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

Noel Bartlow¹ and Laura Wallace²

¹Scripps Institution of Oceanography, UCSD;
soon to be at University of Missouri

²U. Texas Institute for Geophysics (UTIG)
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

Stress on plate interface due to eq.

Stress on eq. plane due to SSE

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:
  \[ X(t) = X(t_0) + Gs(t - t_0) + Ff(t) + L(x, t - t_0) + \epsilon \]

- 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

The 2013-2014 Kapiti SSE

Mw 6.9

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
Total Slip
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

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