Low-Frequency Earthquakes Accompany Deep Slow-Slip beneath the North Island of New-Zealand

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Abstract

Slow-Slip Events (SSEs) haven been observed along the Hikurangi subduction zone of the North Island of New-Zealand. They occur both in the shallow plate interface (<15km depth) and at the deeper end of the seismogenic-zone (>30km depth). Some slow slip events in New-Zealand are also accompanied by tectonic tremors, although tremor is not as common at the Hikurangi subduction zone compared to other subduction zones. We present a systematically generated catalog of low-frequency earthquakes (LFEs) for the central Hikurangi margin. To detect preliminary LFEs from the continuous seismic data we used a Matched-Filter technique with template waveforms from the tectonic tremor catalog of Romanet & Ide [2019]. The resulting detections were gathered as families and an innovative stacking technique was used to extract high-quality waveforms in order to build a set of LFE templates for a second Matched-Filter search. From these second generation detections, we developed a methodology to continuously scan the entire dataset for coherent impulsive waveforms similar to LFE that occuring on the subducting plate interface. The LFEs are organized into episodes of intense activity during deep M7 SSEs that occur absit every 5 years beneath the Manawatu region. One of our LFE bursts occurs during a small, deep SSE recognized at the central Hikurangi margin in 2008 (Wallace and Eberhart-Phillips, 2013). We expect that the other LFE episodes highlight small slow transients that have not yet been geodetically observed. In this presentation, we discuss the spatiotemporal evolution of LFEs in regard to potential aseismic transients that can be observed in the GPS data-set acquired by GeoNet.

LOW-FREQUENCY EARTHQUAKES ACCOMPANY DEEP SLOW-SLIP BENEATH THE NORTH ISLAND OF NEW-ZEALAND

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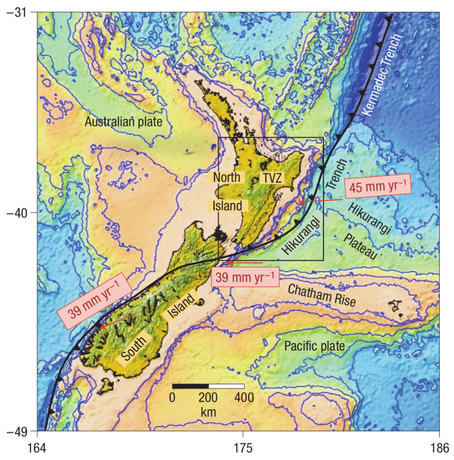
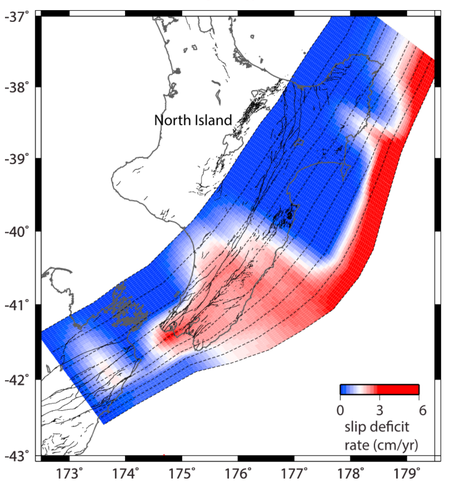
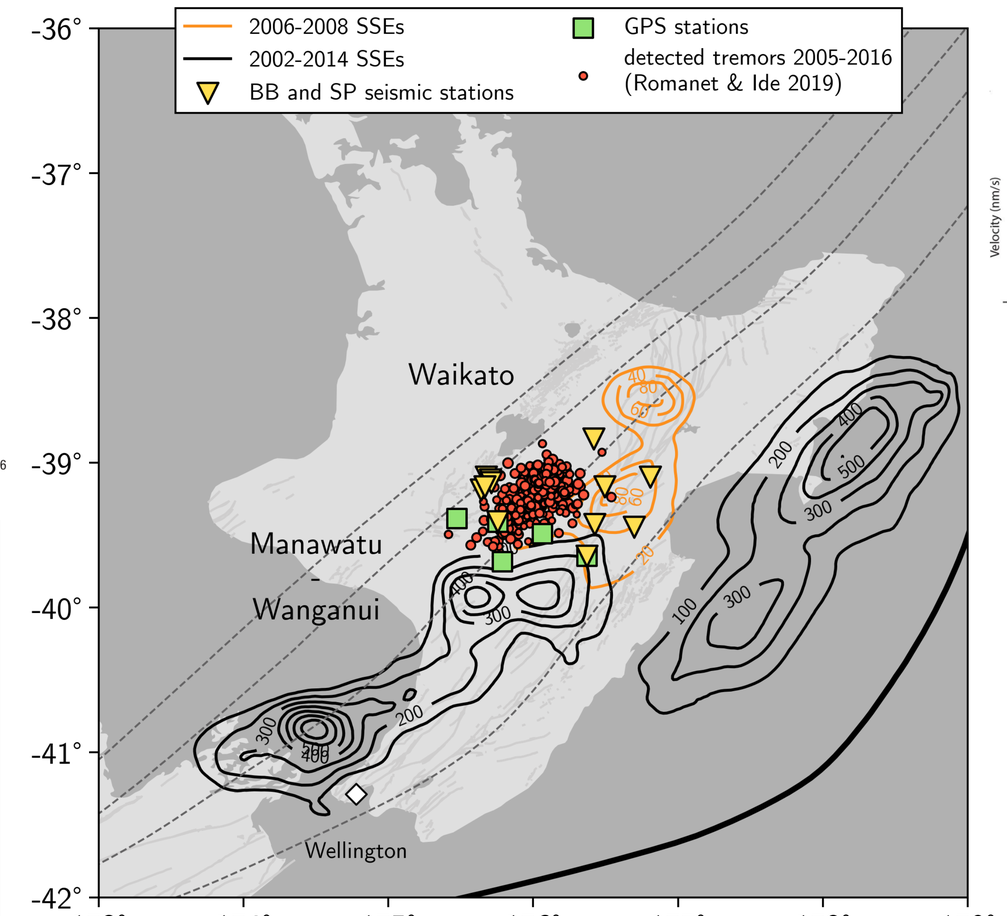
DEEP SLOW-SLIP EVENTS AND NON-VOLCANIC TREMORS IN THE NORTH ISLAND OF NEW-ZEALAND

