Two years of deep slow slip in New Zealand, in fits and spurts

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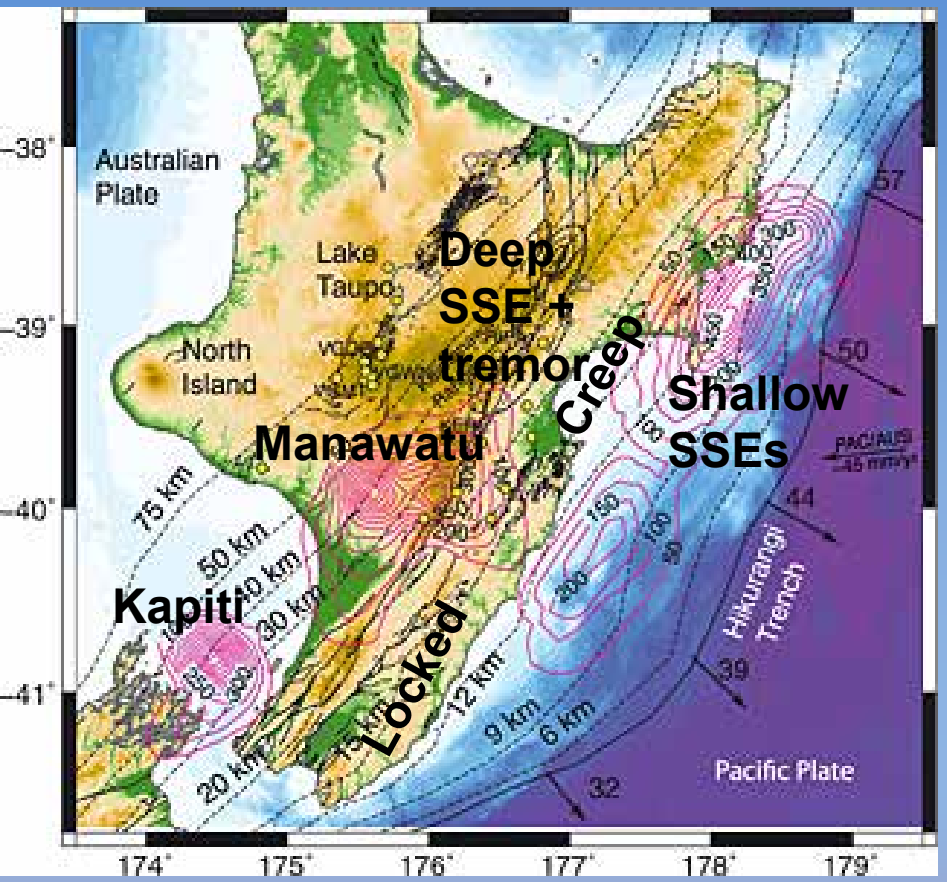
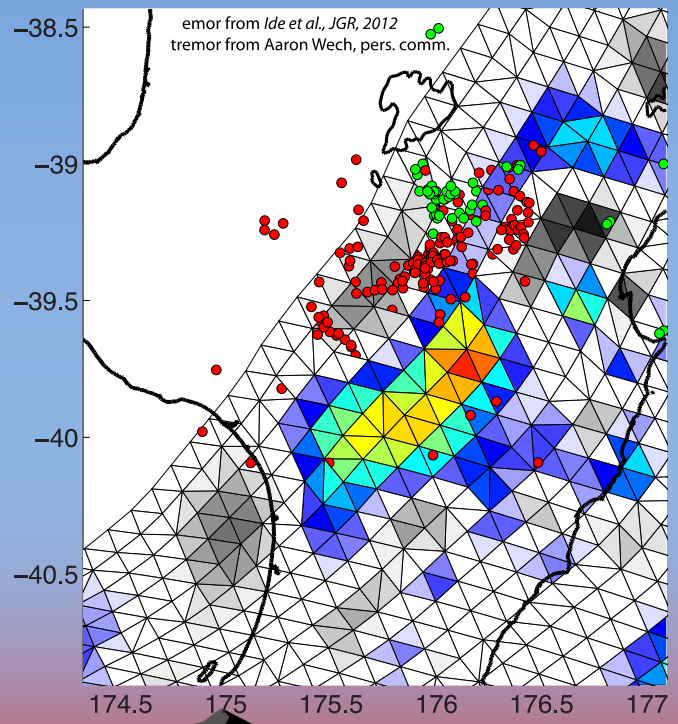
Deep slow slip in New Zealand



