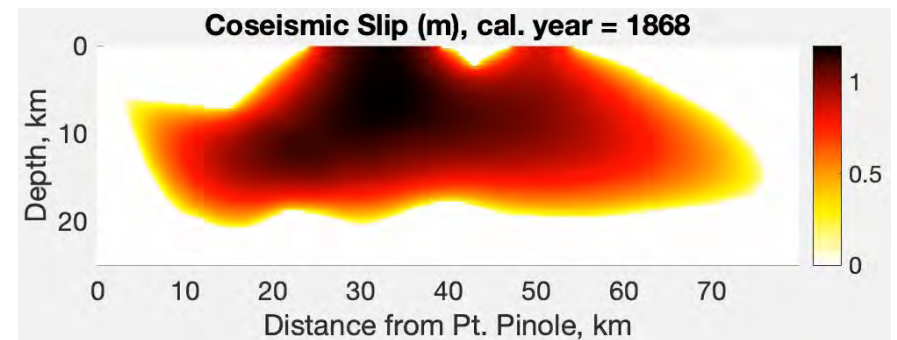
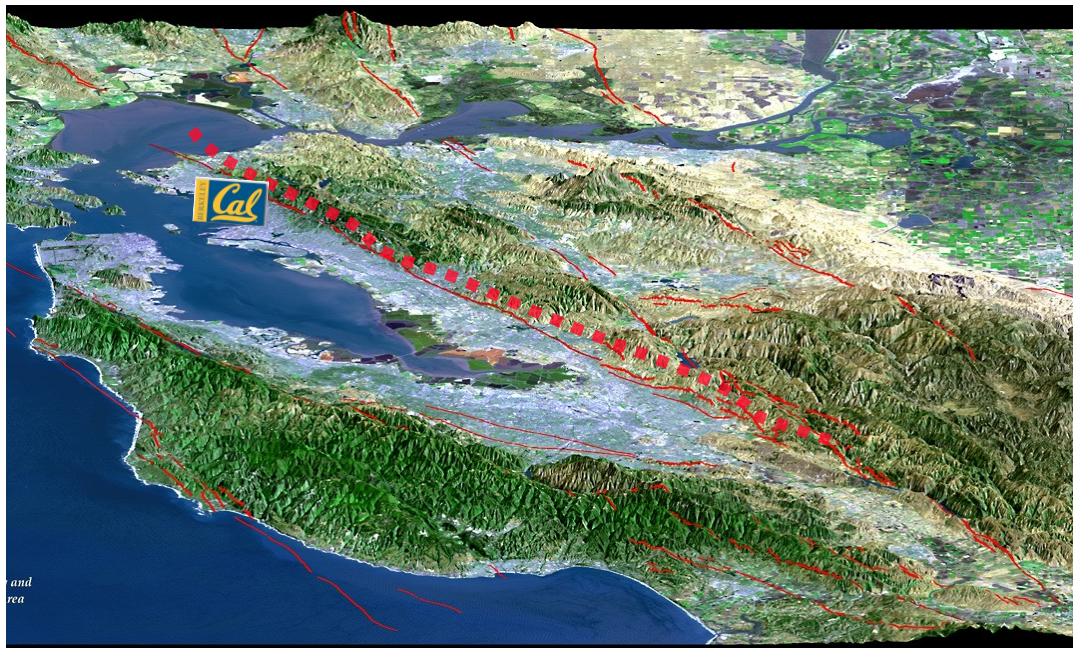


# Implications of decadal changes in fault creep on Hayward fault

Roland Bürgmann, with Manoochehr Shirzaei, Kaj Johnson, Taka'aki Taira, Mostafa Khoshmanesh, Leonard Ohenhen, Yuexin Li



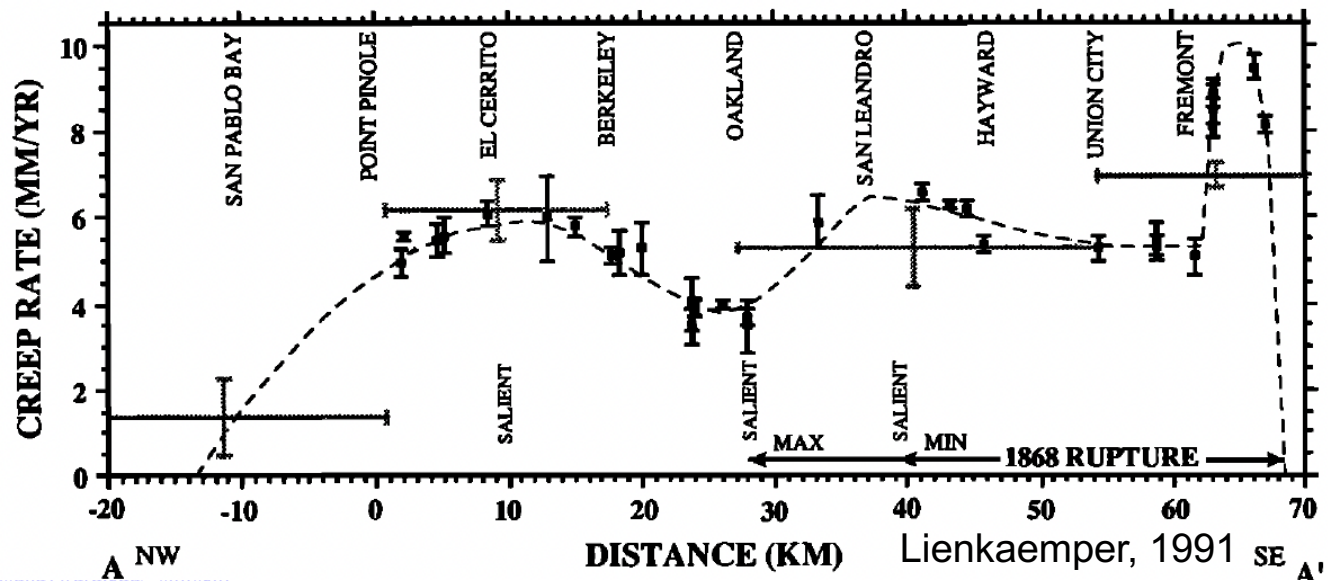
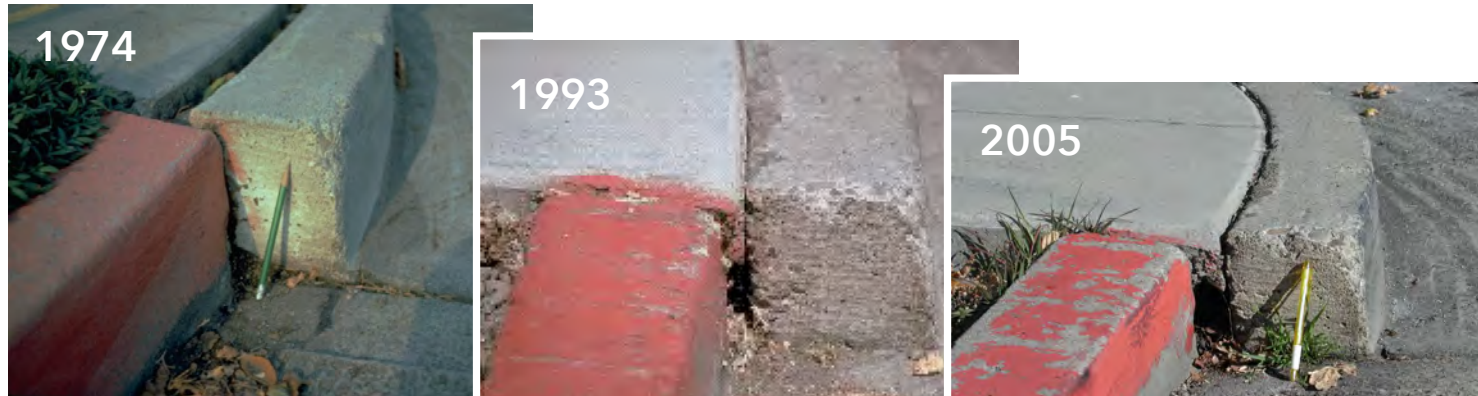
Berkeley  
Seismological  
Laboratory

