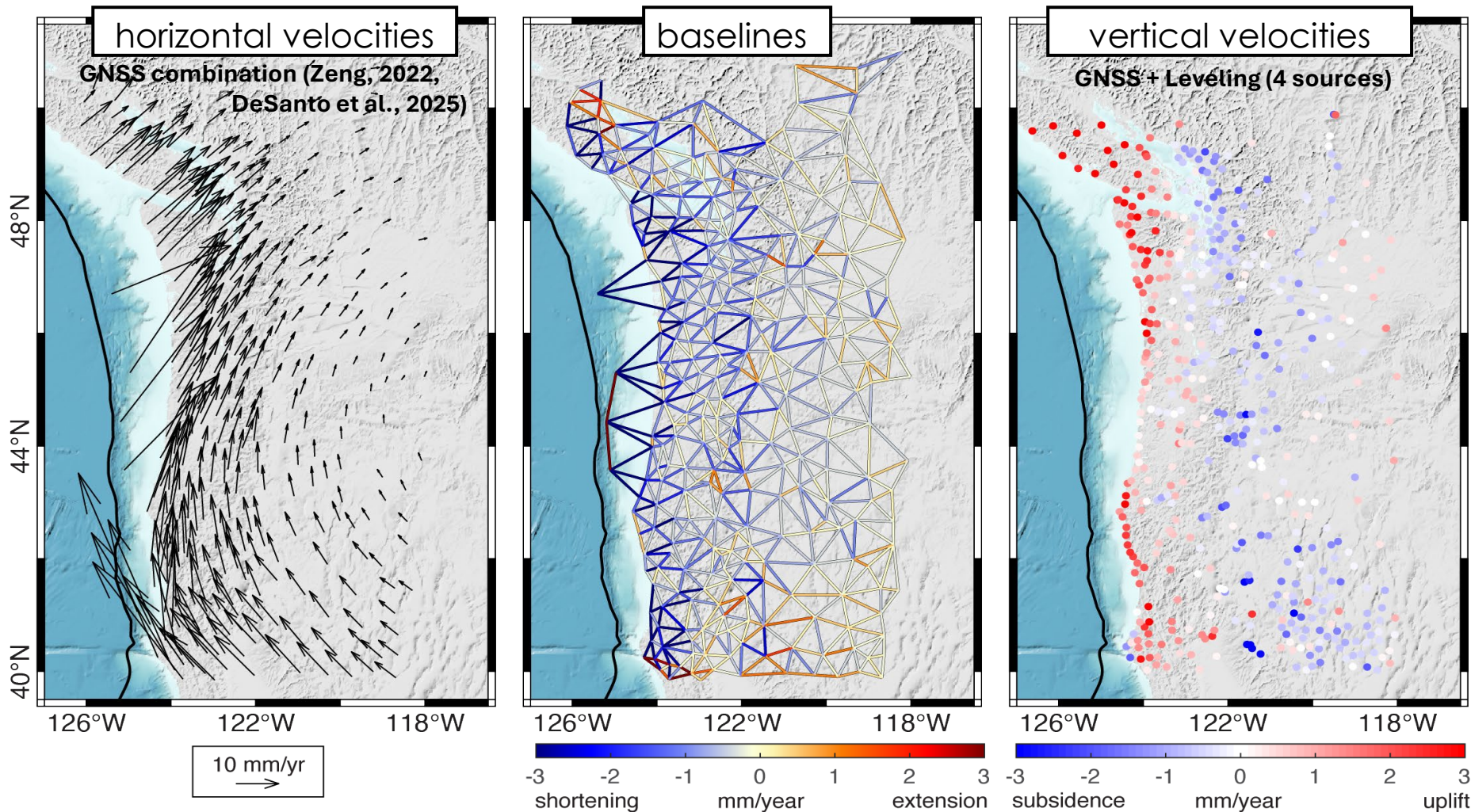


Interseismic Coupling and the Viscoelastic Earthquake Cycle at Cascadia

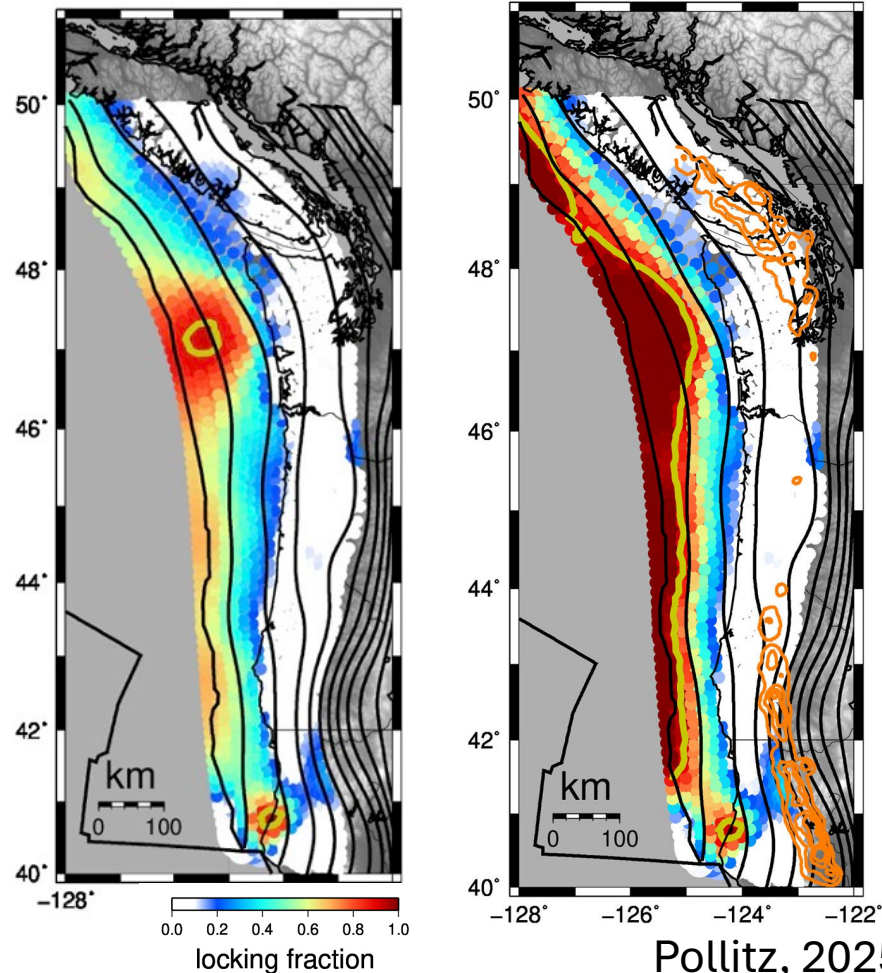


