Revisiting coseismic and postseismic deformation models for the 2002 Mw7.9 Denali, AK Earthquake

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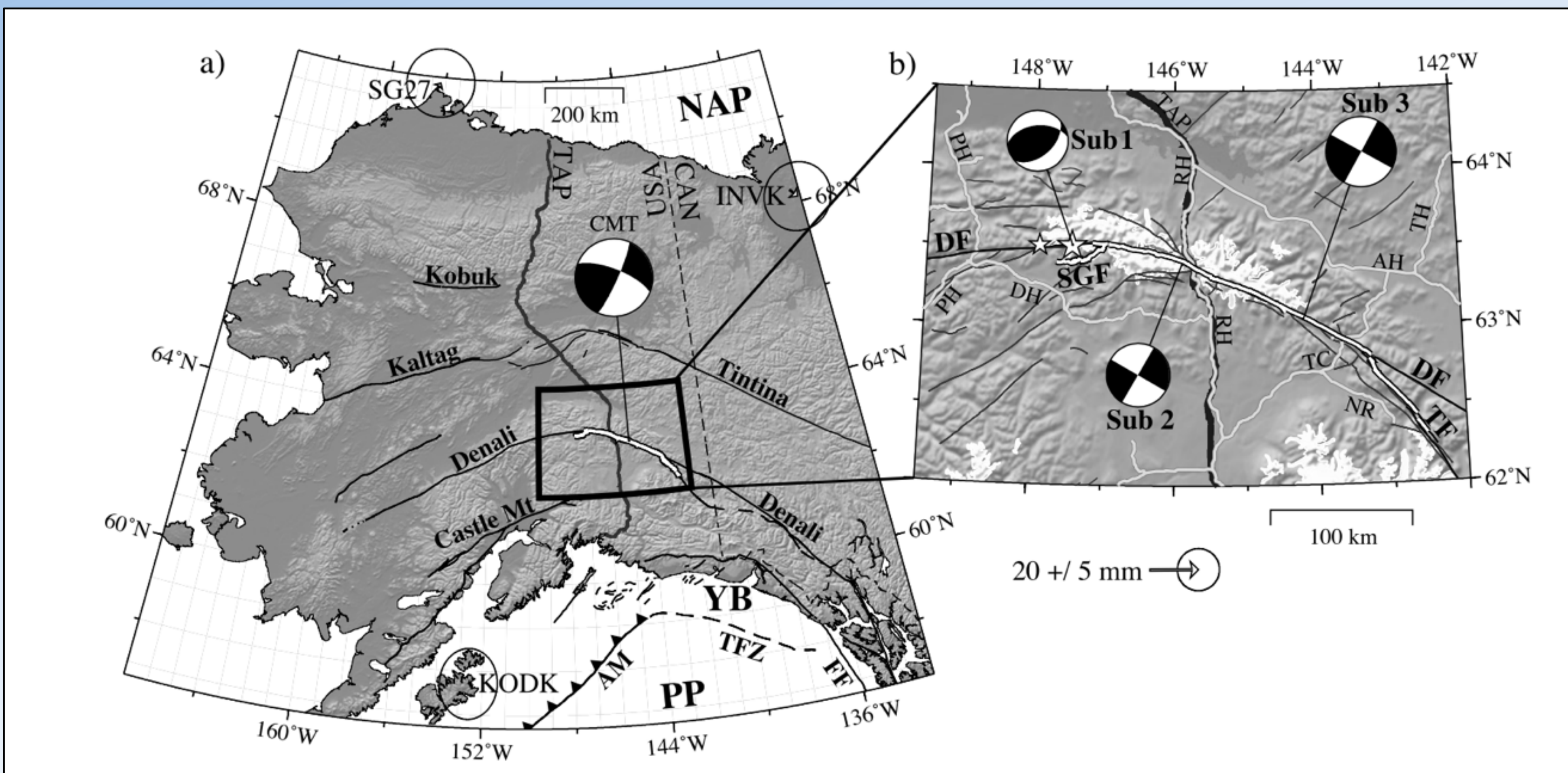
Outline

- Background
- Coseismic data and methods
- Postseismic data and methods
- Model results

Tectonic Context

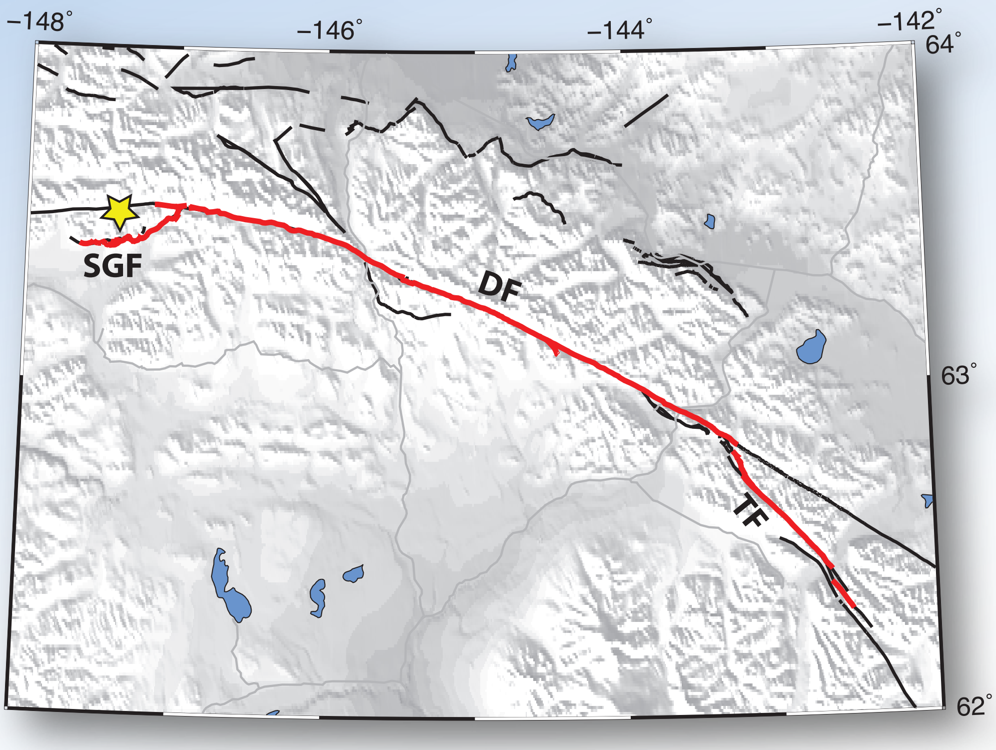
- System of right-lateral strike-slip faults, partially accommodating oblique accretion of the Yakutat block



2002 Mw7.9 Earthquake

- 340 km rupture along three fault segments
- Largest strike-slip event with extensive GPS coverage

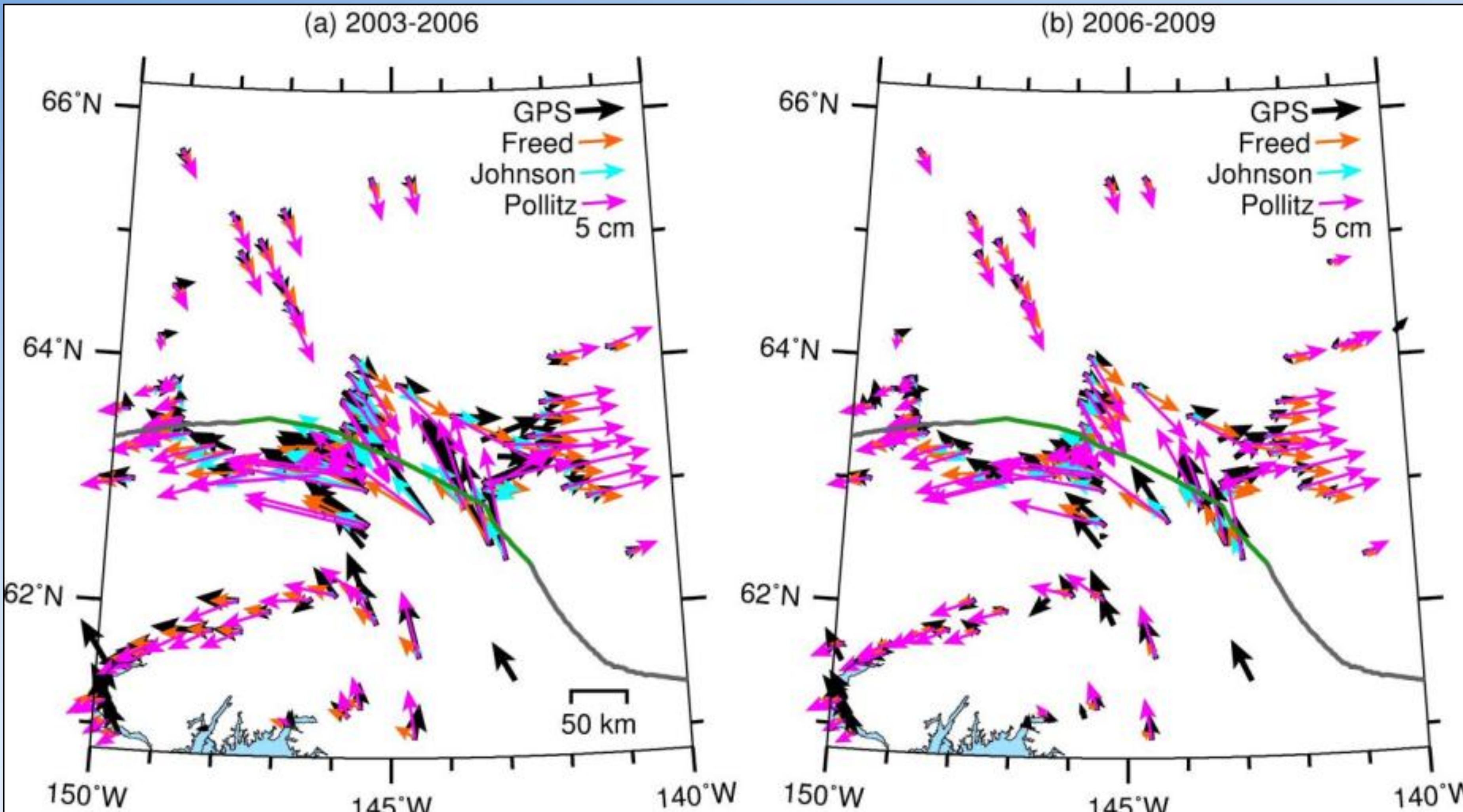
- Insight into earth structure
- Characterize earthquake cycle



