

# Addressing Long-Term Changes in Crustal Deformation From Tectonic and Non-tectonic Processes

Roland Bürgmann

With contributions from Dani Lindsay, Kang Wang, Manoo Shirzaei, Taka'aki Taira, Curtis Baden

## What are most important uses of CGM in SCEC:

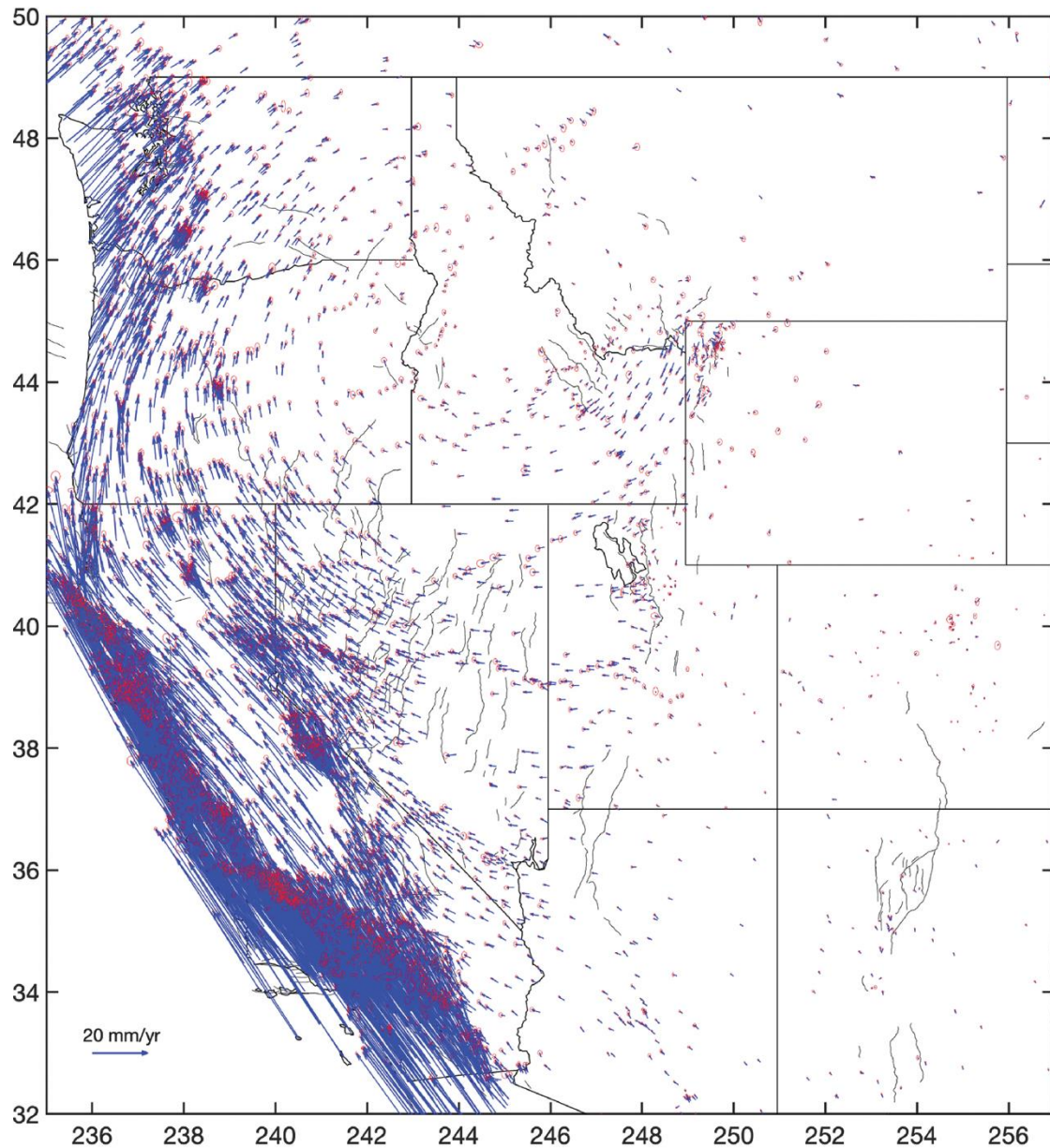
- Plate-boundary deformation field
- Fault slip rates and slip deficit accumulation rates
- Off-fault deformation
- Kinematic coupling of creeping faults
- Earthquake cycle processes

