Subduction sculpting when megathrusts sleep: How interseismic deformation encodes a signature of plate locking in forearc landscapes

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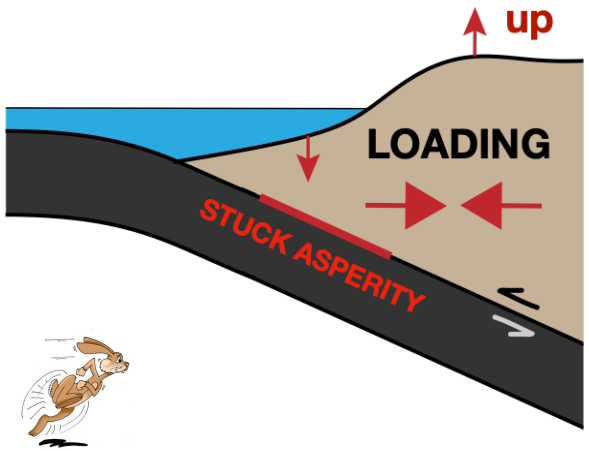
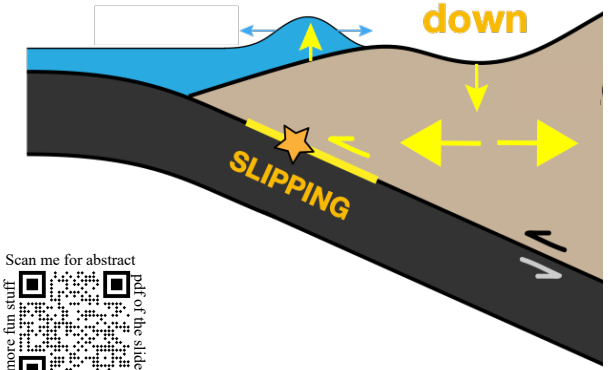
THE STANDARD ELASTIC EARTHQUAKE CYCLE MODEL

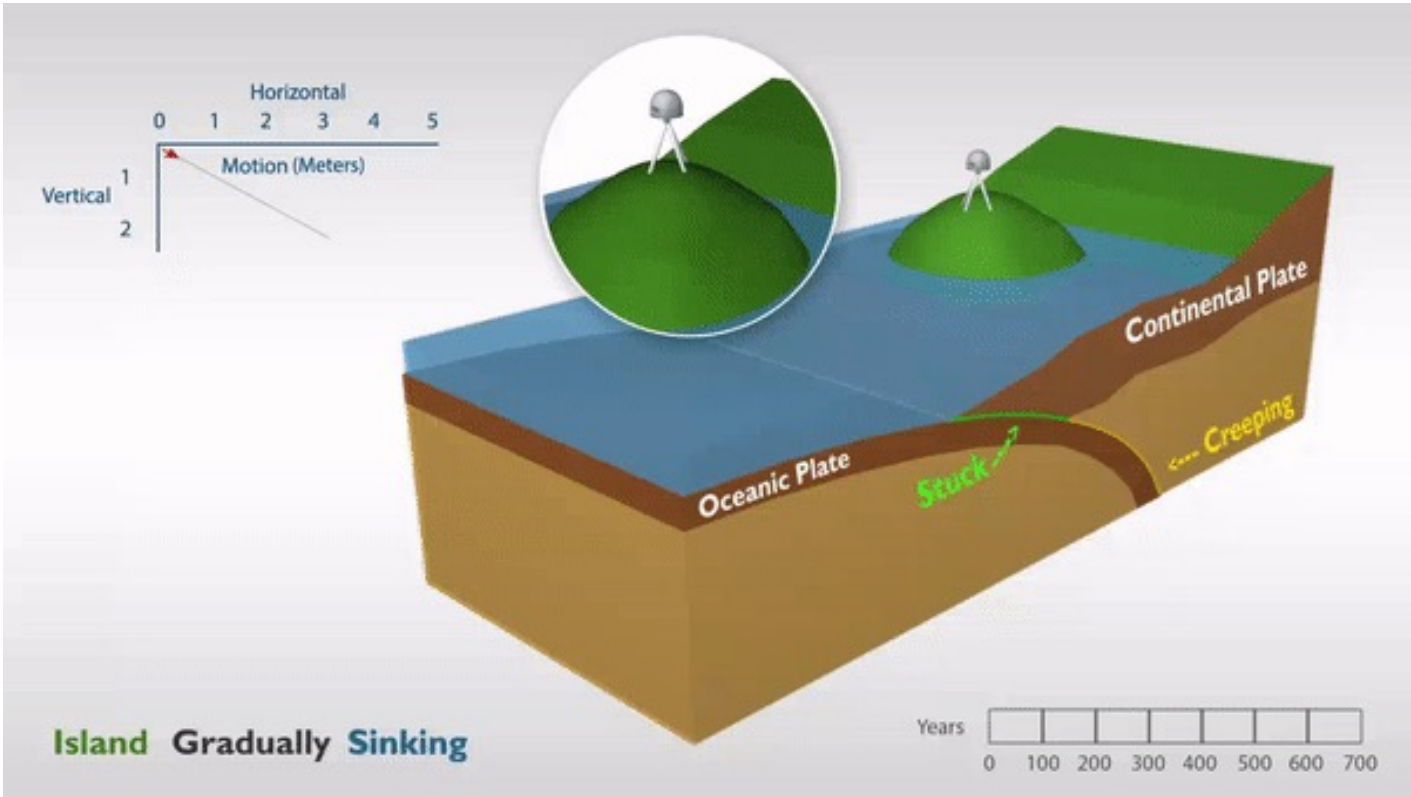
Long-term: downgoing plate descends beneath the upper plate in stick-slip fashion.

Interseismic: locked section is "stuck". Creeping section moves slowly. Upper plate deform elastically.





Coseismic: locked section moves abruptly. Upper plate deform elastically in an opposite sense.



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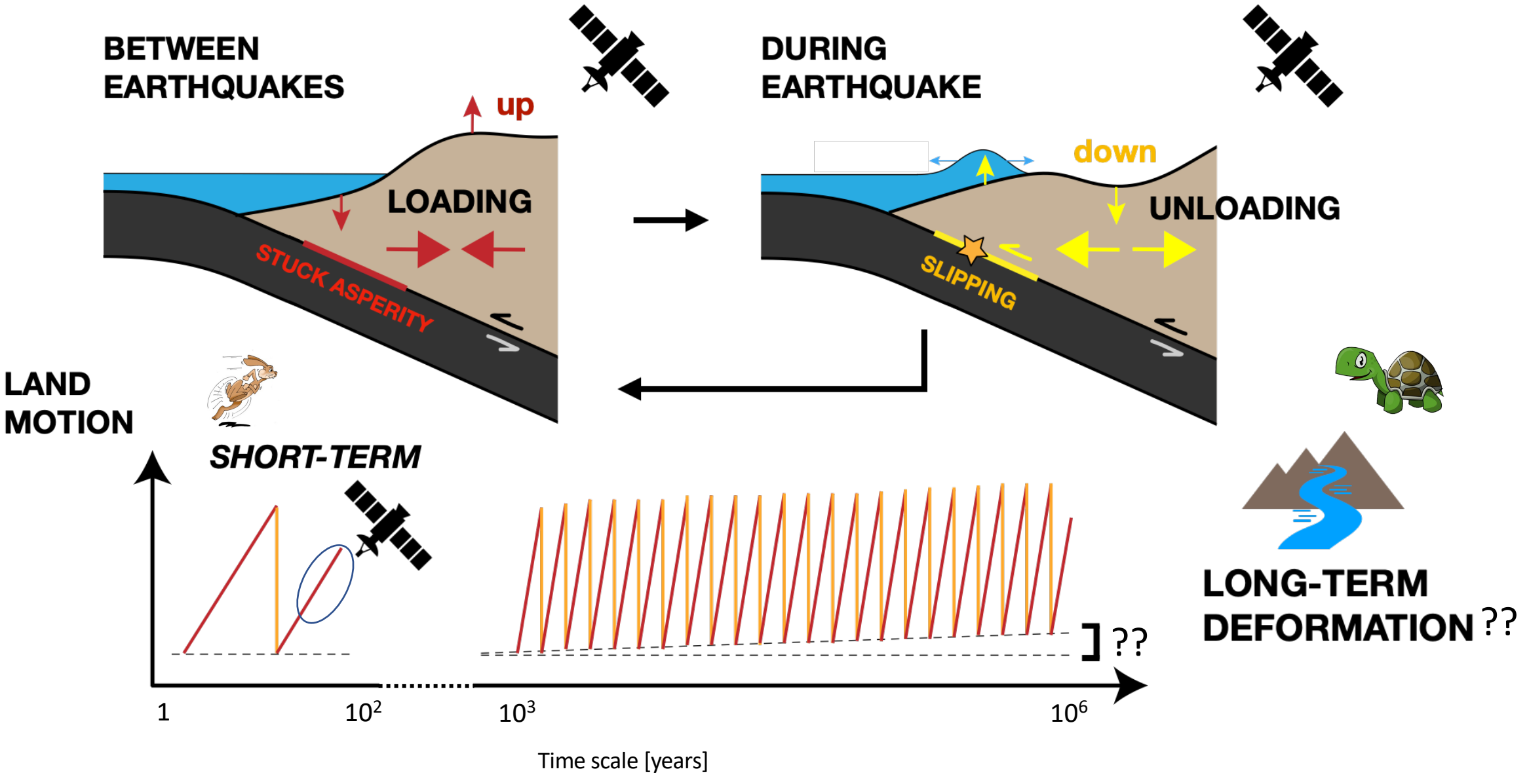
SHORT- AND LONG-TERM DEFORMATION DURING EARTHQUAKE CYCLES



