Source model of the 2005 Miyagi-oki earthquake from broadband strong motion simulation using the empirical Green's function method

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On August 16, 2005, an Mj7.2 interplate earthquake occurred in the Miyagi-oki region (off-shore of the Miyagi prefecture). Before this event, an Mj7.5-class interplate earthquake was expected to occur with high probability based on the fact that such events have repeated at averaged recurrence interval of 37 years in this region (Headquarters for Earthquake Research Promotion, HERP, 2000). It is reported that a part of source region of the last 1978 Miyagi-oki event had ruptured during the 2005 Miyagi-oki earthquake (HERP, 2005; Okada et al., 2005; Kamae, 2006). HERP (2005), then, warns about the possibility of earthquake which will occur in the un-ruptured region of the 2005 event. Therefore, it is important to examine the source characteristics of the 2005 Miyagi-oki earthquake for taking measures to the strong ground motions of the possible next Miyagi-oki event.

We constructed a source model which is composed of strong motion generation areas (SMGA, Miyake et al., 2003) from the simulation of broadband strong ground motions (0.2-10Hz). SMGA is characterized area of the large slip-velocity area and accounts for the observed strong motions in wide frequency range. For most large-to-moderate-size earthquakes, it is found that the SMGAs correspond to the large slip region estimated from kinematic source inversion using the lower-frequency (up to 1Hz) strong motions. Since two pulses are observed in the velocity waveforms, we assumed two SMGAs on the fault plane estimated from F-net moment tensor solution. We synthesized broadband strong motion using the empirical Green's function (EGF) method by Irikura (1986). As an EGF, the records of the Mj4.7 aftershock (September 12, 2005) were used.

Matching the observed and synthetic waveforms, we estimated the location, the size, the rise time, and the rupture time of two SMGAs by forward modeling. The location and the rupture time are estimated with relative to those of the hypocenter determined by JMA (Japan Meteorological Agency). We used the two horizontal component of S-waves recorded at the borehole of four KiK-net stations and on the surface of one K-NET station, which is near to the source region among NIED (National Research Institute for Earth Science and Disaster Prevention) strong motion networks. For inference of the SMGA location, we referred to the slip distribution estimated by kinematic source inversion using low-frequency strong motions (Asano et al., 2005).

The estimated two SMGAs are located about 10km and 30km west to the hypocenter and ruptured 3s and 10s after the initial rupture, respectively. Size and rise time of both SMGAs are 6km x 6km and 0.4s. Assuming above source parameters, we could reproduce two pulses observed in velocity waveforms well. The stress drop of the SMGAs is calculated to be 135MPa using the circular crack formula, on the assumption that all the seismic moment (product of the moment of the EGF event and the low-frequency flat level of the spectral ratio) is imposed to SMGAs. This value seems to be very large compared to the case of crustal earthquakes (e.g. Miyake et al., 2003) or the 2003 Tokachi-oki earthquake (50MPa, Kamae and Kawabe, 2004). However, Kamae (2006) assumed 70-90MPa stress drop on the SMGAs to reproduce the strong motion records of the 1978 and 2005 Miyagi-oki earthquakes. Satoh (2004) found that the flat levels of acceleration source spectra of earthquakes in the Miyagi-oki region are larger than those predicted from empirical relationship. Suzuki and Iwata (2003) also estimated the stress drop of the SMGA to be 80MPa for the 2002 Miyagi-oki earthquake (Mj6.1). The high stress drop of the SMGAs may be the specific characteristics of the interplate earthquakes in the Miyagi-oki region.

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