# Addressing Decadal Changes in Crustal Deformation From Tectonic and Non-tectonic Processes

**Case for exploration of decadal variations in 3D deformation to study:**

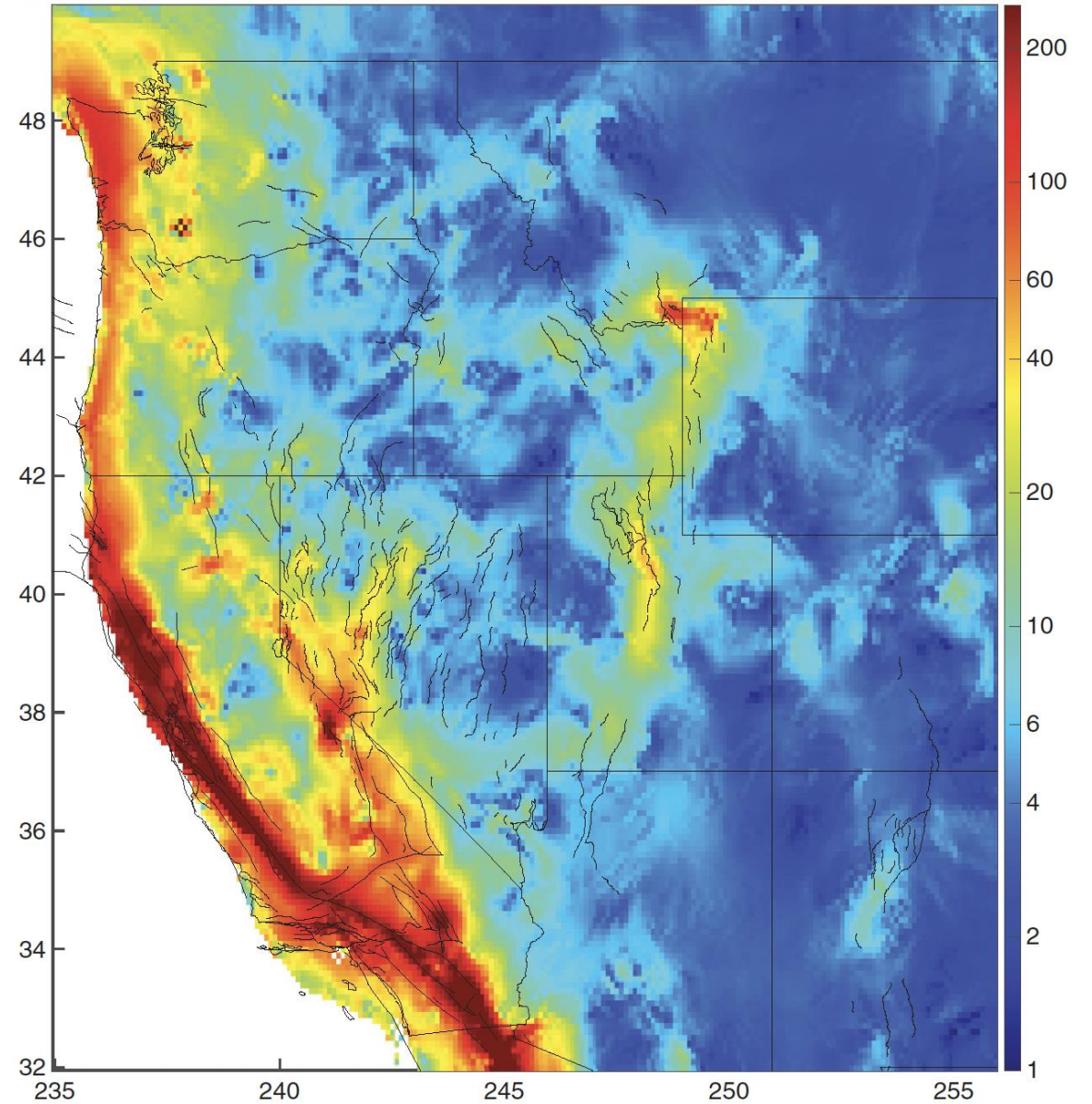
- Earthquake cycle ghost transients
- Climate-driven load deformation transients
- Tectonic vs. non-tectonic vertical land motions
- Long-term evolution of fault coupling

