

## What are Slow Slip Earthquakes?

- SSEs release energy on a fault over longer time periods than normal earthquakes (weeks to months).
- Commonly occur along subduction margin interfaces.
- At deeper depths on the interface, plates slowly slide along each other, whereas at shallower depths friction between the plates causes them to become temporarily stuck.
- Every couple of years stress in the stuck portion builds up and is released in a SSE.

## Why are Slow Slip Earthquakes Important?

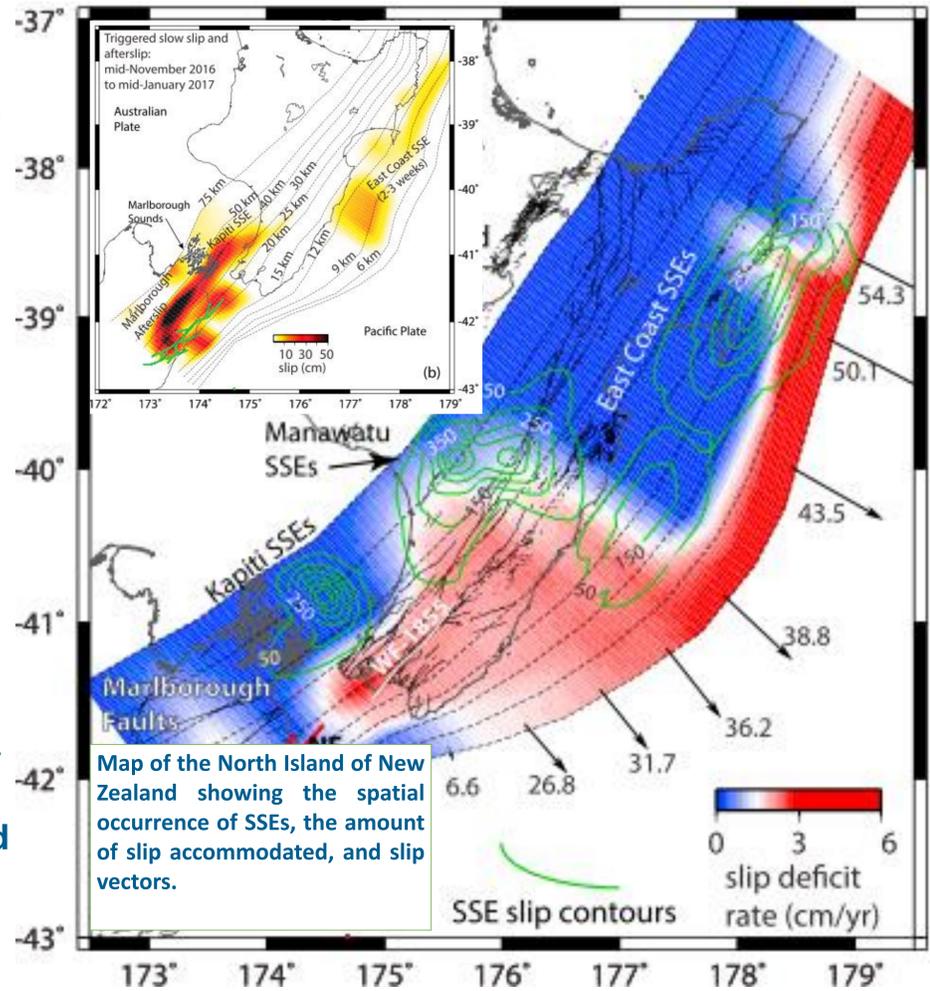
- When the locked portion of the subduction interface experiences a long (hundreds of years) period of being stuck, release of this stress build-up can result in a damaging earthquake.
- SSEs occur next to parts of the subduction interface that experience these damaging earthquakes.
- SSEs may increase stress on the locked part of the interface and trigger damaging earthquakes.
- Understanding this relationship will allow better hazard modelling in regions that experience SSEs.

## Hikurangi Subduction Zone (HSM), New Zealand

- SSEs recorded along HSM in New Zealand between 2002 and 2012.
- Discovered using GPS which can detect sub-centimetre changes in land movements.
- In the northern region SSEs are shallow (<15 km) and occur over two weeks approximately every two years.

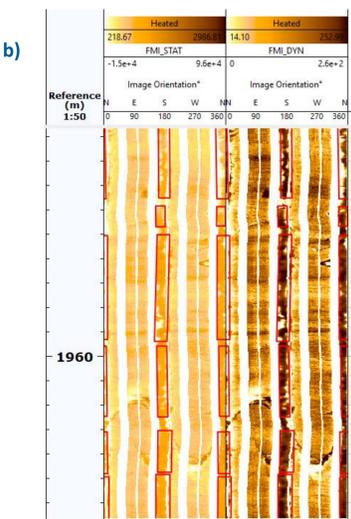
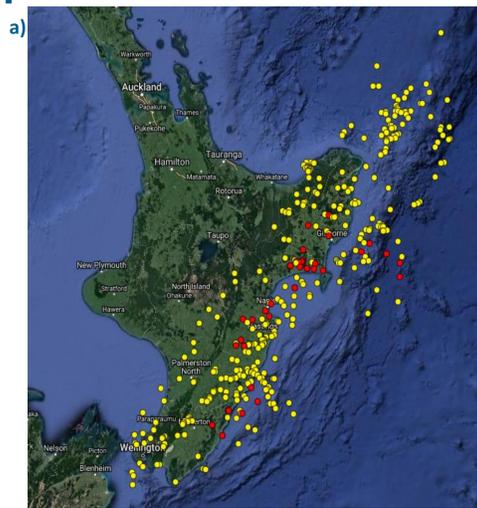
## What is the possible link between the stress regime and subduction interface slip behaviour?

