Simulation of tsunami and long-period ground motions during the M9.0 2011 Tohoku-oki earthquake

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On March 11, 2001, M9.0 earthquake has occurred east off the Pacific coast of Tohoku, as a result of thrust faulting on the interface of plate boundary between the Pacific and North American plates. This earthquake generated tsunami of 30-40m high and strong ground motions up to 1000gal and more. This is one of the best geophysically-recorded great earthquakes and due to this numerous source models were generated using teleseismic, GPS, strong ground motion and tsunami data. The question we addressing here is the possibility of evenly good simulation of observed ground motions and tsunami using the same source model.

Here we used rupture process of the 2011 Tohoku earthquake inverted by the multi-time window linear waveform inversion method using the long-period (20-200s) strong-ground motion data (Yoshida et al., 2011). A single planar fault model of 470 km in strike and 130 km in dip is assumed. The rupture velocity inferred to be slower than 2.5 km/s at early stage of the rupture process. The inverted slip distribution shows a large elongated asperity (large slip area) with a maximum slip of 47 m which is located on the shallower part of the fault plane, slightly north of epicenter (Figure 1). Area of the moment rate large amplitudes, which is responsible for generation of short period ground motions, is shifted to deeper part of the source and have tendency to scatter in a few strong motion generation areas. This is consistent with the empirical Green's function simulation results of Irikura and Kurahashi (2011).

We simulated tsunami using fully nonlinear Bousinessq type model of Watts et al. (2003), and source model of Yoshida et al. (2011) and compared it with observation data and with results of simulation using other source models. Simulation results fit observed tsunami waves in the off-shore area (Figure 2), and inundation data on the coast of the Miyagi and Fukushima prefectures (Figure 3). On the coast of Iwate prefecture, north of asperity, simulated amplitudes are smaller than observed ones. Possible reason of the underestimated simulated amplitudes is a small resolution of used bathymetry data for this area.

Source modeling using ground motions with periods shorter than 20s is troublesome, because we need to calculate large volume of the 3-D Green's functions, instead of a simple 1-D case, which is valid for periods 20s and more. In order to check if the long period source model can explain ground motions at shorter periods, we simulated waves for periods 5s and more using 3-D velocity model compiled from the J-SHIS deep sedimentary structure model, subduction plate model, Conrad and Moho model of Katsumata (2010).

<u>Acknowlegements.</u> We used the seismic waveform data of the F-net, K-NET, and KiK-net networks, tsunami waveform data of the Nationwide Ocean Wave Information network for Ports and Harbours (NOWPHAS), and tsunami field observations of Building Research Institute. Deep sedimentary structure model is developed by NIED.

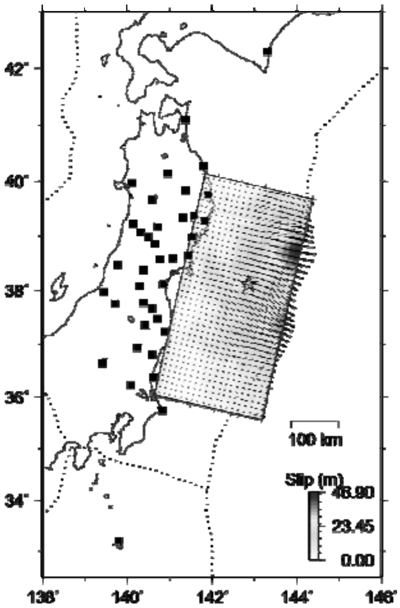

Figure 1. Slip distribution of the source model. Points – hard rock sites used for source inversion.

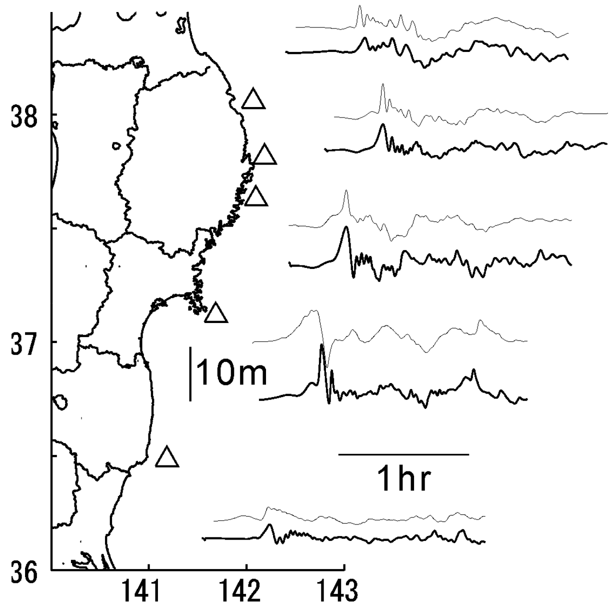

Figure 2. Comparison of observed (upper wave) and simulated (lower wave) tsunami waveforms for off-shore GPS tsunami meters (triangles).

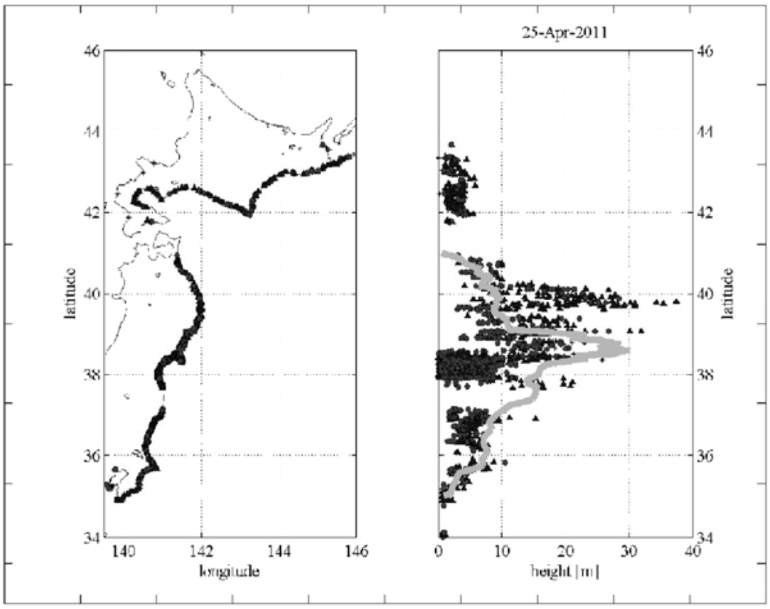

Figure 3. Comparison of observed (points) and simulated (line) maximum amplitudes of tsunami.