# “Interseismic” GNSS Deformation Field Includes ...



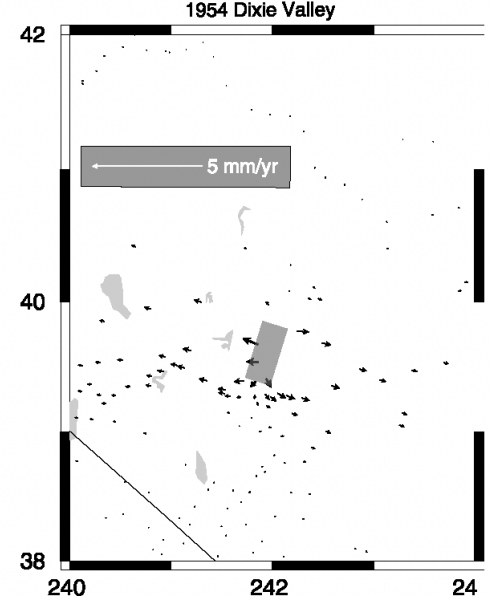
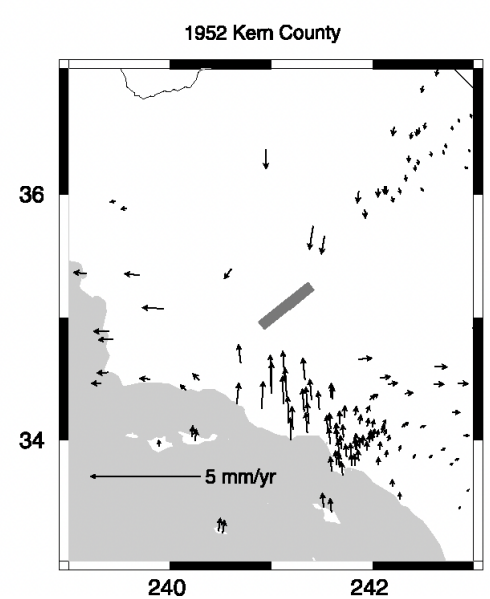
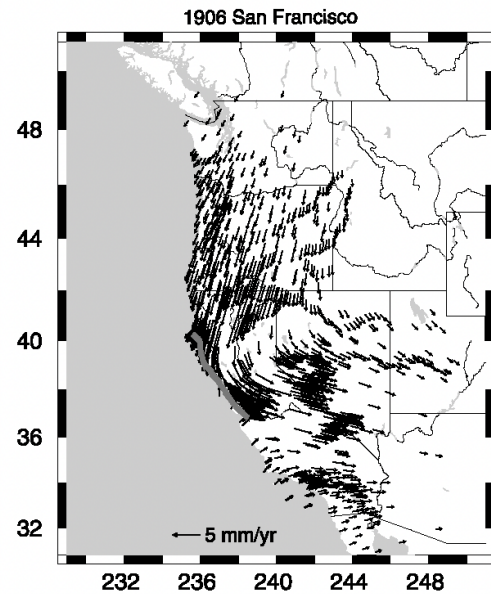