## 2026 SSEC Fault Creep Workshop

Leverage decades of Bay Area fault-creep observations to unlock new insights into earthquake behavior and join the community effort to modernize and expand long-term creep monitoring



# Surface Creep at Rose Street in Hayward



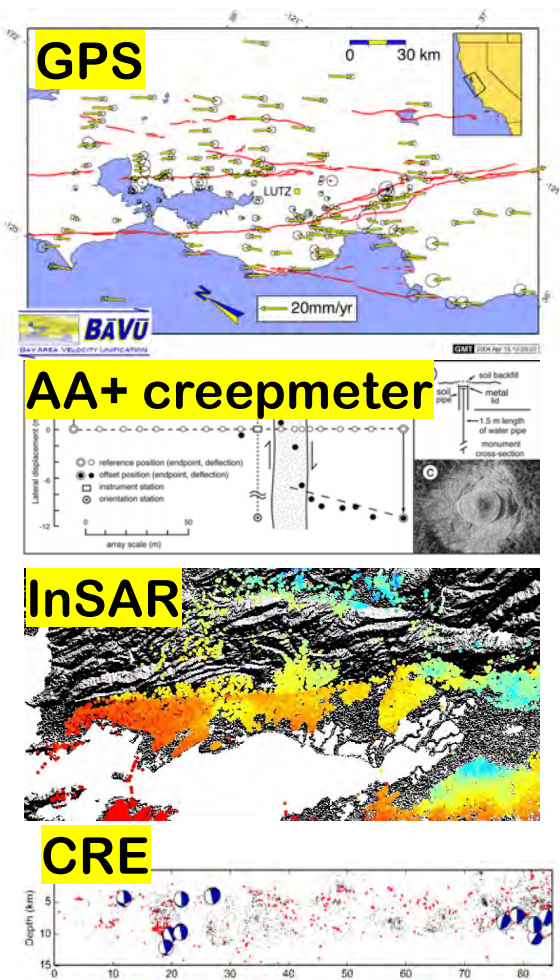
<http://www.mcs>

# Oct. 21, 1868, $M \approx 7$ "Great San Francisco Earthquake"



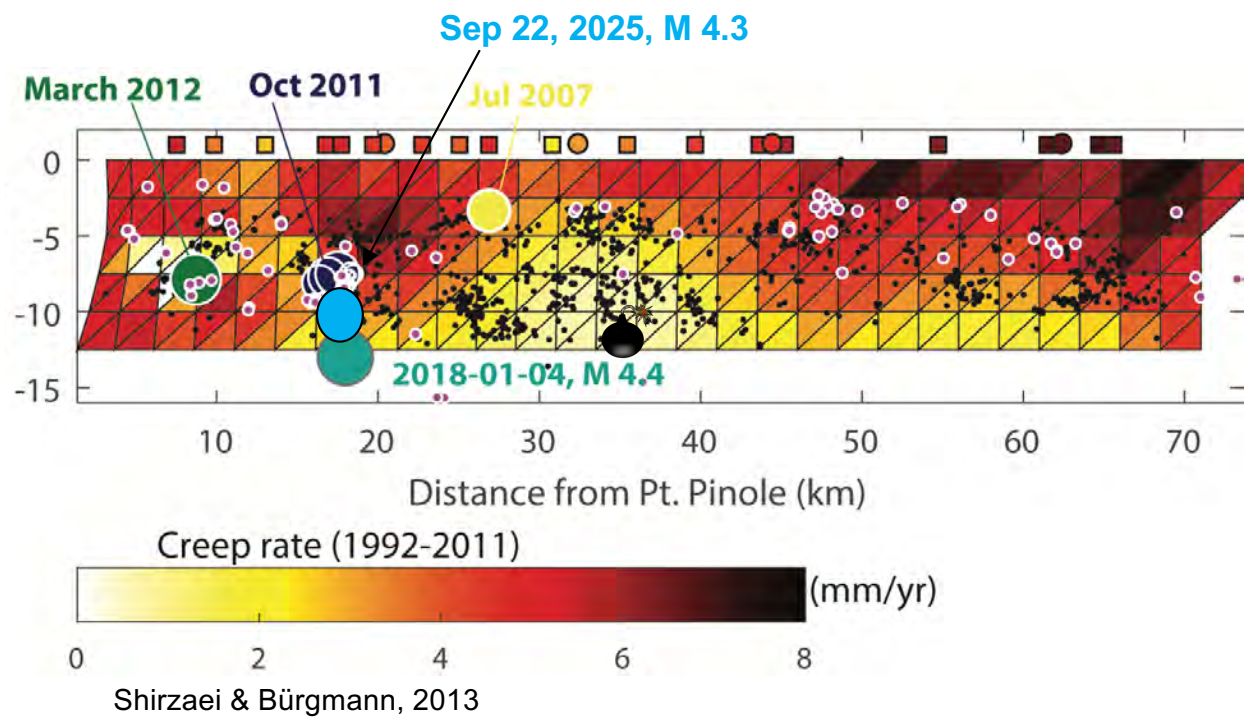
The event was called the "Great San Francisco Earthquake" only until 1906....

