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Real-time tsunami inundation forecast which works for a recurrence of 17 century great Hokkaido earthquake (M8.8)

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Along the Pacific coast of Hokkaido, great recent interplate earthquakes such as the 2003 Tokachi-oki earthquake, generated large tsunamis and caused large disasters along the coast historically. Also, paleotsunami studies revealed that much larger tsunamis attacked the Pacific coast than tsunamis from historical great earthquakes. The most recent tsunami of those great paleotsunamis occurred in 17 century, and many tsunami deposit data were available for this 17 century large tsunami. First, we estimate the fault model for the 17 century great earthquake which can explain the most of tsunami deposit data. The result indicates that the large slip, about 25m, along the plate interface near the trench is necessary in addition to the fault models found by the previous study (Satake et al., 2003). The seismic moment of this 17 century great earthquake is estimated to be 1.7×10^{22}Nm (Mw 8.8). For the 2011 Tohoku-oki great earthquake (Mw9.0), the largest slip of more than 40 m was also estimated at the plate interface near the Japan Trench in addition to the large slip at the deeper plate interface. This suggests that the 17 century great earthquake off Hokkaido had the same source process as the 2011 Tohoku great earthquake. If a great earthquake like the 17 century earthquake occurs off the Pacific coast of Hokkaido, the devastating disaster along the coast is expected. To minimize the tsunami disaster, the research on a development of the real-time forecast of a tsunami inundation area is necessary.

To estimate a tsunami inundation area, it is necessary to carry out a tsunami numerical simulation with a very fine grid system of less than 10 m. Because a computation time is much longer than the available time for a tsunami forecast, we do not have a time to compute the tsunami inundation area after a large earthquake occurs. In this study, we develop a real-time tsunami inundation forecast method using a database where many tsunami inundation areas previously computed using various fault models are saved.

After a great earthquake occurs, a fault model of the earthquake will be estimated from a magnitude and a hypocenter of the earthquake using a scaling relationship of earthquakes. The mechanism of the earthquake is assumed to be an interplate earthquake. From that fault model, a tsunami is computed using the linear long-wave equations. That tsunami simulation takes only 1-3 minutes using a typical PC, so it can be used for a tsunami forecast. Using that result, we develop a method to choose the best tsunami inundation area from the database.

In a database, tsunami inundation areas computed numerically using various fault models and tsunami waveforms at several locations near the inundation area at the ocean depth of about 50 m. The locations are chosen that tsunami propagation with a linear long-wave approximation is good enough for the first wave of tsunami. Those computed tsunami waveforms are used to compare the tsunami waveforms computed from the fault model of an actual earthquake using the linear long-wave equations we describe above. Therefore, the best tsunami inundation area will be chosen by comparison of tsunami waveforms in the database with the tsunami waveforms computed from the fault model of the earthquake.

This method is tested at Kushiro city in Hokkaido. The tsunami inundation areas in Kushiro city from various fault models are numerically computed and saved into a database. The great earthquake which is the same as the 17 century great earthquake occurs as an example. First, the tsunami inundation area in Kushiro city is computed from the source models estimated in this study as an answer. The tsunami waveforms computed using the linear long-wave equations are compared with the tsunami waveforms in the database, and the best inundation area are chosen to be a forecast inundation area at Kushiro. We found that the method worked well enough to forecast the tsunami inundation area at Kushiro.

Keywords: tsunami inundation forecast, 17 century Hokkaido earthquake, Tsunami numerical simulation