Tectonic context *(McCaffrey et al. 2008)*

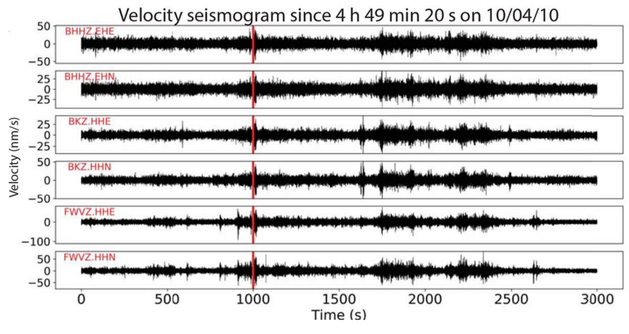


Interseismic coupling *(Wallace et al. 2018)*

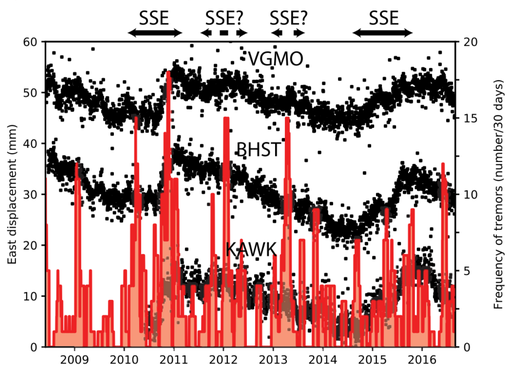




Tremor activity beneath Kaimanawa Range *(Romanet & Ide 2019)*



Relationship between Tremors and SSEs? *(Romanet & Ide 2019)*



MOTIVATION

1. **Improve spatio-temporal resolution of our imaging of slow slip**
2. **Detect more Slow-Slip Events**
3. **Study full spectrum of the Slow-Earthquake phenomena beneath the North Island of New-Zealand**

"Low-Frequency earthquakes as in-situ monitor of when and where SSEs occur"

MINING FOR LOW-FREQUENCY EARTHQUAKE WITH MATCHED-FILTER FROM NVT CATALOG

1. Automated detection of LFE

BackTrackBB (Poiata et al. 2016, 2018)

- kurtosis-based transformation of traces: Characteristic Functions (CF)
- cross-correlation of CFs: Time-delay Estimate (TDE)
- backprojection of all TDEs and stack: Source Location Function
- returns LFE onsets and (preliminary) location

2. Matched-Filter

Fast Matched Filter (Beaucé et al. 2016)

