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Precise aftershock relocation of the 2011 Tohoku earthquake and its relation to regional slip distribution

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One of the characteristics of the 2011 Mw 9.0 off the Pacific coast of Tohoku earthquake is a quite large co-seismic slip at a shallow part of the Japan Trench plate interface. Knowing precise aftershock distribution is a key to clarify the mechanism of the earthquake with such a new aspect. Especially, understanding relationships between the slip distribution and the aftershock activity provides an important clue for elucidating the source rupture process.

Therefore, in this study, we precisely relocated the aftershocks by using data from 20 ocean bottom seismometers (OBSs) deployed between 37N and 38N where the amount of co-seismic slip showed a remarkable transition. The observation area is about 150km x 150km and the station interval is about 25km. We relocated the events in the Japan Meteorological Agency Catalog data from March 28, 2011 to July 12, 2011.

We manually picked arrival times of the PS wave converted at the bottom of the sedimentary layers as well as P and S waves of each aftershock, and located its hypocenter by using hypomh (Hirata and Matsu'ura, 1987). We applied station corrections determined from a time difference between P- and PS-wave arrivals at each station. We utilized the results as the initial hypocenters, and obtained their final hypocenters by applying hypoDD (Waldhauser and Ellsworth, 2000). We used a 1-D velocity structure derived from an existing velocity section (Miura et al., 2003).

Comparing our result to subduction velocity structure (Miura et al., 2005) lying to the north of the study area, it is shown that the aftershock activity along the plate interface between the continental plate and the subducting Pacific plate is low at shallower than 20km depth. In contrast, many aftershocks occur both along the plate interface deeper than 20km depth and within the continental plate. Low aftershock seismicity appears concordant with a large co-seismic slip estimated by previous studies. In addition, the swarm like activity around the oceanic Mohorovicic discontinuity is confirmed at the up-dip of a large co-seismic slip area near the Japan Trench axis.

Keywords: the 2011 Tohoku earthquake, aftershock, slip distribution, subduction, ocean bottom seismometer