# Mapping Surface Deformation to Aseismic Slip at Depth

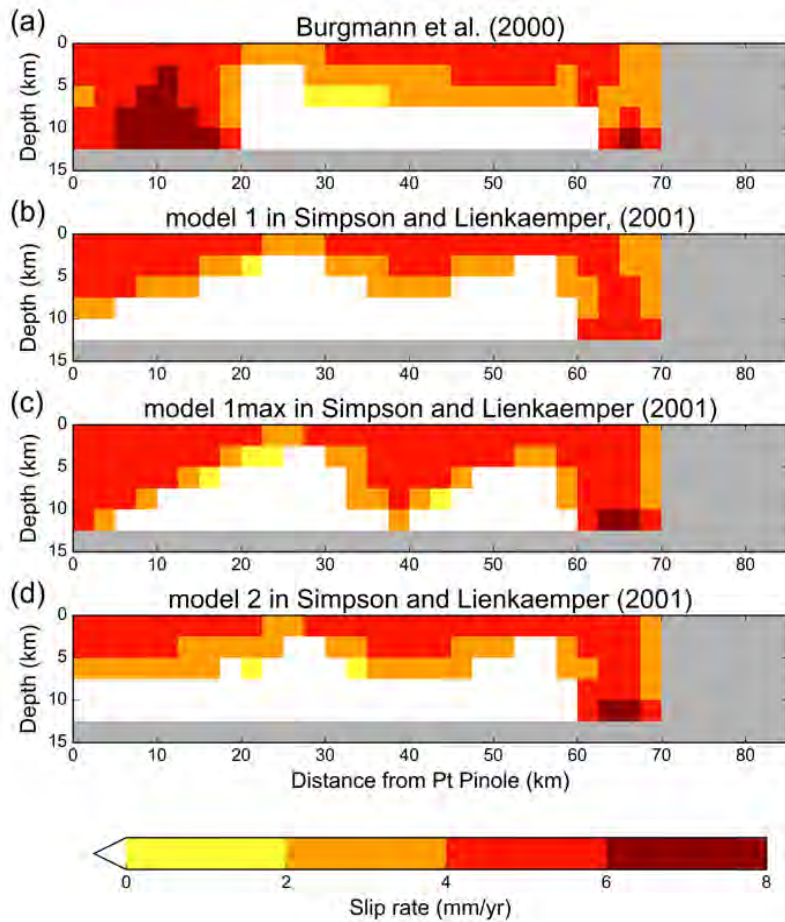


Input: Slip Constraints

Output: Interseismic Fault Creep/Coupling at depth

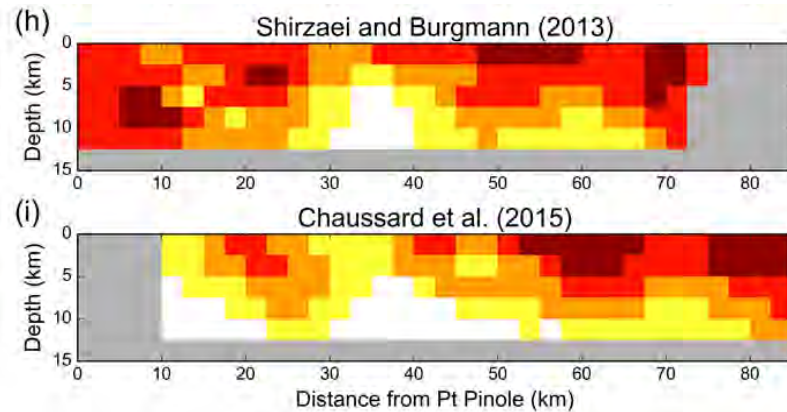


# Mapping Surface Deformation to Aseismic Slip at Depth



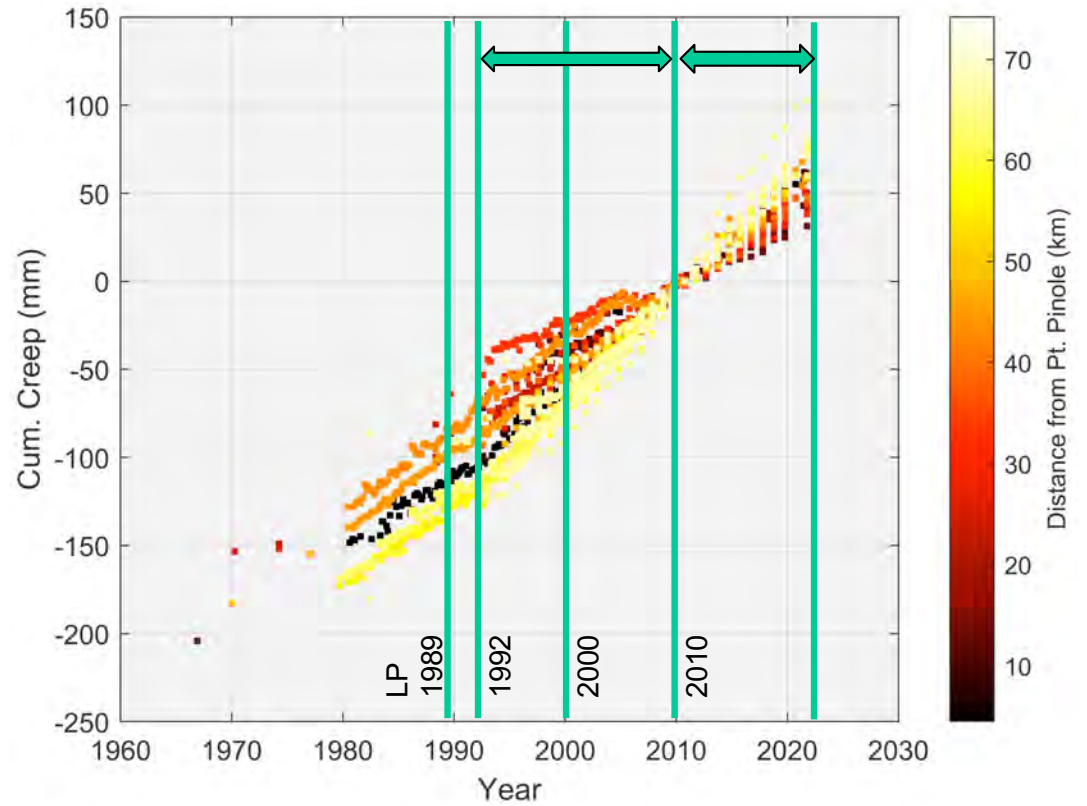
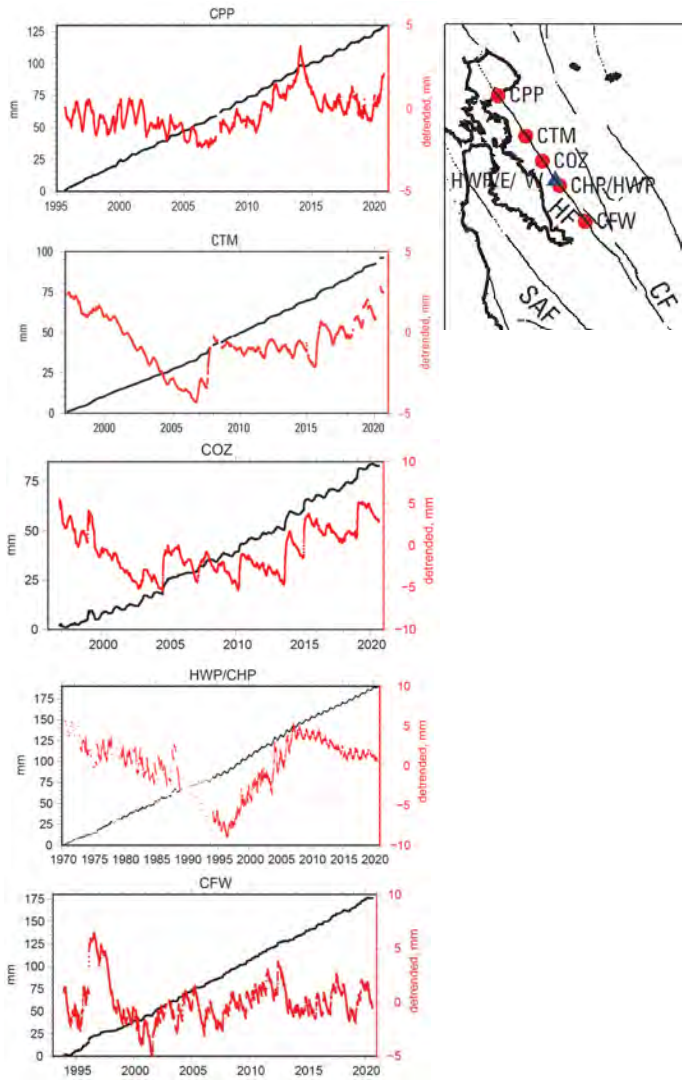
Slip deficit rises at ~M 6.8/100yr  
Paleoseismic recurrence interval ~150 yrs