- 2s pre-pick / 8s post-pick
- 2-10Hz

2.1 LFEs templates

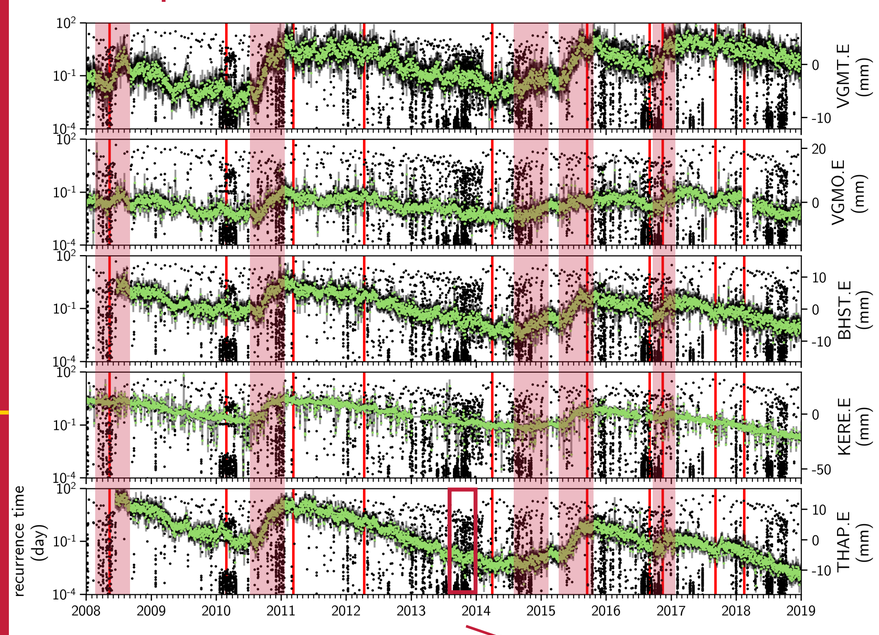
- threshold: 7 x MAD (using reversed template)
- 241 templates
- 50 families with more than 10 detections
- 6148 detections in total

2.2 Tremors templates

- threshold: 7 x MAD
- 335 templates
- 228 families with more than 10 detections
- 48953 detections in total

