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Real-time forecasting of tsunamis associated with earthquakes along the Nankai Trough using offshore tsunami data

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1. Introduction

To mitigate disasters due to large earthquakes and tsunamis occurring along the Nankai Trough, various instruments such as cabled ocean bottom observatories have being installed. In the region, GPS buoys have been deployed. At the offshore stations, a tsunami can be detected before the tsunami attack coastal communities. Several studies showed that the data are useful for real-time tsunami forecasting (e.g., Titov et al., 2005; Tatsumi and Tomita, 2008; Tsushima et al., 2009; Hayashi, 2010). Recently, realistic simulation of strong motion and tsunami has being conducted by employing supercomputers (Furumura and Saito, 2009; Maeda and Furumura, this meeting). In the present study, taking advantages of these technologies, we develop an algorithm for real-time tsunami forecasting of the Nankai Trough earthquakes.

2. Simulation Procedure of Tsunami Forecasting

As a test case, we simulated tsunami forecasting of the 1944 Tonankai earthquake. The simulation was carried out as follows: (1) Tsunami waveforms were computed for observation points by assuming a fault model and were regarded as the tsunami waveforms observed at the offshore and coastal sites. (2) Coastal tsunami waveforms were then estimated from offshore tsunami data by using a tsunami forecasting algorithm. (3) The results of the tsunami forecasting were evaluated by comparing the observed waveforms at coastal observation points with the predicted waveforms.

For calculation of the observed tsunami waveforms, we assumed the fault model presented by Annaka et al. (2003). Assumed slip on the fault plane was uniform. Tsunami propagation was computed by solving the linear long-wave equation numerically. The remarkable point of this computation code is a new installation of the Pefectly Macthed Layer boundary to reduce the reflection of tsunami at physical boundaries effectively. The grid spacing is 500 m and bathymetry data provided by Japan Oceanographic Data Center were used to produce bathymetry grid data (Maeda and Furumura, this meeting).

Tsunami forecasting was performed by applying an algorithm presented by Tsushima et al. (2009). In the algorithm, offshore tsunami waveform data are inverted for initial sea-surface height distribution in source region, and then prediction of coastal tsunami waveforms are synthesized by using the estimated height and pre-computed Green's functions. To stabilize the solution of the inverse problem, we imposed two constraints on the spatial distribution of sea-surface height. One is the smoothing constraint, and the other is the constraint based on a priori knowledge that initial sea-surface height due to an earthquake should be zero if the epicenter is far enough away.

3. Results

We performed the simulated tsunami forecast 15 minutes after the 1944 Tonankai earthquake using the observed tsunami data at 37 offshore stations. At this timing, the pressure variation due to the coseismic seafloor deformation appears in the records at most offshore stations. These sufficient data are expected to constrain the source model strongly, resulting in providing accurate tsunami forecasts. At the coastal sites along the Kii Peninsula and to the west, the forecasted arrival times and peak amplitude of the first tsunami explain well the observations. At the sites along the Shima Peninsula and to the east, the tsunami amplitudes are underestimated. It may be caused by the excessive effect of the damping constraint. The weight of the damping constraint become large at the eastern part of the source region far from the epicenter, resulting in underestimation of initial sea-surface height and coastal tsunami amplitude. However, if we do not impose the constraint, the solution of the inversion become unstable and the forecasting accuracy becomes low. In future, the modification of the constraint or joint use of the other geophysical data such as strong motion and GPS (Tsushima et al., the 2010 JpGU Meeting) is required.

Keywords: real-time tsunami forecasting, ocean bottom pressure gauge, GPS buoy