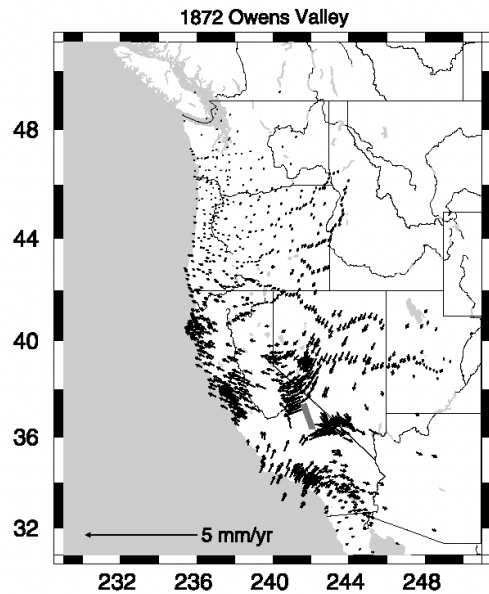
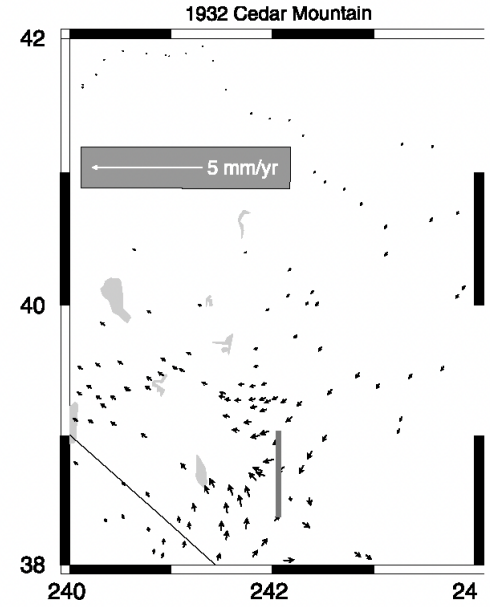
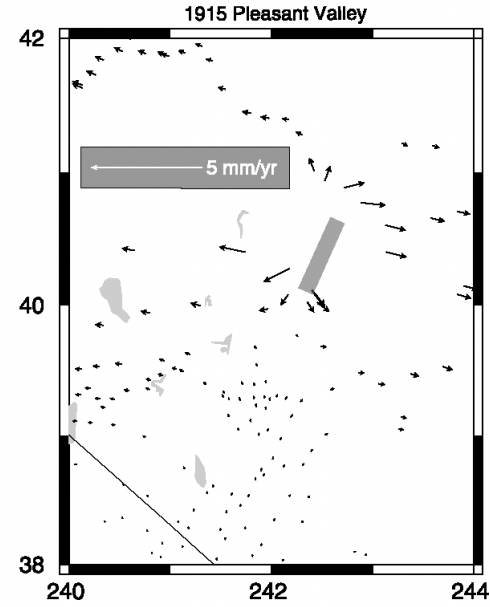
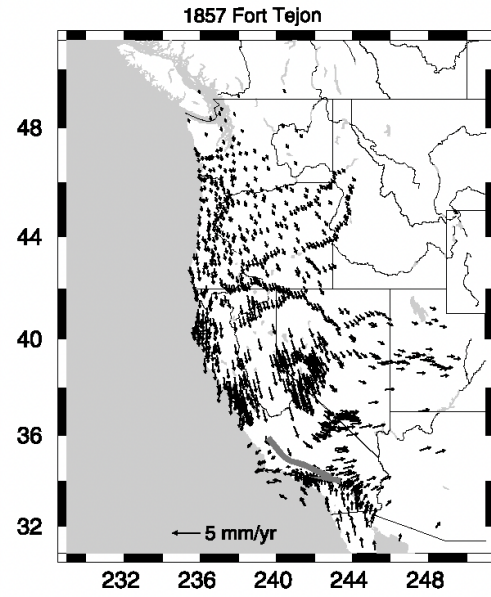
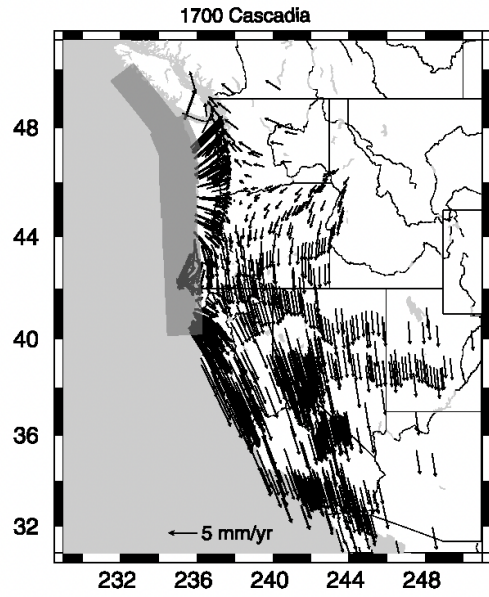
(a)