Kaj M. Johnson
Indiana University
with
Elizabeth Sherrill
GEOMAR, Germany

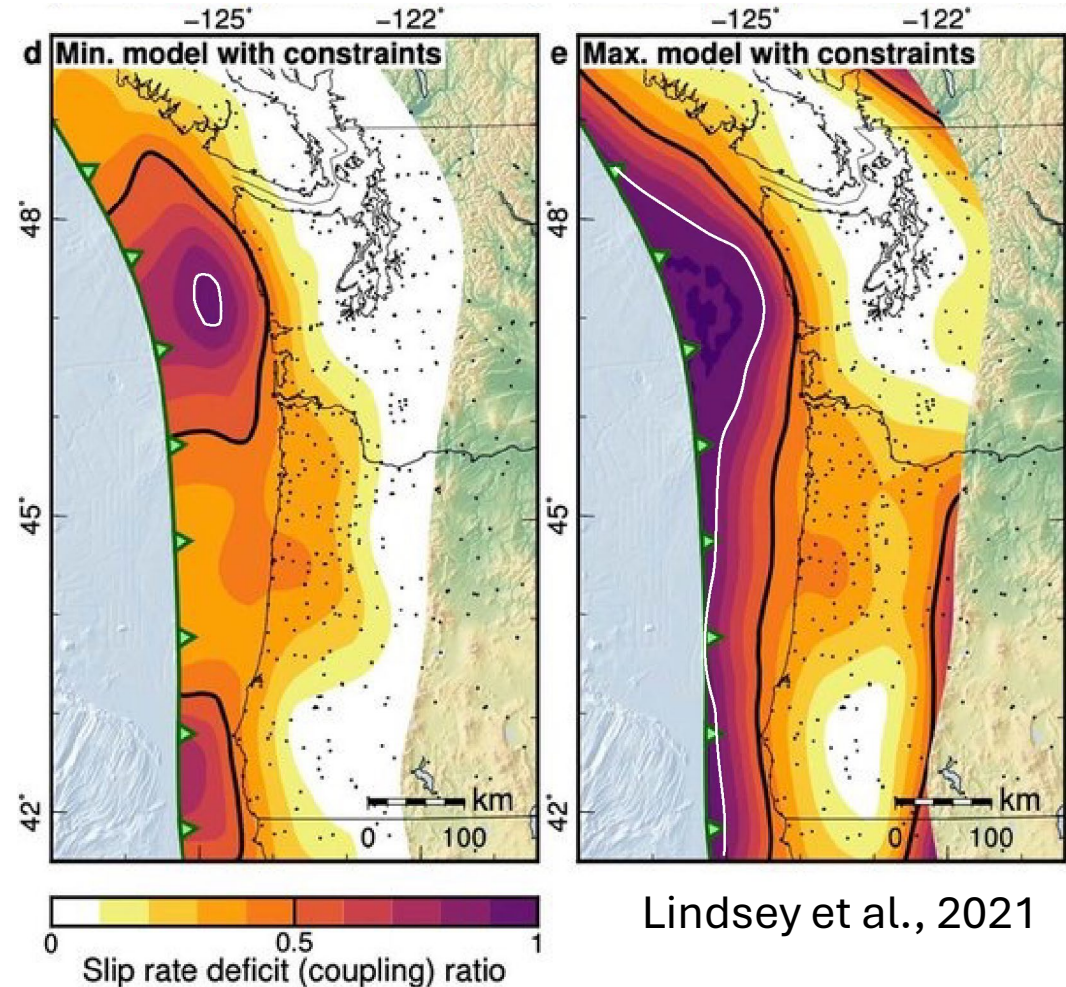
Resolution is Poor, Uncertainty is Large