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SHORT-TERM DEFORMATION IN CASCADIA

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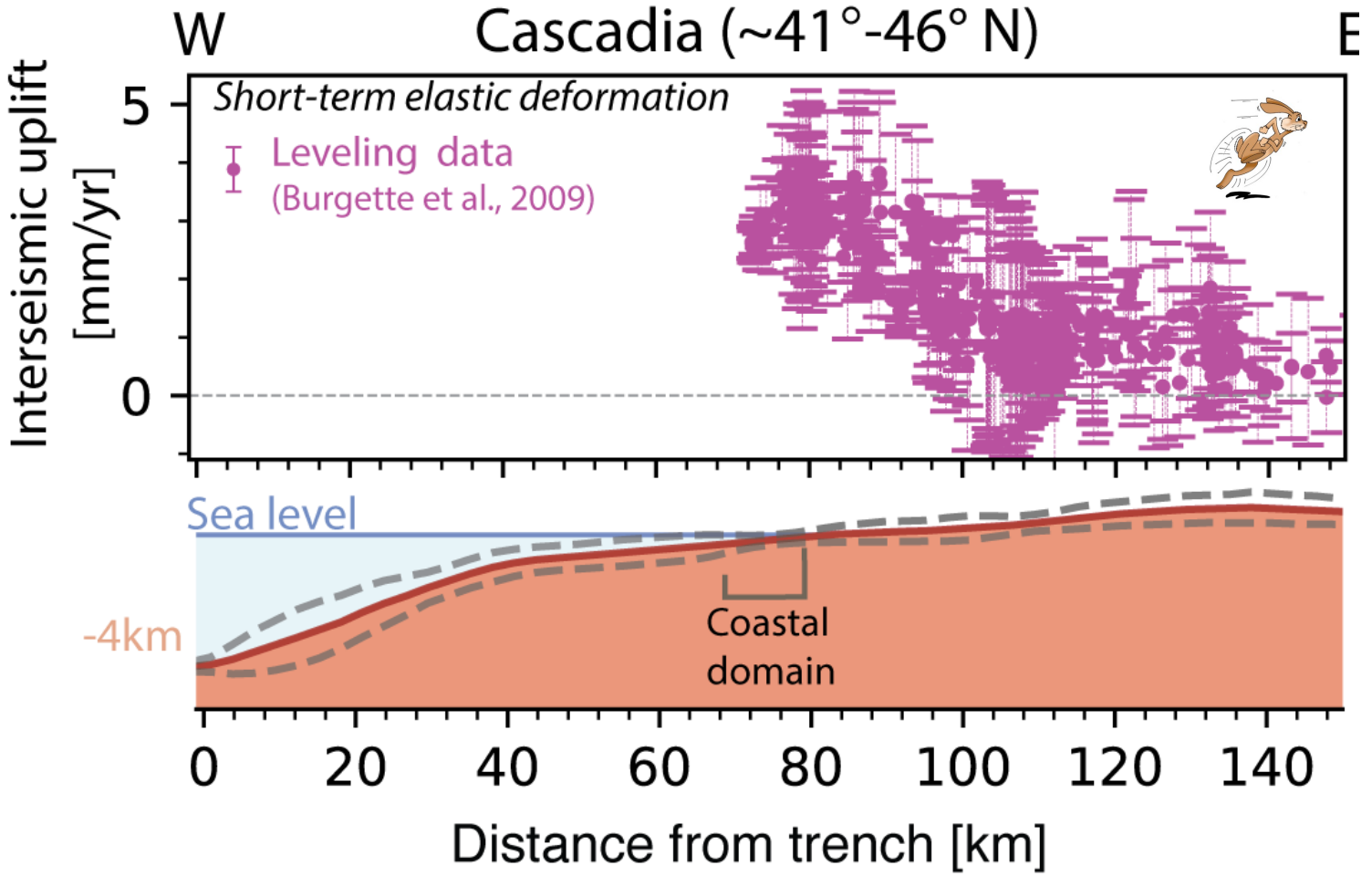

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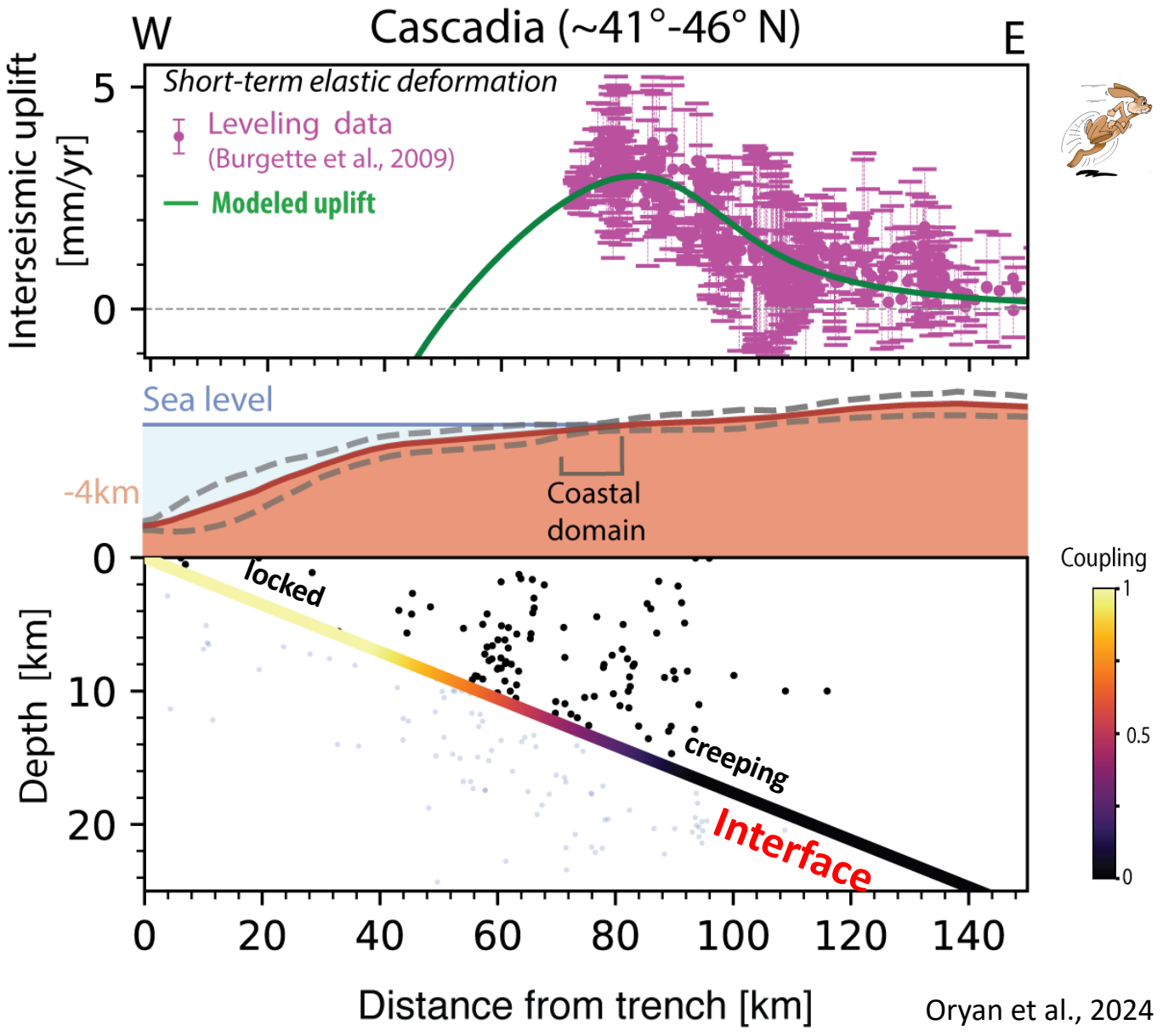