- Do SSEs and locking impact the character of the stress field?
- How are local stress field conditions affected by variable structure across the HSM (frontal thrust, over-riding material, incoming material)?



## Stress Characterisation

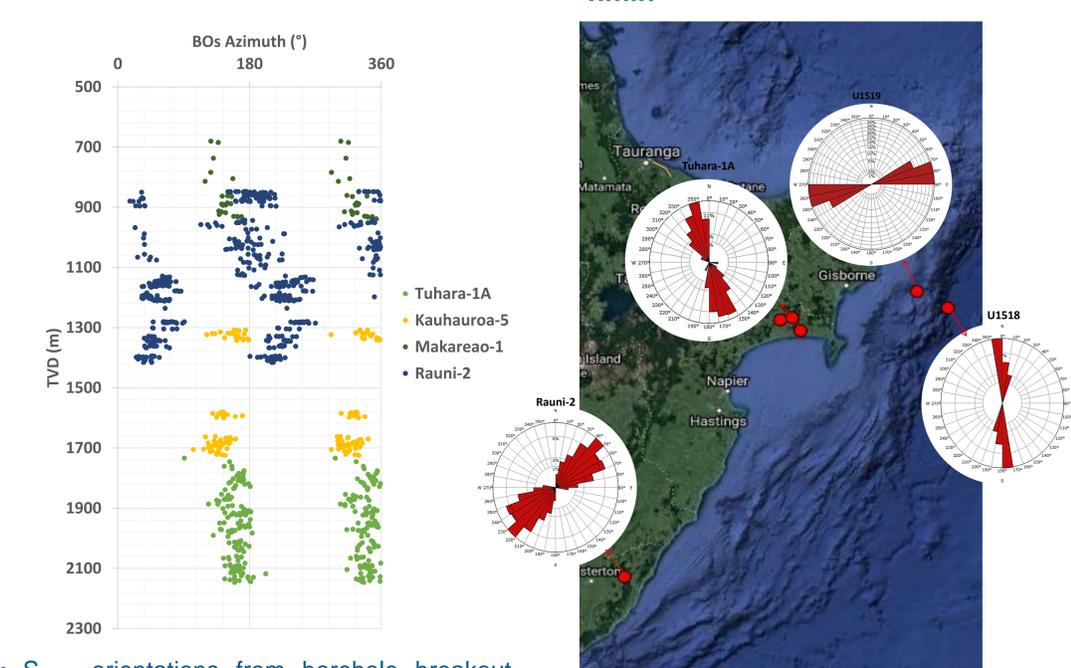
- To determine full tensor of HSM, Borehole breakouts (BOs) and earthquake focal mechanisms are used.
- BOs are well-known indicators that develop perpendicular to the present-day  $S_{Hmax}$  orientation and can be observed by Borehole imaging tools in shallow depths (3-4 km).
- for greater crustal depths,  $S_{Hmax}$  orientation can be determined from Earthquake focal mechanisms.



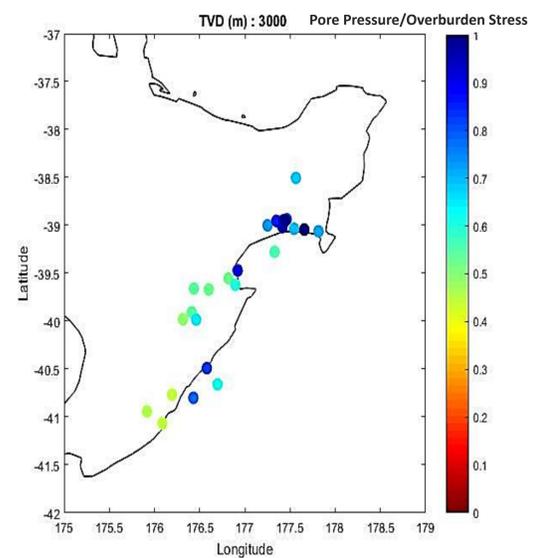
a) Map of the east coast of North Island New Zealand showing locations of industry and IODP wells and earthquake data in this study.

b) Schematic of borehole breakout analysis for  $S_{Hmax}$  and  $S_{hmin}$  orientation determination for Tuhara-1A.

## Preliminary Results – HSM $S_{hmin}$ Orientations



- $S_{hmin}$  orientations from borehole breakout observations vary along the HSM.
- $S_{hmin}$  orientations within individual wells also vary.
- $S_{Hmax}$  orientations at Northern Hawke Bay is sub parallel to HSM trough while in southern East Coast it is almost orthogonal.
- U1518 at the frontal thrust matches stress orientations seen further back in the hangingwall.
- U1519 shows a rotation in stress orientation to the regional trend – related to deformation quiescence in this part of the hangingwall?
- Variations with depth may be due to slip on local structures or changes in pore pressure?



## Future work

- Full analysis of image logs for stress induced fractures and borehole breakout for determination of stress orientation and magnitudes in shallow depths.
- Analysis Moment Tensor data to determine the stress orientation for deep depths.

## References:

- McNamara, D.D., Wu, H.Y., Lee, H., Wallace, L.M., Lee, G., Heeschen, K.U., Elger, J., Saffer, D.M., Barnes, P., and Pecher, I.A., 2018, December, Borehole stress indicators across the Hikurangi Subduction Margin: Preliminary insights from IODP Expedition 372, AGU Fall Meeting Abstracts.
- Wallace, L.M., Webb, S.C., Ito, Y., Mochizuki, K., Hino, R., Henrys, S., Schwartz, S.Y., and Sheehan, A.F., 2016, Slow slip near the trench at the Hikurangi subduction zone, New Zealand, Science, 352 (6286), 701–04.