Smoothed kinematic slip inversions likely do not resolve fully locked areas of the interface

Viscoelastic Cycle Model



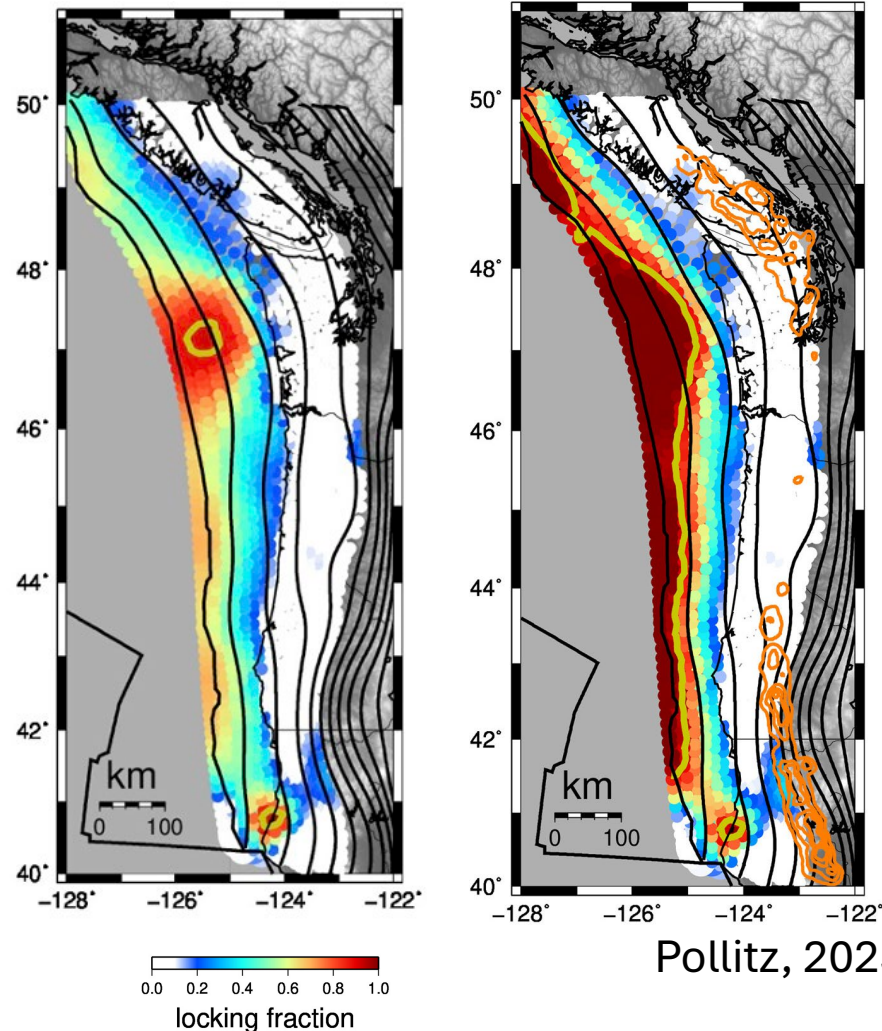
Elastic Halfspace Model



Resolution is Poor, Uncertainty is Large

Main Points:

1. Assumed Earth structure (viscoelastic properties) have “secondary” impact on coupling estimates.
2. The largest source of uncertainty is lack of knowledge about how to parameterize coupling
3. Physical constraints provide important insights