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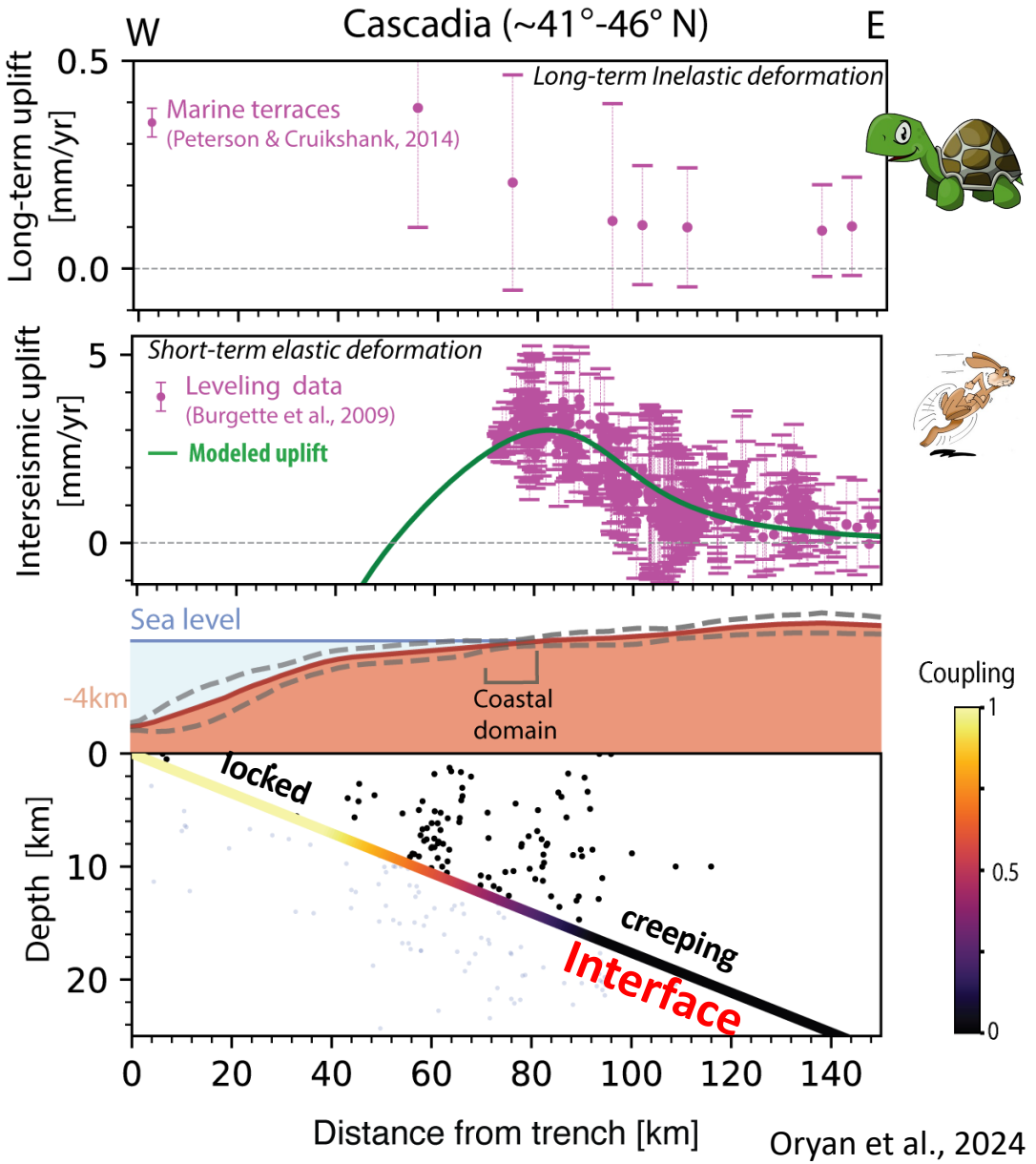

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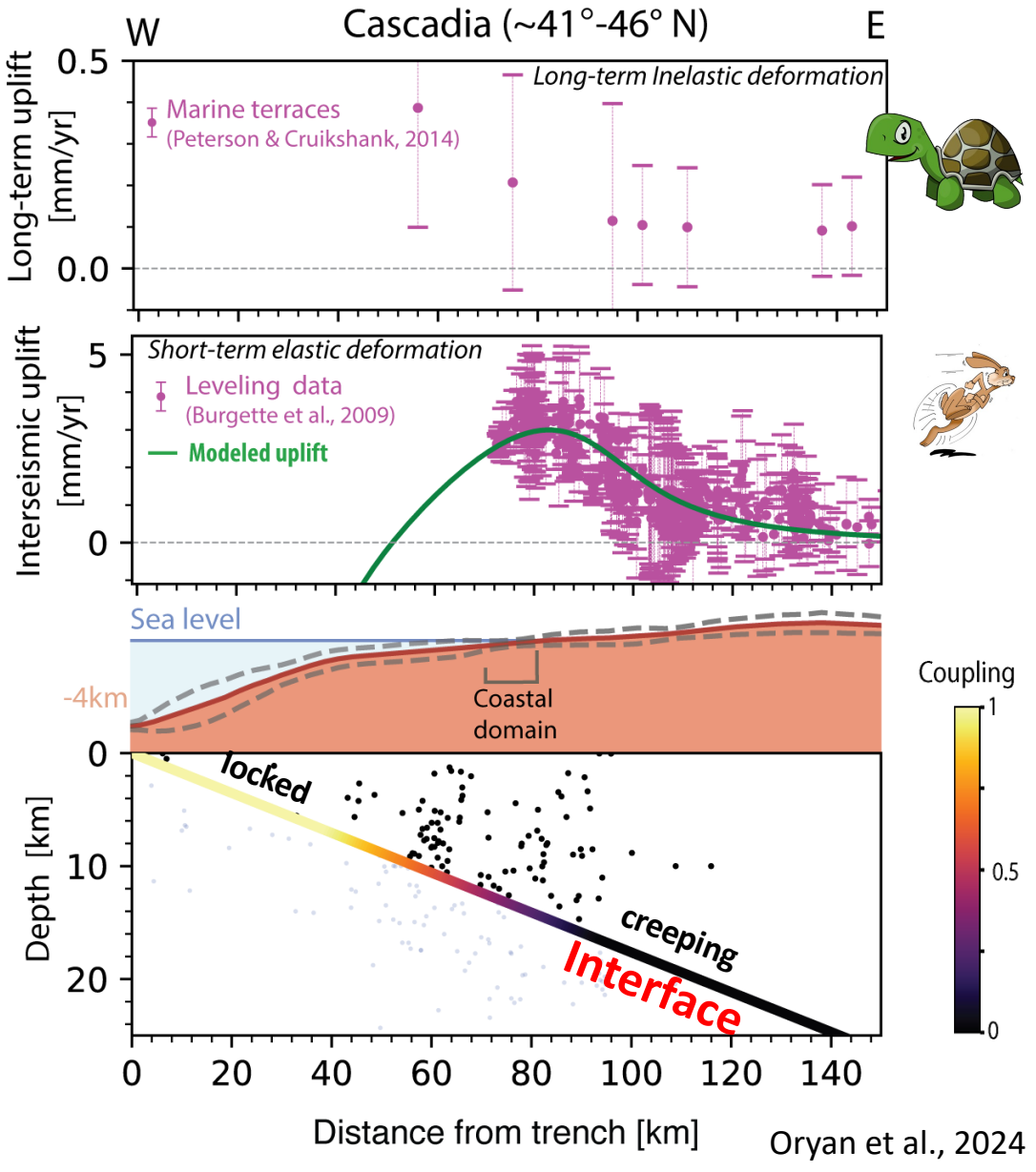
Short- (elastic) and **Long-term (inelastic)** deformation coincide.