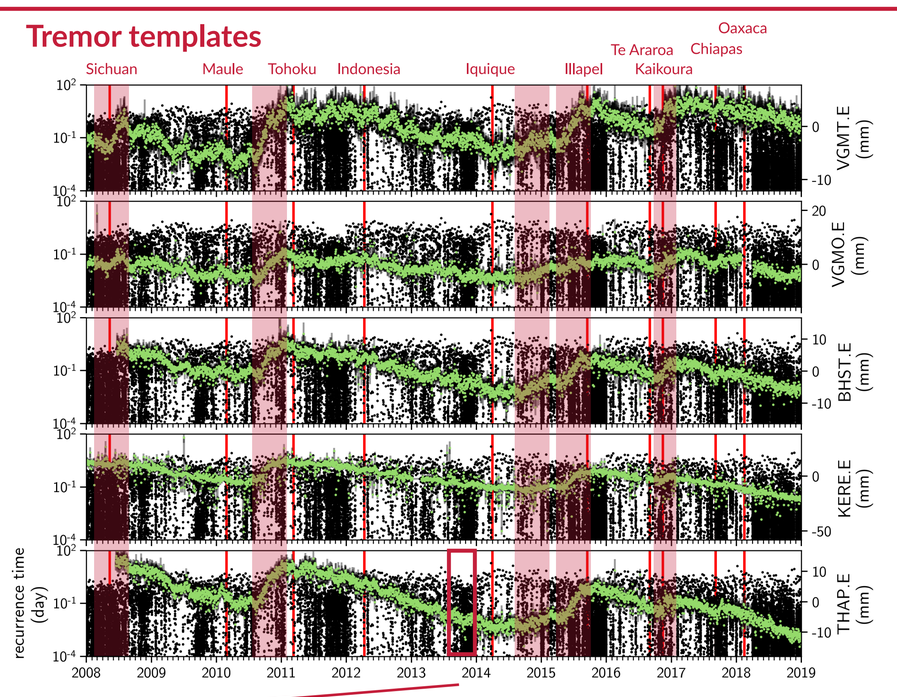
COMPARING GPS EASTERN DISPLACEMENT WITH MF DETECTIONS

LFE templates

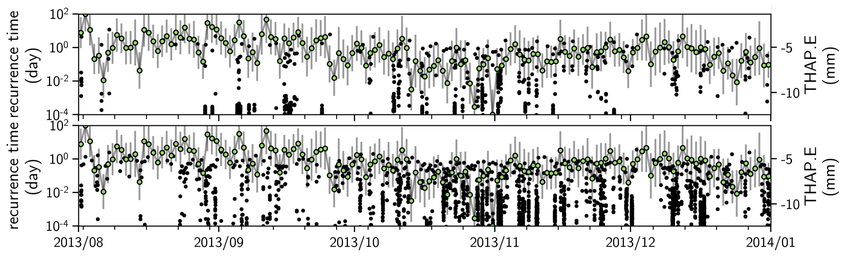


known SSEs

Tremor templates



Clusters in clusters: Intermittent activity



WRAP-UP

1. **LFEs were extracted from the tremors waveforms**
2. **MF-search reveal potential new episods of transient slip**
3. **Post-processing of the families allows to build high-quality second generation templates**

BUILDING SECOND GENERATION TEMPLATES

1. Deblurring Filter

$$y = \begin{cases} \frac{\sigma^2}{\sigma_x^2} m_x + \left(1 - \frac{\sigma^2}{\sigma_x^2}\right) x & \sigma_x^2 \geq \sigma^2, \\ m_x & \sigma_x^2 < \sigma^2, \end{cases}$$

m_x local estimate of the mean
σ_x^2 local estimate of the variance
σ^2 noise threshold

enhance the period where the variance is greater

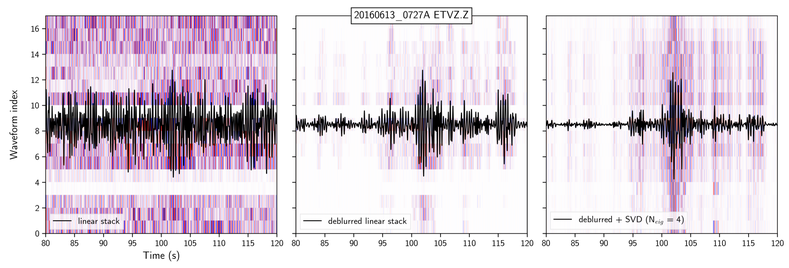
2. Singular Value Decompositon

Selecting the most relevant eigen vectors to reconstruct the filtered data improve the signal to noise ratio

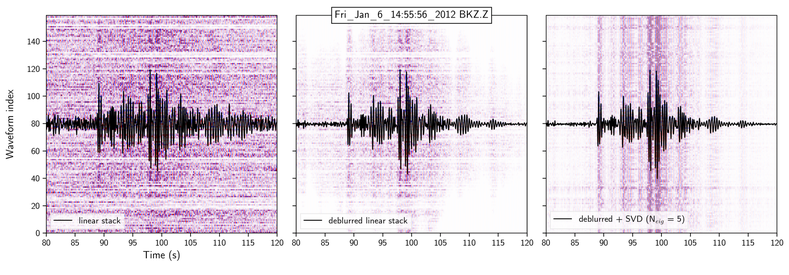
3. Stack of the filtered waveforms

1. Gather detection into families
2. Postprocessing for each station and each components

Family from LFE template



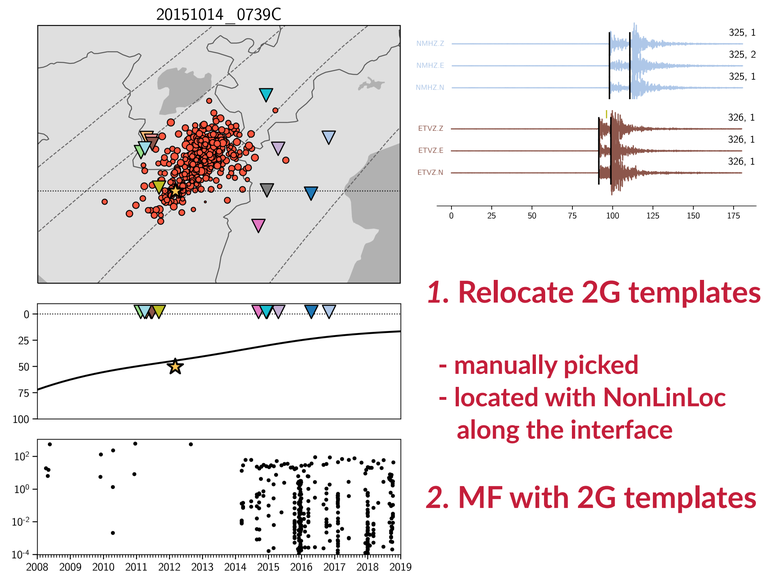
Family from tremor template



1. Relocate 2G templates

- manually picked
- located with NonLinLoc along the interface

2. MF with 2G templates



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