Development of tsunami Green's function database based on linear dispersive-wave theory and its application to real-time tsunami forecasting

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Real-time tsunami forecasting based on source inversion of offshore tsunami data is effective for update of tsunami early warnings. We developed tsunami forecasting method based on inversion of offshore tsunami data for initial sea-surface height distribution, named tFISH (Tsushima et al., 2009). The purpose in this study is improvement of tsunami-waveform Green's function database (DB) that is one of key elements of tFISH algorithm. In tFISH algorithm, tsunami forecasting calculation is based on linear superposition of Green functions. Therefore, error in the functions directly affects tsunami-forecasting error. The present DB is prepared by using tsunami simulations based on linear long wave (LLW) theory. Generally, tsunamis have lone-wave length, and thus this approximation is valid. When a tsunami source is abundant in short-wave length component, however, the resultant tsunami waveforms become dispersive even at the near-field observing point (Saito et al., 2009). In such situation, use of LLW Green function degrades source-estimation accuracy (Saito et al., 2010). To overcome this problem, we have to prepare Green's function DB based on linear dispersive-wave (DSP) theory, instead of LLW. However, the cost of the DSP calculation is much higher than that of LLW simulation. In addition, we have to conduct DSP simulations for more than 3000 cases to construct DB, and thus total computation cost is extremely huge. To overcome this difficulty, we implemented functions to accomplish these huge calculations in realistic calculation time by using K computer and then constructed DSP DB for Nankai-trough region (Tsushima et al., 2015, JpGU). In this presentation, we introduce construction of DSP DB for Kuril-Japan trench region and results of numerical simulations to show effectiveness of DSP Green functions in real-time tsunami forecasting.

In numerical simulations of tsunami forecasting, we assumed the 1933 Sanriku earthquake (magnitude 8.4) as a target event. This earthquake is an outer-rise normal-faulting event. Since the seafloor deformation is abundant in short wavelength and water depth in the source is great, the resultant tsunami waveforms are dispersive. To produce synthetic observation, we assumed earthquake faulting model proposed by Kanamori (1971) and then calculate the tsunami propagation based on nonlinear dispersive-wave theory. Then, we estimated initial tsunami height distribution using the synthetic data at offshore stations to forecast coastal tsunami waveforms. In tFISH inversion with LLW DB, significant source artifact appeared, while the artifact disappeared by applying our DSP DB. At coastal points around which offshore tsunami stations are few, better forecasting results were obtained with DSP Green functions than with LLW ones. This indicates that use of DSP Green functions is important to improve tsunami source estimation and tsunami prediction for dispersive event. Next, we assumed one of the huge Nankai-trough earthquakes proposed by the Cabinet Office: an earthquake with huge slip off Kochi Prefecture. To simplify situation, we neglect finiteness of rupture velocity in production of synthetic observations. It is noteworthy that the resulting synthetic data are less dispersive. Then, we compared the predicted tsunami waveforms at coastal points based on DSP DB and those based on LLW DB. As a result, these show good agreement. This result indicates the possibility that DSP DB works well for both dispersive and non-dispersive events. To clarify this point, we will perform more performance tests in future.

This research used computational resources of the K computer provided by the RIKEN Advanced Institute for Computational Science through the HPCI System Research project (Project ID: hp150216).

Keywords: K computer, Real-time tsunami forecasting, Database, Linear dispersive-wave theory, Disaster mitigation

