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Seismic activity and velocity structure in the Hikurangi subduction zone offshore the North Island of New Zealand

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The Hikurangi Plateau which has anomalously thick (˜12 km) oceanic crust subducts under the Australian plate along the Hikurangi subduction zone offshore the North Island, New Zealand. The plate interface is shallow and we can identify the structure of plate interface in detail on the seismic reflection sections obtained by seismic surveys in the region [e.g., Bell et al. 2010]. Some topogrphic features on the plate interface such as seamounts and high-amplitude reflectivity zones have been identified. The onshore GPS network has been develped since 2000 in the North Island, and the mechanical coupling coefficient along the plate interface has been estimated along the Hikurangi subduction zone. In its northern part (north of -40 degrees), the coupling region is narrow and the down-dip limit is shallow at about 10 km depth. Although almost all of the coupling region is under the sea, ocean bottom seismic observation had not been conducted. Therefore, seismicity and hypocenter distribution in detail has not been well understood. SSEs (Slow slip events) have been observed along the down-dip limit of the coupling region. They occur at much shallower depths than other subduction zones. Tremors and swarms accompanying these events were also reported [Kim et al., 2010; Delahaye et al., 2009].

Marine seismic observation was conducted for the first time offshore Gisborne to observe earthquakes and low-frequency events accompanying SSEs. Four OBSs were deployed in April 2012 and recovered after a year-long observation. The northern two instruments were a broadband type and the other southern two were equipped with 1Hz seismometers. Although the data recorder of one of the broadband type OBSs recorded only intermittently, good data were obtained from the others. During the observation period, two major seismic events occurred around the OBS array. One of the events is a large SSE around the Hawke's Bay to the south of the array from mid-February 2013. First, I extracted event waveforms by applying the STA/LTA event-detection algorithm, and determined hypocenters using manually picked P- and S-wave arrival times. Waveforms of these events were, then, used as templates, and more events were detected by employing a Matched-filter technique. Differential arrival times were calculated by taking cross-correlation of waveforms of paired events. I applied double-difference tomographic analysis (TOMODD [Zhang and Thurber, 2003]) to both absolute and differential travel time data. Focal mechanisms were also calculated using P-wave polarity data. As a result, I successfully detected a number of events that were not observed by the onshore seismic network, and determined their hypocenters. Although few events occurred on the seamounts and HRZs along the plate interface, hypocenters are concentrated on the margin of the HRZ. In velocity structure analysis, I could resolve structure under the offshore region where previous studies using data from onshore stations could not have resolution. However, these velocity structure models are in good agreement in the region where both results have resolved. Quite a few earthquakes accompanying SSEs were observed. Seismic swarms which accompanied the past SSEs in this region occurred in the areas of stably high seismicity. Small coupling regions which are caused by irregular topography of the plate interface may exist in these ares.

Keywords: seismicity, slow slip, plate interface, structure