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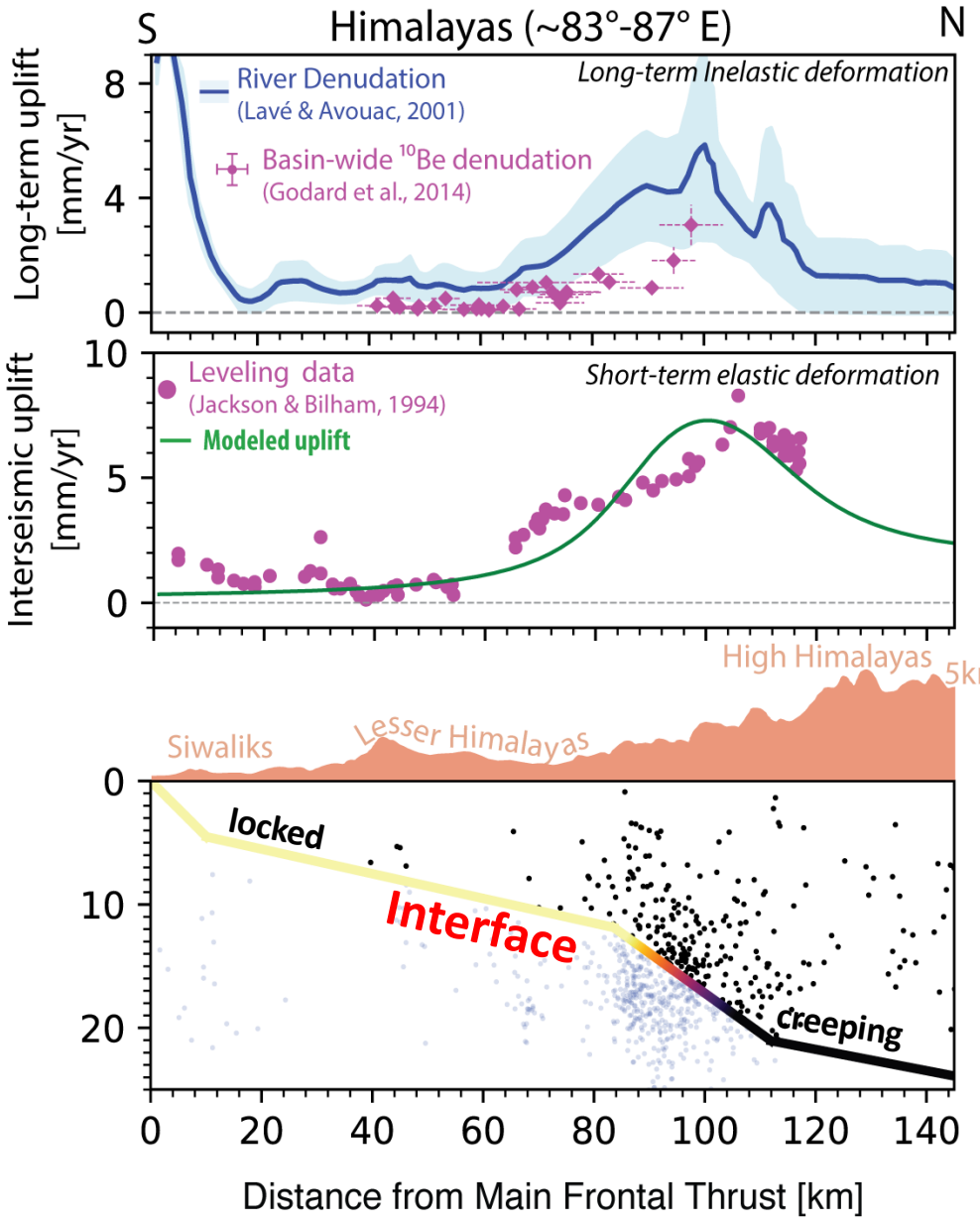

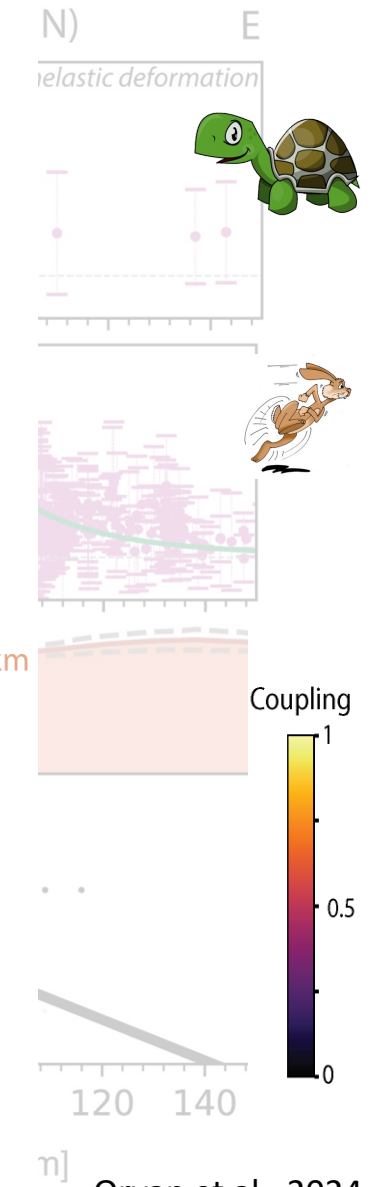

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SHORT- AND LONG-TERM DEFORMATION IN CHILE

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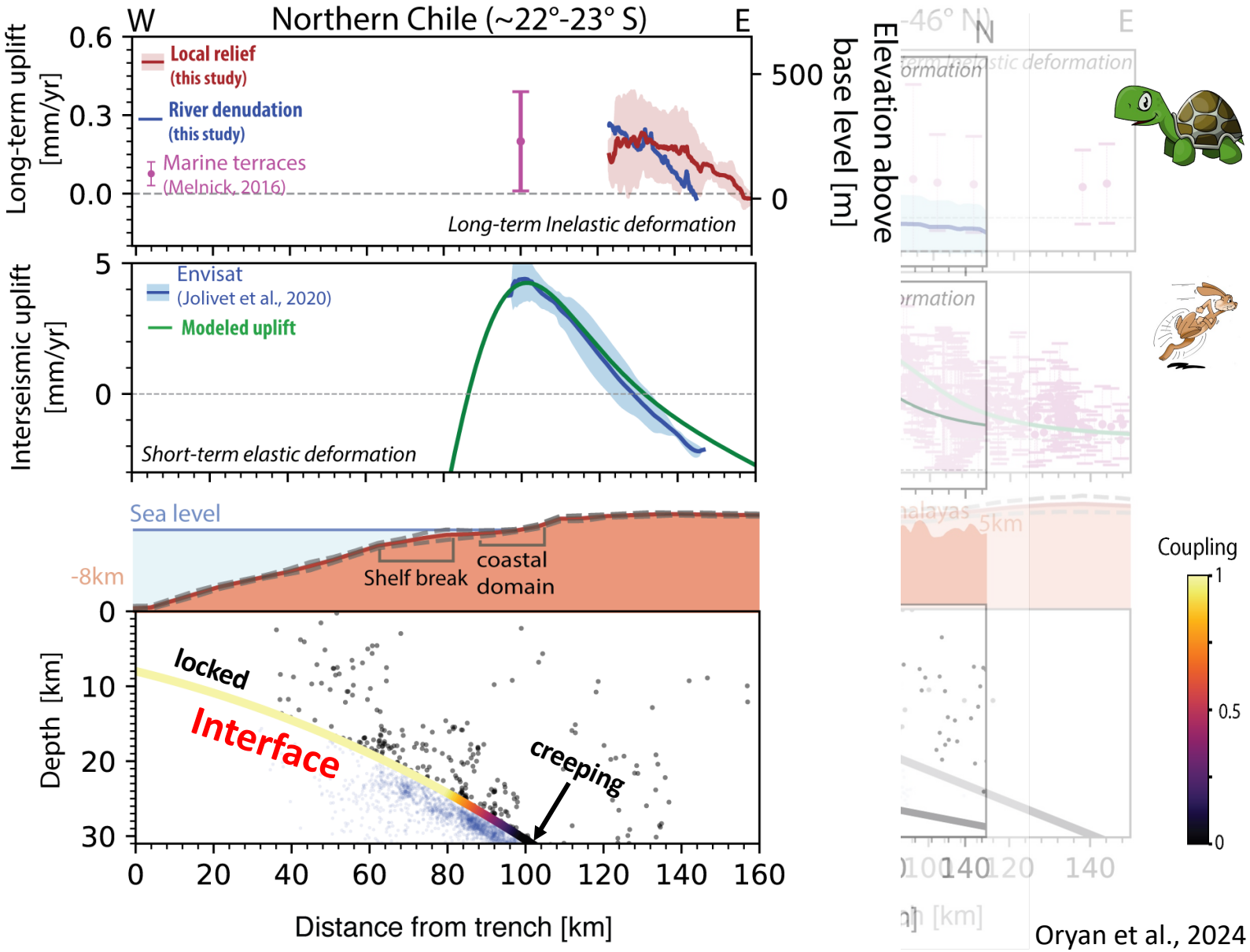