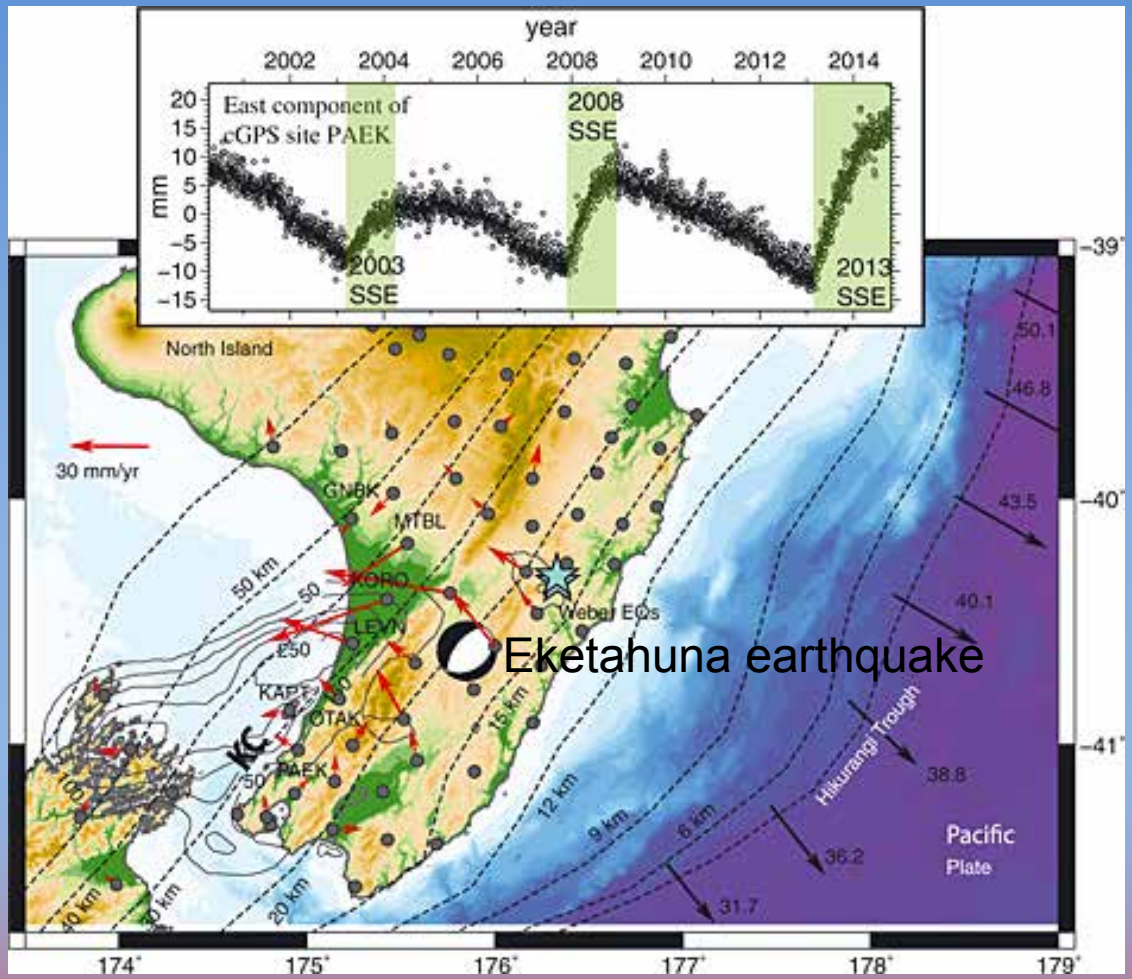
- Slip between 30 and 50 km depth
- Long duration (~1 year)
- Tremor on downdip edge



Wallace, L. M., and D. Eberhart-Phillips (2013), Newly observed, deep slow slip events at the central Hikurangi margin, New Zealand: Implications for downdip variability of slow slip and tremor, and relationship to seismic structure, GRL

Deep slow slip in New Zealand

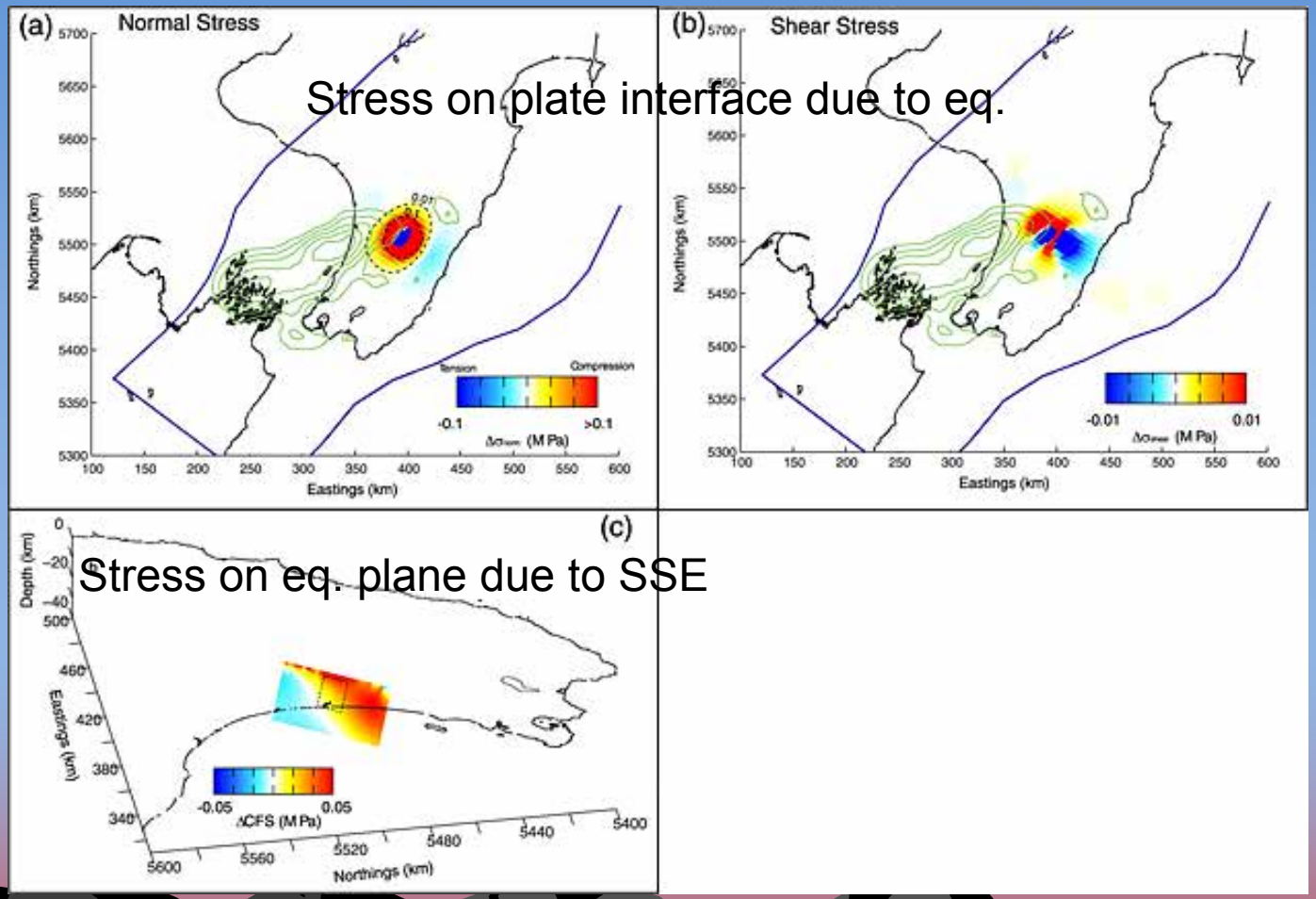
- 2013/14 Kapiti SSE bigger than previous ones