→ High earthquake hazard!  
UCERF Forecast: 33 % of  $M \geq 6.7$  by 2043





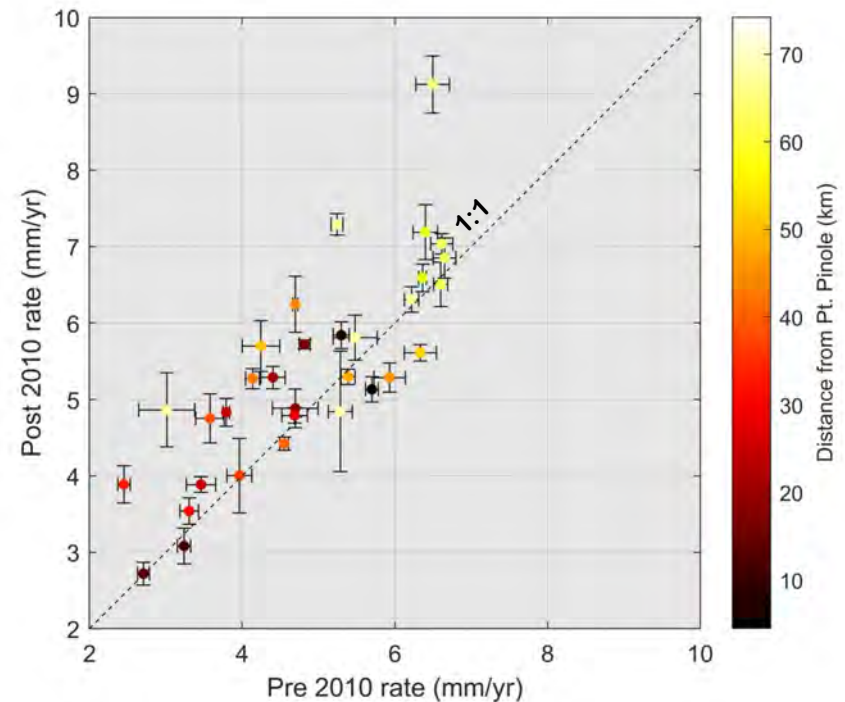
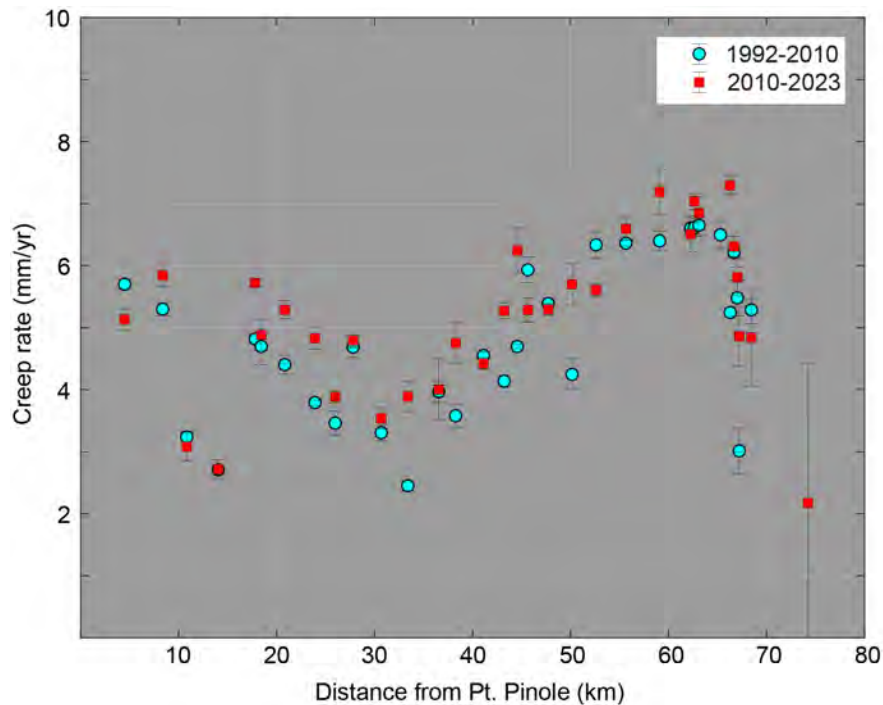
# Creep rate changes From Creepmeter and AA Data



Langbein et al., 2024 (USGS OFR)

