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Investigation on Tsunami Source Inversion Methods for Real-time Inundation Predictions (2)

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1. Background

In preparation for giant tsunamis, online observation networks of offshore tsunami and onshore ground deformation have been actively deployed. For instance, NIED is developing the S-net system that will consist of 150 observation stations and will cover wide areas around the Japan Trench. Some analysis methods that utilize the online observation networks and predict tsunami inundation in real time have been proposed so far. Most of them find the best-matched solution from the database of pre-computed inundation simulation results (e.g., Baba et al., 2012; Gusman et al., 2014; Yamamoto et al., 2014). Although the database approaches have an advantage of rapid analysis speed, it would be difficult to comprehensively deal with all the inundation situations caused by megathrust earthquakes of which fault rapture processes are complicated and spread across wide areas.

Another approach to predict the tsunami inundation after earthquakes occur is based on the real-time inundation simulation with the input of instantly predicted tsunami sources. The recent development of high-performance computing makes the inundation simulation rapid enough, and in most cases the simulations can be completed before tsunamis arrive at the coastline (e.g., Oishi et al., 2015). However, in terms of the instant tsunami source analysis method, the existing methods (e.g., Tsushima et al., 2014; Ohta et al., 2011) are designed to predict the arrival time and maximum wave height at the coastline and do not necessarily consider the accuracy of site-specific inundation predictions.

2. Tsunami Source Inversion Method for Real-time Inundation Prediction

Therefore, we develop a suitable source analysis method for accurate tsunami inundation predictions. Oishi et al. (2014, SSJ Fall Meeting) proposed an inversion method that put a high priority on the reproducibility of the observed waveform in the offshore regions near the high-resolution inundation prediction area (i.e., the innermost area of the nested grid system in inundation simulations), which enables to provide good prediction accuracy of the incident wave at the high-resolution inundation prediction area. In addition, in this study, we propose a method that incorporates the crustal deformation prediction based on onshore GPS geodetic observation data, which is very accurate in the inshore and inland regions. Our method predicts the sea-surface and crustal deformations in the landward side of offshore tsunami observation stations using only the GPS geodetic observation data and predicts the sea-surface deformation in the open-ocean side of offshore tsunami observation stations using the tsunami data. We expect that the present method can improve the accuracy of the inundation predictions by accurately incorporating the land subsidence as well as the sea surface deformation in the area of tsunami propagation path between the offshore tsunami source and land.

3. Application to the 2011 Tohoku-Oki tsunami

The present source analysis method is applied to the 2011 Tohoku-Oki tsunami and the resulting source models are used in the 5-m-resolution inundation simulations of Sendai and Miyako cities. As a result, the observed waveforms at the coastal areas are well reproduced demonstrating that the present method can accurately predict the incident wave at the high-resolution inundation prediction areas. The source model is repeatedly updated using the observed data of a longer time period and provides the well-converged incident waveform when sufficient data are used. After the convergence, the predicted inundated regions show good agreement with the observation.

Keywords: Inundation simulations, real-time tsunami source prediction