Dynamic Triggering of Low Frequency Tremor Revealed by the OBS Array of Arrays near the Japan Trench

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In the Japan Trench subduction margin, both fast and slow slip, such as the M9 Tohoku-Oki megathrust event, low frequency tremors and very low frequency earthquakes (VLFEs) have been observed. Because almost all of the events occur under the sea floor, observation capability of the on-land seismic networks is limited in their detection and the location of the sources due to far distance and network geometry relative to source region.

To observe offshore seismicity with high precision and resolution, we have installed three arrays of ocean bottom seismometers (OBSs) on offshore Fukushima prefecture near the trench axis, where is the southern end of the rupture area of the 2011 M9 Tohoku-Oki earthquake. This region is spatially correlated with a source region of VLFEs [Matsuzawa et al., 2015], earthquake swarm [Nishikawa and Ide, 2018], and after slip [Tomita et al., 2017].

Each array consists of one broad band OBS, and six 1Hz short period OBSs. Those seven OBSs form a triangular array with diameter of 1km, and 300m to 500m of interstation distance. Continuous observation was performed between September 2016 and October 2017. From the observed data, we identify two episodes of low frequency tremors, triggered by M7.8 event in offshore Solomon Islands on October 2016, and M7.7 event in offshore Kamchatka Peninsula on July 2017, respectively. In both cases, the tremors are triggered by Rayleigh wave. However, those episodes show contrasting characters. The episode of October 2016 continues for 7 minutes, and finishes after passage of Rayleigh wave. On the other hand, the episode of July 2017 continues even after passage of Rayleigh wave, and lasts for more than 12 minutes.

To reveal the origin of these tremors, we use beamforming technique to estimate back azimuth and apparent velocity of incoming wave observed by an array. Observed tremors are beamformed in horizontal components of OBSs after their absolute orientations are determined using particle-motion of T-phase. From the resulting beam, we estimate hypocenter of tremors every 60 seconds by grid search. Hypocenter of two tremor episodes are clustered in a narrow region within the Array of Array network. The tremor activity probably indicates the potential for the occurrence of shallow slow earthquakes near the Japan Trench, in which VLFEs and after slip are activated after the 2011 Tohoku-Oki earthquake.