Coseismic and Postseismic Deformation

- Coseismic
  - Release of elastic strain
  - Short time scale (<1 day)
- Postseismic
  - Afterslip
  - Viscoelastic relaxation (Lower crust, upper mantle)
  - Poroelastic rebound

Previous Studies



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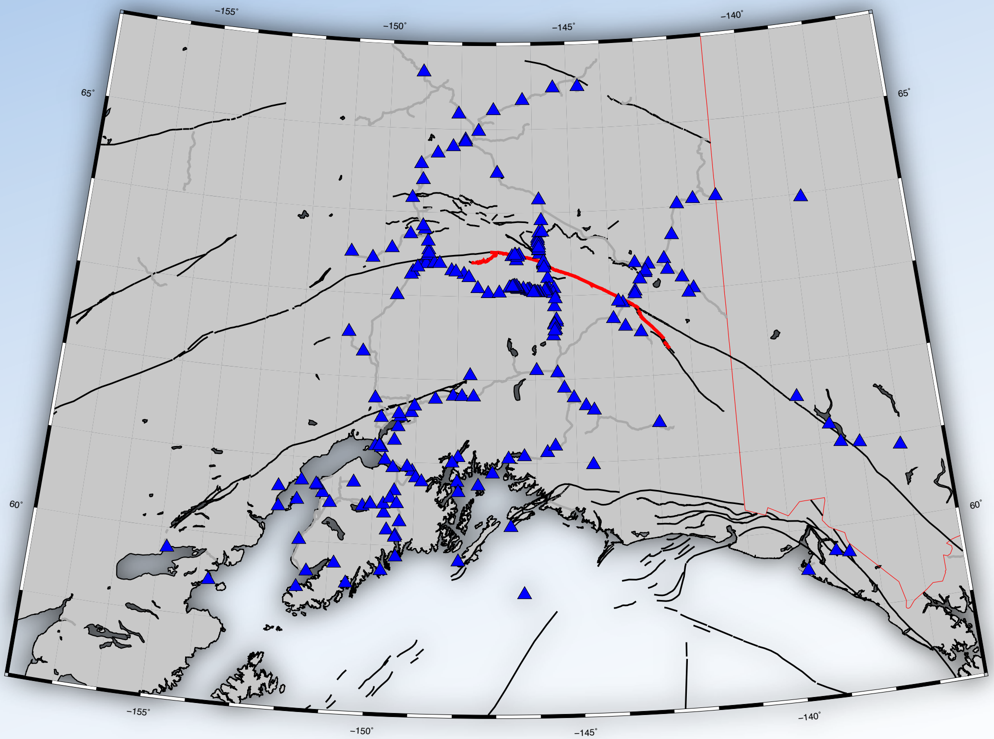
Coseismic Datasets

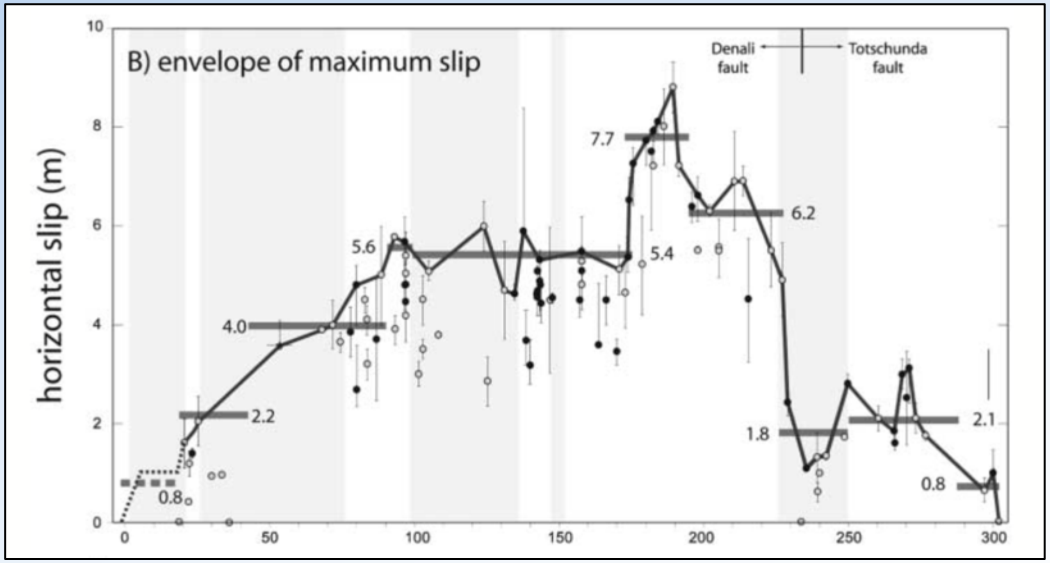
- 232 GPS sites
  - cGPS and campaign
- Differing data quality requires multiple methods of displacement estimate

