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Characterized source model for the 2011 Tohoku earthquake based on peak moment rate distribution

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We proposed a characterized source model based on peak moment rate distribution of the 2011 Tohoku earthquake. The asperities estimated from the total slip distribution inverted from the long-period ground motion (e.g., Yoshida et al., 2011, EPS) do not coincide with the strong motion generation areas (SMGAs) estimated using the empirical Green's function method (e.g., Kurahashi and Irikura, 2011, EPS) for the M9 Tohoku earthquake. Yoshida et al. (2011, SSJ) proposed a characterizing procedure of the source model using peak moment rate distribution. We developed a characterized source model for the M9 Tohoku earthquake for simulating the long-period (a period of 10-100 s) strong-ground motion records.

We, firstly, characterized the source model from the total slip distribution following the procedure of Somerville et al. (1999). One asperity area is extracted on the shallow margin of the fault. We used a smoothed ramp function as a slip rate function. Pulse width of the smoothed ramp function is determined with 2 Mo/M, where Mo and M are an average moment and average maximum moment rate on the asperity and background, respectively. We determined the pulse width of 57.2 s and 39.8 s for the asperity and the background. The shot-period (about 20 seconds) components of the calculated velocity waveforms do not agree with the observed ones.

Secondly, we characterized the source model based on the peak moment rate distribution. The characterized procedure bases the peak moment rate distribution, instead of the total slip distribution. The other part of the procedure is same as the one of the slip-distribution based model. The 4 areas extracted based on the peak moment distribution (High moment/slip Rate Area, hereafter HRA) are identified. The largest HRA is similar to the asperity which is identified based on the total slip, but the other 3 HRAs are located on the deeper part of the fault. Slip rate functions of HRAs and background are determined by the same procedure for the slip distribution based model.

Assuming the circular rupture propagation (Vr=2.5km/s), we calculated velocity waveforms using the peak moment rate based source model (HRA model). However, the arrival times of the largest waves of the calculated waveforms do not agree with the ones of the observed records.

We made a complex rupture pattern for the HRA model. The rupture velocity inside each HRA is given to be 0.8Vs and the rupture velocity on the background is 2.5 km/s. The calculated waveforms using the HRA model with the complex rupture pattern agree with the observed ones. The short-period components of the calculated waves are emerged from the deeper and small HRAs.

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Keywords: characterized source model, peak moment rate, strong ground motion, megathrust earthquake