# Decadal Creep-rate Changes From Creepmeter and AA Data

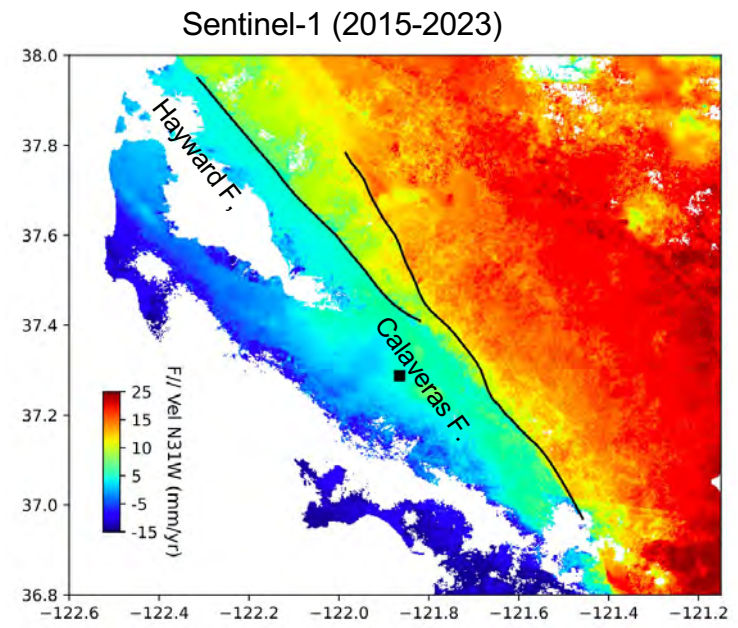
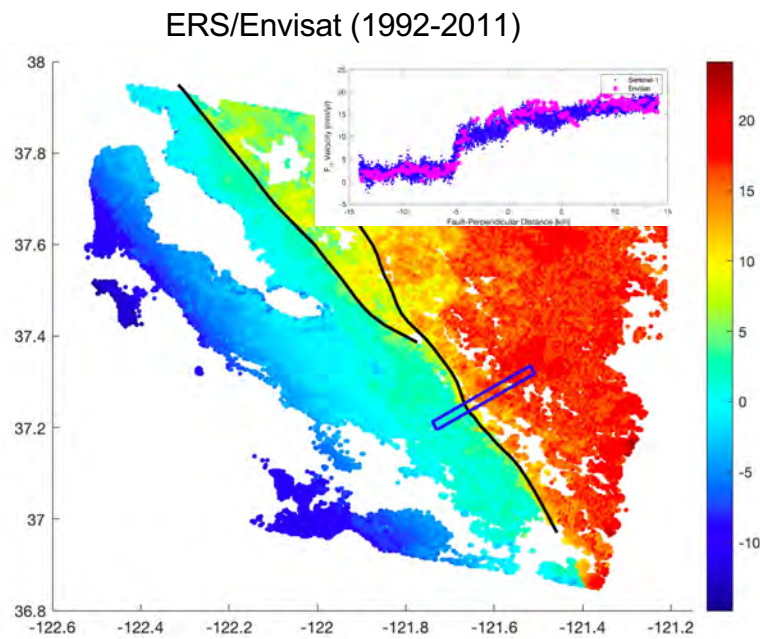
1992 – 2010 vs. 2010 – 2023



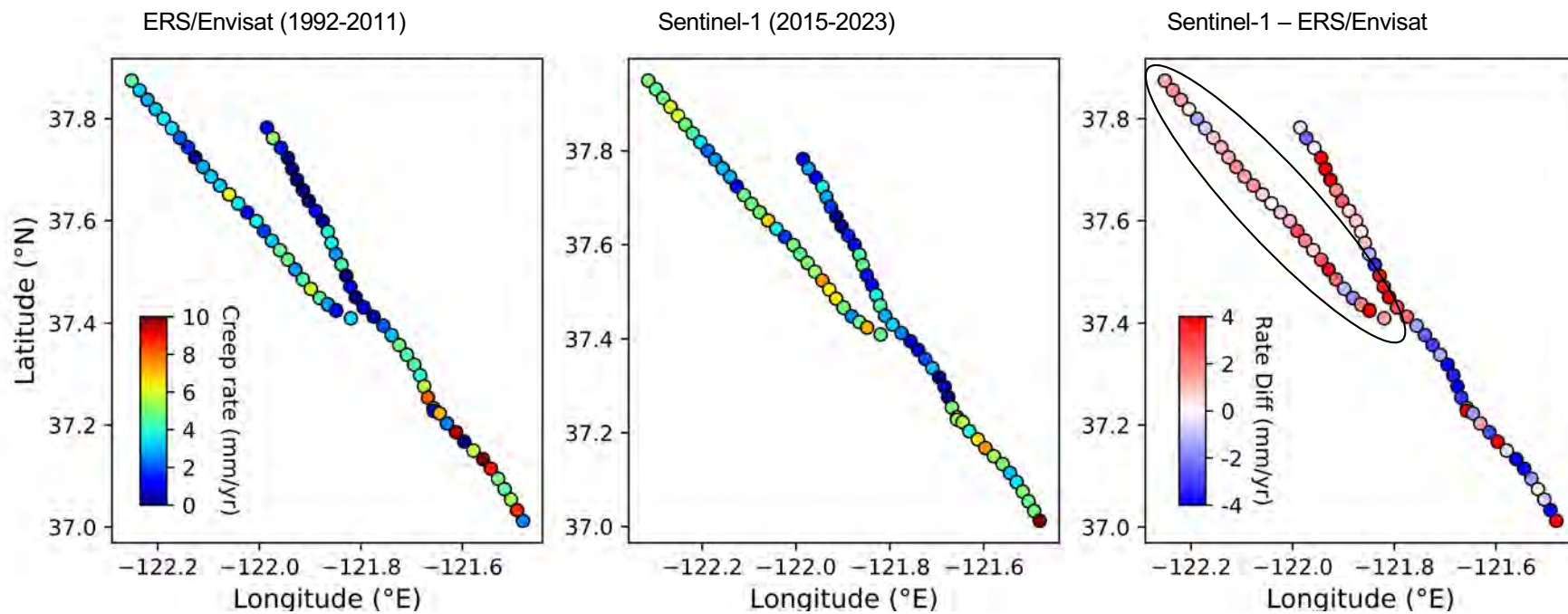
Alignment Array data from McFarland, Lienkaemper, Caskey, and Elliot, 2017  
U.S. Geological Survey data release (ver. 2.1, October 2022)

