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

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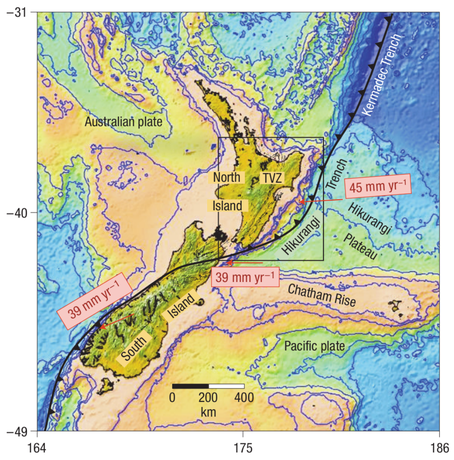
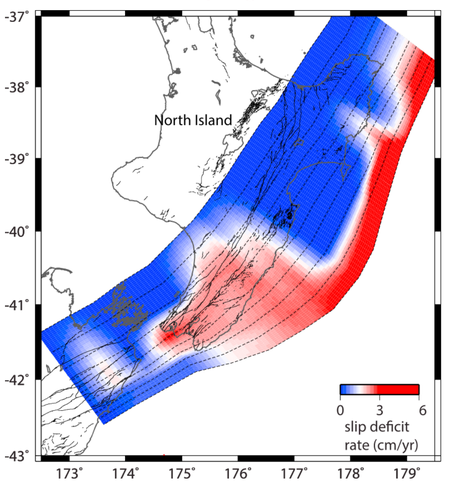
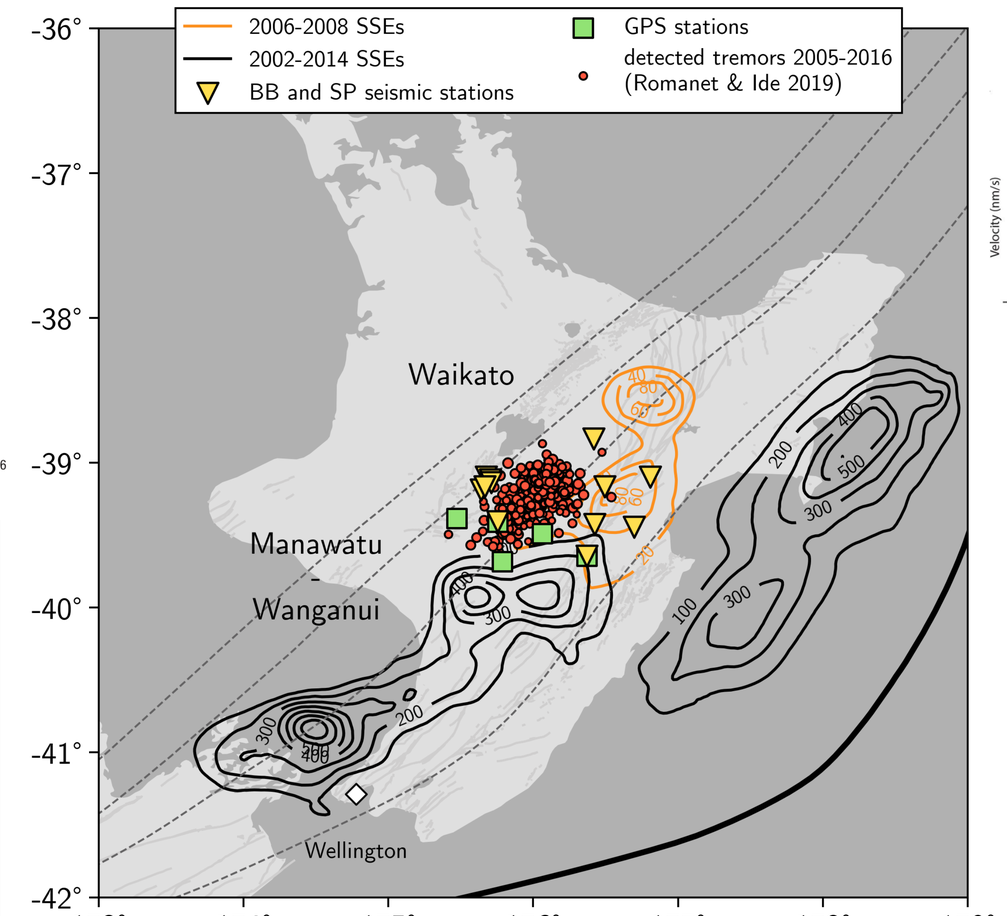
DEEP SLOW-SLIP EVENTS AND NON-VOLCANIC TREMORS IN THE NORTH ISLAND OF NEW-ZEALAND