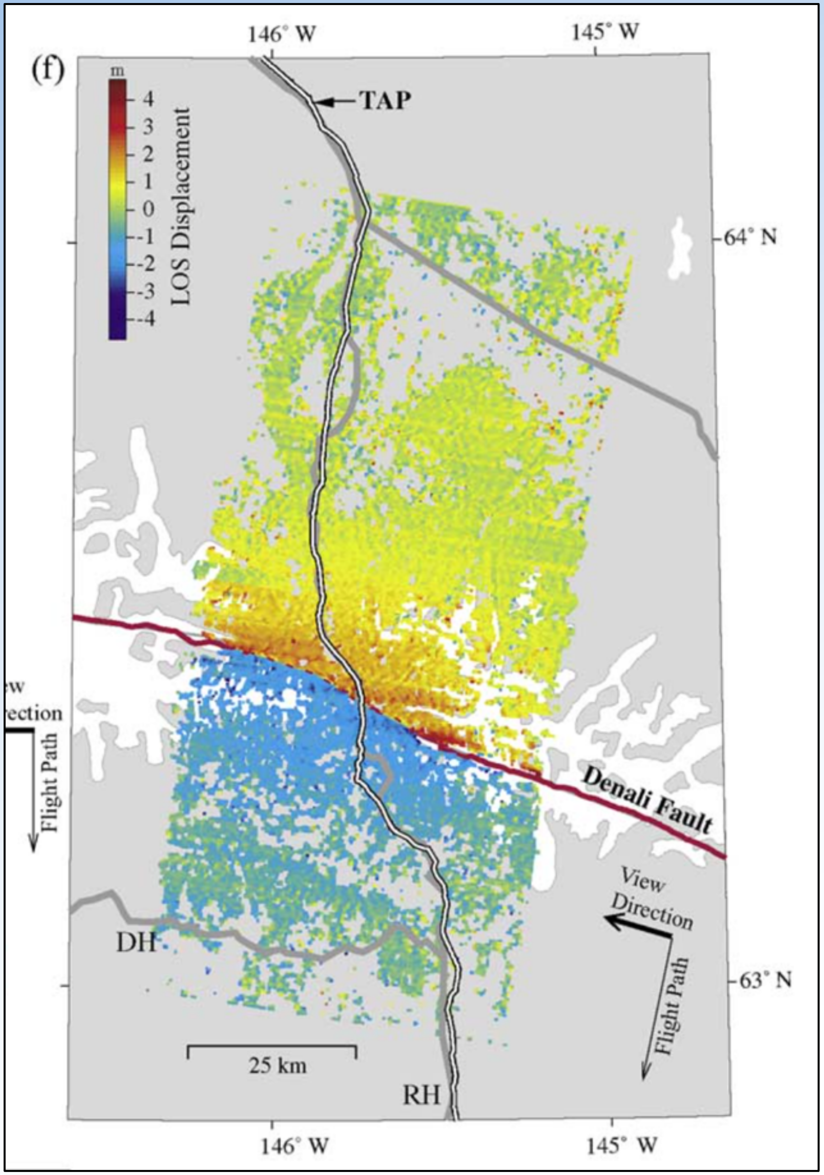
GPS Site Locations



Coseismic Datasets

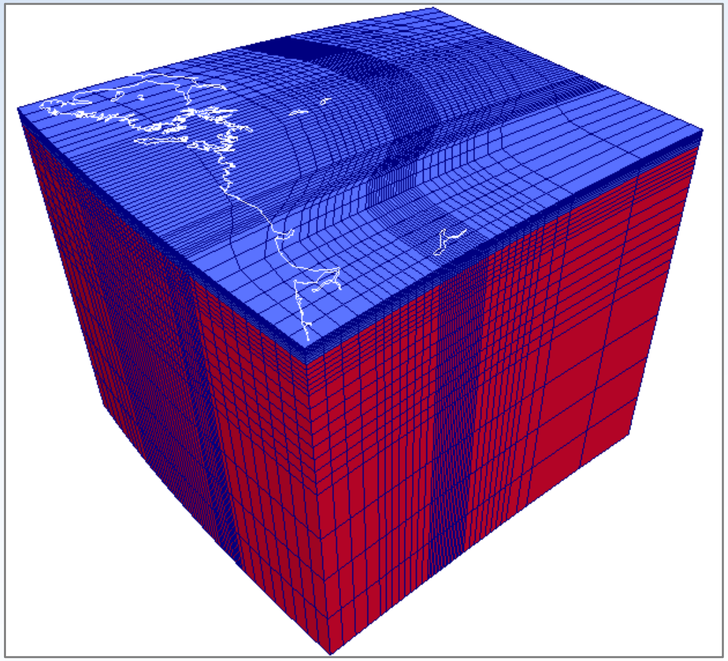
- SAR offset data (Elliot et al., 2007)
- Geologic measurements (Haeussler et al., 2004)

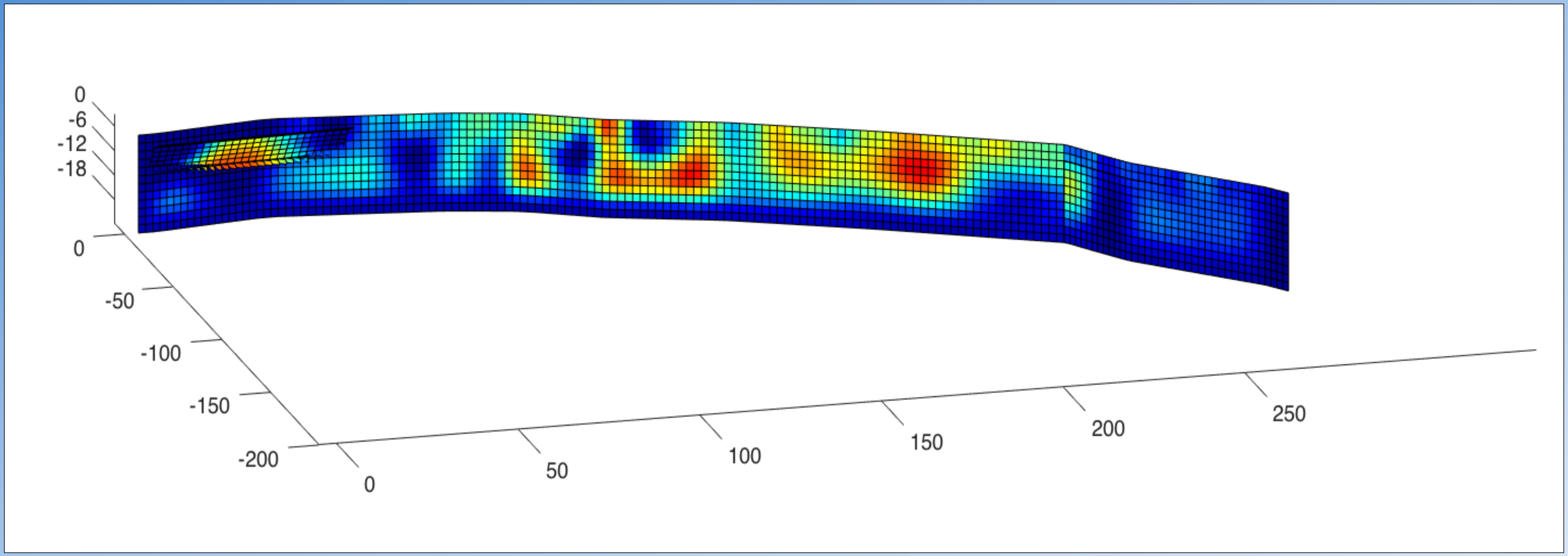




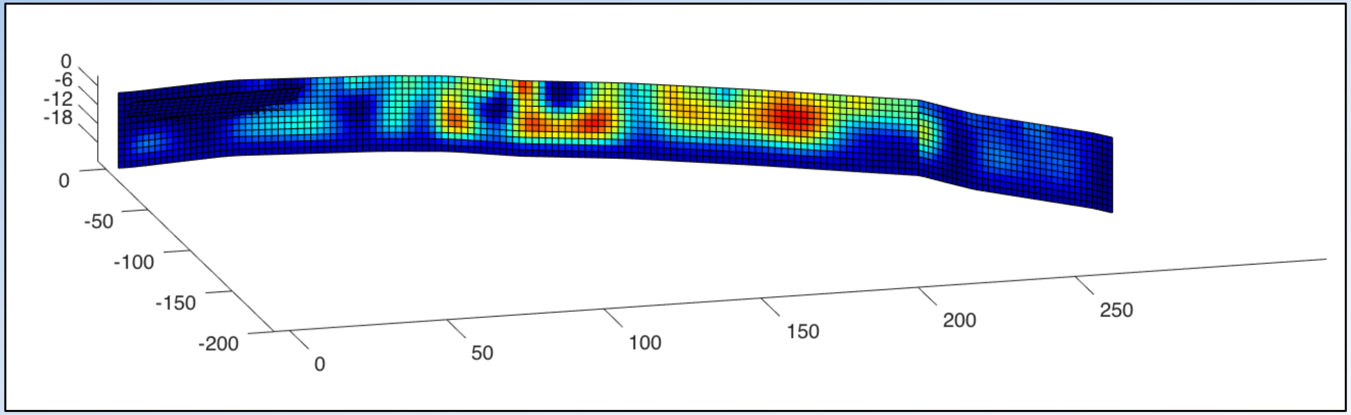
Coseismic Inversion Method

- Bounded variable least squares inversion (right-lateral strike-slip, north-side-up dip slip)
- Laplacian smoothing minimizes 2nd spatial derivative
- Earth model
  - Spherical earth
  - ak135 velocity model