Shirzaei et al., 2026 submitted to *Science*

# Decadal Creep-rate Changes From InSAR

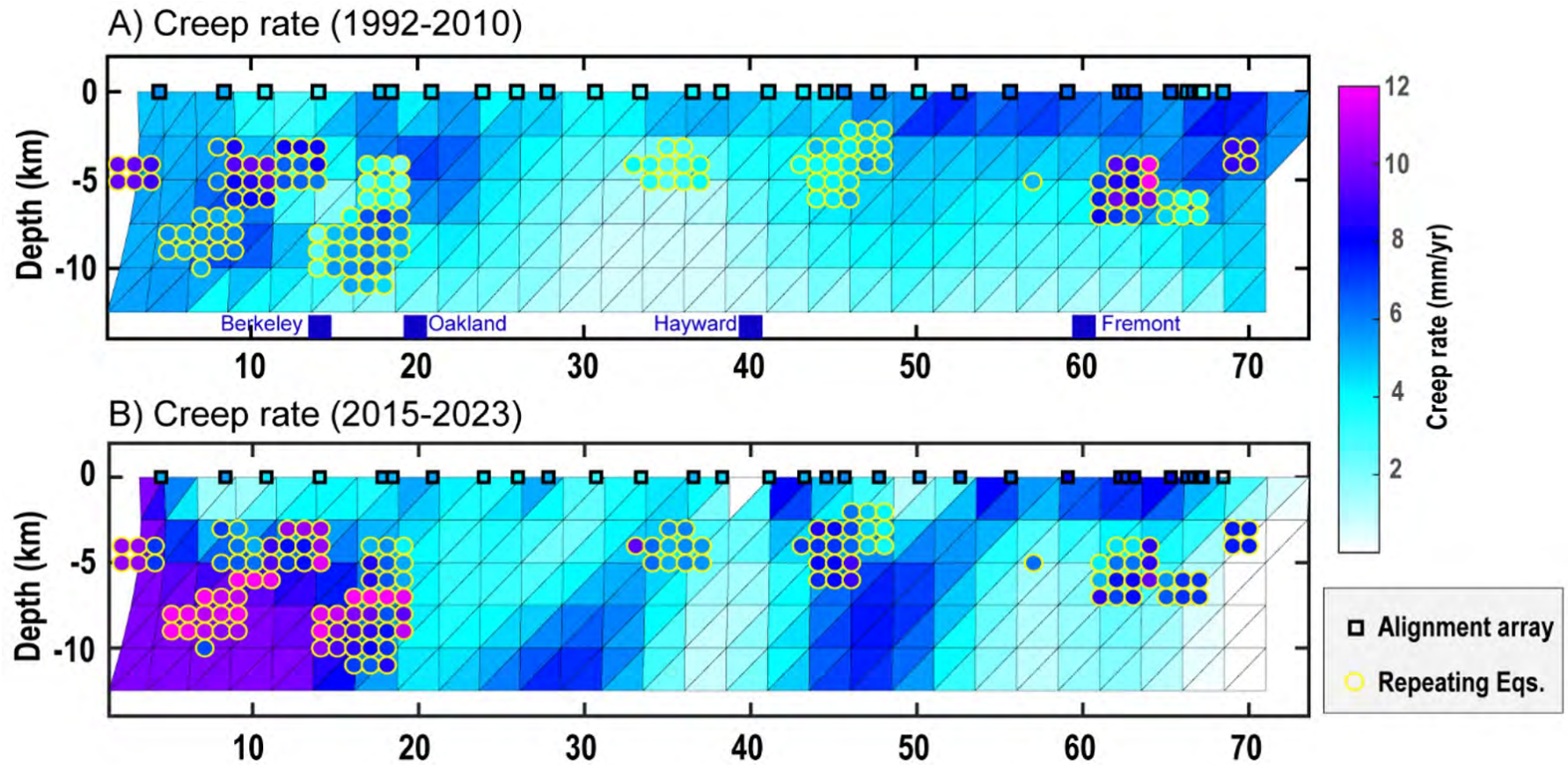


# Decadal Creep-rate Changes From InSAR

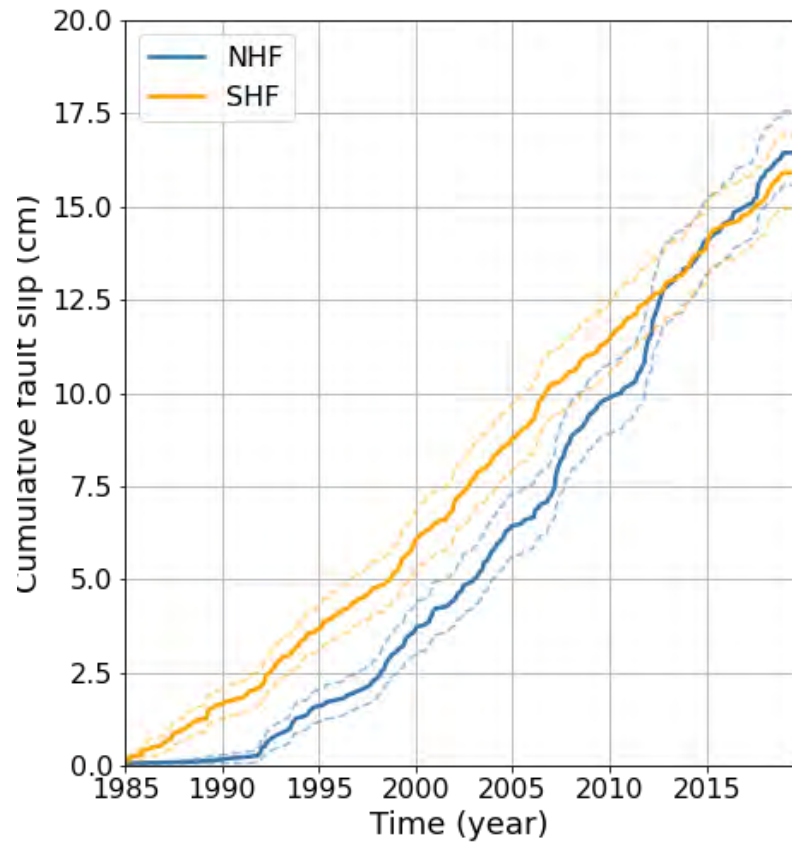
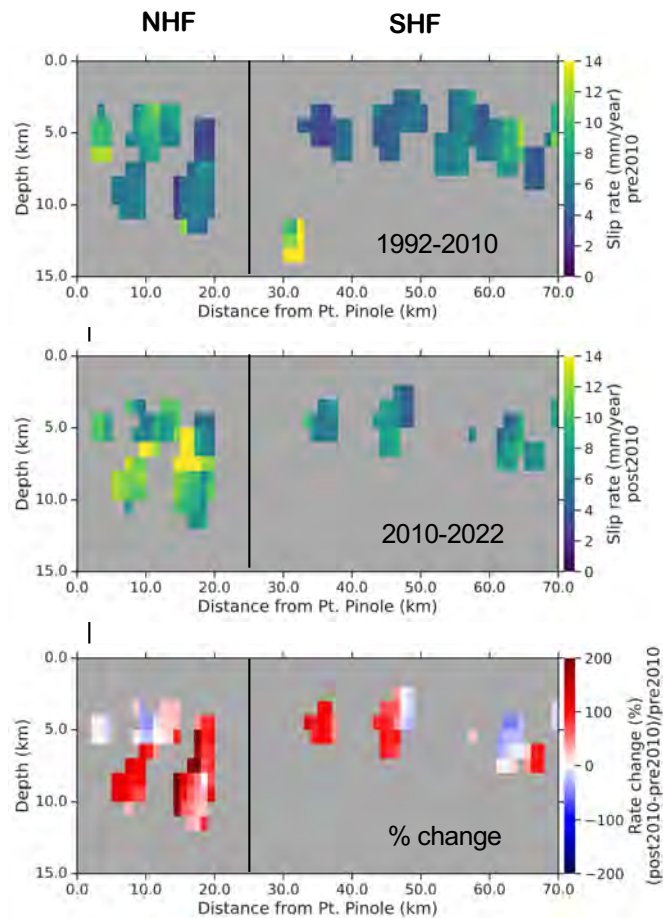