Wallace, L. M., N. Bartlow, I. Hamling, and B. Fry (2014), Quake clamps down on slow slip, GRL.

2014 Eketahuna earthquake

- Occurred Jan. 20, M 6.3 normal faulting event within slab
- ~100 kPa clamping stress applied to slipping region



Wallace, L. M., N. Bartlow, I. Hamling, and B. Fry (2014), Quake clamps down on slow slip, GRL.

Network Inversion Filter

- Fits GPS data as:

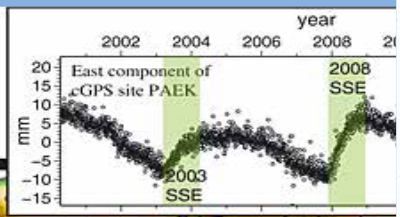
$$\boldsymbol{X}(t) = \boldsymbol{X}(t_0) + G\boldsymbol{s}(t - t_0) + Ff(t) + L(\boldsymbol{x}, t - t_0) + \epsilon$$

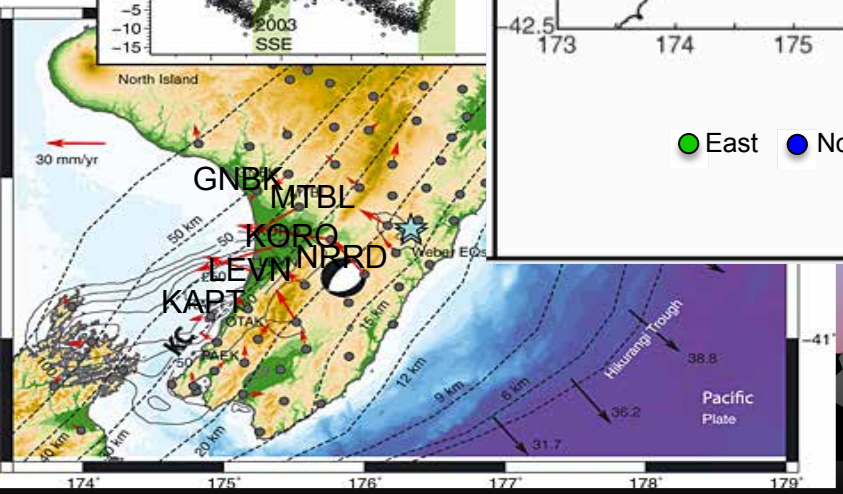
- Estimates space-time evolution of fault slip.
  - Two "tunable" parameters: spatial smoothing, temporal smoothing
- Based on Kalman Filter
  - Balances noisy data with imprecise physical model
- At each time step, the filter predicts slip and slip rate, then updates with data
- NIF code (MATLAB) available from http://faculty.missouri.edu/~bartlowno/software.html

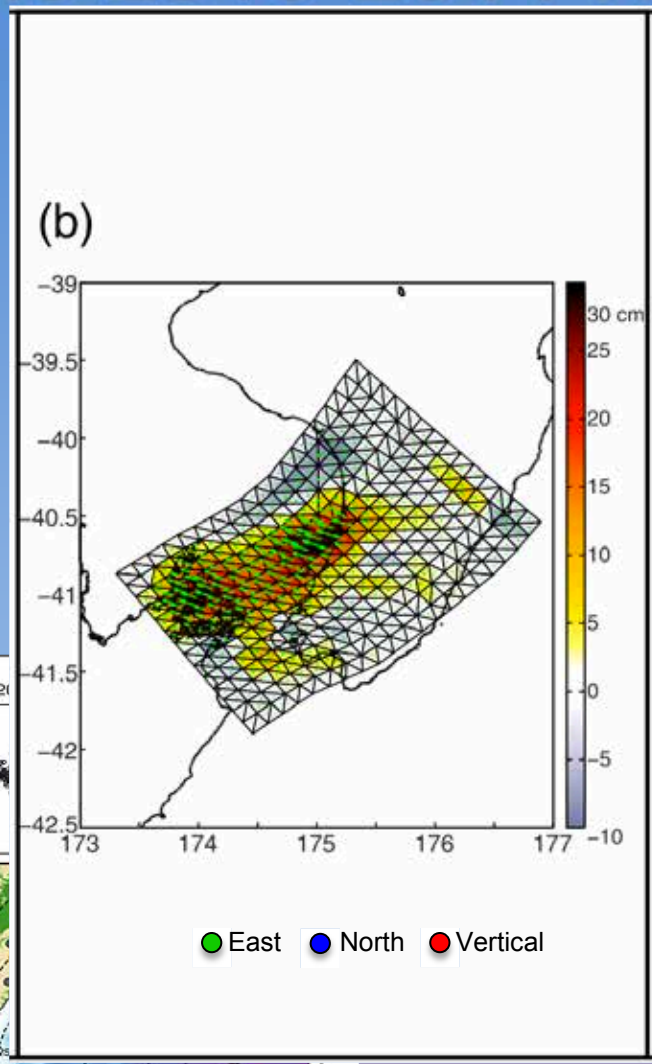
see Segall and Matthews, *J. Geophys. Res.*, 1997.

