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Slow Slip Event Detection and Associated Seismic Activation in the Hikurangi Subduction Zone, New Zealand

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Slow slip events (SSEs) are recognized as an important factor influencing seismic activity in subduction zones, yet their role is not explicitly represented in standard statistical models of earthquake occurrence such as the Epidemic-Type Aftershock Sequence (ETAS) model. Recent work by Nishikawa and Nishimura (2023) demonstrated that incorporating SSE-related effects into the ETAS framework improves the representation of seismicity in the Hikurangi subduction zone, New Zealand. However, their analysis was limited by the small number of available SSEs, despite the frequent occurrence of SSEs in this region. This highlights the need for a more comprehensive SSE catalog and a systematic evaluation of SSE-earthquake interactions.

In this study, we construct a detailed SSE catalog for the Hikurangi margin using GNSS time series data from 53 stations distributed along the east coast of New Zealand's North Island, with one reference station on the western side. GNSS data provided by the Nevada Geodetic Laboratory were detrended and analyzed using an automated detection method based on Nishimura et al. (2013), employing an Akaike's information criterion-based metric to identify candidate events. Event durations were first estimated by fitting a double-hinge model to stacked displacement time series. Using the derived durations, station displacements associated with each SSE were calculated and used in a slip inversion. Fault geometry and slip were estimated using rectangular fault Green's functions, with fault planes constrained to the subduction plate interface based on the Slab2.0 model, and the resulting seismic moment was used to calculate the moment magnitude.

To investigate the relationship between SSEs and seismicity, earthquake data from the GeoNet catalog spanning January 2003 to December 2025 were analyzed, selecting events with Mw $\geq$ 2.5 occurring within ±90 days and 100 km of each SSE fault center. Seismicity rate changes were evaluated using a simplified temporal ETAS-based swarm detection method following Nishikawa and Ide (2017) to assess seismicity rate increases near SSEs.

Our analysis identifies 63 SSEs over approximately two decades, with moment magnitudes ranging from Mw 5.7 to 6.9. Of these events, 33 are associated with increased seismicity occurring in close temporal proximity to the SSEs. In cases where an SSE is associated with multiple earthquake swarms, the swarms generally occur in spatially similar areas rather than being widely separated. While the occurrence of seismic activation shows a clear temporal relationship with SSE timing, no clear differences are observed in SSE magnitude or large-scale fault geometry between events with and without associated seismicity.

These results indicate that SSE-related earthquake triggering in the Hikurangi subduction zone cannot be explained solely by static stress changes, and may involve additional mechanisms such as fluid migration or fault-zone heterogeneity.