Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SSS37-09 Room:303 Time:May 21 11:15-11:30

Postdiction of Source Model for the 2011 Tohoku Earthquake

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There are many studies on strong ground motion validation for past earthquakes, applicability of the methodology of strong ground motion prediction, and strong ground motion prediction for forthcoming earthquakes. We here define postdiction (= prediction after the fact) as a method of ground motion prediction posterior to the earthquake based on the knowledge prior to the earthquake. We examined the postdictability of the source model for the 2011 Tohoku earthquake. The postdiction will be validated for the observed ground motions using the empirical Green's function method and other techniques.

<Parameters available prior to the earthquake>

The fault plane was considered to be a multiple rupture involving the Miyagi-oki, southern Sanriku-oki, Fukushima-oki, and Ibaraki-oki regions as a single megathrust event. We excluded the central Sanriku-oki region due to the aseismic information and the offshore regions from northern Sanriku-oki to Boso-oki due to the tsunami earthquakes and normal faulting information. The rupture area was estimated to be 35,000 kmˆ2 with Mw 8.3 (after Murotani et al., 2008) and 8.5 (after Sato, 1989). The earthquake magnitude was limited to around the size of the 869 Jogan earthquake, and did not reach to that for the Tohoku earthquake.

We set a characterized source model based on the recipe for strong ground motion prediction. We also incorporated with the double-corner source spectral model (Miyake and Koketsu, 2010) for plate-boundary earthquakes. In this model, size and stress drop for strong motion generation areas are respectively half and double of those for asperities. The 20%-sized asperities were located to be the same position of the historical earthquakes. The stress drop for 10%-sized strong motion generation area was 14 (after Murotani et al., 2008) and 30 MPa. (after Sato, 1989). The rupture starting point was set to the central eastern edge of the southern Sanriku-oki region. The rupture was assumed to propagate radially from the hypocenter as well as the rupture starting points of asperities and strong motion generation areas.

<Parameters unavailable prior to the earthquake>

After the Tohoku earthquake, we learned different locations and sizes between asperities for long-period components and strong motion generation areas for short-period components. In this postdiction, the strong motion generation areas were located inside the asperities. The model did not allow multiple ruptures and reverse propagation as seen in the Tohoku earthquake.

<Problems>

Based on the knowledge prior to the earthquake, the source model for the Tohoku earthquake seems to be limited to the Jogan earthquake size. To assume a M9-class earthquake, we need a rupture area over the Tohoku region; from northern Saniku-oki to Boso-oki including the off-shore regions. It is unlikely to model this size prior to the earthquake. The rupture area for the Tohoku earthquake resulted in a standard deviation of Murotani et al. (2008), therefore, we propose the rupture area with variability for a given magnitude toward megathrust source modeling.

Keywords: Tohoku earthquake, source model, scaling, validation, prediction, postdiction