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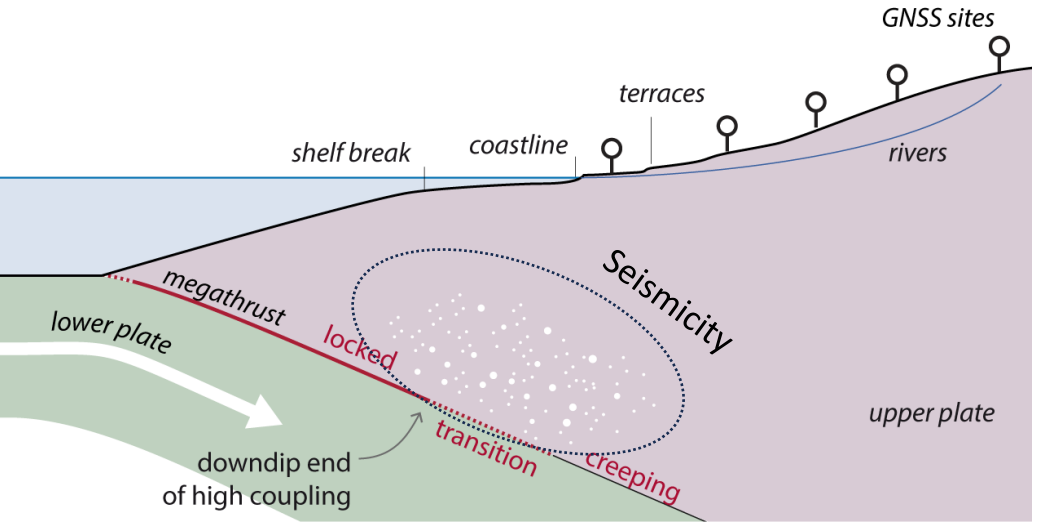
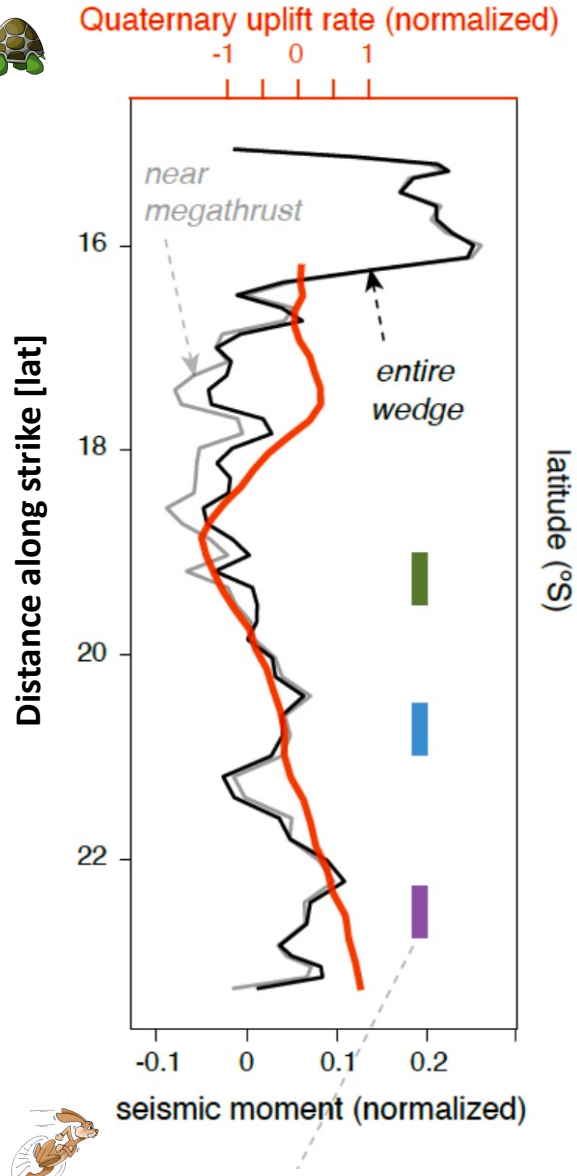
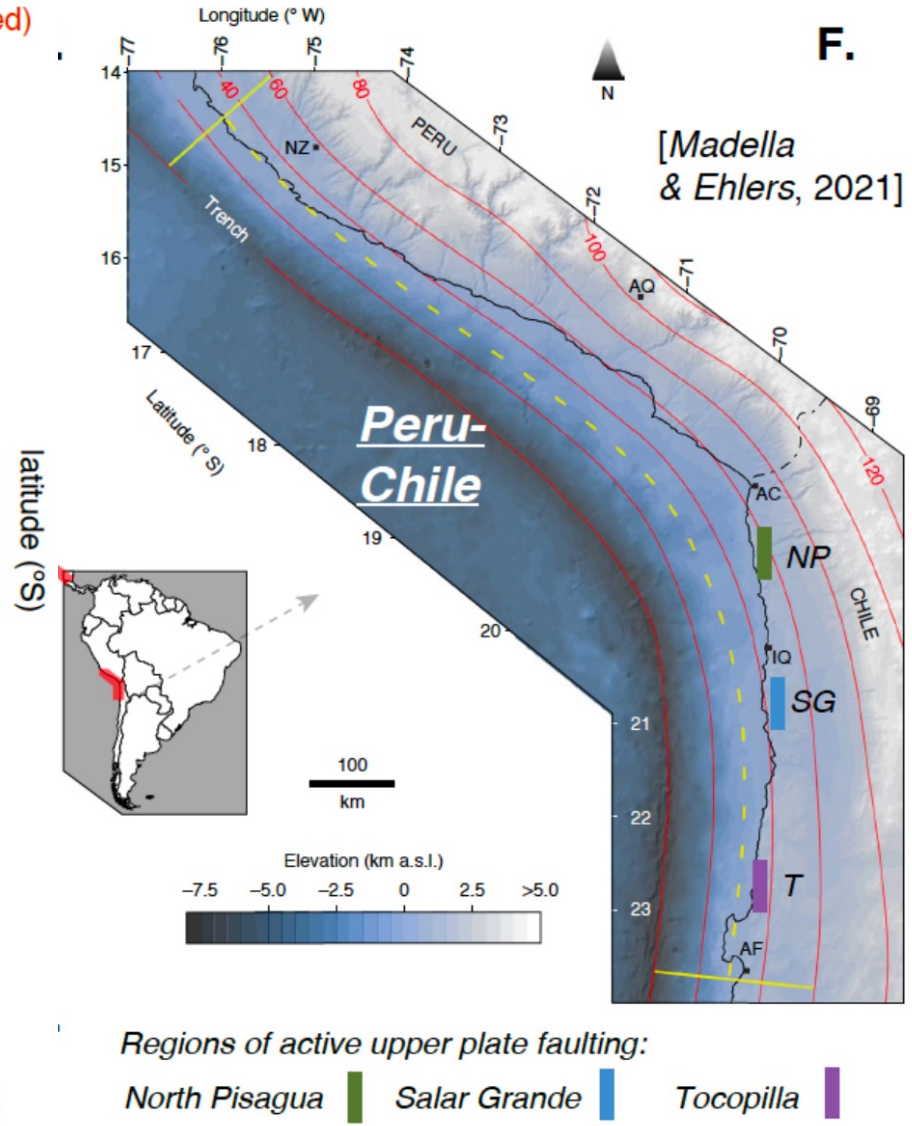
UPPER PLATE SEISMISTY AND LONG-TERM UPLIFT IN CHILE

Moment release of earthquakes within a distance of 15km of the interface correlates with **long-term coastal uplift** rates along the coast of Chile.