# Decadal Creep-rate Changes From InSAR

1992 – 2010 ERS & Envisat vs. 2015 – 2023 Sentinel-1

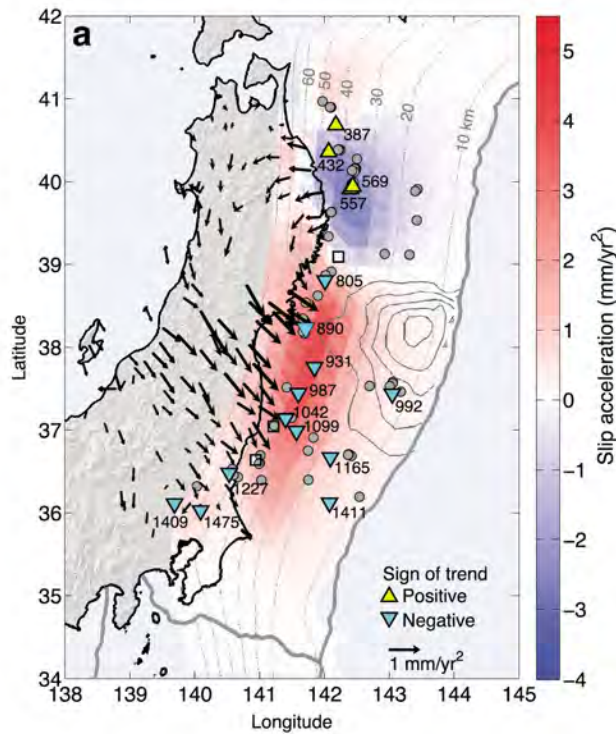


# Decadal Creep-rate Changes From Repeaters

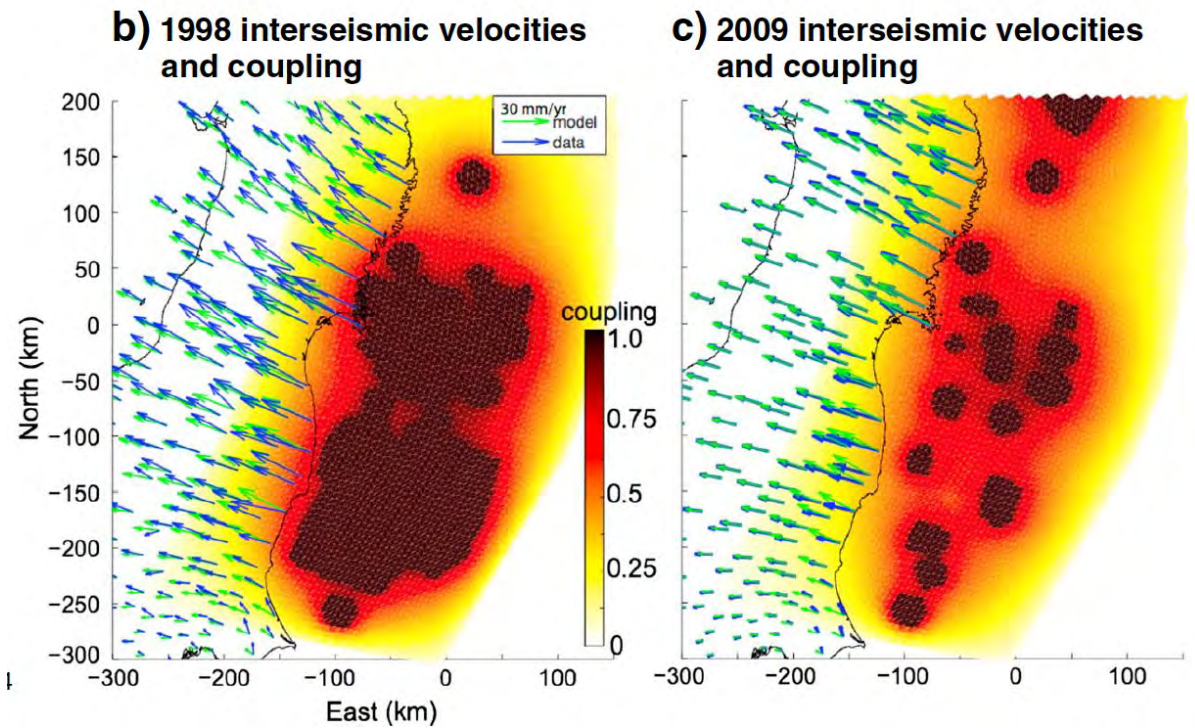


Taka'aki Taira, 2025, Shirzaei et al., 2026 submitted to *Science*

# Decadal Acceleration on Hayward Fault is Reminiscent of 1996 - 2011 Acceleration of Japan Trench Megathrust Slip

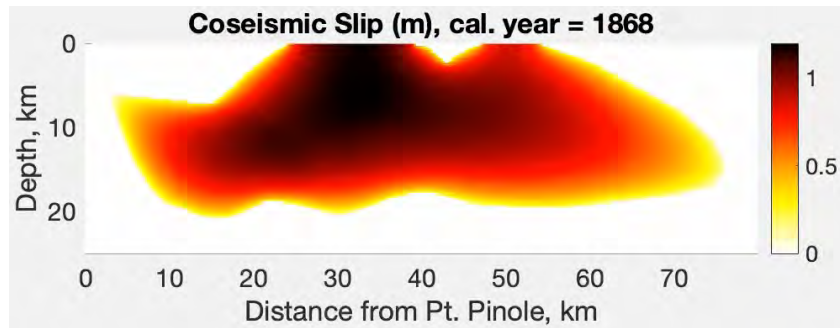


Mavrommatis, Segall, Uchida, and Johnson, 2015 GRL



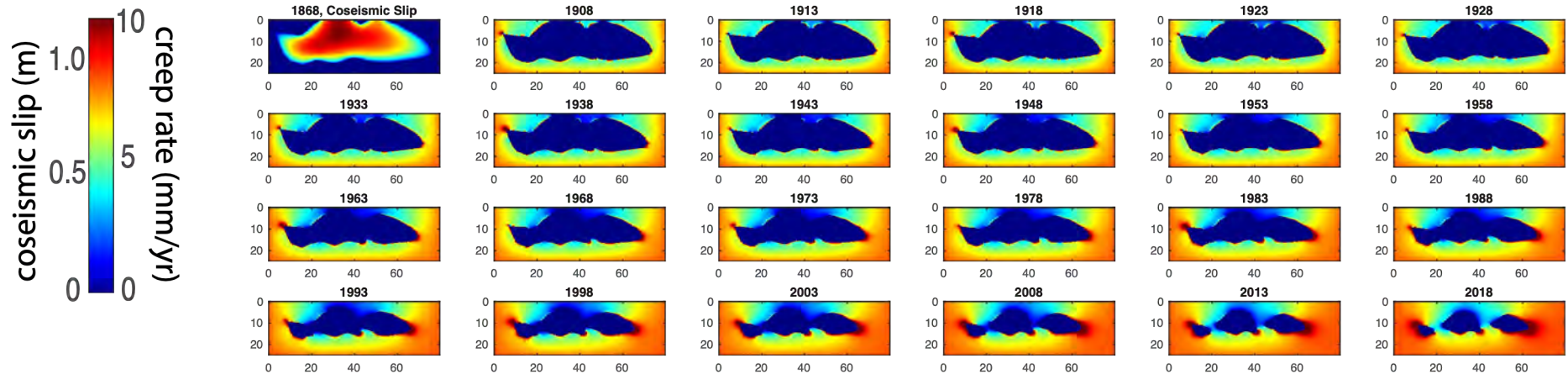
Mavrommatis et al., 2017 JGR  
Johnson et al., 2016 GRL

# Shrinking Asperity Model for Hayward Fault



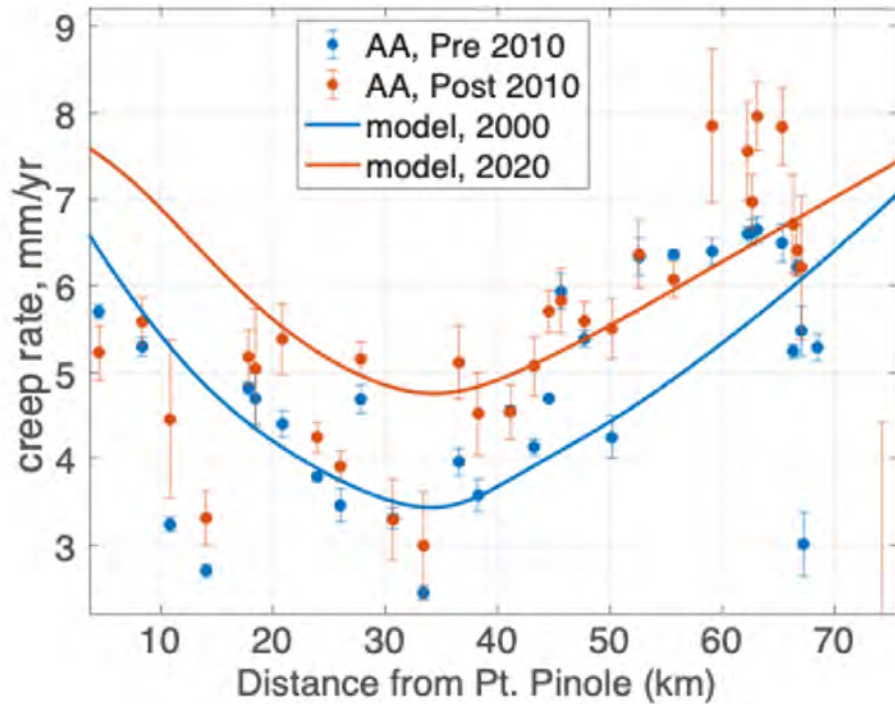
- Coseismic slip imposed over initial asperity area with applied stress drop distribution
- Asperities shrink following fracture mechanics model of Cattania and Segall (2019 JGR)
- Creep rate is solved for over incremental “crack growth” boundary element calculations