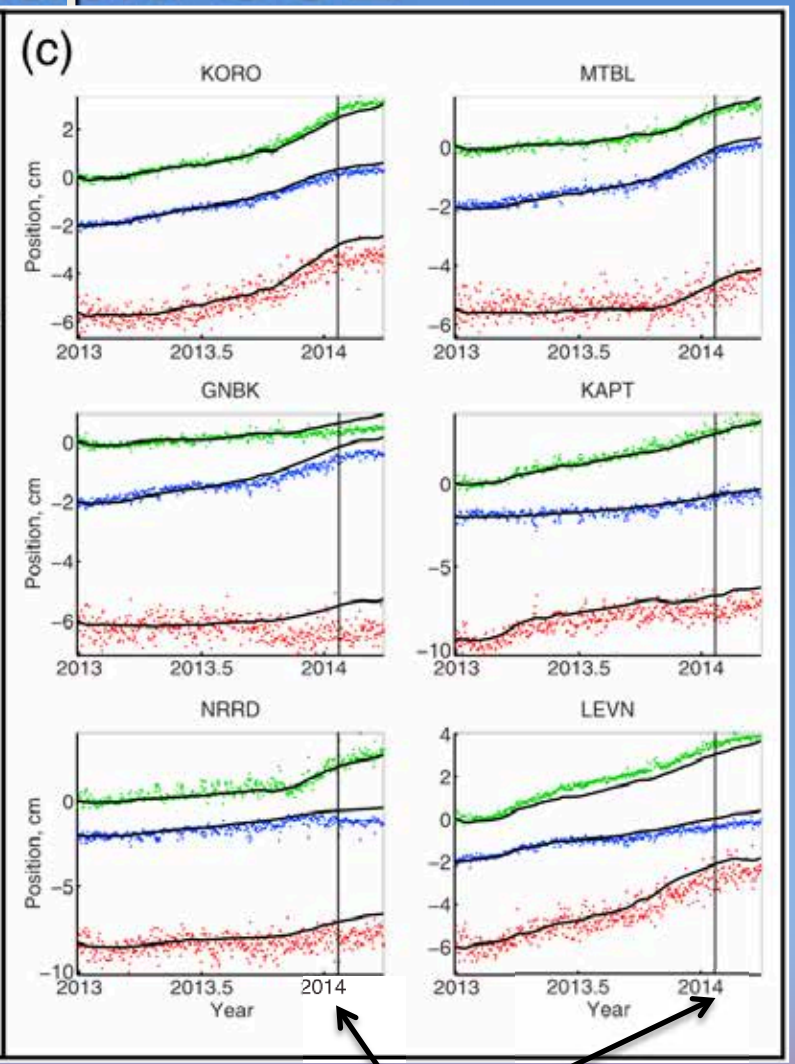
The 2013-2014 Kapiti SSE

Mw 6.9







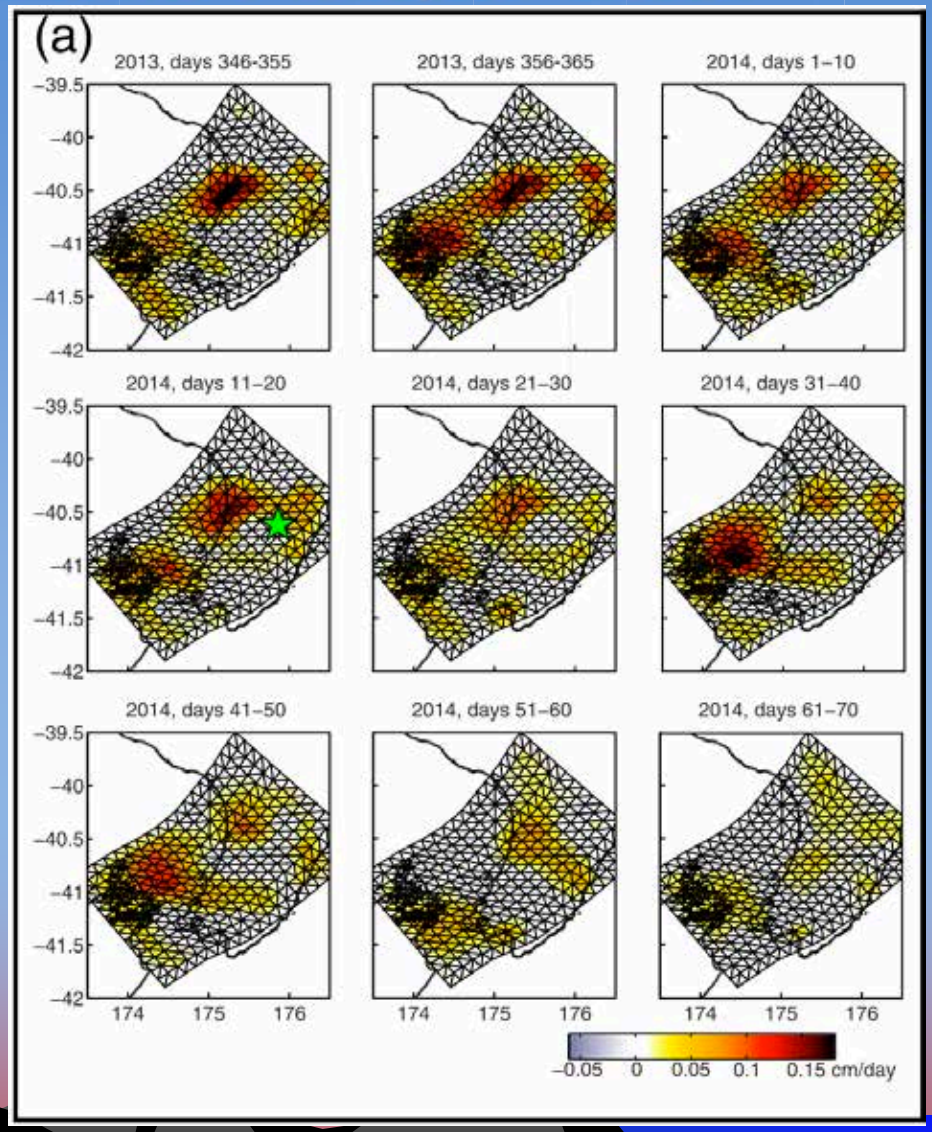


Time of earthquake

Wallace, L. M., N. Bartlow, I. Hamling, and B. Fry (2014), Quake clamps down on slow slip, GRL.