2nd invariant of the strain rate tensor ( $10^{-9}/\text{yr}$ )

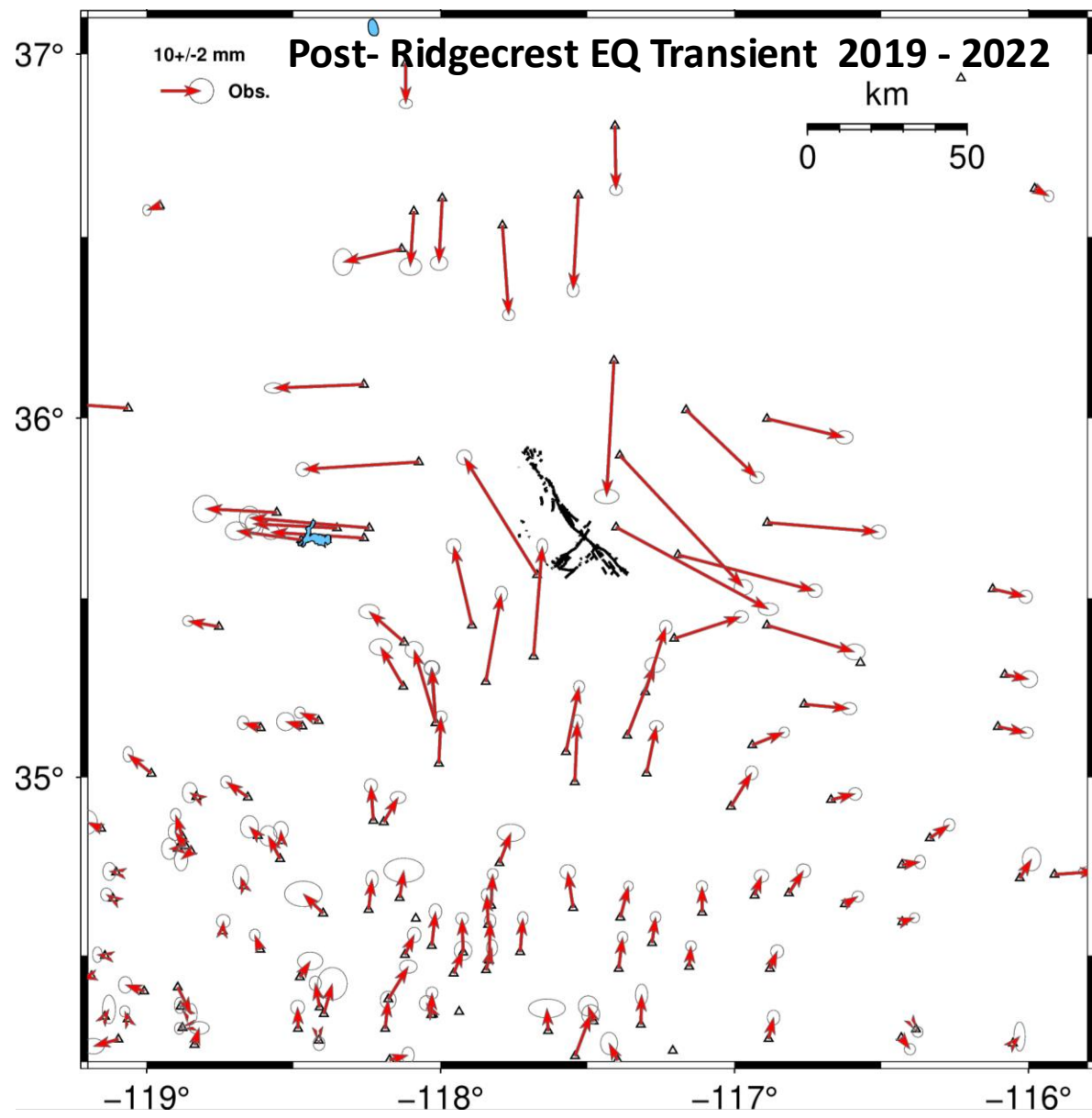
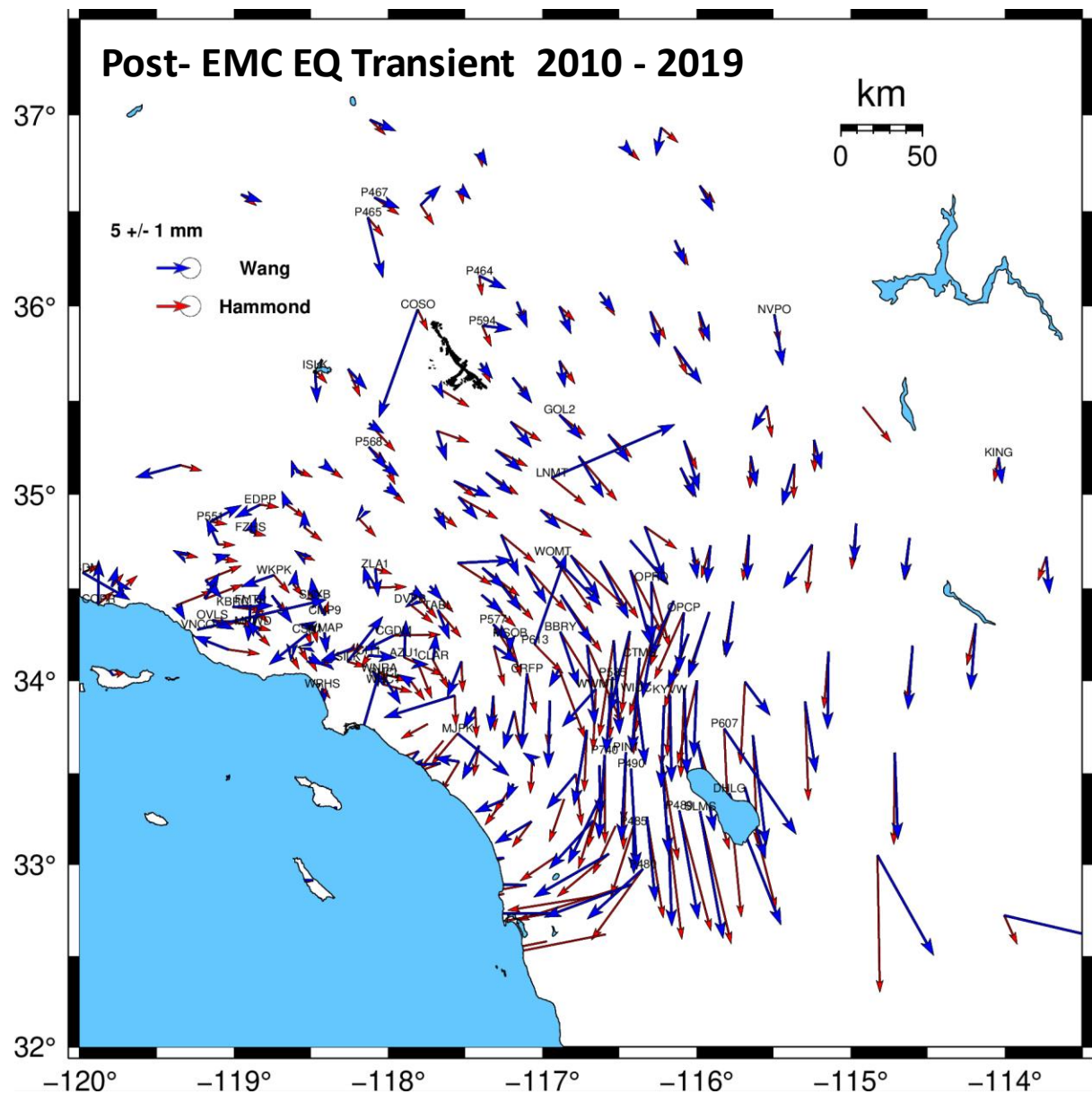




