

## Small low-frequency tremor coincident with slow slip events near the Japan Trench

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Understanding the changes in rates of transient deformation prior to large earthquakes in subduction zones is critical for predicting impending earthquakes and tsunamis. In the 2011 Tohoku-Oki earthquake, the shallow plate-boundary thrust at the Japan Trench slipped tens of meters to generate a devastating tsunami. Some slow slip events (SSEs) and intense foreshock triggered by SSEs have been reported prior to the megathrust event. At several subduction zones around the world, SSEs have been commonly observed to be accompanied by tectonic tremors. Here, we investigate low-frequency tremor activity accompanying SSEs prior to the 2011 Tohoku-Oki earthquake using ocean bottom seismometers deployed just above the coseismic slip area of the 2011 Tohoku-Oki earthquake before the mainshock occurred. To identify tectonic tremor activity accompanying the SSEs, we used three-component continuous seismograms in an ocean bottom seismometer (OBS) network. We investigated the ratio of two envelopes in order to remove the effects of regional earthquakes and stormy weather, using one station as a reference site. We identified three excitations with durations exceeding three days on the envelope ratio between January 25 and March 9, 2011, prior to the Tohoku-Oki earthquake. Similar excitations of envelope ratio were identified at the beginning of and during the SSEs detected by ocean bottom geodetic observations in 2008. They showed that low frequencies of 5-8 Hz dominated. These observations suggest that the excitations accompanying the SSEs could have been due to small low-frequency tremors associated with episodic SSEs; thus the shallow plate-boundary thrust near the trench could be characterized as a general location of slow earthquakes.

Keywords: low-frequency tremor, slow slip, the 2011 Tohoku-Oki earthquake