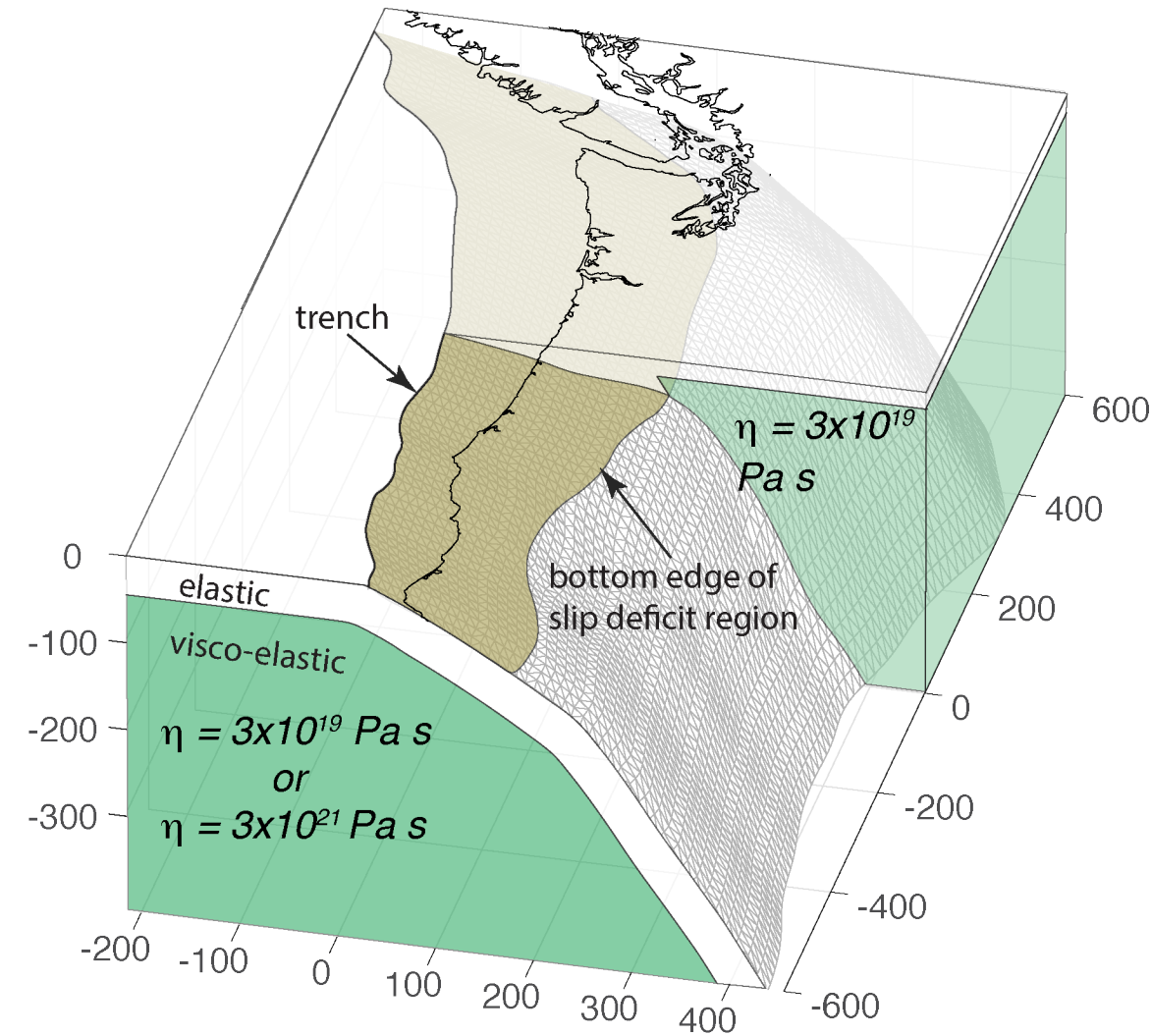


Pollitz, 2025

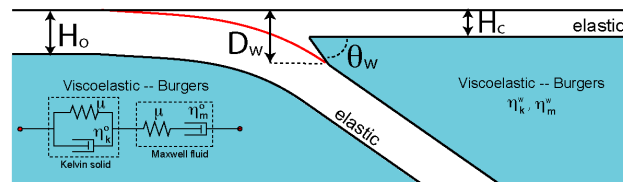
Viscoelastic Earthquake Cycle Model

Impose periodic earthquake sequence for fixed recurrence time and Earth structure (viscosity, elastic properties).

