P115

# Earthquake Swarm Detection along the Hikurangi Trench, New Zealand: Insights into the Relationship between Seismicity and Slow Slip Events

○Tomoaki NISHIKAWA, Takuya NISHIMURA, Yutaro OKADA

## 1. Introduction

Earthquake swarms, which are anomalous increases in the seismicity rate without a distinguishable mainshock, often accompany transient aseismic processes, such as fluid migration (e.g., Yoshida et al., 2019) and episodic aseismic slip along faults (e.g., Ozawa et al., 2003). Investigations of earthquake swarm activity can provide insights into the causal relationship between aseismic processes and seismicity. Slow slip events (SSEs) along the plate interface in the Hikurangi Trench, New Zealand, are often accompanied by intensive earthquake swarms. However, the detailed spatiotemporal distribution of these earthquake swarms is still unclear. Here we used the epidemic-type aftershock-sequence (ETAS) model (Ogata, 1988; Zhuang et al., 2002) to detect earthquake swarms ($M \geq 3$) and created a new earthquake swarm catalog (1997–2015) along the Hikurangi Trench.

## 2. Data and Methods

Figure 1 shows the location of our study region in the Hikurangi Trench. The study region comprises an approximately 500 km long trench section, that extends 200 km in the direction of Pacific Plate motion relative to Kermadec Plate motion (Bird, 2003). As the focus of our study is on earthquake swarms associated with shallow SSEs, we selected the location and size of our study area to encompass the source regions of the shallow SSEs off the east coast of the North Island (Wallace & Beavan, 2010; the magenta contour in Figure 1).

We used all of the $M \geq 3.0$ earthquakes that occurred inside the study region during the 1997–2015 period to detect earthquake swarms. We followed the earthquake swarm detection method published in Nishikawa and Ide (2018), and Nishikawa et al. (2019). We defined earthquake swarms as anomalous earthquake clusters that do not obey the Omori–Utsu aftershock law, which states that aftershock seismicity rates exhibit a power-law decay. We detected such anomalous seismic clusters using the ETAS model.

We used the GNSS time-series data from a continuous GNSS network, which is operated and maintained by GeoNet, to detect the crustal deformation that is potentially due to shallow SSEs accompanied by earthquake swarms. We estimated the daily GNSS displacements (north–south and east–west components) and detected transient crustal movements via the method of Nishimura et al. (2013) and Nishimura (2014).

We then compared the earthquake swarm catalog with the detected GNSS transient displacements, and existing SSE (e.g., Wallace & Beavan, 2010) and tectonic tremor (e.g., Todd & Schwartz, 2016) catalogs.

## 3. Results and Discussion

We found that most of the detected (119) earthquake swarm sequences were intraslab events, and their epicenters were mainly concentrated along the east coast of the North Island, whereas many tectonic tremors were located inland. Twenty-five of the detected earthquake swarm sequences occurred within 25 days before and after transient eastward GNSS displacements due to known or newly detected SSEs. We found that the earthquake swarms sometimes preceded the GNSS displacements by more than several days.

SSE-induced stress loading (Figure 2a) is not a plausible triggering mechanism for these pre-SSE earthquake swarms. We instead propose that high fluid pressure within the slab, which accumulated before the SSEs, may have caused intraplate fluid migration, which in turn triggered the pre-SSE earthquake swarms (Figure 2b). This mechanism is consistent with recent observations that suggest the accumulation and drainage of fluids within the subducting slab before and after an SSE, respectively, in the Hikurangi Trench (e.g., Warren-Smith et al., 2019).

Our results suggest that there are complex relationships between seismicity, slow fault deformation processes, and the accumulation and drainage of intraplate fluids in the Hikurangi Trench. Further investigations of the interplay between these phenomena in the Hikurangi Trench and other subduction zones is essential to elucidate the underlying physics of seismicity and slow earthquakes.

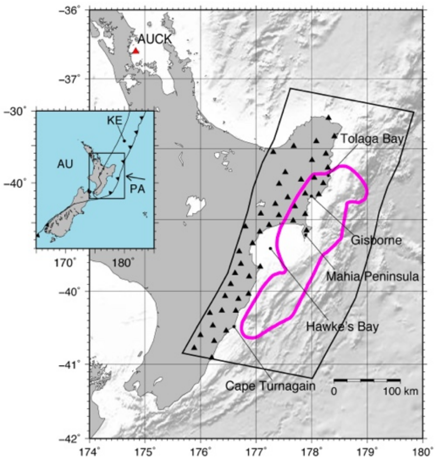


**Figure 1. Our study region and shallow SSE source regions along the northern and central Hikurangi Trench.** The black polygon indicates our study region. The thick magenta contour is the 50-mm total slip contour for the 2002–2010 shallow SSEs (Wallace & Beavan, 2010). The black triangles are the GNSS stations used in this study. The red triangle indicates station AUCK, which was fixed for the GNSS displacements. The inset map shows the tectonic setting of New Zealand; PA, KE, and AU indicate the Pacific, Kermadec, and Australian plates, respectively, with the black arrow representing PA plate motion relative to KE.

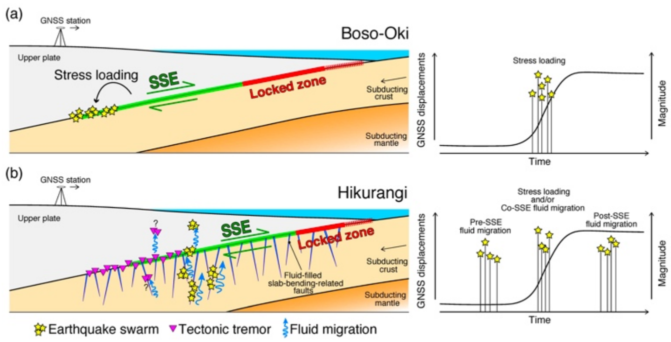


**Figure 2. Two earthquake swarm triggering mechanisms in subduction zones.** (a) Earthquake swarm triggering via SSE-induced stress loading. This mechanism is plausible for the earthquake swarms in the Boso-Oki region of eastern Japan (Fukuda, 2018). (b) Earthquake swarm triggering via pre- and/or post-SSE fluid migration. We prefer this triggering mechanism to explain the generation of earthquake swarms in the Hikurangi Trench. Pressurized fluids accumulate within the subducting slab prior to the onset of SSEs and drain after the SSEs (Warren-Smith et al, 2019). This accumulation of pressurized fluids sometimes breaks a low-permeability seal, with the fluid then beginning to migrate along preexisting intraplate faults (pre-SSE fluid migration), triggering pre-SSE earthquake swarms. The occurrence of an SSE along the plate boundary enhances the permeability of the surrounding rocks and induces post-SSE fluid migration, which in turn triggers post-SSE earthquake swarms.