Retrospective evaluation of tFISH/RAPiD performance: tsunami forecasting based on offshore tsunami and GNSS data

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tFISH (Tsushima et al., 2009) is an algorithm for real-time tsunami forecast that inverts the waveform data recorded offshore to estimate the distribution of the initial sea-surface height, synthesizes tsunami waveforms at coastal tide-gauge stations.
We have been made a retrospective evaluation of tFISH based on the offshore tsunami data of the Sanriku-oki earthquake (Mw7.3) occurred on March 9, 2011, the largest foreshock of the 2011 Tohoku-oki earthquake. By comparing the calculated waveforms with observations, it was confirmed that the coastal tsunami waveforms obtained by tFISH agree well to the observations ~ 6 min after the earthquake, or ~ 25 min before the arrival of the first wave to the coast. However, it is difficult to estimate the initial sea surface height accurately by the offshore tsunami data immediately after the earthquake, and the inaccuracy caused significant underestimation of forecasted tsunami heights along the coast.
In this study we test tFISH/RAPiD (Tsushima et al., 2014) that incorporates RAPiD algorithm (Ohta et al., 2012) into the coastal tsunami forecasting based on the tsunami waveforms synthesized by using a real-time estimated tsunami source model, with using the GNSS data obtained during the same earthquake, as well as the offshore tsunami waveforms.
The onshore GNSS data of GEONET operated by Geospatial Information Authority of Japan (GSI) are available in real time and it is expected that a source model of an M-7 class earthquake can be obtained within ~ 3 min after the earthquake occurrence, giving the initial sea surface height distribution for the tsunami computation, a RAPiD solution. In tFISH/RAPiD, a RAPiD solution is used as a starting model for tsunami forecasting, and then the tsunami source model is iteratively improved with time by including the tsunami waveforms observed at offshore stations into the source estimation.
Our results show that the RAPiD solution obtained after the M 7.3 earthquake provided the coastal tsunami waveforms agree fairly well to the observations and the forecasting based on the real-time geodetic data complement the very early tsunami forecasting. We note here that our test proves that tFISH/RAPiD would work even for M-7 class inter plate earthquakes, much smaller than the case previously tested.
The good agreement of the tsunami waveforms based on the RAPiD solution to the observations further suggests that the tsunami calculation based on the onshore geodetic data can provide a valuable information for early coastal tsunami forecasting, when there are no offshore stations near the source area and tFISH would not work well.

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