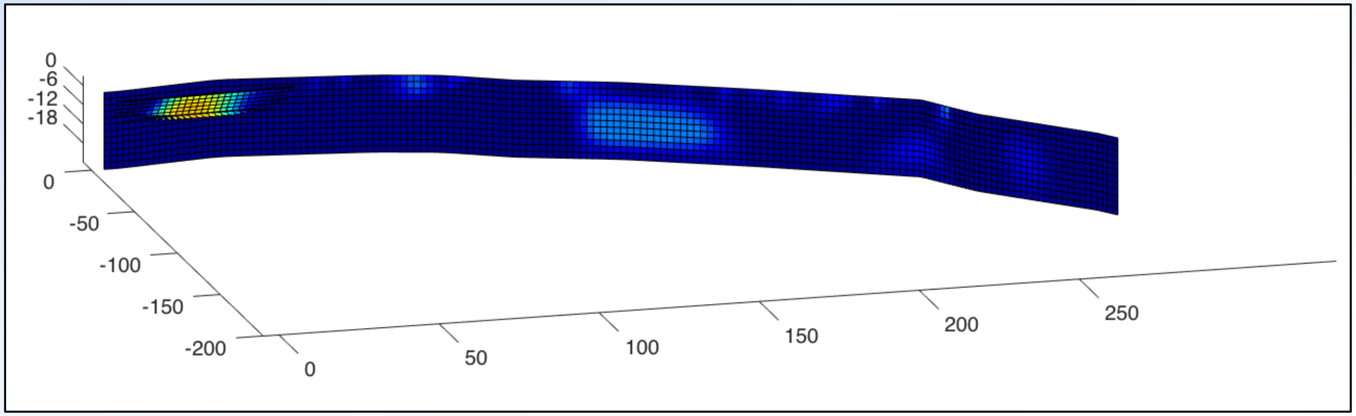


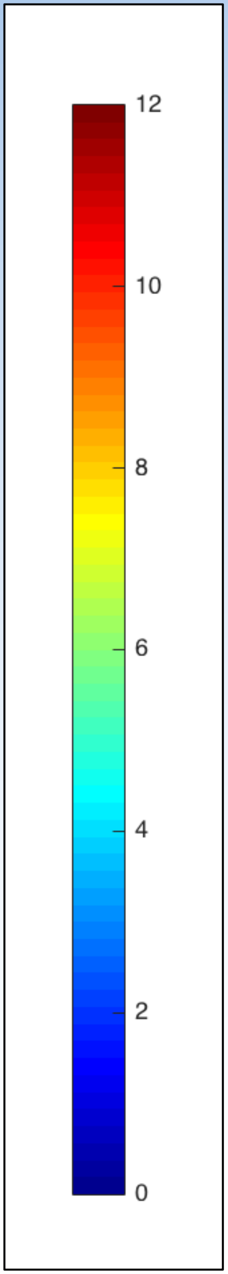


Strike-slip

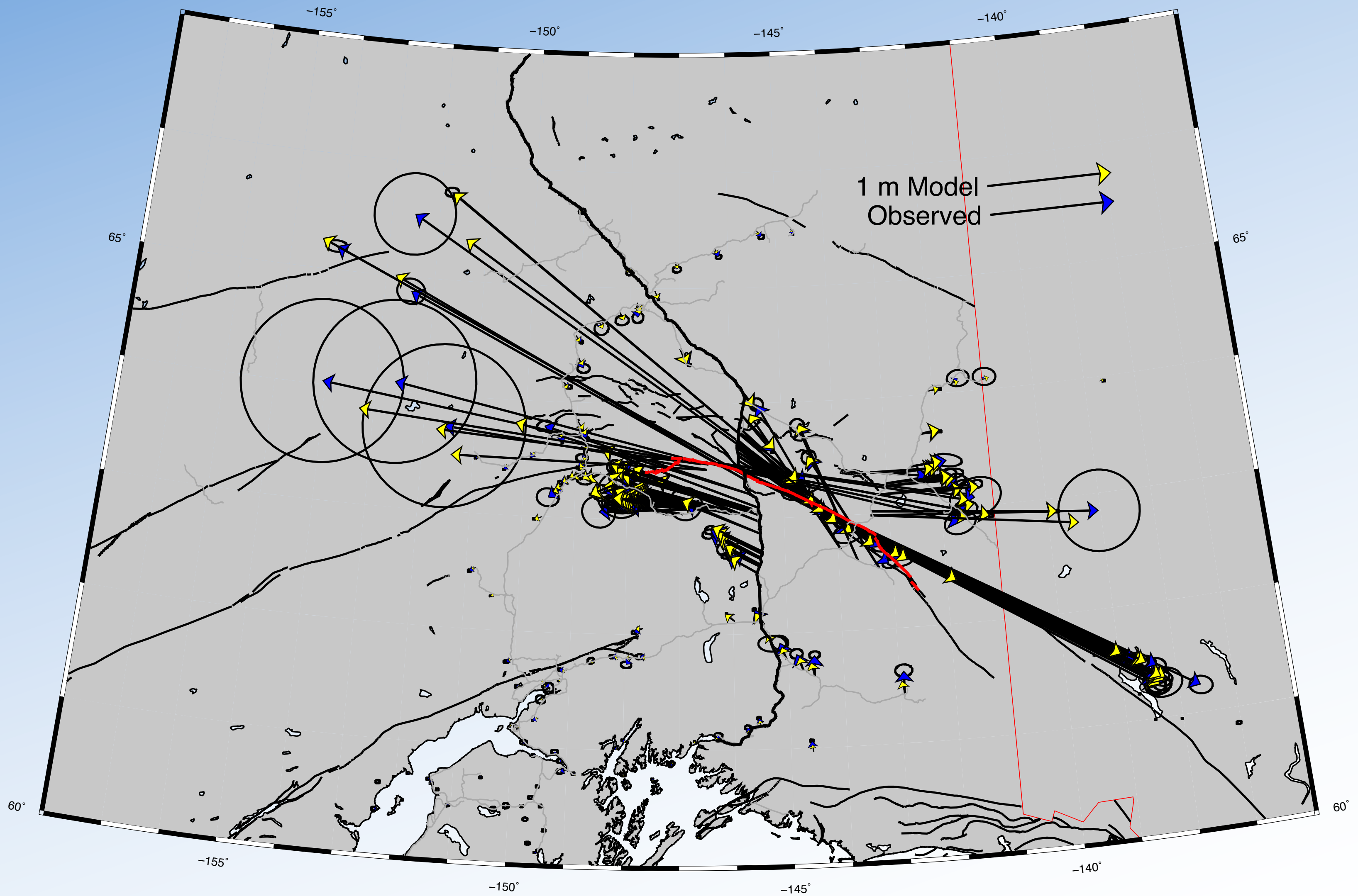


Dip slip



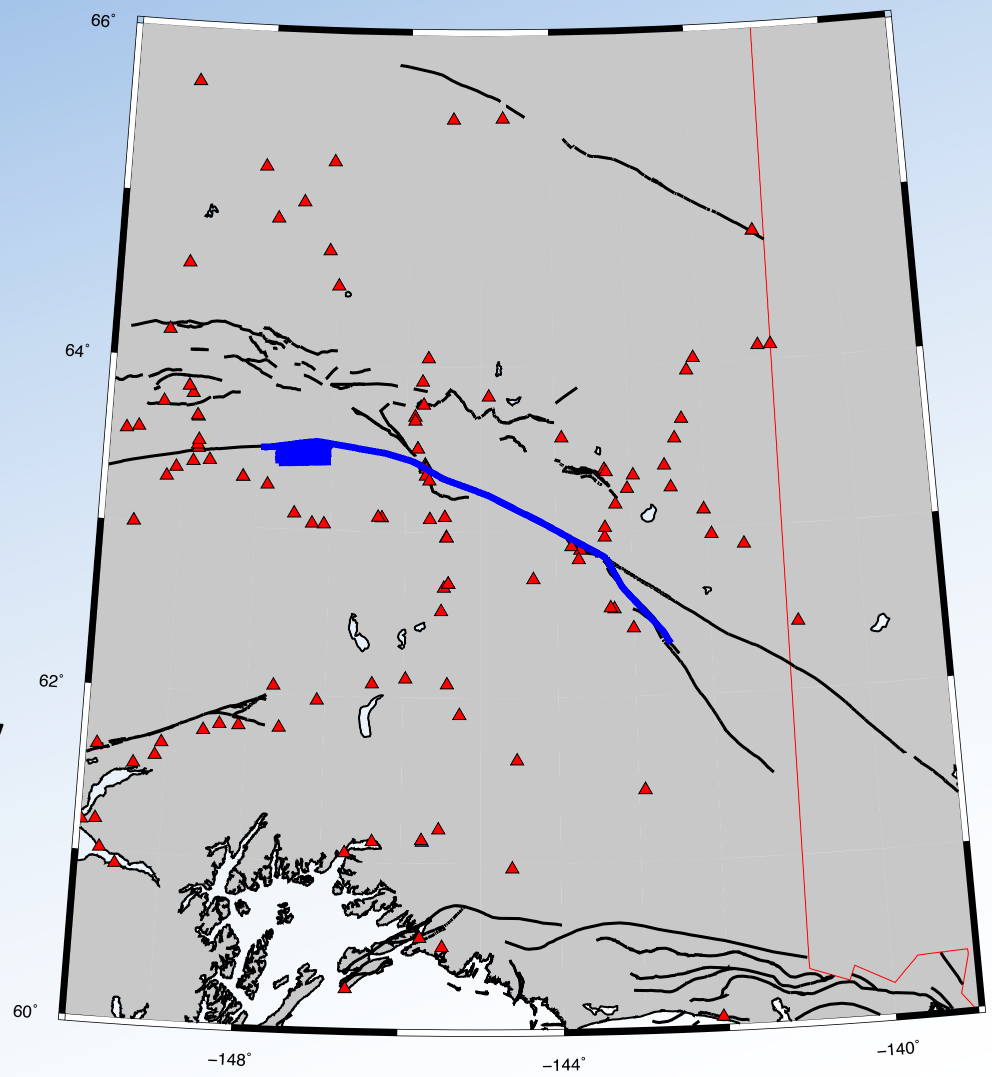


GPS Coseismic Displacments



Postseismic Datasets

- Smaller set of 140 GPS sites
- Restricted by
  - quality of campaign coverage
  - Reliable pre-earthquake velocity