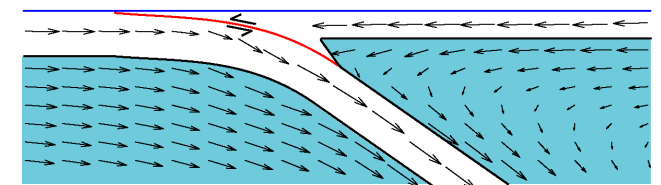
Solve for interseismic coupling



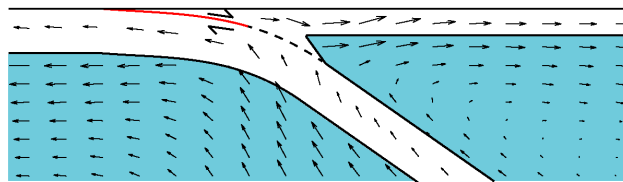
(a) Subduction zone geometry



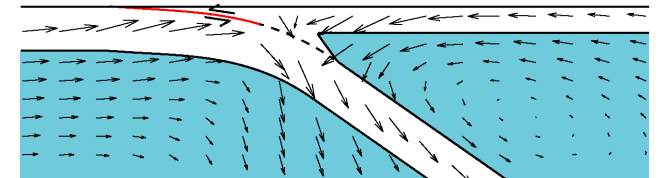
(b) long term (steady mantle flow)



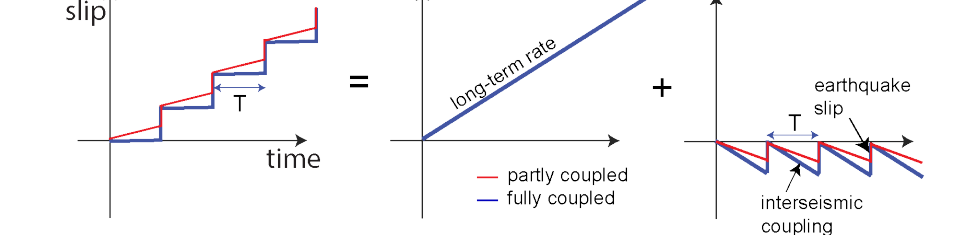
(c) interseismic coupling (steady flow)



(d) repeated earthquakes (transient flow)