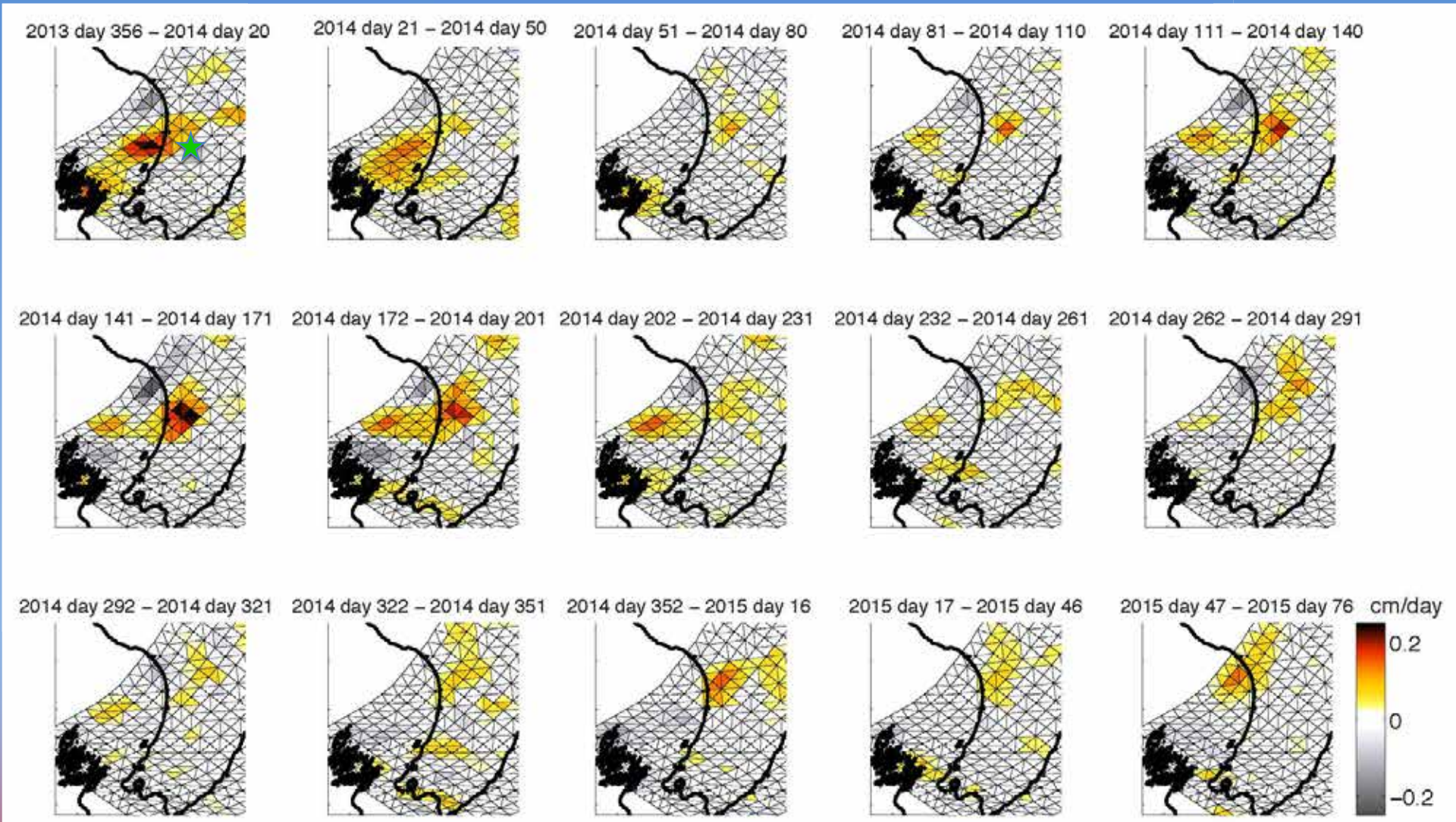
The 2013-2014 Kapiti SSE

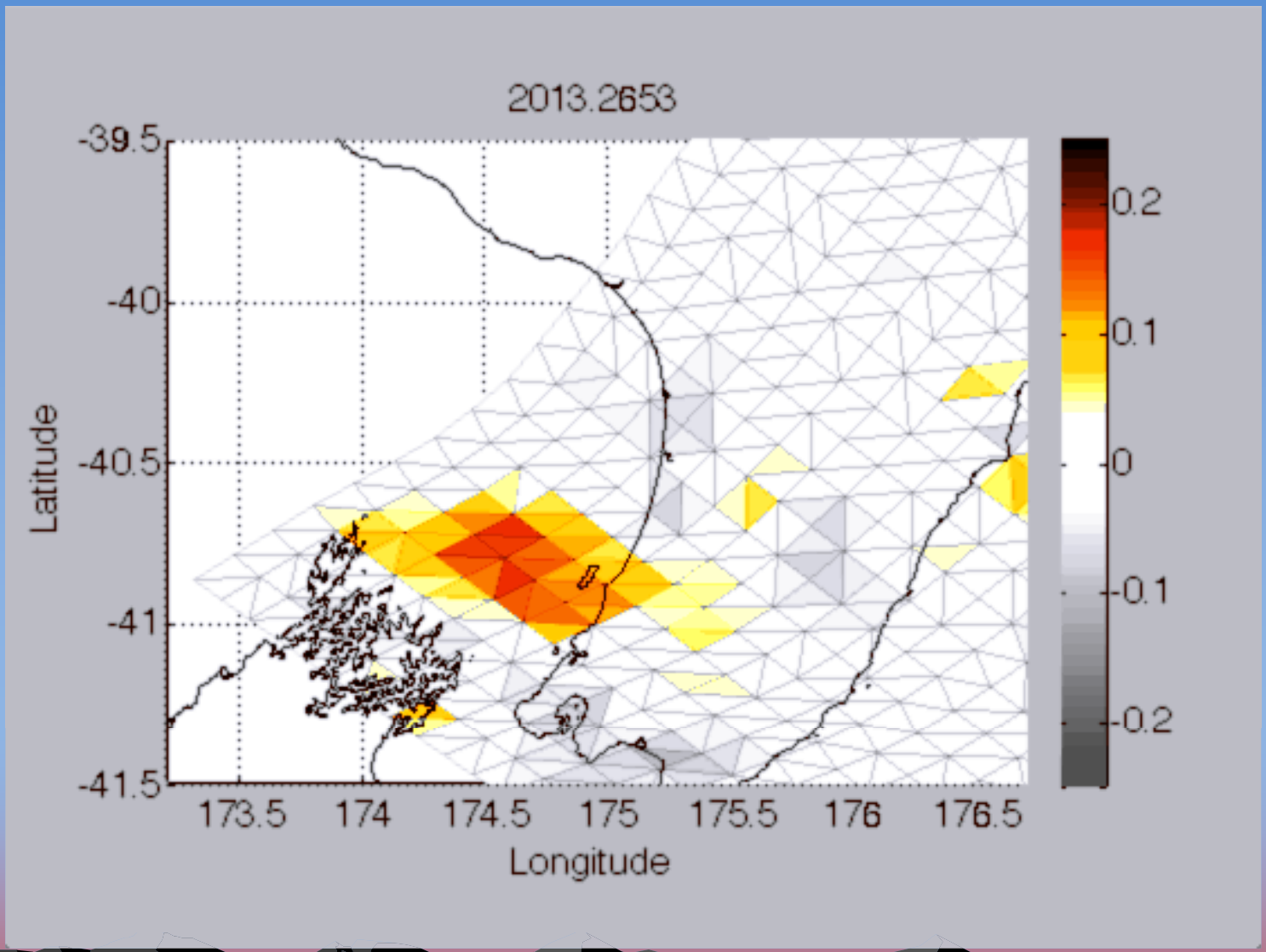
- Rapid (~10 days) deceleration of northern slipping area