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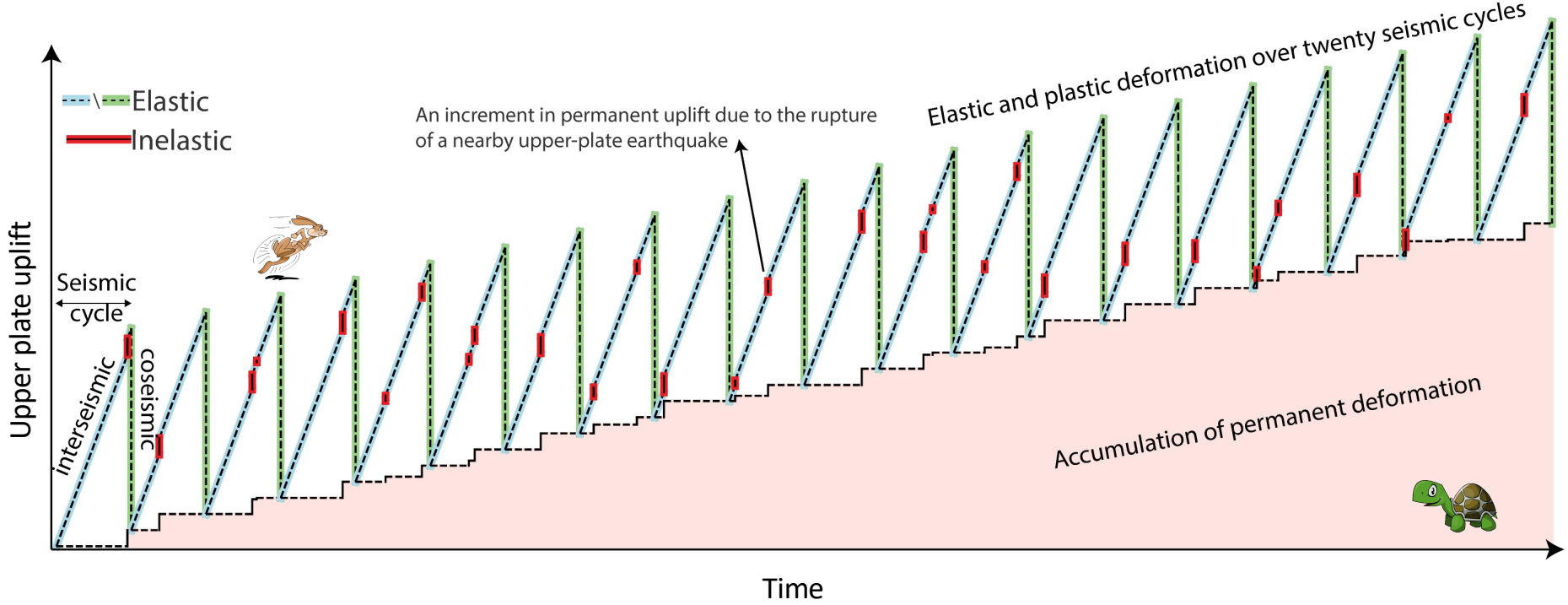
Madella and Ehlers [2021]

HOW INTERSEISMIC FAULT LOCKING IMPRINTS FOREARCS ?

- **Upper plate stresses** induced by locking gradients push parts of the upper plate to **failure** during the interseismic period.
- Repeated **failure** over multiple earthquake cycles could explain the overlap between short- and long-term deformation.



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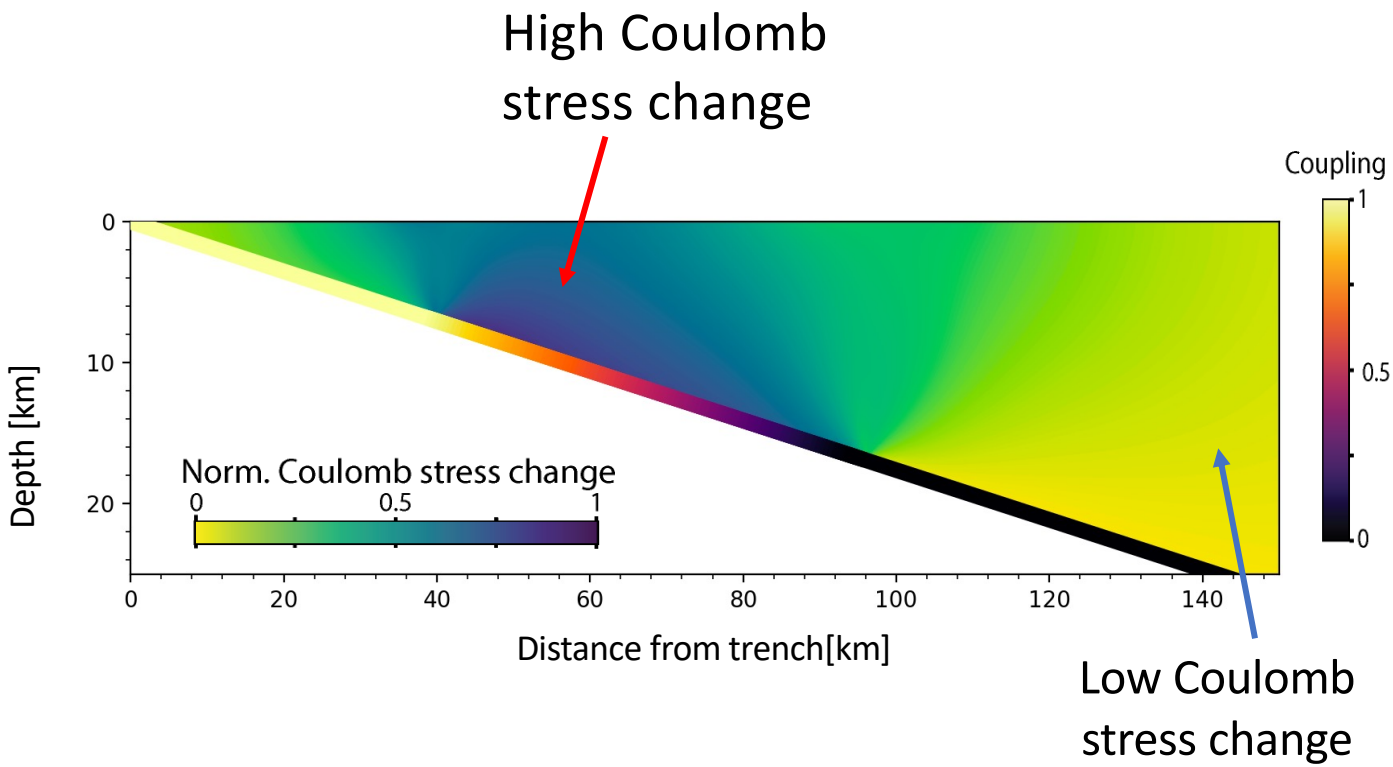
MODELING INTERSEISMIC INELASTIC DEFORMATION ACROSS UPPER PLATES

- We compute upper plate Coulomb stress change imparted by locking gradients.
- We link stresses and seismicity [Dieterich, 1994] and populate millions of synthetic earthquakes spanning thousands of years and dozens of seismic cycles according to the Coulomb stress change.
- We use the Okada solution to sum events surface displacement.



Coulomb stress change assuming thurst optimally orientated faults (30°)

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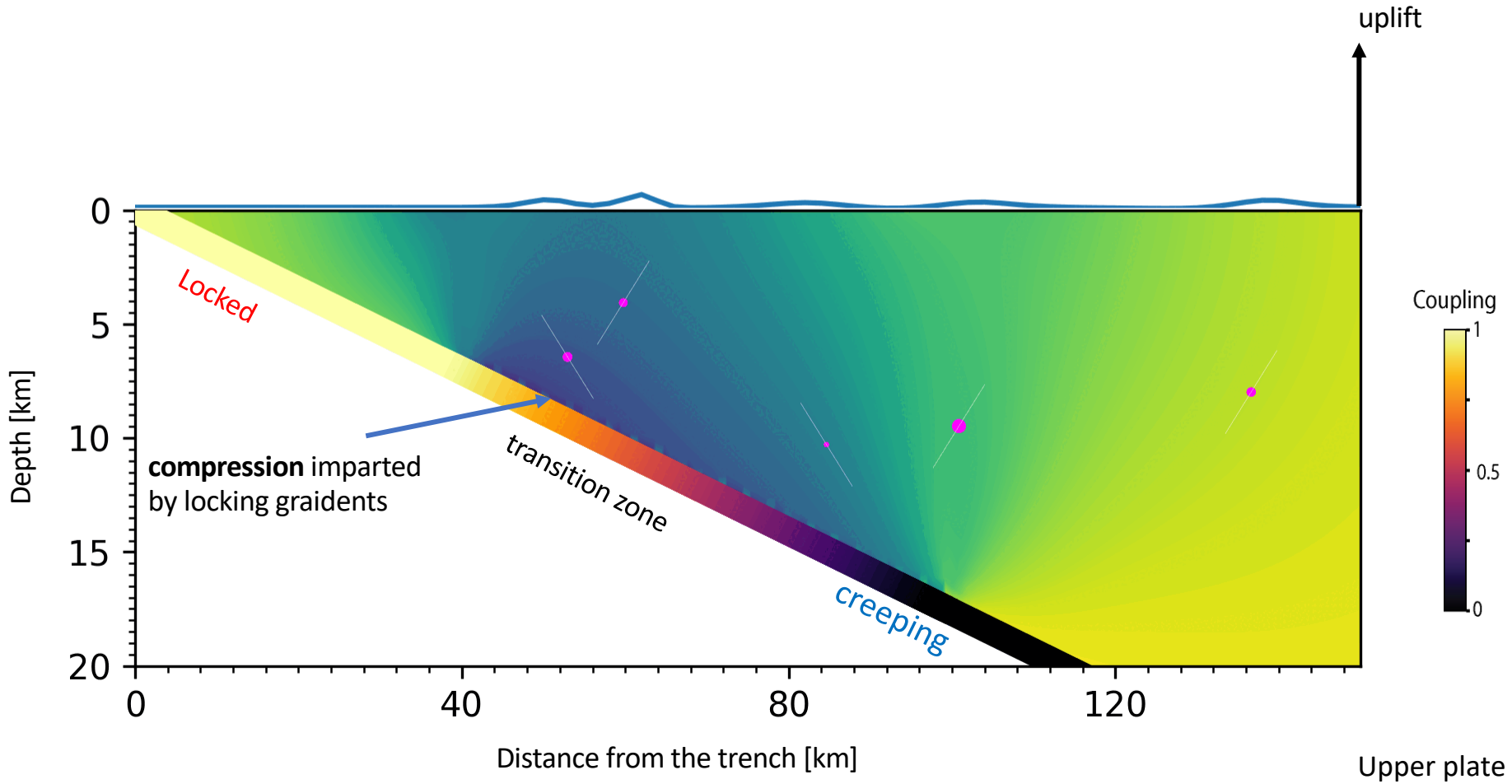
MODELING INTERSEISMIC INELASTIC DEFORMATION ACROSS UPPER PLATES

