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Simulation of strong ground motions from the 2011 Tohoku earthquake and a recipe of predicting strong ground motions for

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1. Introduction

Source models of the 11 March 2011 mega-thrust earthquake with Mw 9.0 off the Pacific coast of Tohoku have been investigated by many authors using variety of data-sets from very long-period data such as GPS and Tsunami to short-period data such as teleseismic short period P waves and strong ground motion data. The main slip distributions from very long-period data were located east of the hypocenter toward the Japan Trench zone (Ozawa, et al., 2011 and Fujii and Satake, 2011). A unified source model was constructed through joint inversion of teleseismic, strong motion, and geodetic datasets by Koketsu et al. (2011) and Yokota et al. (2011). They showed that the main rupture propagated not only in the strike direction but also in the dip direction and included both the deep area called the Miyagi-oki region and the compact shallow area near the Japan Trench. On the other hand, we made a source model for generating short-period ground motions comparing observed strong motions with simulated ones using the empirical Green's function method. Our results showed that strong motion generation areas located along the down-dip edge of the source fault. Koper et al. (2011) found the frequency-dependent rupture process of the 2011 Mw 9.0 Tohoku Earthquake comparing source models using backprojection (BP) imaging with teleseismic short-period ($<$1 s) P waves, and finite faulting models (FFMs) of the seismic moment and slip distributions inverted from broadband ($>$3 s) teleseismic P waves, Rayleigh waves and regional continuous GPS ground motions. Their results showed indicate that the down-dip environment radiates higher relative levels of short-period radiation than the up-dip regime for this earthquake.

That is, the source models summarized above have common features of the source models that the main slip distributions from the long-period data were located east of the hypocenter toward the Japan Trench zone, while short-period generation areas located west of the hypocenter. These results are not consistent with the basic idea of the recipe of predicting strong ground motions developed based on slip distributions from the waveform inversions for inland crustal earthquake with M 7 class. The recipe was so far constructed based on an idea that large slip areas coincide with strong motion generation area.

In this study, we first summarized source models for generating strong ground motions and then propose an improved idea for recipe of predicting strong ground motions for mega-thrust earthquakes.

2. Source models of strong ground motions

We estimate a source model for generating strong ground motions from this earthquake using the characterized source model. Five wave-packets in the observed seismograms were identified, which originated from five strong motion generation areas (SMGAs) on the source fault. The locations of the SMGAs are constrained using the back-propagation method of Kurahashi and Irikura (2010).

Then we obtain the final solutions for the area and initiation point by comparing the observed seismograms of each wave-packet and the synthetic ones at many stations using a trial and error approach. Locations of those five SMGAs seem to correspond to source segments divided for past seismic activity in the region off the Pacific coast of Tohoku by the Headquarters for Earthquake Research Promotion of Japan (HERP). SMGA 1 is located in the source region of Southern Sanriku-oki west of the hypocenter and SMGA 2 in that of the Middle Sanriku-oki north of the hypocenter. SMGA3 is located in the source region of the Miyagi-oki, SMGA 4 is located in that of Fukushima-oki and SMGA 5 is located in that of Ibaraki-oki.

These results suggest a way how to locate such strong motion generation areas for predicting strong ground motions from the mega-thrust earthquake.

3. Methodology of predicting strong ground motions for mega-thrust earthquake.

Detailed methodology of predicting strong ground motions is introduced in the session.

Keywords: great earthquake, source parameter, source model, scaling, asperity, rupture area