of large earthquakes [Miyazaki et al., 2004]. There are a few examples of supplementarily using 1-Hz GPS data in cases of medium-sized earthquakes [Ji et al., 2004, Kobayashi et al., 2006]. However, the source process of a medium-sized earthquake has not yet been studied using only 1-Hz GPS data. In this study, we compared 1-Hz GPS and strong motion waveforms generated from this event and confirmed the capability to infer the source process of this event. We performed a waveform inversion for the source process of this earthquake using only 1-Hz GPS data. Definitely, we compared the result with that of a preliminary joint inversion of geodetic and strong motion data.

Static and dynamic ground displacements from this earthquake were observed at one-second intervals by GEONET, of the Geographical Survey Institute of Japan. 1-Hz GPS data were obtained by analyzing these observations using the methods described by Larson et al. [2003]. Though there is a little noise that be not caused by repeatable errors such as multipath, we assumed that strong ground motions were obtained at 1-Hz GPS data adequately. We used 1-Hz GPS data of 12 stations, which were selected from among the stations within approximately 50 km of the hypocenter so as to cover all directions. The GPS waveform data were windowed for 60 s.

We adopted the 42 km in length by 18 km in width fault model with (strike, dip) = (203, 37) and the hypocenter (latitude: 39.028N, longitude: 140.880E, depth: 6.0 km), which were determined by Hikima et al. [2008] for the preliminary source inversion of geodetic and strong motion data. The fault model was divided into 189 subfaults of 2 km by 2 km. We assumed the rupture velocity to be 2.8 km/s for the first time window. The Green's functions were computed using a wavenumber integration method developed by Zhu and Rivera [2002]. We also used the 1-D velocity structure models that Hikima et al. [2008] obtained for strong motion stations close to the GPS stations. The data were then inverted to infer the source process of the earthquake using the inversion codes by Yoshida et al. [1996] with the revisions by Hikima and Koketsu [2005].

In the result, the total seismic moment of 2.7 x 10^{19} Nm (Mw 6.9) and maximum slip of 5.1 m obtained herein are approximately equal to the respective values of 2.5 x 10^{19} Nm and 5.7 m for the preliminary joint inversion. In both the slip distributions, large and small asperities were also inferred to the south and northeast of the hypocenter. In both the source time functions, the rupture propagated bilaterally from the hypocenter. Since the rupture velocity to the south was higher, the southern asperity grew to a peak slip earlier than the northern asperity.

Definitely, both static and dynamic features in this inversion result agree with those obtained in the result of the preliminary joint inversion. This agreement demonstrates the ability of 1-Hz GPS data to infer not only static but also dynamic features of a medium-sized earthquake. We believe that these detailed disagreements will be reduced by the constant monitoring of much higher rate (e.g., 10 Hz) sampling GPS, that will be important for other many topics using high-rate sampling GPS in the future.

Acknowledgement.

We acknowledge the National Research Institution for Earth Science and Disaster Prevention, Japan (NIED) for providing K-NET and KiK-net data and the Geographical Survey Institute for providing GEONET data.