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Source process and broadband waveform modeling of 2011 Tohoku earthquake using Spectral-Element Method

Seiji Tsuboi[1*], Takeshi Nakamura[1]

[1]JAMSTEC

We have calculated broadband synthetic seismograms for Mar. 11, 2011 Tohoku earthquakes using the Spectral-Element Method. We use finite source models by using a set of sub-events distributed along the fault surface, retrieved by inversion of body waves (Nakamura et al, 2010). The finite source model used in this simulation estimates Mw to be 9.1. The fault dimension is 460 km times 240 km with the source duration time of 150 sec. We use the Earth Simulator2 of JAMSTEC to calculate preliminary synthetic seismograms for this finite source model. We used 726 processors of the Earth Simulator 2, which should provide synthetic seismograms that are accurate up to about 5 second and longer. The comparison of the synthetic seismograms with the observation for this event, at teleseismic stations, shows that synthetic P-waveforms model the observed seismogram quite well, reflecting that the finite source model is quite precise.

The stations along the Pacific coast of Tohoku region show near field displacement with eastward horizontal movement and subsidence of the ground, which matches with the observed crustal deformation. This source model shows that the maximum slip occurs at depth of 20 km and propagates to shallower region, which is consistent with the fact that the tsunami excitation was significant for this event. Azimuthal dependence of misfits of synthetic waveforms and observation, especially for surface waves, may reflect the discrepancies of three-dimensional mantle structure used in this simulation with the actual Earth.

Keywords: 2011 Tohoku earthquake, earthquake rupture process, broadband seismograph, theoretical waveform, Spectral-Element Method