Marine observations of slow earthquakes using ocean bottom seismometers in the northern part of the Hikurangi subduction zone, NZ

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The Pacific Plate subducts beneath the Australian Plate at a rate of ~5 cm/year along the northern Hikurangi trough off the North Island, New Zealand, and the seismic activity is very high. In addition to regular earthquakes, slow earthquakes including slow slip events (SSEs) and tremor have been observed offshore on the shallow plate interface. SSEs are relatively frequent in the northern part of the Hikurangi subduction margin, occurring every 1-2 years. Therefore, this frequent, repeating occurrence offers an excellent chance to capture accompanying seismicity as well as the SSE itself using temporary deployments of ocean bottom instruments directly overlying the shallow (<10 km) SSE source.

We conducted an international collaborative observation from May, 2014, through June, 2015, using 15 ocean bottom seismometers (OBSs) and 24 ocean bottom pressure gauges (OBPs). We were successful in capturing an SSE directly beneath the network, and obtained a precise slip distribution of the event. The slip reached near the trough axis, and that the slip was reduced in the area of subducted seamounts. The tremor activity initiated near the end of the SSE and it lasted for more than two weeks, within a limited region over one of the subducted seamounts. Stress inversions from focal mechanisms of earthquakes during the SSE cycle revealed temporal variations in stress orientations suggestive of an increase in pore fluid pressure within the slab and along the plate interface during the period prior to SSEs in the area, and a subsequent reduction of pore fluid pressure following SSEs. Furthermore, variations of shear wave splitting delay times and Vp/Vs suggested that filling and emptying of cracks and pore spaces accompanied the fluid pressure changes. These observations of long-lasting tremor activity and temporal variation of focal mechanisms and cracks in tandem with the occurrence of SSEs suggest a potential role of fault-valving in the generation of slow earthquakes.
We conducted another temporary OBS deployment from Oct. 2018 through Oct. 2019 using 5 OBSs in the same region of the 2014-2015 observation spanning the subducted seamount where we recorded offshore tremor activity previously. A large SSE occurred during the observation period in April-May 2019 around our OBS network, and we were successful in capturing seismic activity accompanying the SSE. The seismicity increased around the start of the SSE and continued throughout the event. Some of the activity shows a large low frequency component, and it is likely that tremors were activated. We are conducting further investigations.

Keywords: Hikurangi subduction zone, marine seismic observation, tremor, plate interface geometry