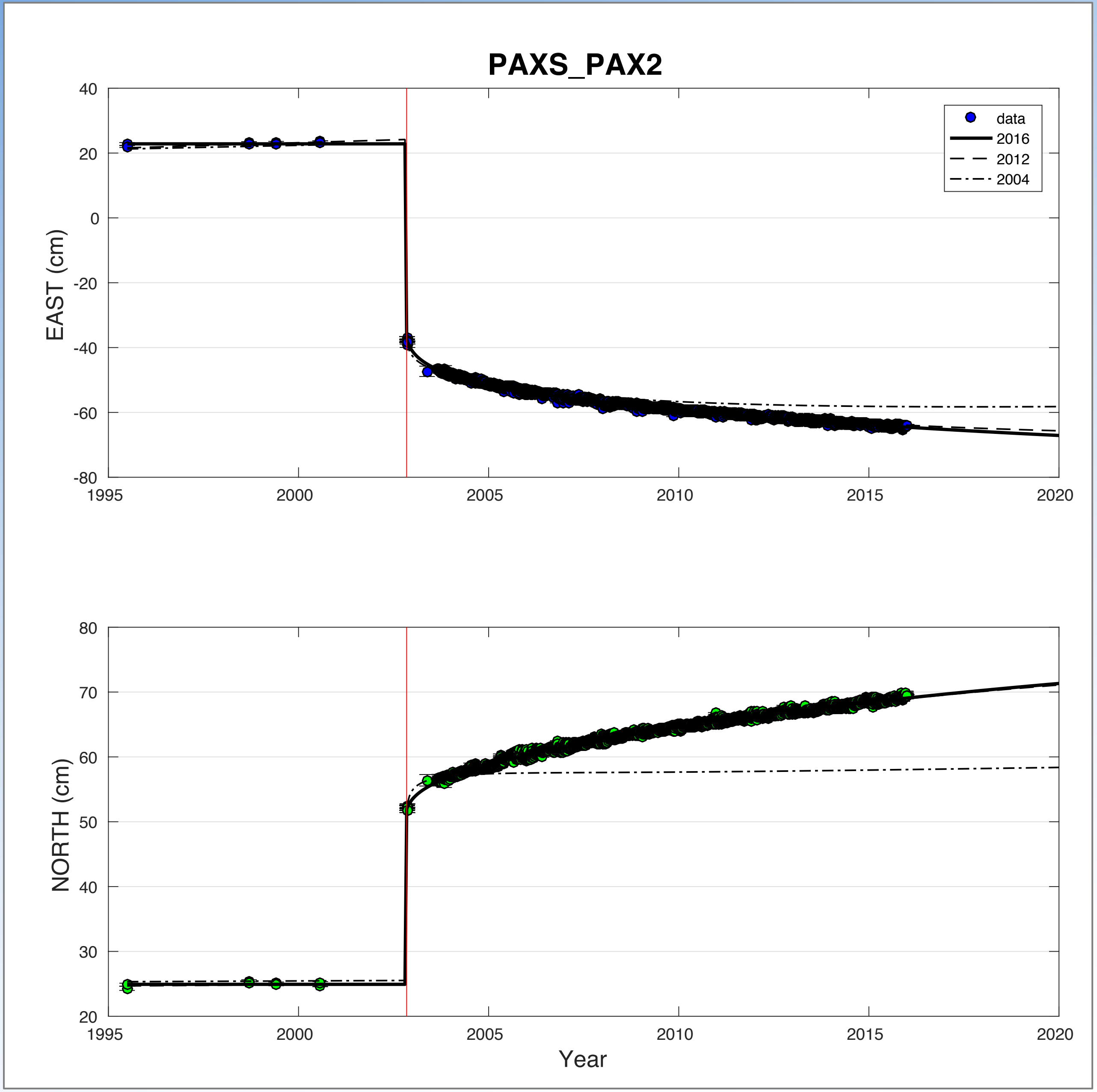


Time Series Fitting

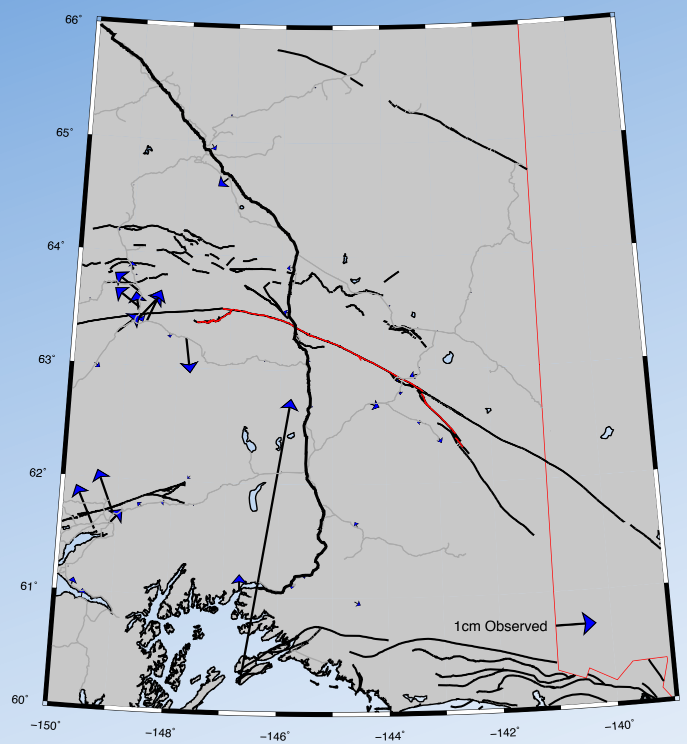
$$y = a + bt + c\sin(2\pi t) + d\cos(2\pi t) + e\sin(4\pi t) + f\cos(4\pi t) + H(t - t_d)[g + h\ln\left(1 + \left(\frac{t - t_d}{\tau_L}\right)\right) + k(1 - e^{-(t-t_d)/\tau_E})]$$

- Time series parameterization
  - Decay times are optimized with grid search using 14 continuous sites
  - Isolates transient displacement component
  - Allows resampling at common epochs
  - Not a predictive tool

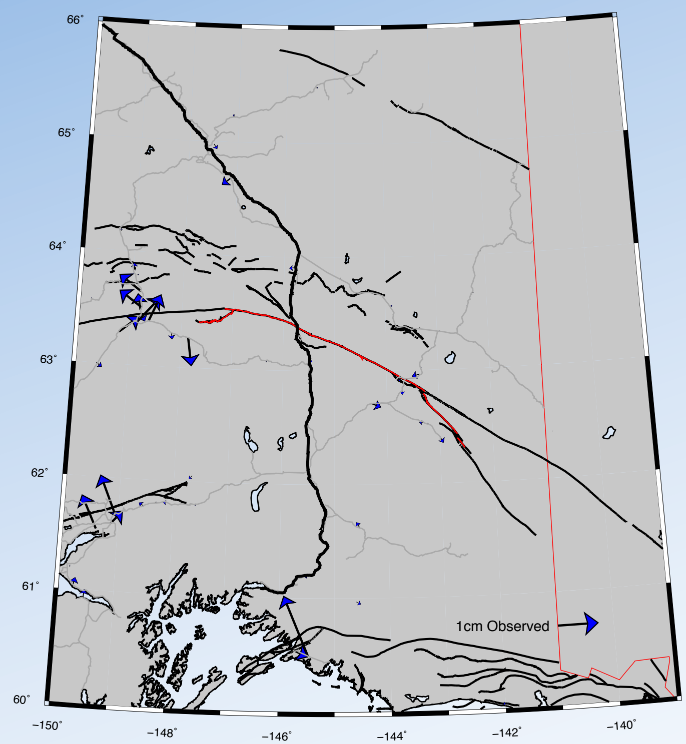
- Postseismic time series are split into 3 year displacement windows
- Many campaign sites have limited temporal availability
- Tradeoff between secular velocity and exponential decay



