海底電磁場データを用いた津波速度場の推定

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Estimation of tsunami velocity field using seafloor electromagnetic data

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A pair of earthquakes occurred on both sides of the Kuril Trench on 15 November 2006 and 13 January 2007. The interplate underthrust earthquake of the 2006 event (Mw 8.1) had a larger seismic moment than the outer-rise normal fault earthquake of the 2007 event (Mw 7.9) (Fujii and Satake, 2008). Toh et al. (2011) reported that the electromagnetic (EM) variations during the tsunami passages were recorded about 1 hour after the origin time of each earthquake by a seafloor geomagnetic observatory located about 800km away from the epicenters. The article also reported that the relationship between the EM variations and the particle motions of conductive seawater are confirmed using Sanford's (1971) theory.

However, Sanford's (1971) theory neglects the self-induction effect and is applicable only to ocean currents moving slowly. The phase velocity of tsunami in pelagic environments exceeds 200 m/s and hence the self-induction term needs to be considered. Here we report our simulation result on the tsunami-induced EM signals observed at the seafloor based on three-dimensional (3-D) non-uniform thin-sheet approximation by McKirdy, Weaver, and Dawson (1985). Our newly written numerical code accommodates not only the inducing non-uniform source fields caused by particle motions of conducting seawater at the time of tsunami passage but also the self-induction effect within the ocean and its conductive substrata. Horizontal particle motions were calculated by Fujii and Satake (2008) with two types of hydrodynamic approximation, viz the Boussinesq approximation and the long-wave approximation.

The calculated EM variations associated with the initial wave of the tsunami at the time of 2006 event are consistent with the observed ones even by the long-wave approximation, while the numerical predictions do not reproduce the observation associated with subsequent tsunami phases.

As for 2007 event, the EM variations accompanied by distinct subsequent tsunami phases are partly simulated by the Bousinessq approximation. However, the amplitudes of the calculated EM variations were about half of those of the observation in both hydrodynamic approximations used here.

The disagreement between the calculation and the observation probably stems from the assumed tsunami velocity field, for there were no tsunami waveform observatories near the seafloor geomagnetic observatory when the two tsunamis occurred.

We, therefore, estimate the tsunami waveforms that explain the observed EM variations. The waveforms are calculated by Cornell Multi-grid Coupled Tsunami Model (COMCOT, Version 1.7), which employs linear water equations and applies the method to mimic physical dispersion by numerical dispersion proposed by Imamura et al. (1988) to weak dispersive waves over slowly varying bathymetry. The EM observatory locates in the open ocean where the bathymetry slowly varies so that the dispersion effect of the tsunami was recovered in the case of 2006 event. As for the 2007 event, the dispersion effect was larger and hence this model was not sufficient to reproduce the dispersion of the latter event. This implies that seafloor EM data can be used to recover tsunami velocity fields at least for weakly dispersed tsunamis.