Tectonic context *(McCaffrey et al. 2008)*

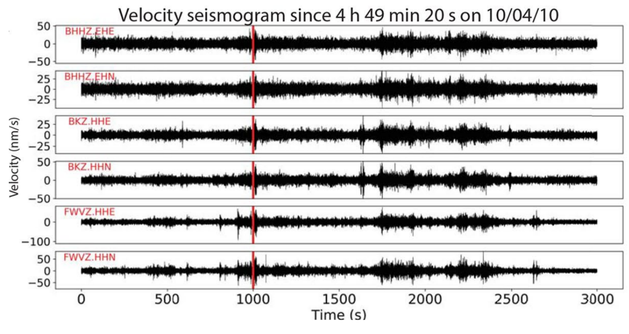


Interseismic coupling *(Wallace et al. 2018)*

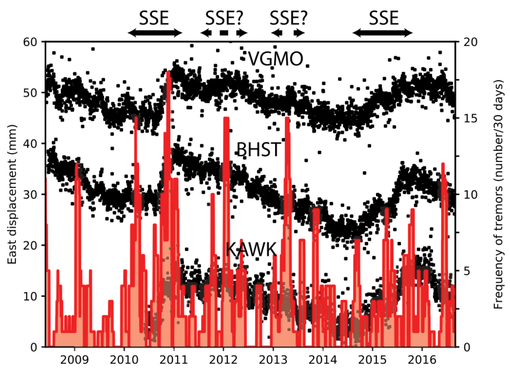




Tremor activity beneath Kaimanawa Range *(Romanet & Ide 2019)*



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

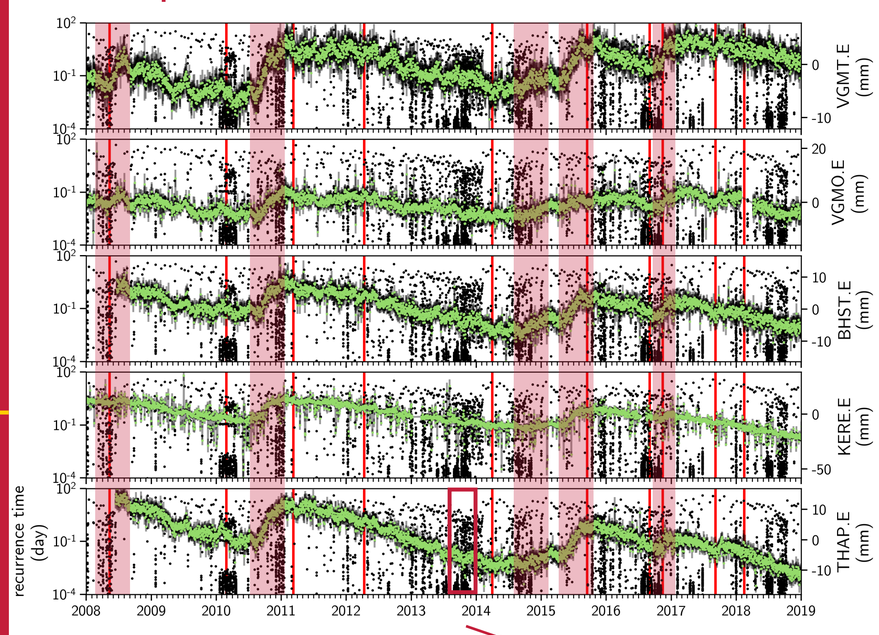
- threshold: 7 x MAD (using reversed template)
- 241 templates
- 50 families with more than 10 detections
- 6148 detections in total

