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Application of back-projection method to OBS data for understanding rupture propagation of the 2011 Tohoku earthquake

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The rupture process of the 2011 Tohoku earthquake was remarkably complicated. To discuss what constrains the rupture propagation, it is important to clarify the space and time variation of seismicity before and after the Mw 9.0 event. High-resolution seismicity around the rupture region of the main shock is required for such discussion. We used data from a dense array of 31 ocean bottom seismometers (OBSs) that were deployed before and recovered after the main shock off Ibaraki. The station interval of the array was about 6km. Accurate OBS positions were determined by applying the LSQR algorithm to the acoustic measurements between the vessel and OBS.

In this study, we tried to estimate the initial rupture area by applying back-projection method to these OBS array data.

First of all, we constructed a 3-D velocity structure model off Tohoku by compiling the results of marine seismic surveys (e.g., Mochizuki et al., 2008; Miura et al., 2005) and the tomography under the Japanese islands (Matsubara and Obara, 2011). In this case, P-wave velocities are given to grid points at a horizontal grid spacing of 10km and a vertical grid spacing of 5km. Then, we constructed a travel time field bounded by 35.5N - 40.5N and 141E - 144.5E (about 300km X 540km) with the same grid interval. To refine the theoretical travel time field, we referred to precise hypocenters of aftershocks determined with OBS data from aftershock observations (Shinohara et al., 2012).

After constructing the theoretical travel time field, we measured the array response function to confirm the resolution of the apparent slowness vector arriving at the array, applied a proper frequency filter selected with consideration of the sediment under each OBS, and estimated the initial rupture area of the main shock by projecting semblance values.

Keywords: the 2011 Tohoku earthquake, ocean bottom seismometer, back-projection