

Simulation of strong ground motions from the Evaluation of the 2011 Mw 9.0 Tohoku earthquake

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The 2011 Mw 9.0 Tohoku earthquake occurring in the subduction zone off the Pacific coast of Tohoku, Japan was observed by dense networks of geophysical instruments including strong-motion, teleseismic, tsunami, and geodetic sensors. Long-period source models have been constructed from separate and joint inversions of long-period data including long-period strong motion data. On the other hand, short-period source models have been done from the back-projection method using short-period teleseismic data and the empirical Green's function method using strong motion data. Most of slip distribution inverted from long-period records such as geodetic and tsunami data are placed at depths shallower than the hypocenter toward the trench. On the other hand, short-period seismic energy obtained by the back-projection method was generated mainly from the down-dip areas near the coasts of Pacific coast. The observed strong motions have five wavepackets that correspond to specific strong-motion generation areas (SMGAs). The origins of the wavepackets were retrieved from the original seismograms using a semblance analysis. Then, we estimate a short-period source model for generating strong ground motions from this earthquake by comparing the observed records from the mainshock with synthesized motions based on a sperity/SMGA(strong motion generation area) source model and the empirical Green's function method. We find that five small-asperities in the down-dip areas generate short-period motions of engineering interest but large asperities in the shallower area east of hypocenter generate mainly long-period ground motions. We call such small asperity SMGA. Another problem is that the short-period source models with such SMGAs cannot simulate impulsive waves with high acceleration and velocity seen at onsets of the wave-packets in strong motion records observed near the source fault. To generate the impulsive waves, more heterogeneous model is needed with higher stress parameters within a small sub-area inside the SMGAs. Then we propose multi-scale heterogeneous model as a recipe of predicting strong ground motions for mega-thrust subduction earthquakes. Recent other Mw 9.0 class subduction earthquakes such as the 2004 Mw 9.1 Sumatra earthquake and the 2010 Mw 8.8 Maule earthquake are known to have almost the same period-dependent source model mentioned above. However, the M 8 class earthquakes such as the 1978 Mw 7.8 Miyagi-oki earthquake and the 2003 Mw 8.3 Tokachi-oki earthquake seem to have different characteristics, showing that the strong motion generation areas locate inside large slip areas considered to be "asperity". Then, the asperity areas have two to four times larger than the strong motion areas.

Keywords: the 2011 Tohoku earthquake, subduction earthquake, strong ground motion, characterized source model, strong motion generation area, the empirical Green's function method