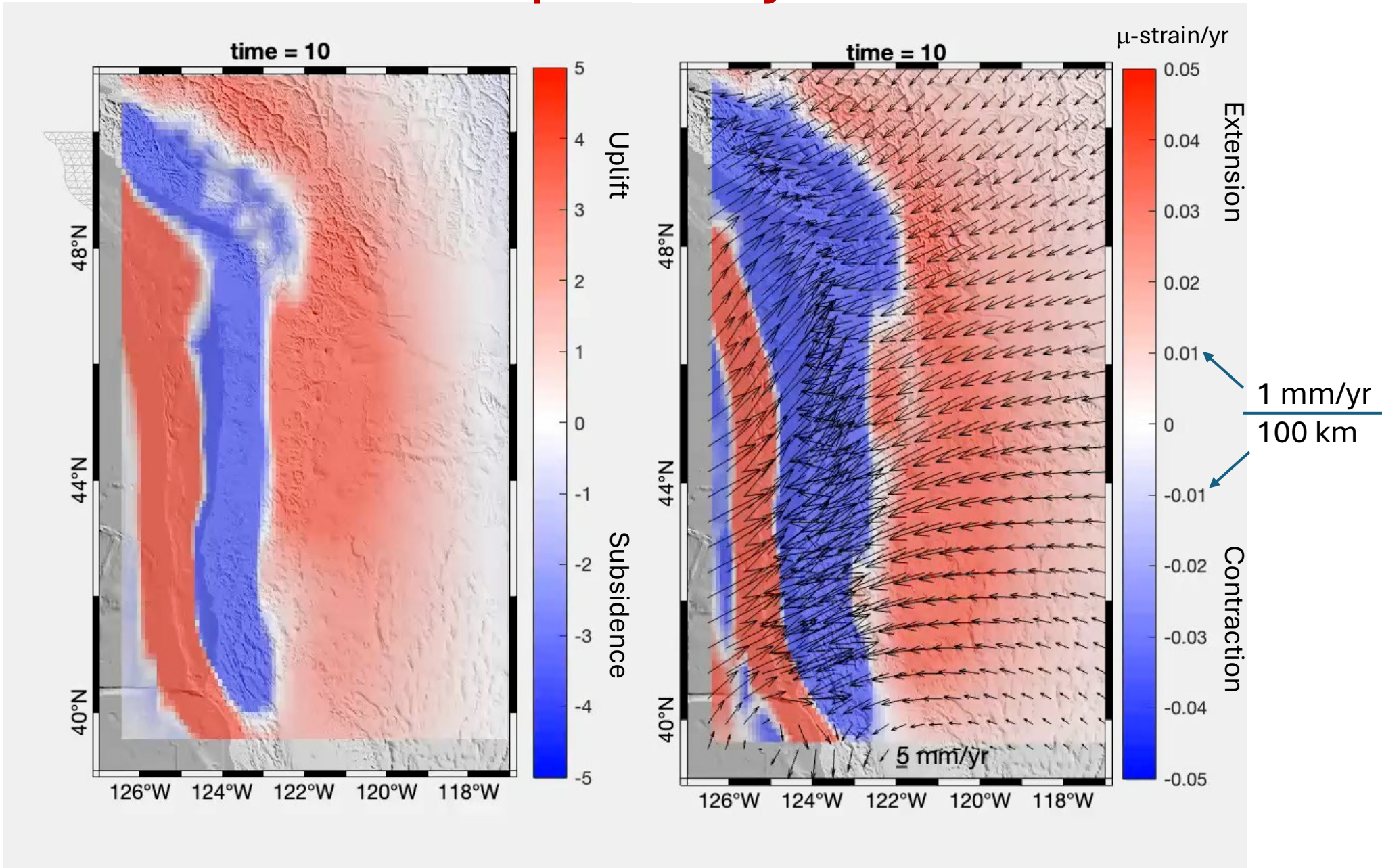


(e) periodic slip history



Viscoelastic Earthquake Cycle Model

Recurrence time:
500 yrs



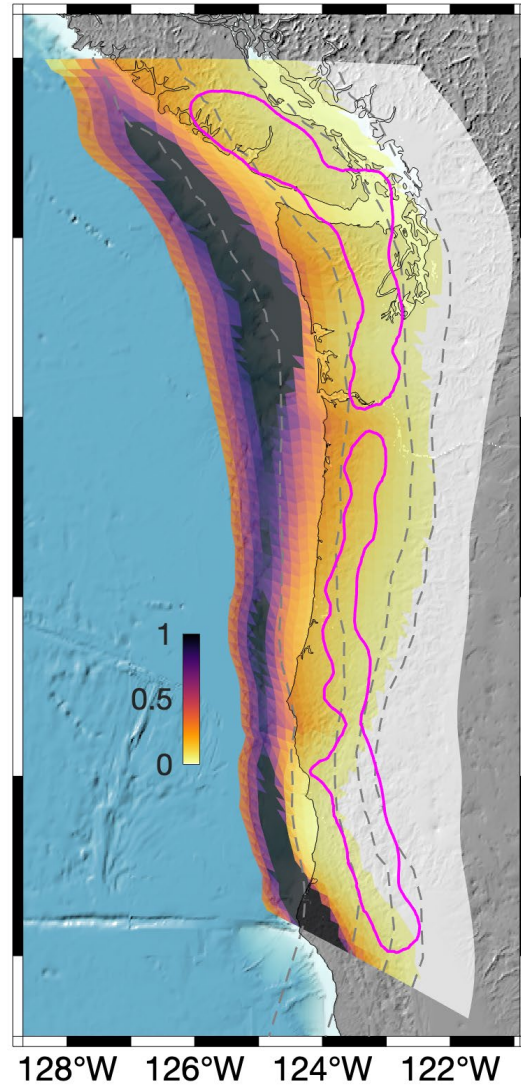
Interseismic Coupling Estimates

Elastic

500-year cycle

Locked Zone
 $M_w = 8.85$