2003-2006

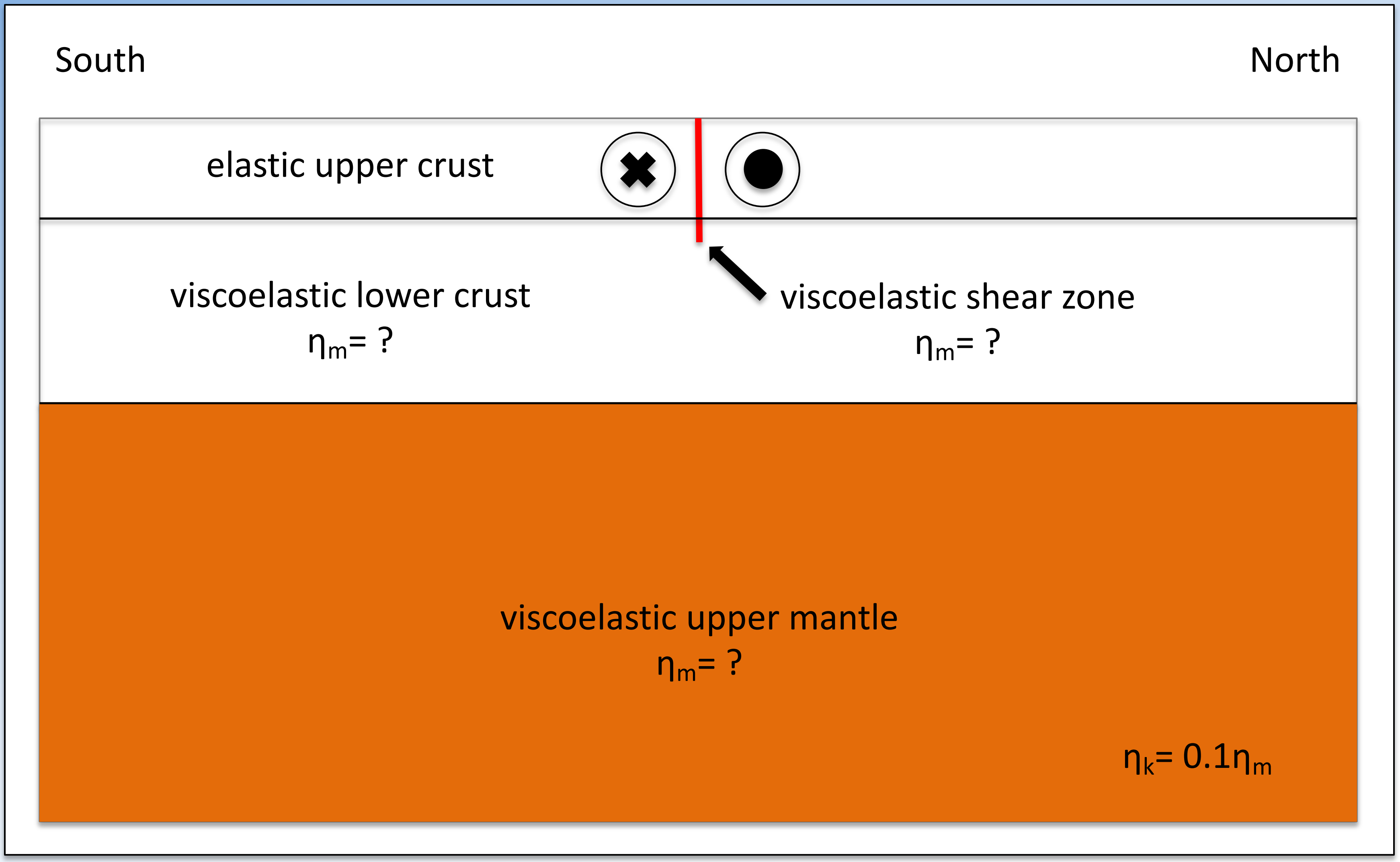


2006-2009

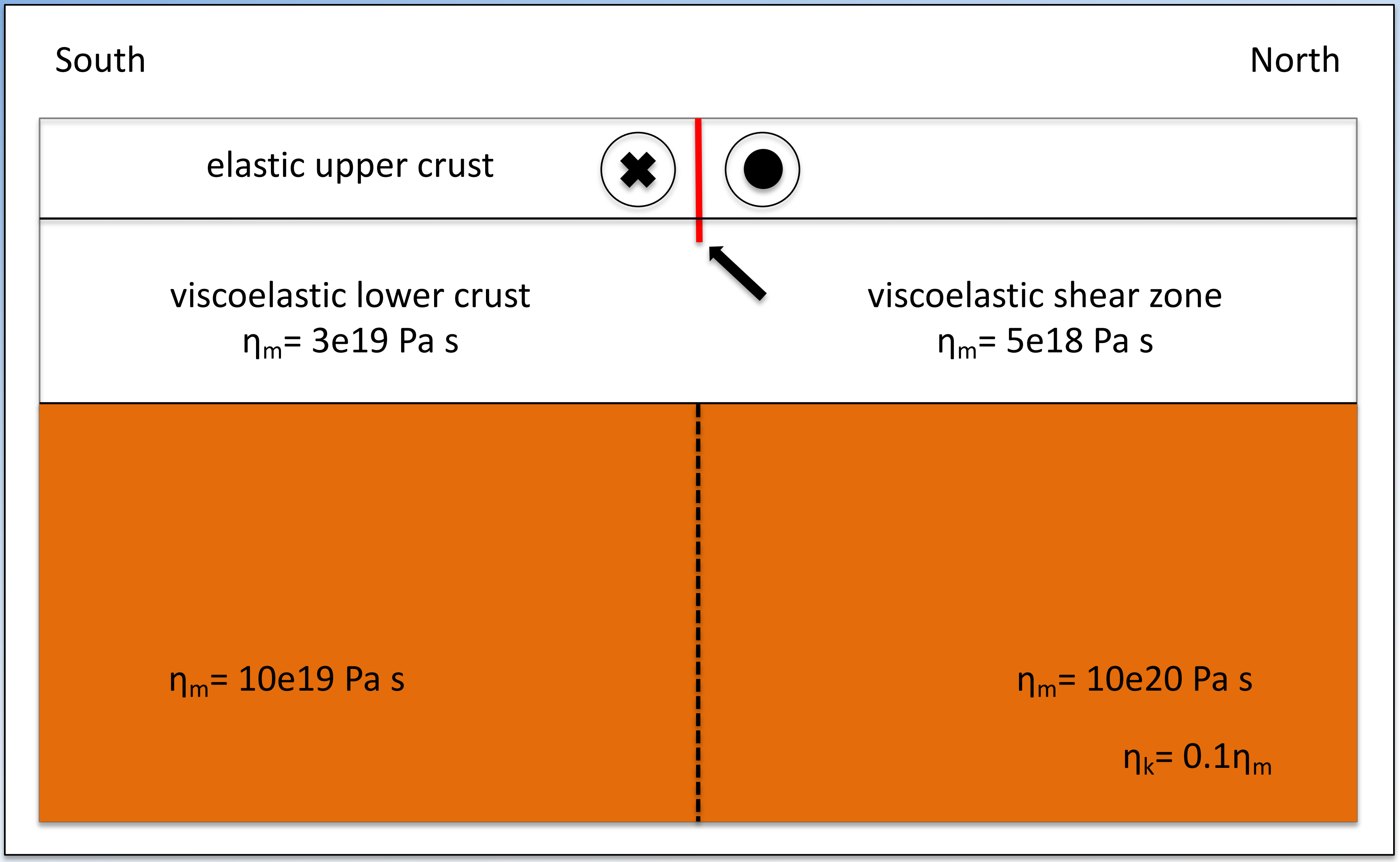


How does a priori velocity assignment affect postseismic displacement estimates?