10 degree dip, fully locked to 40km

Uplift during three seismic cycles producing average long-term rate of 0.1 mm/yr



Upper plate Coulomb stress change

Low — High

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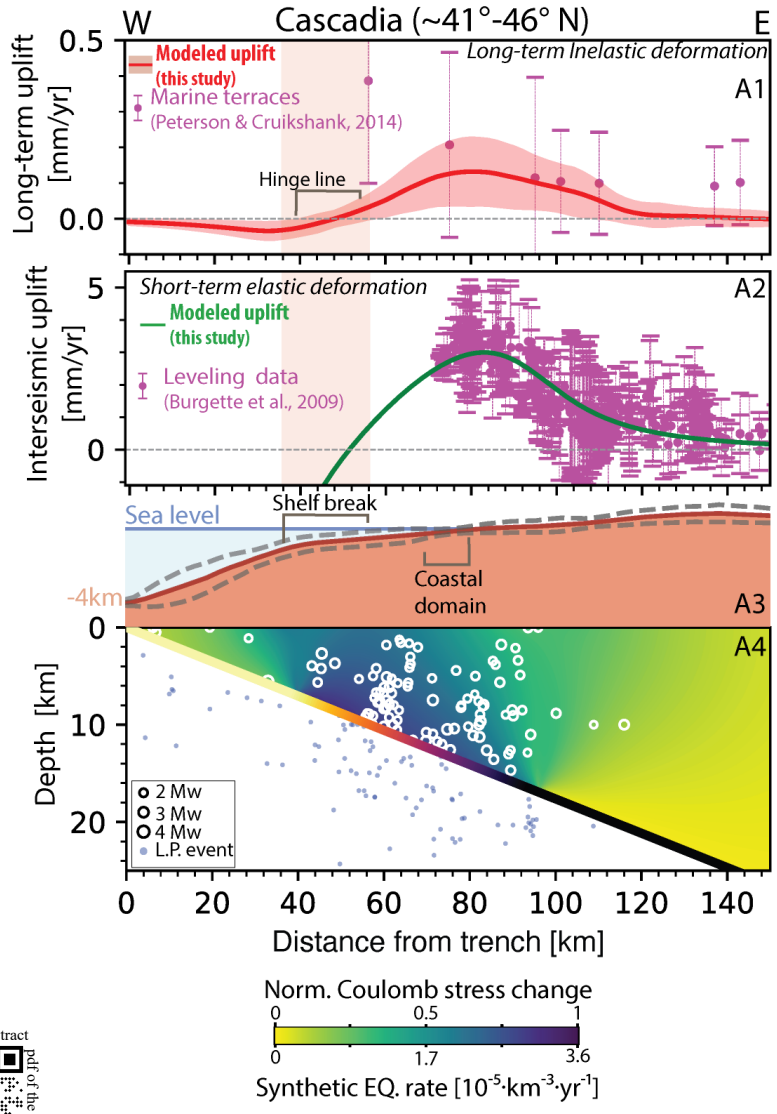
DEFORMATION IN CASCADIA,HIMALYAS AND CHILE



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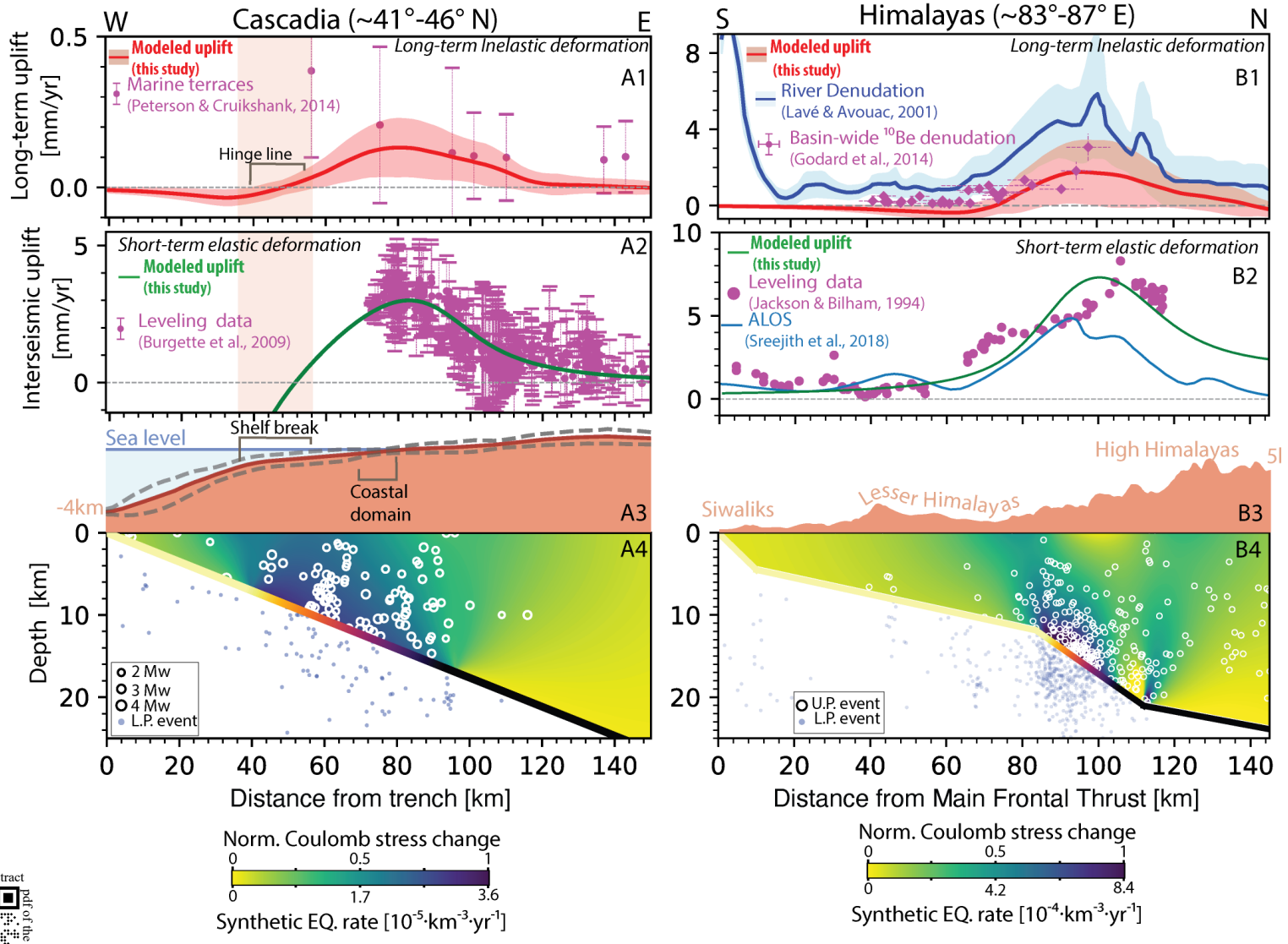