# Enduring and Far-Reaching Earthquake Cycle Ghost Transients

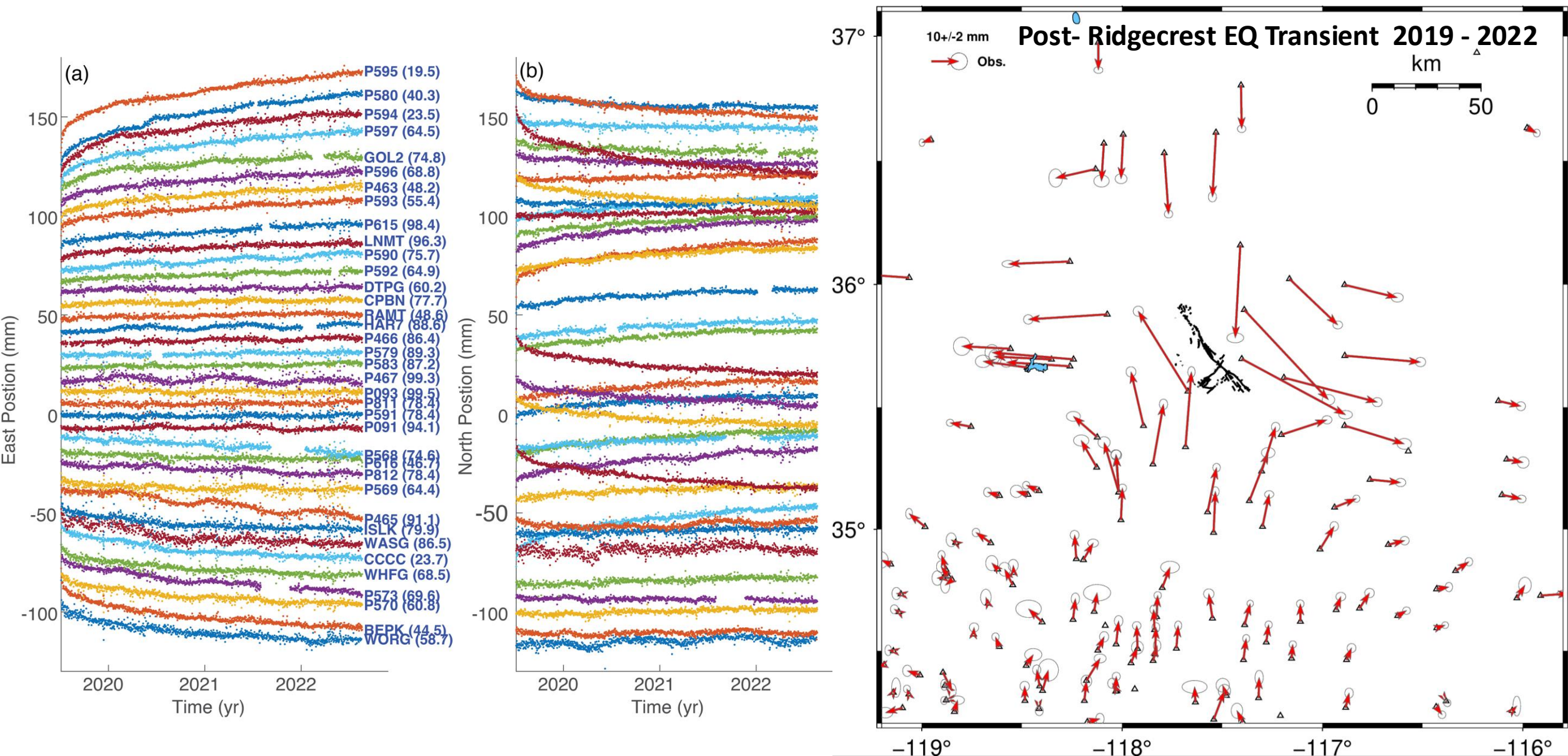


# Enduring and Far-Reaching Earthquake Cycle Ghost Transients