Postseismic Deformation Model

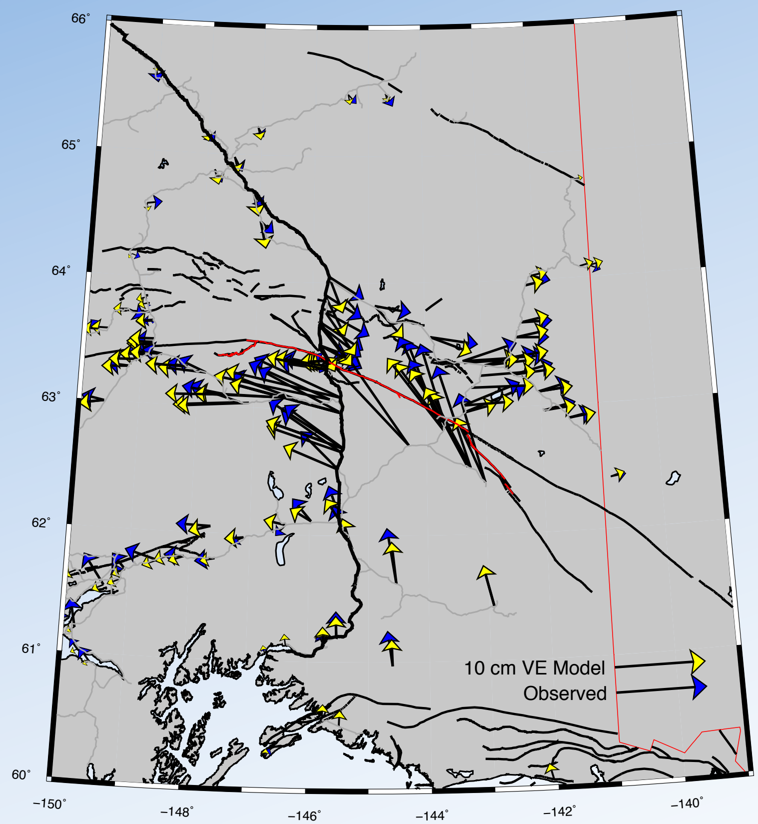


Postseismic Deformation Model

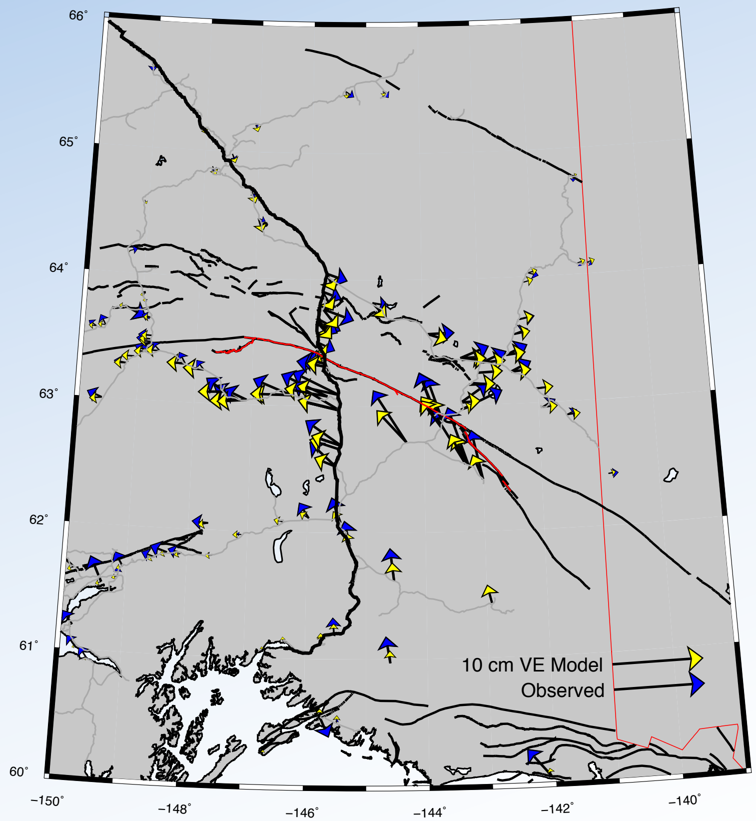


VE only model

2003-2006

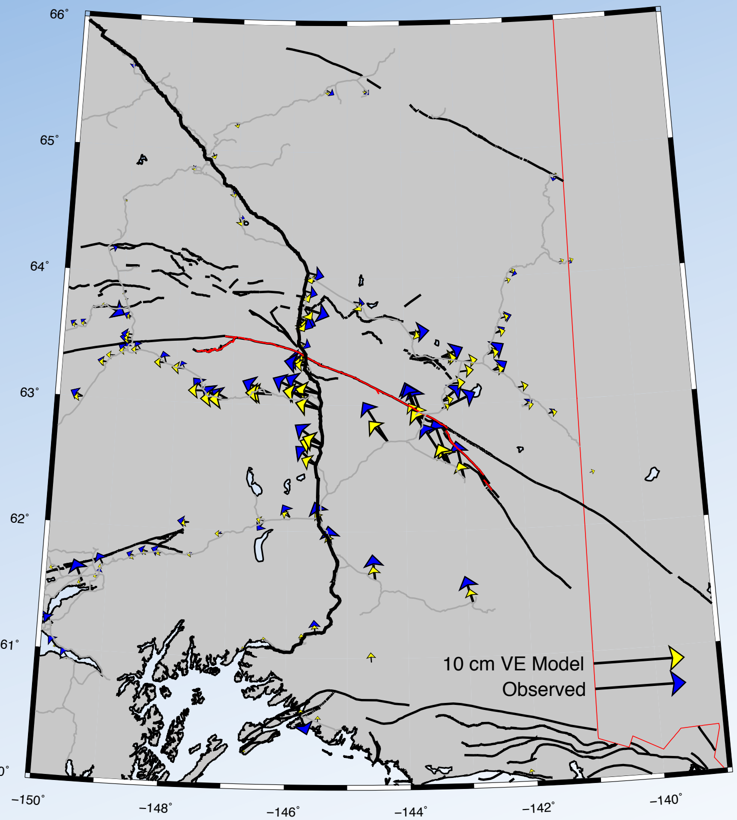


2006-2009

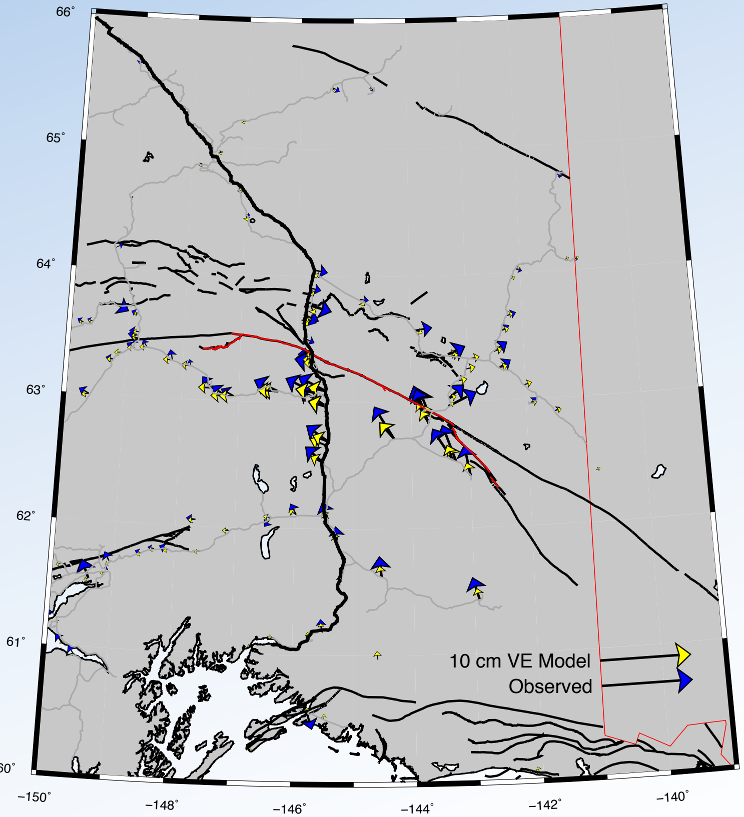


VE only model

2009-2012

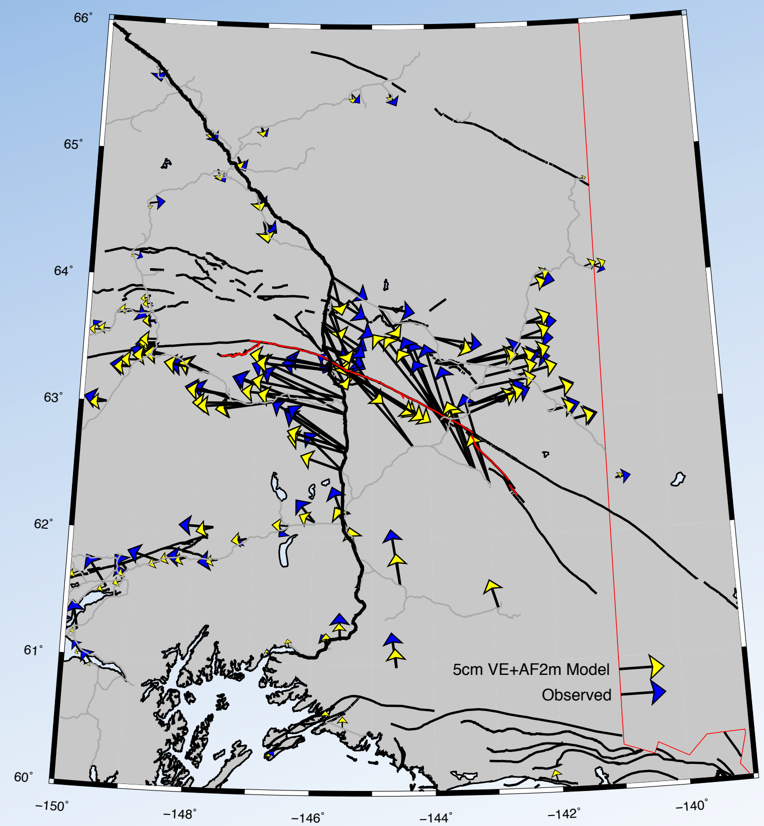


2012-2015



VE + 5m contoured afterslip

2003-2006



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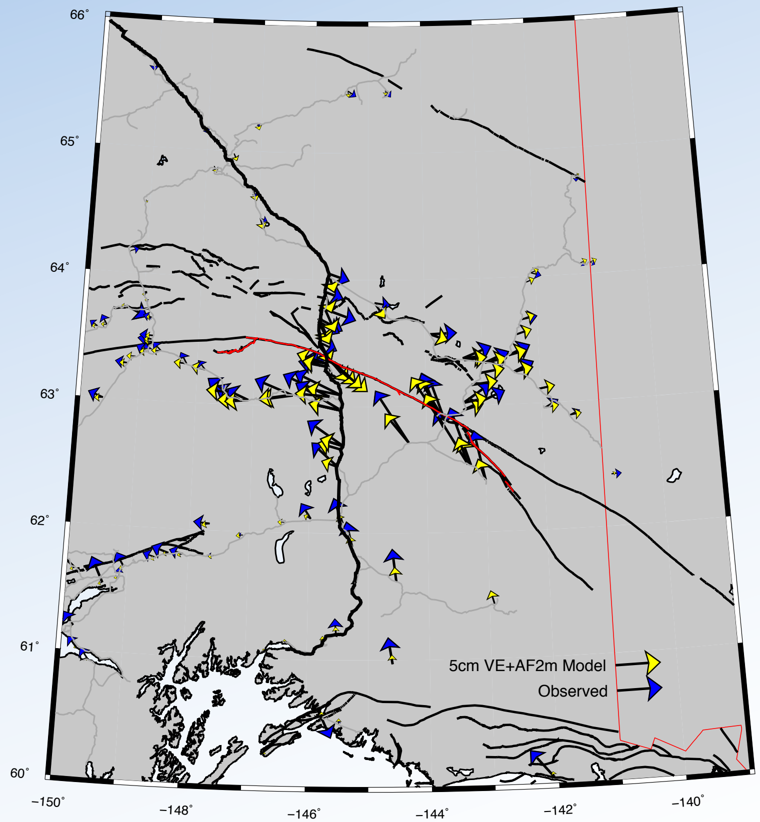

