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Global tsunami simulations from seismic CMT solutions: Developing a real time tsunami simulator

SAITO, Tatsuhiko[1*], TANAKA, Sachiko[1], INAZU, Daisuke[2], MIYOSHI, Takayuki[1]

[1]NIED, [2]RCPEV

Because the earthquake does not always occur with the anticipated magnitude, it is important to quantitatively predict tsunami height and its arrival time based on a real-time simulation with the seismic magnitude and the mechanism correctly estimated from the observed seismograms. This study develops a tsunami simulator that calculates the tsunami propagation from the seismic CMT solution estimated by the real-time seismogram analyses. The simulation is conduced with the whole earth model in order to calculate the tsunami from the earthquakes occurred in any oceans and include all the waves scattered from all the coasts and sea-bottom topography. Focusing on the tsunami in offshore regions, which does not show strong nonlinear behavior, we can rapidly synthesize the tsunami waveforms from arbitrary initial tsunami-height distributions by superposing the Green's functions loaded from the database constructed in advance.

In order to examine the validity of this simulator, we conducted a tsunami simulation for the 2011 Tohoku-oki earthquake. The moment magnitude of the CMT solution was estimated as MW 8.8 from the seismograms recorded by the velocity-type strong motion seismographs in Japan. Employing a scaling relation between the moment magnitude and the earthquake fault size, we obtained a uniform slip of 15 m on the fault of 300 km in length and 150 km in width. We calculated the initial tsunami height distribution from the fault model and simulated the tsunami propagation from the tsunami source. The simulation can successfully reproduce the tsunami height more than 4 m off the coast of Miyagi (observed height is ˜5.8 m, and calculated is ˜4.8 m). However, it was difficult to reproduce the detail of the waveforms because we employed a simple fault model in the simulation.

For the 2006 Kuril earthquake, tsunami warning/advisory was issued at the Japanese coast of the Pacific Ocean and canceled the warning/advisory 5 hours after the earthquake occurrence. But, the maximum tsunami height arrived at some parts in northeastern Honshu, Japan after the cancelation. The tsunami scattered from the Emperor seamounts constitutes the maximum tsunami height [e.g. Koshimura et al. 2008 GRL]. The ocean-bottom pressure gauges located at Sagami bay recorded the leading tsunami and the maximum-height tsunami at 2 hours and 8 hours after the earthquake occurrence, respectively. Our tsunami simulator can successfully simulate the arrival times of both the leading wave and the maximum wave, whereas it was impossible to simulate the maximum tsunami arrival if we limit the simulation area to around Japan.

Keywords: tsunami, simulation, CMT solution