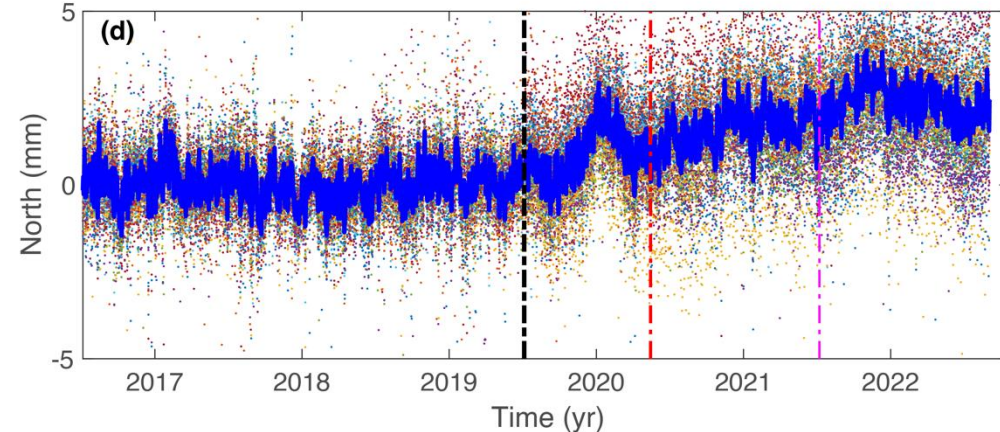
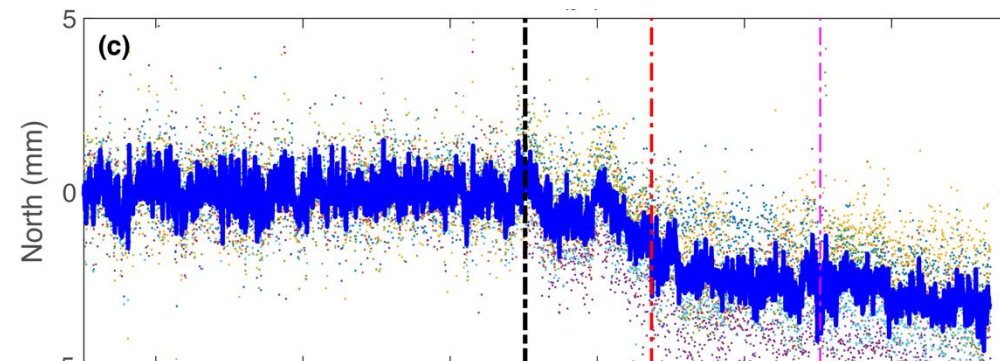
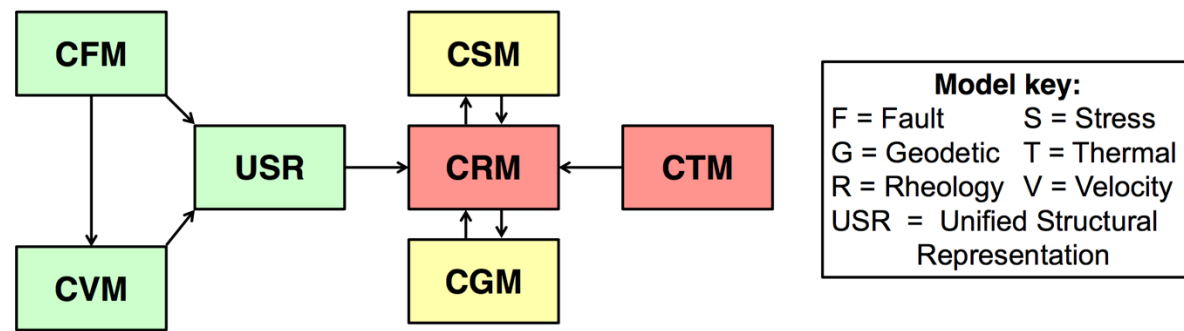
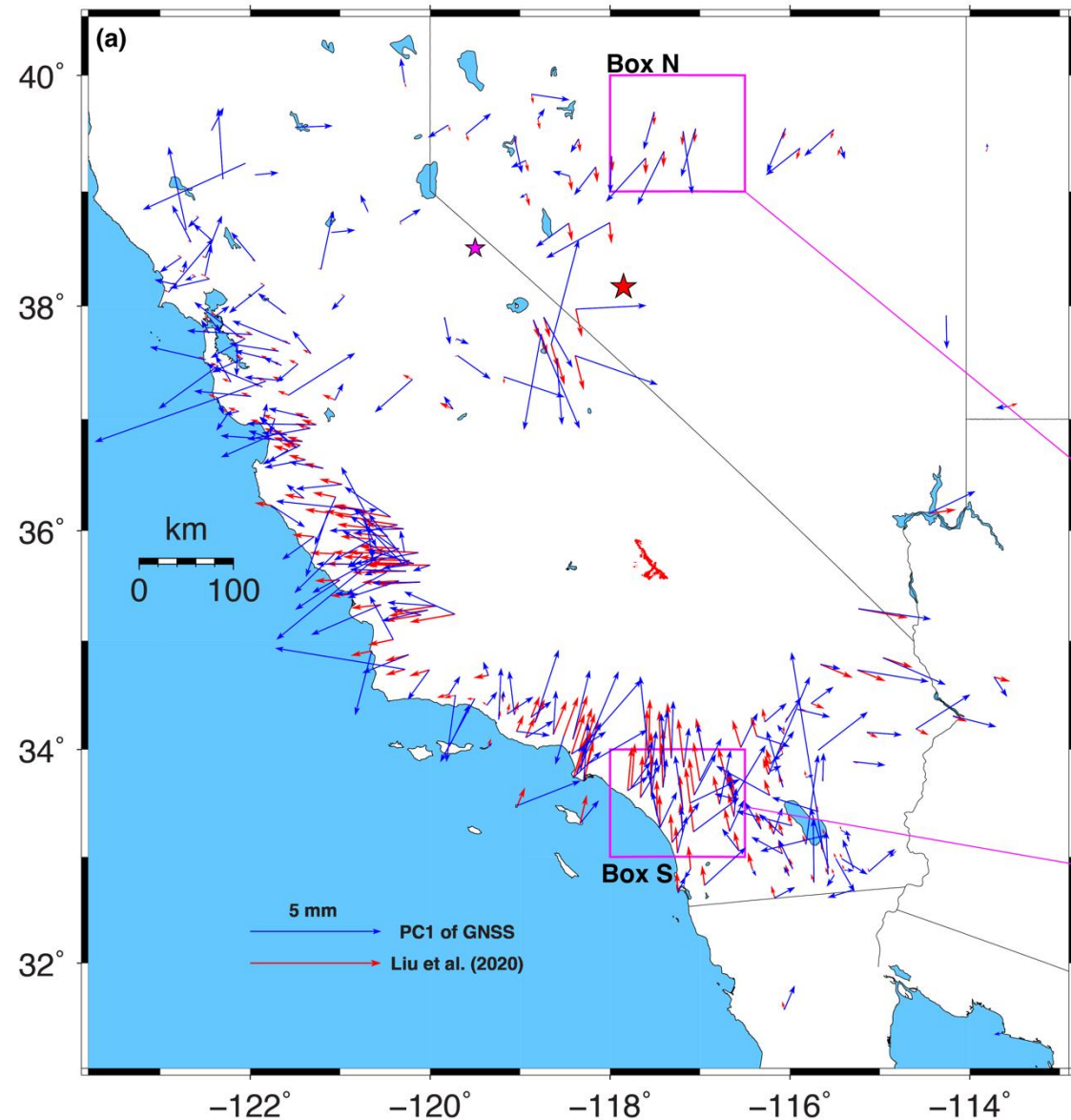


