A forward analysis approach using ocean-bottom pressure data for real-time tsunami forecast

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We developed real-time tsunami forecast methods using only ocean-bottom pressure data from a dense offshore observation network without inversion analyses, which can yield large uncertainties (Aoi et al., 2015, AGU). We propose a rapid and simple method of estimating the approximate tsunami source location using offshore ocean-bottom pressure data and multi-index method to rapidly match between offshore tsunami observations and pre-calculated offshore tsunami waveforms (Yamamoto et al., 2014, AGU; Suzuki et al., 2015, JpGU; Yamamoto et al., 2015, AGU). In these studies, a set of about 2,000 tsunami scenarios prepared for a research project of nationwide probabilistic tsunami hazard assessment for Japan (Hirata et al., 2014, AGU) are used, because they consider any possible tsunami sources that may affect the Pacific coast of Japan. The tsunami waveforms at locations of the Seafloor Observation Network for Earthquakes and Tsunamis along the Japan Trench (S-net) and maximum coastal tsunami heights along the Pacific coasts of Japan are calculated. These data are registered in the proposed Tsunami Scenario Bank (TSB).

To estimate the approximate tsunami source location, we define the tsunami centroid location (TCL), which is the centroid location of the maximum absolute amplitude of the real-time ocean-bottom hydrostatic pressure changes. To determine whether the TCL can approximate the tsunami source location, which is assumed to the centroid location of the absolute values of the initial sea surface height displacements, we examine approximately 1,000 near-field synthetic tsunami scenarios and a realistic tsunami scenario of the 2011 Tohoku earthquake. From these examinations, we confirm that in most scenarios, the TCLs obtained within a few minutes after an earthquake occurrence are close to the corresponding tsunami source locations.

To quickly select dozens of appropriate tsunami scenarios that can explain the offshore observations, we use multiple indices. The key feature of the method is a rapid matching between offshore tsunami observations and pre-calculated offshore tsunami waveforms. We apply three indices, which are the correlation coefficient and two kinds of variance reductions normalized by the L2-norm of either the observed or calculated waveform, to match the observed waveforms with the pre-calculated waveforms in the TSB. To examine whether our method can select appropriate tsunami scenarios, we conduct synthetic tests using “pseudo observations.'' Based on the test results, we confirm that the method can select appropriate tsunami scenarios within a certain precision by using the two kinds of variance reductions, which are sensitive to the tsunami size, and the correlation coefficient, which is sensitive to the tsunami source location. At the same time, the coastal tsunami information coupled with the selected tsunami scenarios are forecast.

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