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# Shallow micro low-frequency tremor before the Tohoku-Oki earthquake

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Slow earthquake activity is one of the important phenomena to understand slip behavior in the shallower part of the subduction zone, especially to understand the generation of tsunami earthquakes. Recently, SSEs and low-frequency tremor have been observed near the trench by using ocean bottom observations, and these have been located in the updip portion of a coseismic slip area [Wallace et al., 2016; Yamashita et al., 2015]. In addition, Ito et al. [2015] observed tremor sequences from the excitation of ambient noise amplitude, accompanied with SSE in the source area of the Tohoku-Oki earthquake's mainshock. However, the signals observed within these sequences showed very weak amplitude and were observed at only one station, nearest to the Japan Trench. Here, we report on our detection of micro low-frequency tectonic tremor (mLFT) activity prior to the 2011 Tohoku-Oki earthquake near the Japan Trench by using modified frequency scanning method (mFSM) as applied to ocean bottom seismometers (OBSs) .

The original frequency scanning method [Sit et al., 2012] proposed a tremor detection method of calculating envelope waveform ratios through different bandpass filters of broadband data in the Cascadia margin. We modified this analysis for short period OBS seismic data recorded at 17 OBSs deployed in an area near the trench axis offshore Miyagi Prefecture, northeast Japan. Three bandpass filters of 2–4 Hz, 10–20 Hz, and 0.5–1.0 Hz, corresponding to the dominant frequency band of tremors, local earthquakes, and ocean noise, respectively, were applied to the OBS records for a period between November 19, 2010 and March 9, 2011. This duration is the same as the deployment period of TJT2 station which is located nearest to the Japan Trench, and is also before the largest foreshock of the Tohoku-Oki earthquake. The results of applying the mFSM show three major tremor sequences, suggesting tremor activity in the shallowest part of the subduction zone. The sequences agree with the results of Ito et al [2015]. Furthermore, we successfully detected tremors at landward stations in the second sequence. We estimated the energy release from the envelope amplitude of two horizontal components filtered at 2-4Hz after removing site effects. The energy estimates are in general very weak, compared with tremors typically observed in other regions. The energy released near the trench just before the largest foreshock is larger than at any other period, suggesting that the mLFTs occurred nearby the Japan Trench. The mLFT activity likely increased during the three days before the largest foreshock of the Tohoku-Oki earthquake. In addition, we also evaluated the tidal response of the tremor activity at each OBS site. However, we could not find any characteristic tidal response before the mainshock.