Micro Low-Frequency Tremor Activity Before the Tohoku-Oki Earthquake

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An understanding of slow earthquakes in shallow subduction zone regions is necessary to form a complete picture of the accumulation and liberation of elastic strain energy along shallow subduction interfaces, which occasionally generate large tsunamigenic slips. A slow slip event (SSE) and tectonic tremors (TTs) occurred approximately one month prior to the occurrence of the 2011 Tohoku-Oki earthquake near the Japan Trench (Ito et al., 2013; 2015). These preceding events could demonstrate the nucleation of fast slip event from slow slip activity. We report the detail of 2011 TT activity based on short period ocean bottom seismometer (OBS) data using a modified frequency scanning method (m-FSM; Katakami et al., 2017) at a single OBS that allows robust TT detection because the TT signal amplitude was near ambient background noise levels.

The TT activity prior to the Tohoku-Oki earthquake was composed of three major sequences. The first occurred ~1.5 months before the mainshock, and the second followed a ~2-week quiescence period; the final sequence started just before the largest foreshock activity. Because the amplitude of the activity was very small, we had not determined the exact hypocenters of the TTs using differential arrival times of TT signals. Therefore, we have approximated TT source locations based on the spatiotemporal variations of TT seismic energy observed at OBS network. The locations of the three TT activity sequences differ. The source region of the second sequence is estimated to be 50 km landward which coincide to the SSE fault, while the other two TT sequences occurred close to trench which located in the updip portion of SSE fault.
These TTs could be occur accompanied with SSE. This spatio-temporal TT activity distributions revealed possible TT migrations from updip to downdip side on the plate boundary to the epicenter of the largest foreshock. These small amplitude TTs might be cause by low effective stress in very shallower part of the subduction zone. Several reports have revealed the occurrence of slow earthquakes preceding large earthquakes, in which the SSEs migrated toward the rupture initiation points of the earthquake mainshocks (Radiguet et al., 2015; Ruiz et al., 2014). In this study, we show that TTs occur during SSE activity, and, thus, that temporal and spatial changes in activity reflect the SSE expansion processes that occur before a large earthquake. Therefore, slow earthquake monitoring may be extremely important in understanding current elastic stress field conditions near plate boundaries.

Keywords: nucleation, tectonic tremor, triggering