2.2 Tremors templates

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

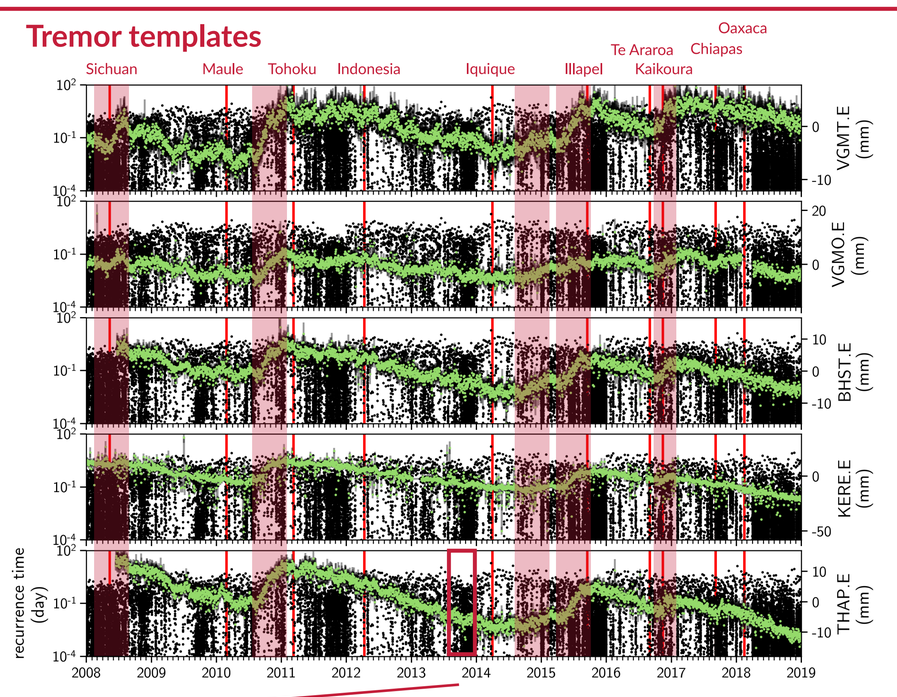
COMPARING GPS EASTERN DISPLACEMENT WITH MF DETECTIONS

LFE templates

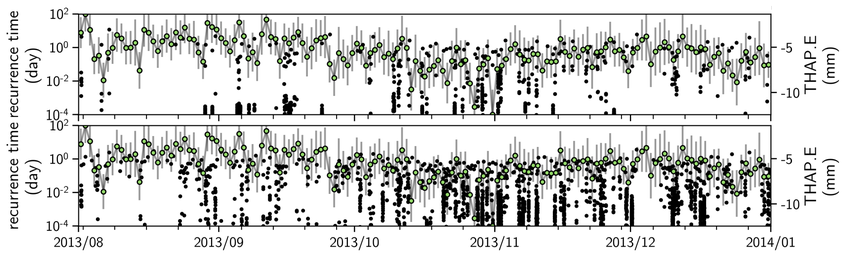


known SSEs

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

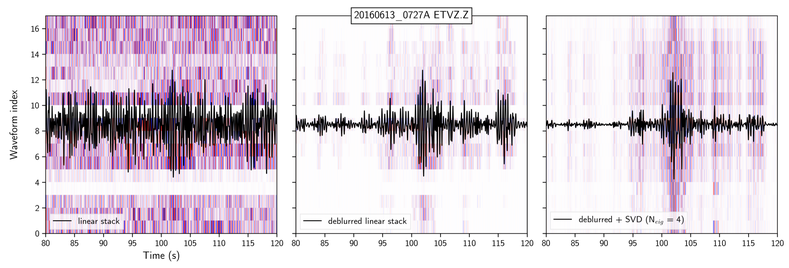
2. Singular Value Decompositon

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

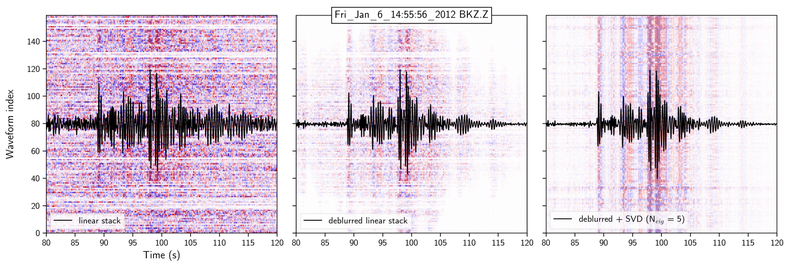
3. Stack of the filtered waveforms

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

Family from LFE template



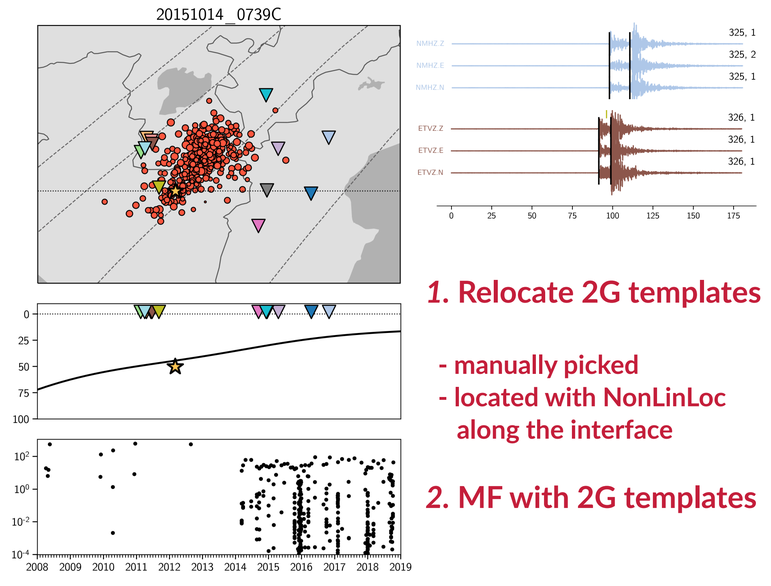
Family from tremor template



1. Relocate 2G templates

- manually picked
- located with NonLinLoc along the interface

2. MF with 2G templates



References

McCaffrey, R., Wallace, L. M., & Beavan, J. (2008). Slow slip and frictional transition at low temperature at the Hikurangi subduction zone. Nature Geoscience, 1(5), 316.

Wallace, L. M., Hreinsdóttir, S., Ellis, S., Hamling, I., D'Anastasio, E., & Denys, P. (2018). Triggered slow slip and afterslip on the southern Hikurangi subduction zone following the Kaikōura earthquake. Geophysical Research Letters, 45(10), 4710-4718.

Romanet, P., & Ide, S. (2019). Ambient tectonic tremors in Manawatu, Cape Turnagain, Marlborough, and Puysegur, New Zealand. Earth, Planets and Space, 71(1), 59.

Poiata, N., Vilotte, J. P., Bernard, P., Satriano, C., & Obara, K. (2018). Imaging different components of a tectonic tremor sequence in southwestern Japan using an automatic statistical detection and location method. Geophysical Journal International, 213(3), 2193-2213.

Beaucé, E., Frank, W. B., & Romanenko, A. (2017). Fast matched filter (FMF): An efficient seismic matched-filter search for both CPU and GPU architectures. Seismological Research Letters, 89(1), 165-172.