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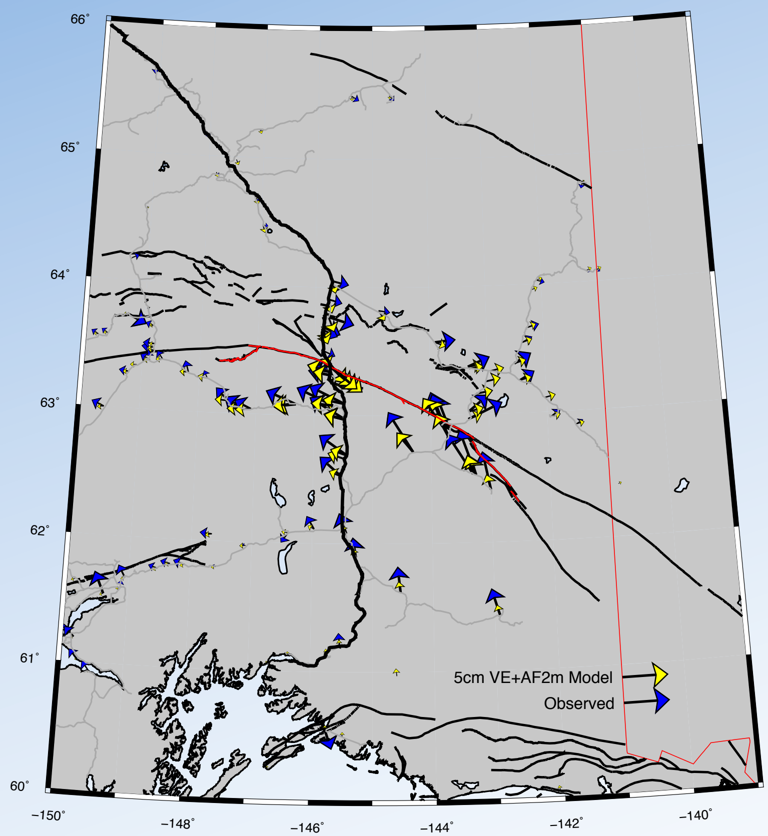
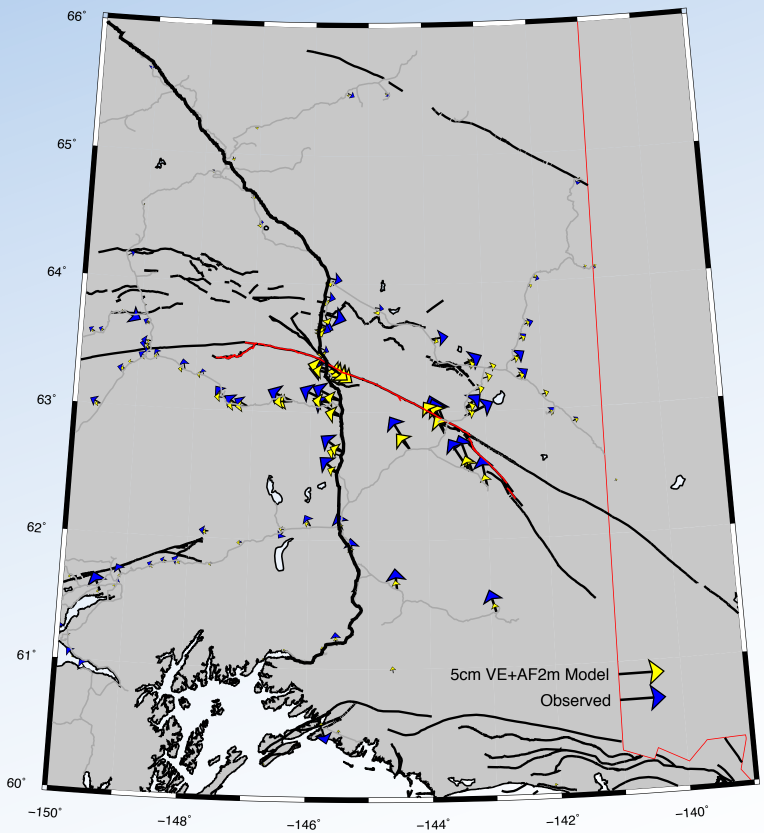
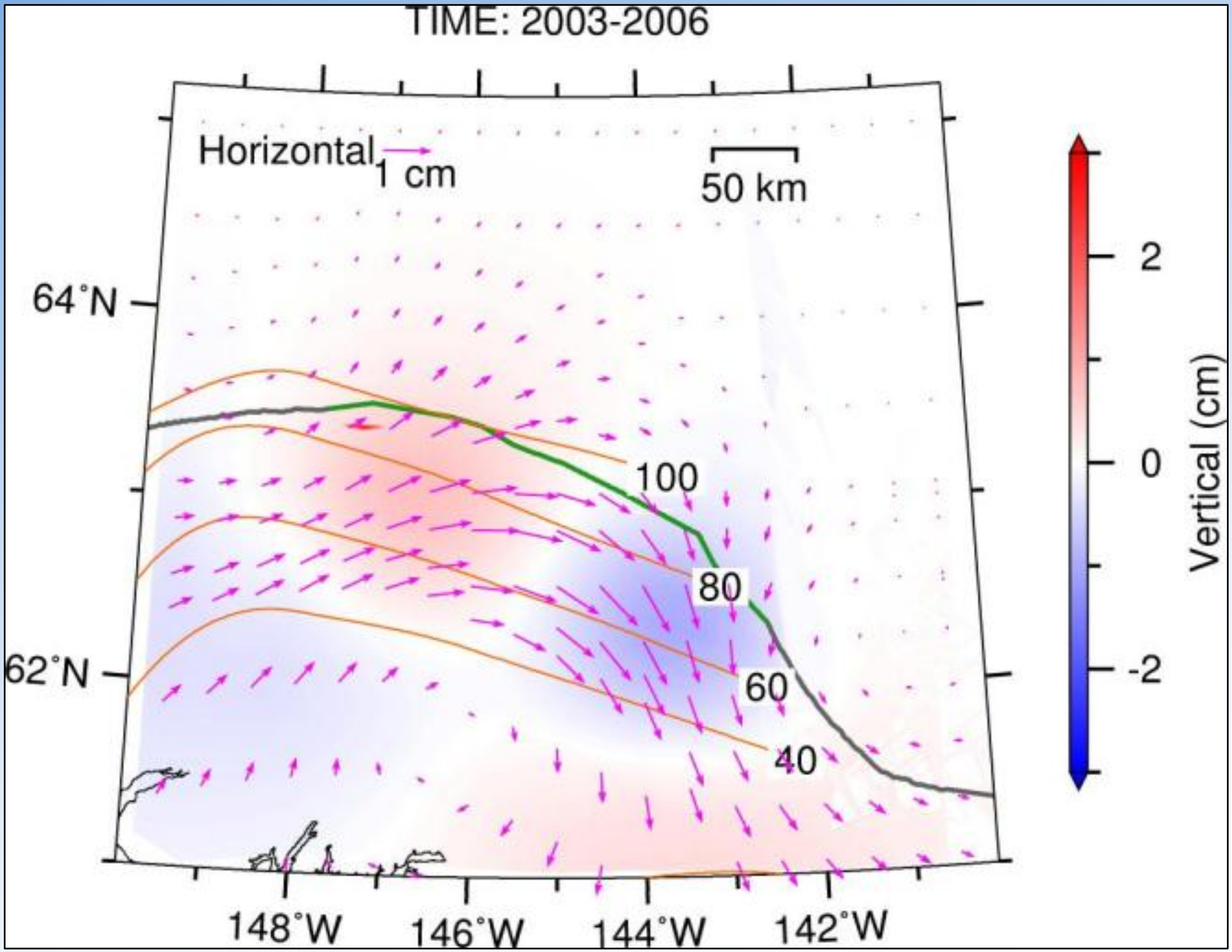


2012-2015



Slab Effects



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Summary

- Extent of observations are adequate to characterize the postseismic phase of the deformation cycle
- Develop a unified coseismic and postseismic earth model
- Inclusion of elastic slab may correct the model prediction biases

Questions