- Slip briefly accelerates in the south
- End of Kapiti SSE?



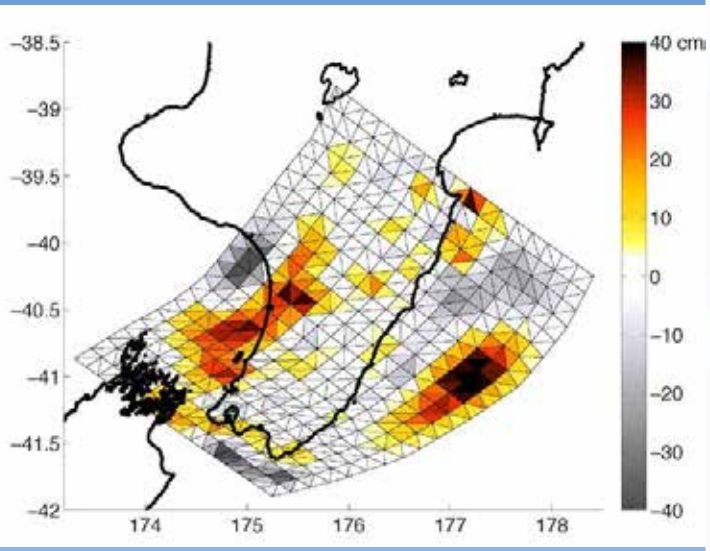
Wallace, L. M., N. Bartlow, I. Hamling, and B. Fry (2014), Quake clamps down on slow slip, GRL.