Entire Interface
 $M_w = 9.07$

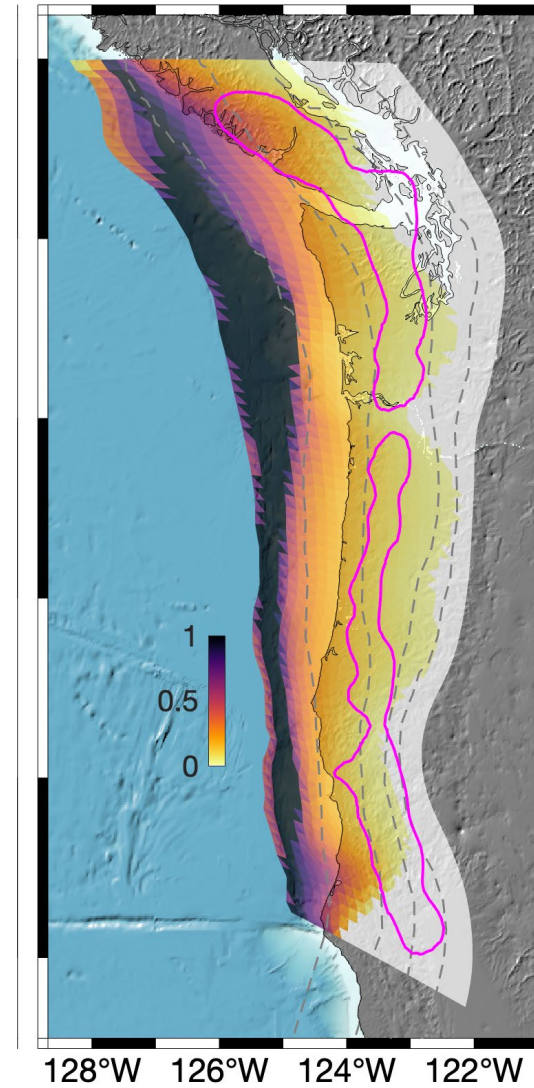


Viscoelastic

500-year cycle

Locked Zone
 $M_w = 8.88$

Entire Interface
 $M_w = 9.12$



Fit to Geodetic Data

Viscoelastic Model

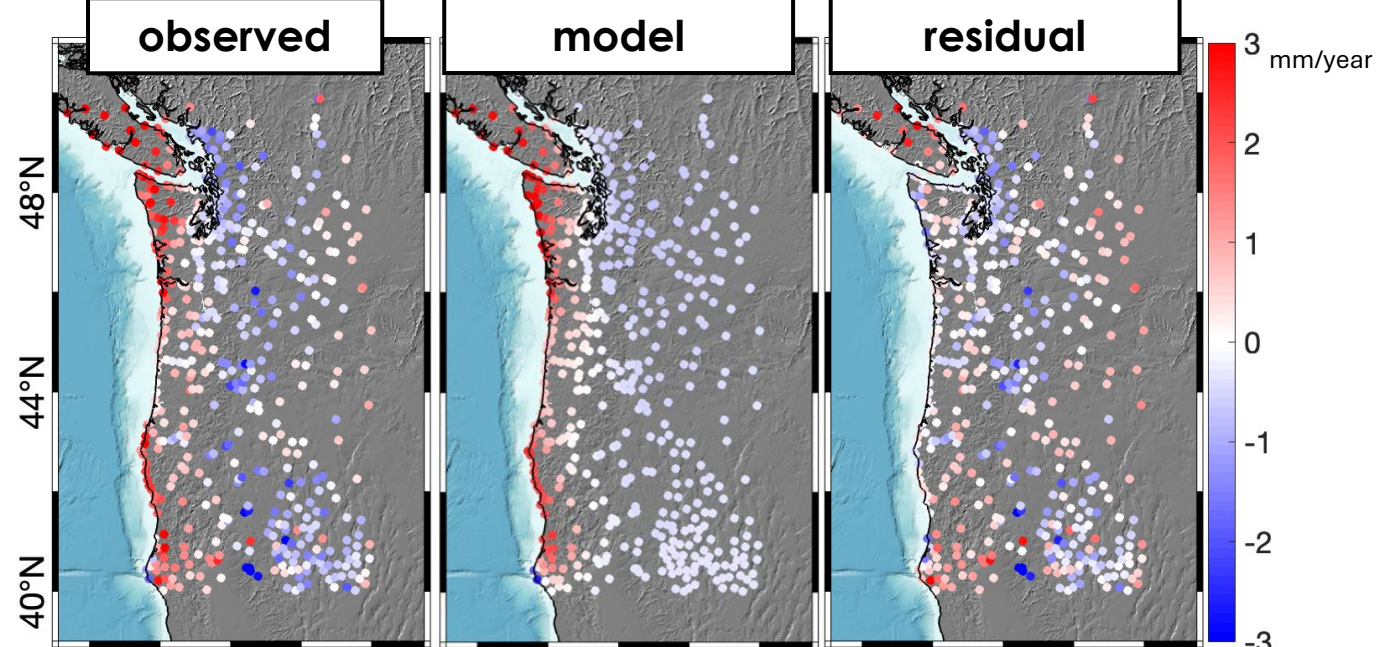
Vertical patterns:

