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Retrospective evaluation of tFISH performance: Forecasting of tsunami caused by the M 7.3 earthquake on Mar. 9, 2011

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On March 9, 2011, the largest foreshock (Mw7.3) of the 2011 Tohoku-Oki earthquake occurred accompanying tsunami with amplitude of about 50 cm at coastal tide-gauge stations in Iwate and Miyagi prefecture. When the earthquake occurred, nine ocean bottom pressure gauges (OBPGs) were installed by Tohoku University around the epicenter, which recorded tsunami with amplitude of 10-30 cm. Kubota (2012) estimated the slip distribution of this earthquake from detailed analysis of the tsunami waveforms. These waveforms were obtained from retrieved OBPGs after the earthquake, however, these offshore data would contribute to an improvement of the accuracy of tsunami forecast if they were available in real-time.

We applied tFISH algorithm to this offshore tsunami data and calculated the waveforms of the coastal tide-gauge stations. We inverted the waveform data recorded offshore to estimate the distribution of the initial sea-surface height, synthesized tsunami waveforms at coastal tide gauge stations, and then compared the calculated waveforms with observations to evaluate the accuracy of the forecast. As a result, it turned out that coastal tsunami waveforms calculated 6 min after the earthquake, or 25 min before the arrival of the first wave to the coast show good agreements with observations in arrival times with misfits less than 2 min. Amplitudes were estimated in the range of 50 to 200 % of the tide-gauge records. This early and accurate forecast by the tFISH was achieved by dense coverage of OBPGs in the range of the tsunami source. The main packet of the tsunami signal reached the offshore stations within 6 min after the earthquake, making the initial sea surface height estimation accurate.

The results of this study demonstrate that tFISH can provide accurate forecast of tsunamis generated by frequent M7 class earthquakes when dense offshore observation networks are available in real-time.

Keywords: Near-field tsunami forecasting, ocean-bottom pressure gauge, tsunami waveform inversion