## 1868 – 2018 snapshots of interseismic creep rate (mm/yr)

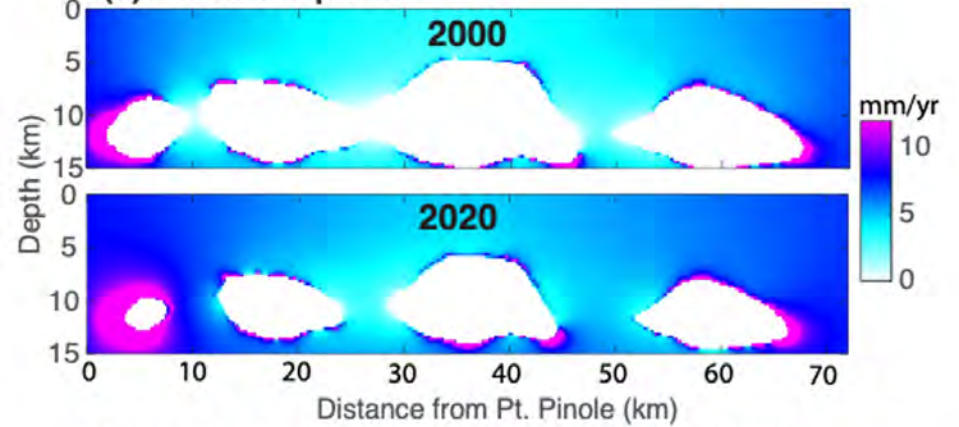


# Comparison of Model and Observed Creep Rates

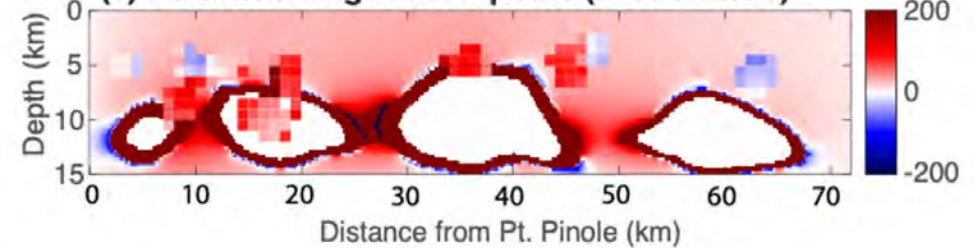
(d) Model and observed surface creep rates



(b) Model creep rate



(c) Percent change in creep rate (2000 to 2020)



Alignment Array data from McFarland, Lienkaemper, Caskey, and Elliot, 2017  
U.S. Geological Survey data release (ver. 2.1, October 2022)

## Variable Fault Coupling and Earthquake Potential Along the Hayward Fault

- We find decadal accelerations in fault creep rate on the Hayward fault from InSAR, surface creep and repeating earthquakes
- These decadal creep-rate changes may reflect continued interseismic shrinking of rupture asperities late in the earthquake cycle of the Hayward fault
- Asperity erosion through the earthquake cycle may be a ubiquitous feature of partially coupled faults