- ✓ **Uplift** along coast
- ✓ **Subsidence** inland

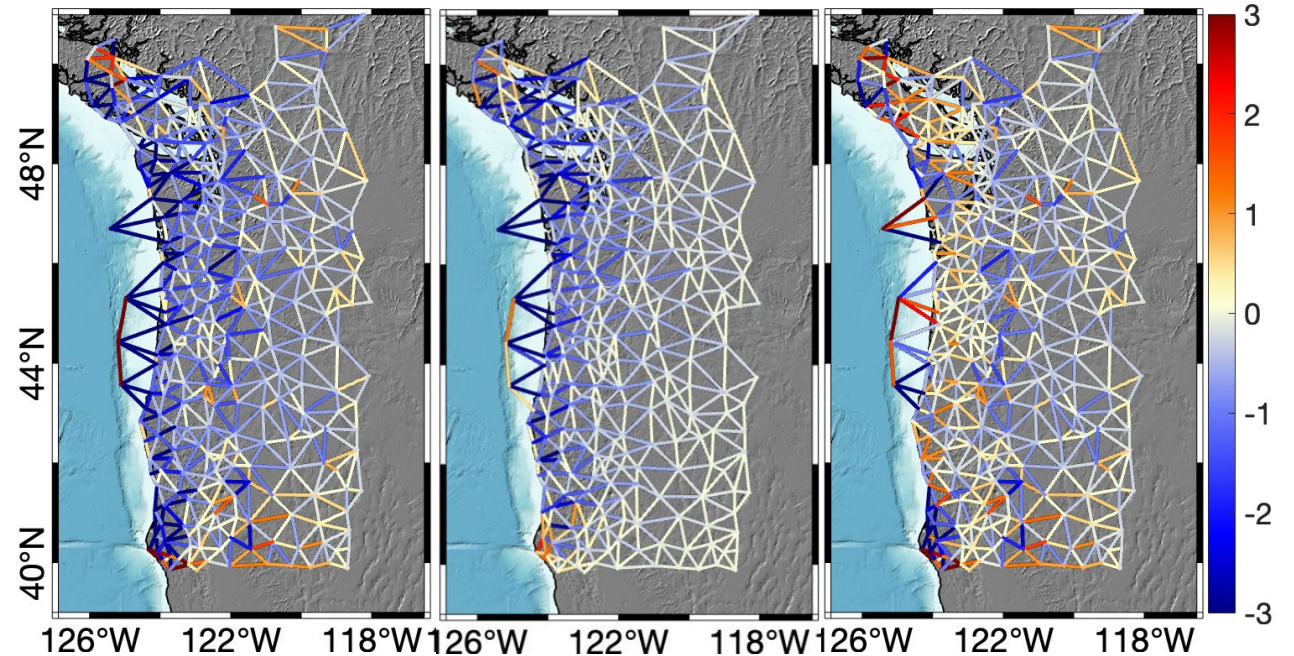
Horizontal patterns:

- ✓ High **shortening** rates near the coast
- ✓ Decreased **shortening** out to ~600 km from coast in north

Vertical



Horizontal



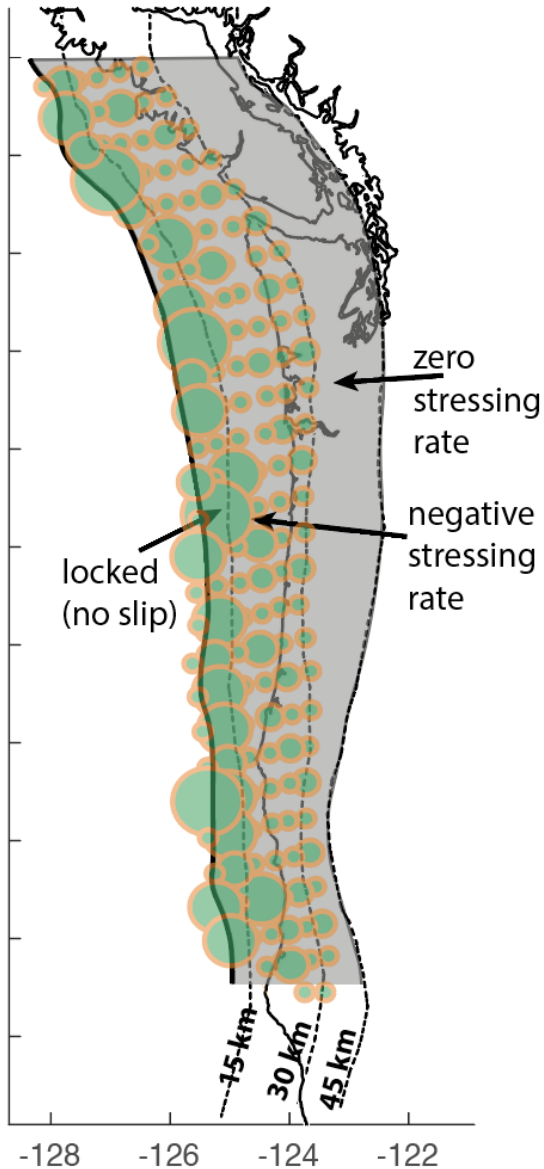
Simple Physical Constraints on Coupling

Do we expect coupling to vary smoothly?

If locked areas (asperities) are stationary and creep is steady, smooth coupling distributions are expected

If creep can release stored stress, coupling can be more heterogeneous.

Physical Constraints on Interface Coupling



Interface is:

(a) fully locked

OR

(b) creeping at zero stressing rate

AND

(c) “process” zone of negative stressing rate surrounding locked asperities

Inversion Result: Locked Asperities with Process Zone

Inversion Result: Locked Asperities with Process Zone

Stationary vs. Non-stationary Locking

Conclusions

1. Assumed Earth structure (viscoelastic properties) have “secondary” impact on coupling estimates.
2. Inversions with interseismic viscoelastic relaxation favor shallower coupling
3. Non-smoothed asperity models with physical constraints imply 70-80% of moment accumulation is in fully locked areas.