Seismic array observations in the source region of the 2011 Tohoku-oki earthquake using ocean bottom seismometers

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Japan Trench is one of the most important subduction zones when discussing the conditions for the occurrence of slow earthquakes. Recent studies have identified slow earthquake activities such as slow slip events (SSEs) (Kato et al., 2012; Ito et al., 2013), tectonic tremors (Ito et al., 2015) and very low frequency earthquakes (Matsuzawa et al., 2015) in the shallow part of the Japan Trench subduction zone. However, these previous observations are still very limited because of the sparse seismic network. For the purpose of examining detailed activities of shallow seismicity including tectonic tremors, we deployed ocean bottom seismmeter (OBS) arrays near the trench axis. In this study, we analyze 6 months of observed array data to investigate offshore seismicity and evaluate the fundamental performance of OBS arrays.

We installed three OBS arrays (AoA1-3) at an interval of about 20 km apart near the trench where the anticipated slip area of SSEs and the high coseismic slip area are overlapping. Each array consists of 5 stations each with the inter-station spacing at about 500 m. The station at the center of array has a broad-band OBS while the other 4 stations have short-period OBSs. We use the data obtained from the first observation period of AoA which has been performed for about 6 months from the end of October 2014 to the beginning of May 2015.

For each set of array data, we conduct a coherence analysis using the moving-window correlation technique to detect coherent signals and estimate their incoming directions (e.g. Fletcher et al., 2006). For every 4 s time window, the optimum direction and apparent velocity are measured by maximizing the average cross correlation of all pairs of seismograms within an array, under the assumption of plane waves.

We successfully detect many coherent signals. The number of signals detected simultaneously by all three arrays is about 2,500, which includes regional and distant earthquakes or artificial signals like airgun shooting. About 1,000 signals correspond to the regional events in the earthquake catalog of the Japan Meteorological Agency (JMA). Although tectonic tremors have not been observed in this period, we identified the anomalous increase of seismicity which did not appear in the JMA catalog after the M6.9 shallow event that occurred in February 2015 in the northern part of Tohoku-oki area. This suggests that the OBS array observation has the potential to detect shallow seismic signals which could not be detected by onshore seismic networks.