Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

HDS26-P07 Room:Convention Hall Time:May 20 18:15-19:30

Pre-calculated tsunami inundations for site-specific tsunami early warning

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During the 2011 Tohoku tsunami, within only 3 minutes after the earthquake, the JMA issued three types of messages for coastal areas in Japan, which are tsunami advisory, tsunami warning, and major tsunami warning. These advisory and warning messages are visualized as color-coded lines along the Japanese coastlines on a small-scale map and broadcast on television. These messages save many lives but unfortunately, in the case of 2011 Tohoku, are not enough to convince all people to immediately evacuate. We argue that large-scale maps of predicted tsunami inundation area and height could better illustrate impending tsunami dangers and convince more victims to evacuate immediately.

To produce maps of predicted tsunami inundation, accurate information about tsunami source and pre-calculated tsunami inundation are required. In this study we focus on the pre-calculated tsunami inundation aspect. We are building a database of pre-calculated tsunami inundation and developing a method to extract the appropriate scenario from the database for tsunami warning purpose. We have simulated tsunami inundations using a high-resolution bathymetry dataset (1 arc-sec) in Kushiro, Hokkaido from 304 thrust earthquake scenarios in the subduction zone offshore of Hokkaido. The simulated maximum tsunami inundations in Kushiro and tsunami waveforms at 45 observation points within 12 km from the shoreline are stored in a database.

For a test case study, we simulated tsunami inundations in Kushiro from a hypothetical great earthquake offshore Hokkaido using the high-resolution bathymetry dataset to get a reference for validation. The tsunami waveforms at the observation points can be simulated using linear shallow-water equations on a lower resolution grid system to reduce the simulation time. Tsunami waveforms at the observation points from the scenarios in the database can be searched to find ones that best resemble those from the hypothetical event by using RMS analysis with shifting of waveforms by an optimal time shift. Then the simulated tsunami inundation of the corresponding scenario is chosen as the predicted tsunami inundation. When compared with the tsunami inundation of the hypothetical event, the predicted tsunami inundation has Aida number K that is within the threshold of +/- 0.4. To complete the linear tsunami simulation and searching process, it requires less than 3 minutes with a regular laptop computer. We found that the method worked well enough to forecast the tsunami inundation area in Kushiro.

Keywords: Pre-calculated tsunami inundation, tsunami early warning, tsunami waveform