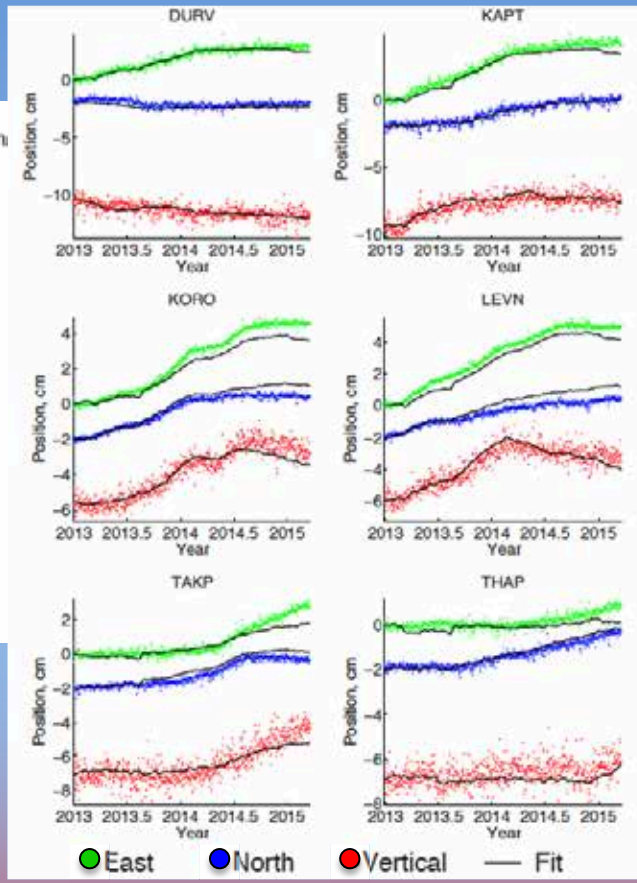
2014-2015 Manawatu SSE

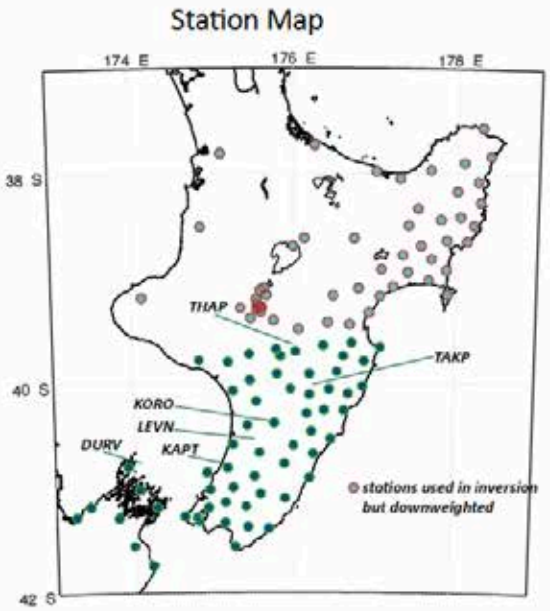



2013.2653
-39.5
-40
-40.5
-41
-41.5
Latitude
173.5
174
174.5
175
175.5
176
176.5
Longitude
0.2
0.1
0
-0.1
-0.2

Total Slip


-38.5
-39
-39.5
-40
-40.5
-41
-41.5
-42
174
175
176
177
178
40 cm
30
20
10
0
-10
-20
-30
-40


DURV
KAPT
KORO
LEVN
TAKP
THAP
Position, cm
Year
2013
2013.5
2014
2014.5
2015
East
North
Vertical
Fit

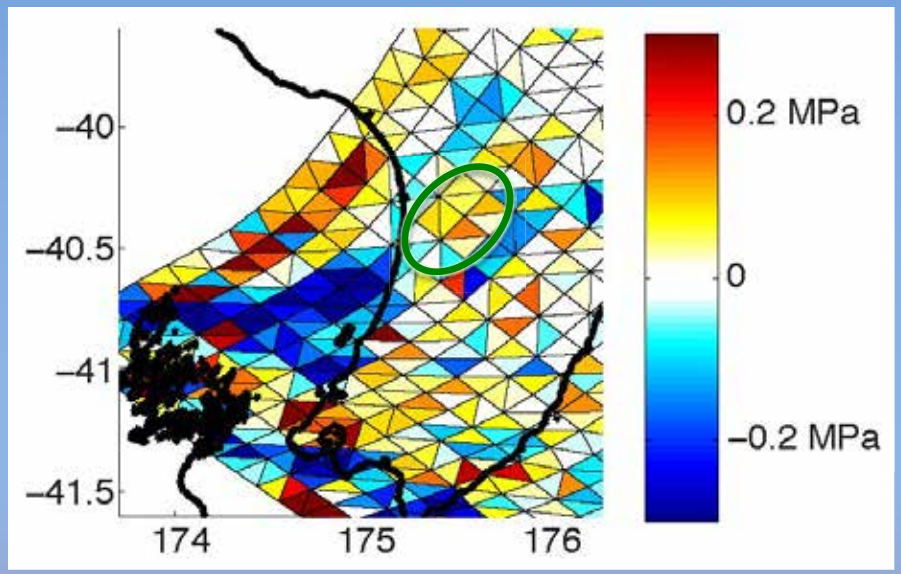

Station Map
174 E
176 E
178 E
38 S
40 S
42 S
THAP
TAKP
KORO
LEVN
DURV
KAPT
stations used in inversion
but downweighted

