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Rapid Determination of Appropriate Source Models for Tsunami Early Warning using a Depth Dependent Rigidity Curve: Method and Numerical Tests

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Recently, tsunami early warning technique has been improved using tsunami waveforms observed at the ocean bottom pressure gauges such as DONET and S-NET systems in Japan. However, for tsunami early warning of near field tsunamis, it is still essential to determine appropriate source models using seismological analysis before large tsunamis hit the coast, especially for tsunami earthquakes which generated significantly large tsunamis. In this paper, we develop a new technique to determine appropriate source models from which appropriate tsunami inundation along the coast can be numerically computed.

The technique is tested for four large earthquakes, the 1992 Nicaragua tsunami earthquake (Mw7.7), the 2001 El Salvador earthquake (Mw7.7), the 2004 El Astillero earthquake (Mw7.0), and the 2012 El Salvador-Nicaragua earthquake (Mw7.3), which occurred off Central America, and one tsunami earthquake off Sumatra in Indonesia, the 2010 Mentawai earthquake (Mw7.7). In this study, fault parameters were estimated from the W-phase inversion, then the fault length and width were determined from scaling relationships. At first, the slip amount was calculated from the seismic moment with a constant rigidity of 3.5 x 10**10N/m2. The tsunami numerical simulation was carried out and compared with the observed tsunami. For the 1992 Nicaragua tsunami earthquake, the computed tsunami was much smaller than the observed one. For the 2004 El Astillero earthquake, the computed tsunami was overestimated. This indicates that the tsunami early warning is difficult for a tsunami earthquake because the appropriate slip amount is difficult to estimate. In order to solve this problem, we constructed a depth dependent rigidity curve, similar to suggested by Bilek and Lay (1999). The curve with a central depth estimated by the W-phase inversion was used to calculate the slip amount of the fault model. Using those new slip amounts, tsunami numerical simulation was carried out again. Then, the observed tsunami heights, run-up heights, and inundation areas for the 1992 Nicaragua tsunami earthquake were well explained by the computed one. The other tsunamis from the other large earthquakes were also reasonably well explained by the computed ones. Therefore, our technique using a depth dependent rigidity curve was worked to estimate an appropriate fault model which reproduces tsunami heights and inundation area near the coast. The technique may be worked in the other subduction zones by finding a depth dependent rigidity curve in that particular subduction zone.