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Tsunami source estimation of the 2011 Tohoku-oki earthquake (M9.0) and its foreshock (M7.3) using ocean bottom magnetic

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The electromagnetic induction theory predicts that motion of conductive seawater in the geomagnetic field induces variation of electromagnetic fields as known as dynamo effect. Thus electromagnetic observation is expected to be a novel tsunami meter that can detect propagated direction of tsunamis in addition to the sea level change (e.g. Toh et al., 2011). When the 2011 Tohoku-oki earthquake (M9.0, March 11) occurred, an ocean bottom electromagnetometer (here after OBEM) settled near the Japan Trench (39.0N latitude, 144.8E longitude, 5830m deep) clearly recorded tsunami induced magnetic signals.

The variations in the magnetic field after the main shock show a unipolar impulsive wave for a short duration (about 4 min) in all three components. The vertical magnetic field indicates the tsunami travel time to the OBEM station (4 minutes from the initial rupture). Amplitude of the vertical impulse (15 nT) corresponds to 2.3 m of sea level change. In addition, the horizontal magnetic field components indicate propagated direction of tsunami to the OBEM station (WNW). Based on this information, the tsunami source of the main shock was determined along the Japan Trench but at about 100 km north from main rupture zone of the main shock (around 39.0-39.5N latitude, 144.8E longitude). Joint analysis of OBEM data and offshore sea-level gage data (GPS gages and deep pressure gages) supports this location and constrained the tsunami source to a narrow east?west area (<30 km in width). On the other hand, the tsunami induced vertical magnetic signal associated with the foreshock was detected after 10 minutes from the rupture initiation. Based on the back propagation curves of the arrival time of tsunami to the OBEM station and the offshore sea-level stations, the tsunami source of the fore shock was determined around 38.4N latitude and about 80km west from the Japan trench, almost same location of the epicenter. Thus the estimated tsunami sources of the fore and main shocks are quite different although the epicenters of main and fore shocks are determined in the almost same location. In addition, elastic fault models are hard to explain observed tsunami waveforms by the main shock including OBEM data although it can explain observed tsunami waveforms by the fore shock. They imply different source mechanism of these tsunamis and thus detailed study of the tsunami source model is required especially for the main shock.

Keywords: tsunami electromagnetism, OBEM, 2011 Tohoku-oki earthquake