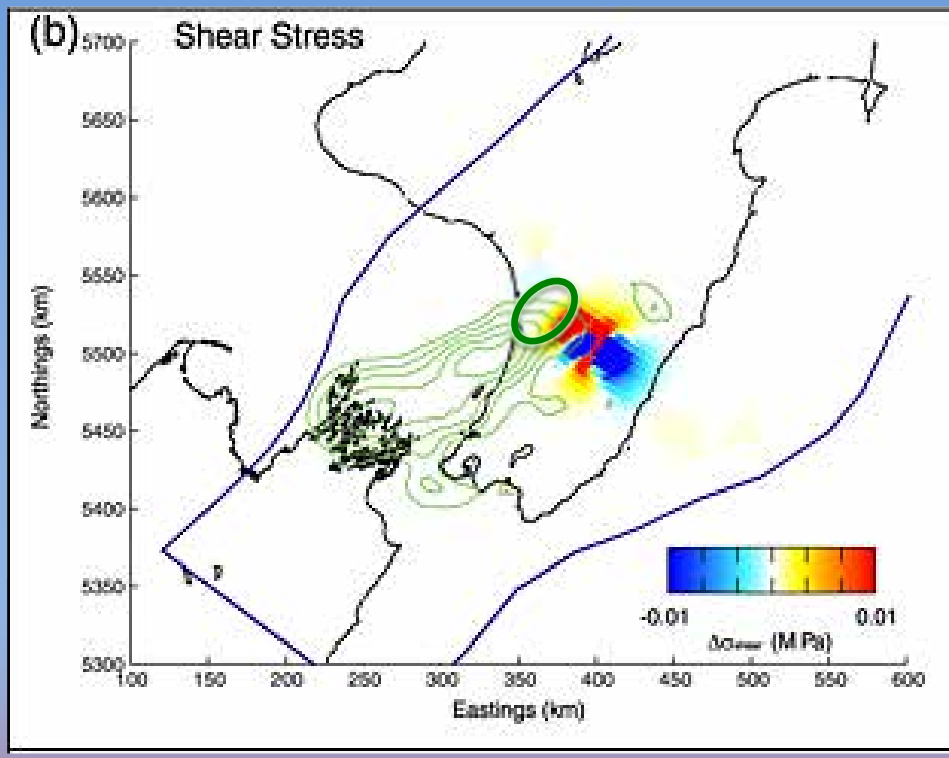
Stress changes on plate interface

- Area of Manwatu slip put under positive shear stress

Eketehuna eq: ~ 10 kPa shear increase,
but ~ 50 kPa clamping normal stress

Kapiti SSE: ~100 kPa





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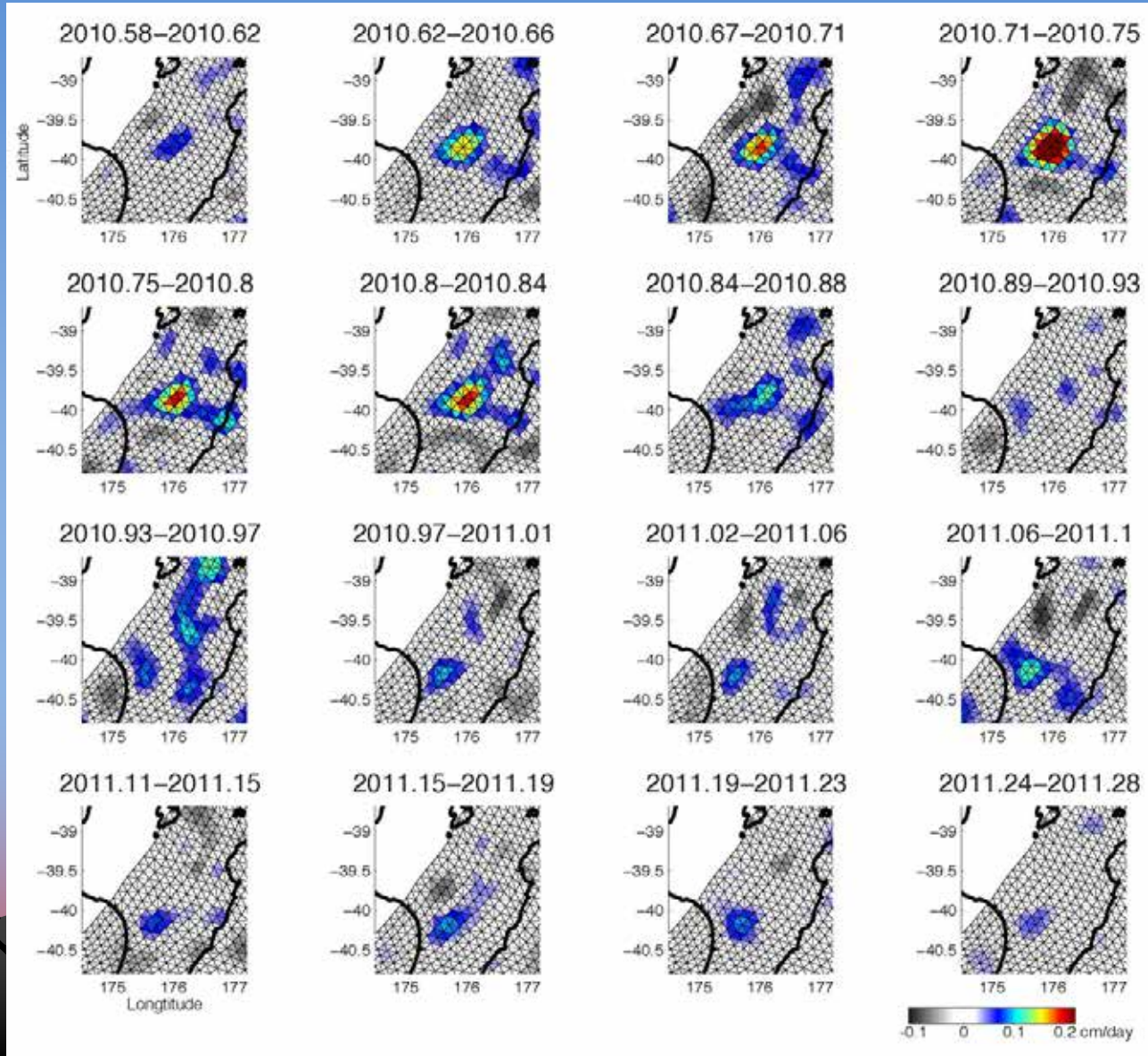
Comparison to other Manwatu SSEs

Possibly clock-advanced relative to “usual” repeat interval (5.5 years)



Conclusions

- Hikurangi experiences two types of slow slip: shallow, rapid events and deeper, slower events
  - Deeper slow slip comparable to Cascadia ETS depth
- The 2013/2014 Kapiti SSE was decelerated by an earthquake
  - The earthquake may have been slow slip triggered
- The Manawatu SSE may have been clock-advanced by Kapiti SSE stress changes
- Slow slip events are sensitive to very small stress purturbations