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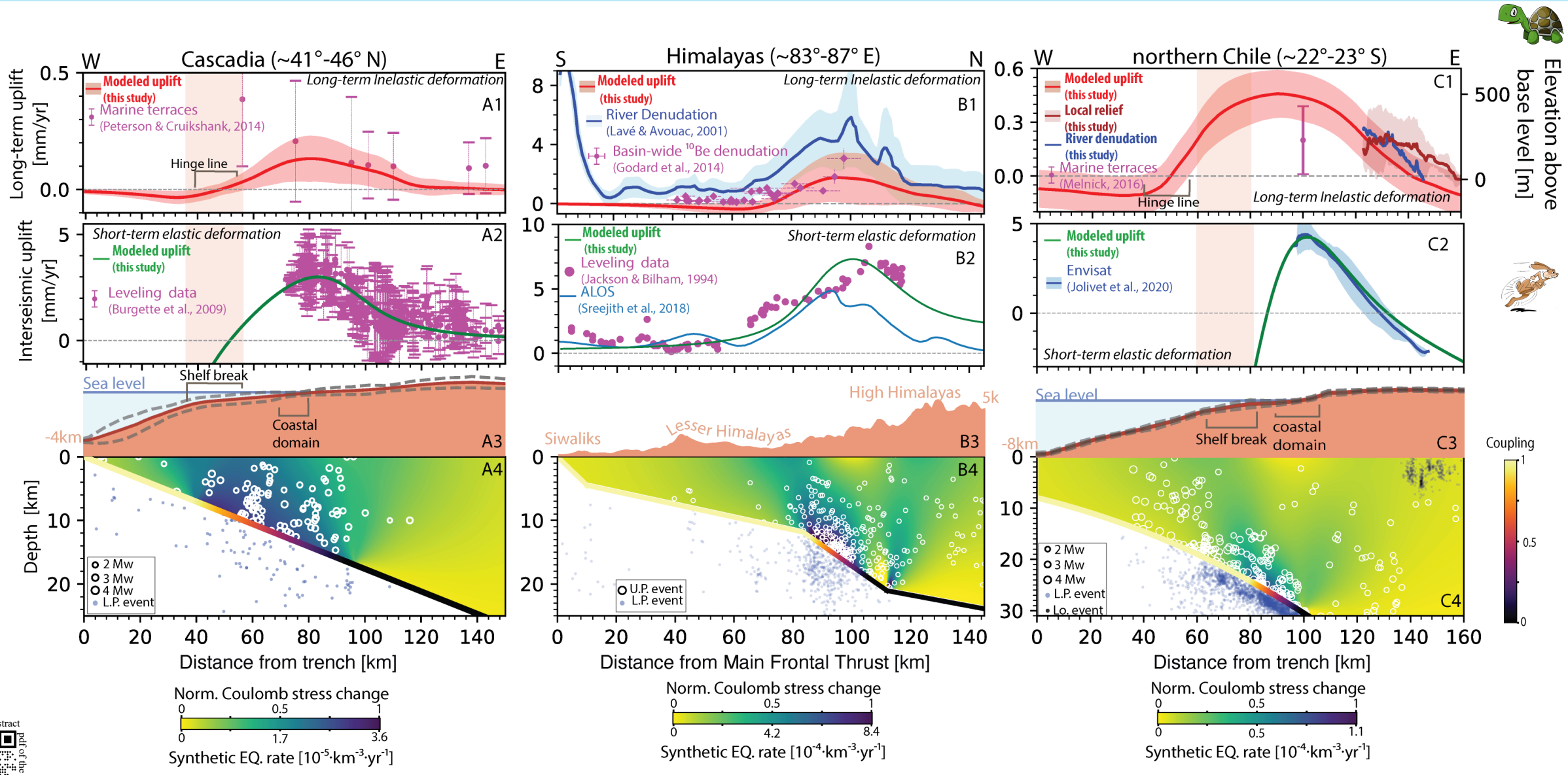

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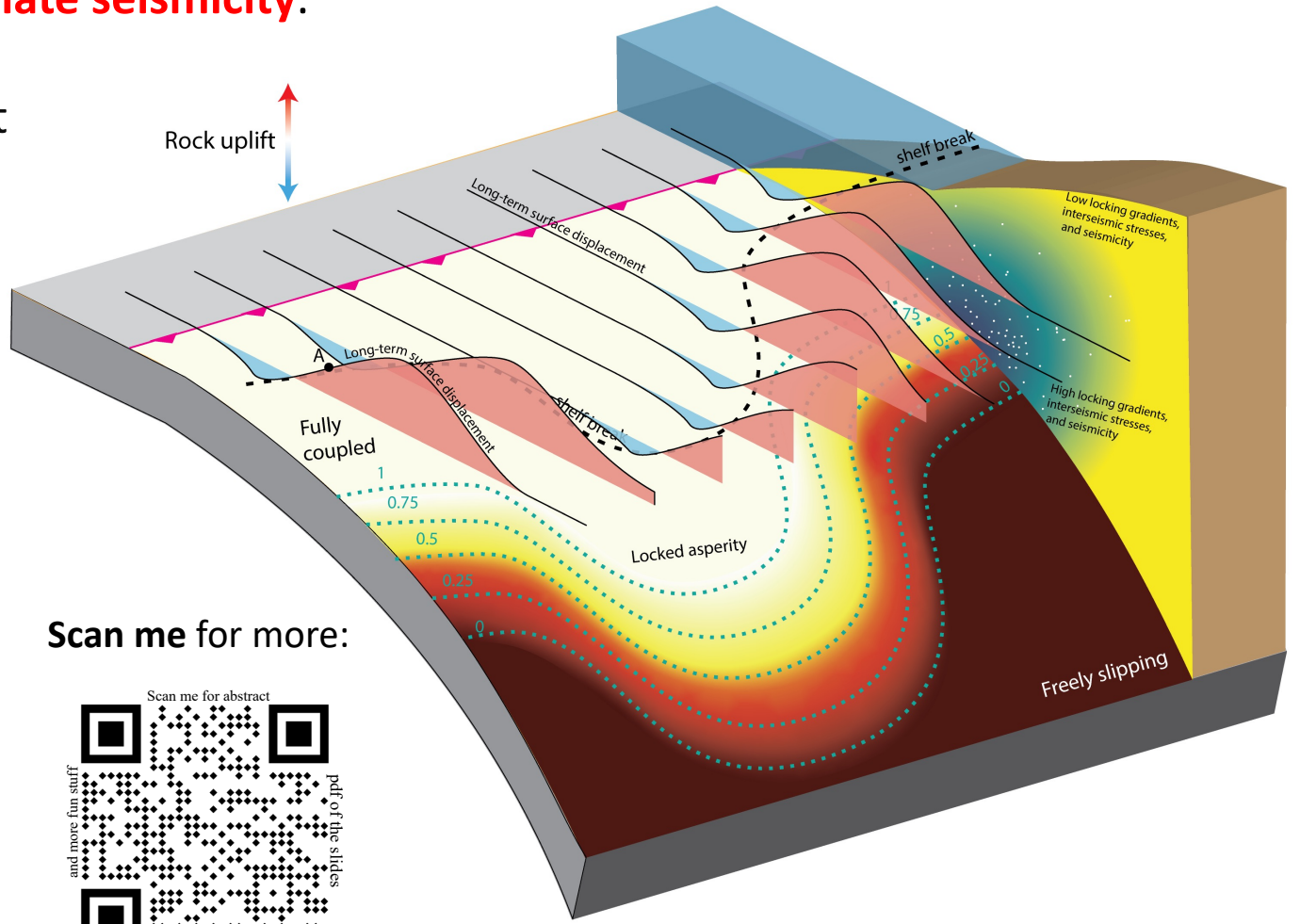
TAKE AWAY MESSAGE

- Variations in the degree of **megathrust locking** generate increments of **non-recoverable brittle deformation** within the overriding plate.
- This is expressed primarily as interseismic **upper plate seismicity**.
- Over time, this process **imprints** subduction landscapes one seismic cycle at a time hinting that megathrust locking remains stable over multiple earthquake cycles.
- Geomorphology can play an important role in constraining Earth's greatest source of seismic hazard.



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Curious about how geomorphology can help advance our understanding of seismic hazards?

- Visit **EP21C-09 ! Tuesday 09:50AM - 152A**

Interested in understanding how upper plate inelastic deformation influences both coseismic and aseismic megathrust behavior?

- Visit **T41C-3253 ! Thursday AM Poster Hall**

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