# Enduring and Far-Reaching Earthquake Cycle Ghost Transients

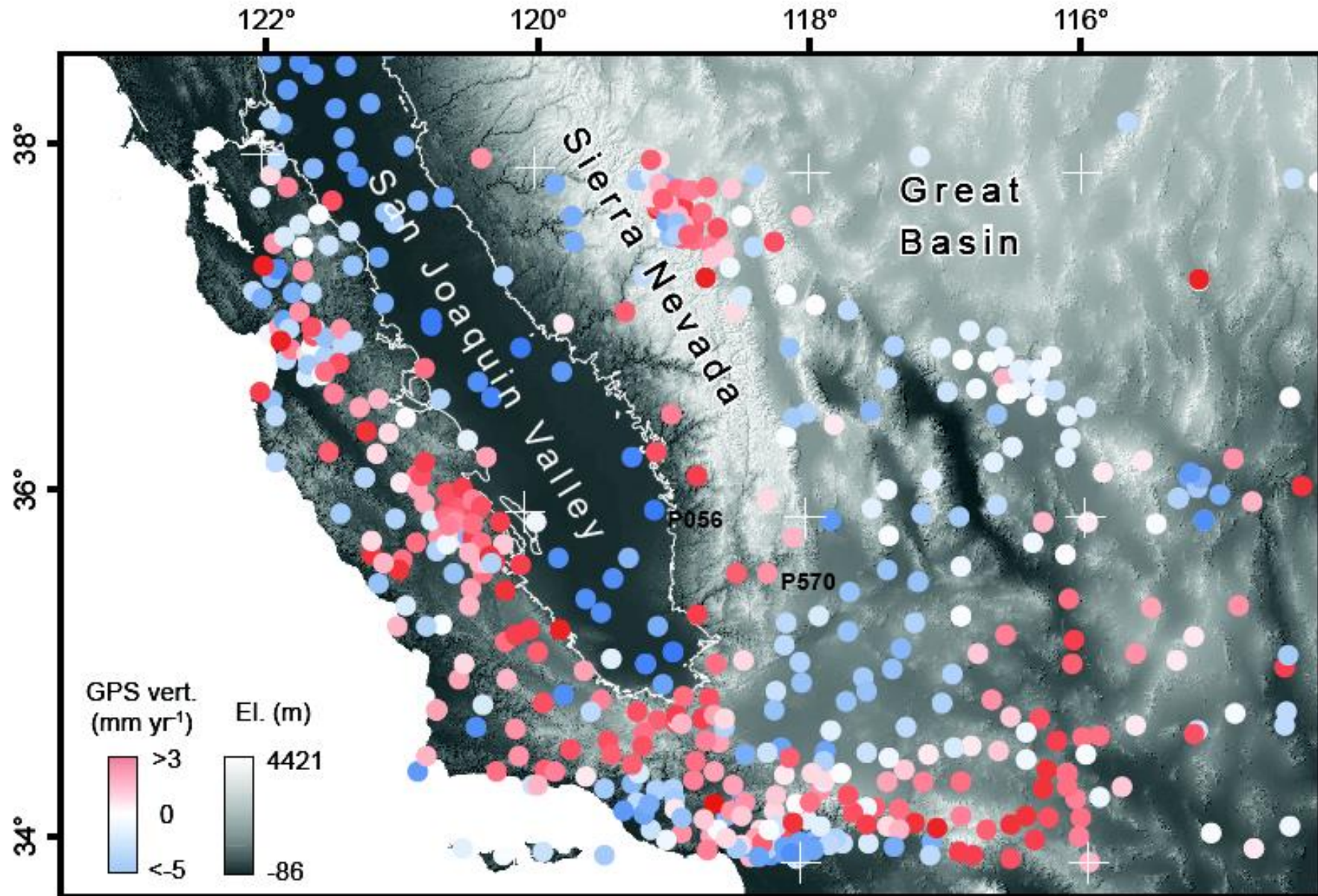




# Enduring and Far-Reaching Earthquake Cycle Ghost Transients

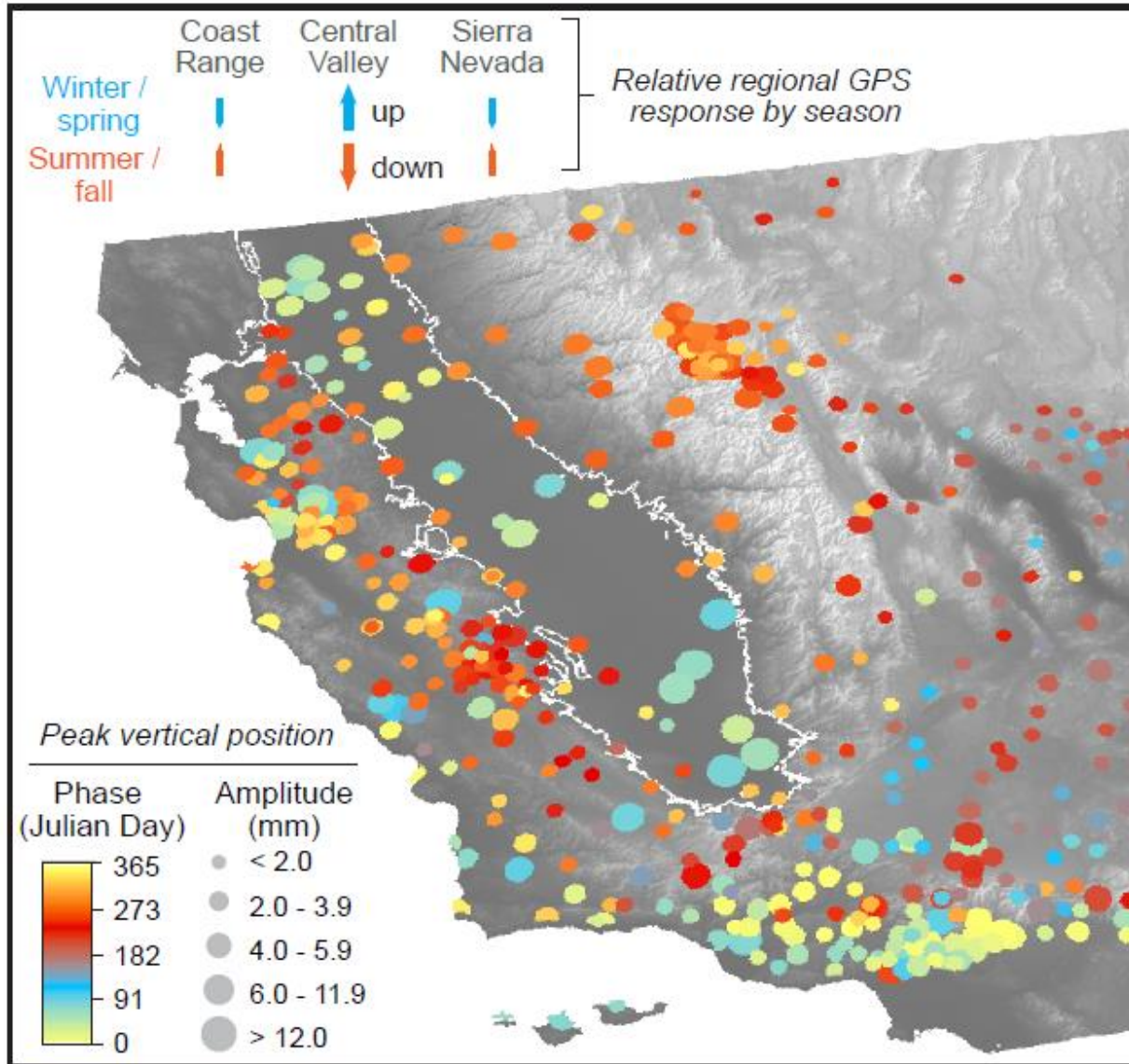


# “Interseismic” Vertical GNSS Velocity Field and ...

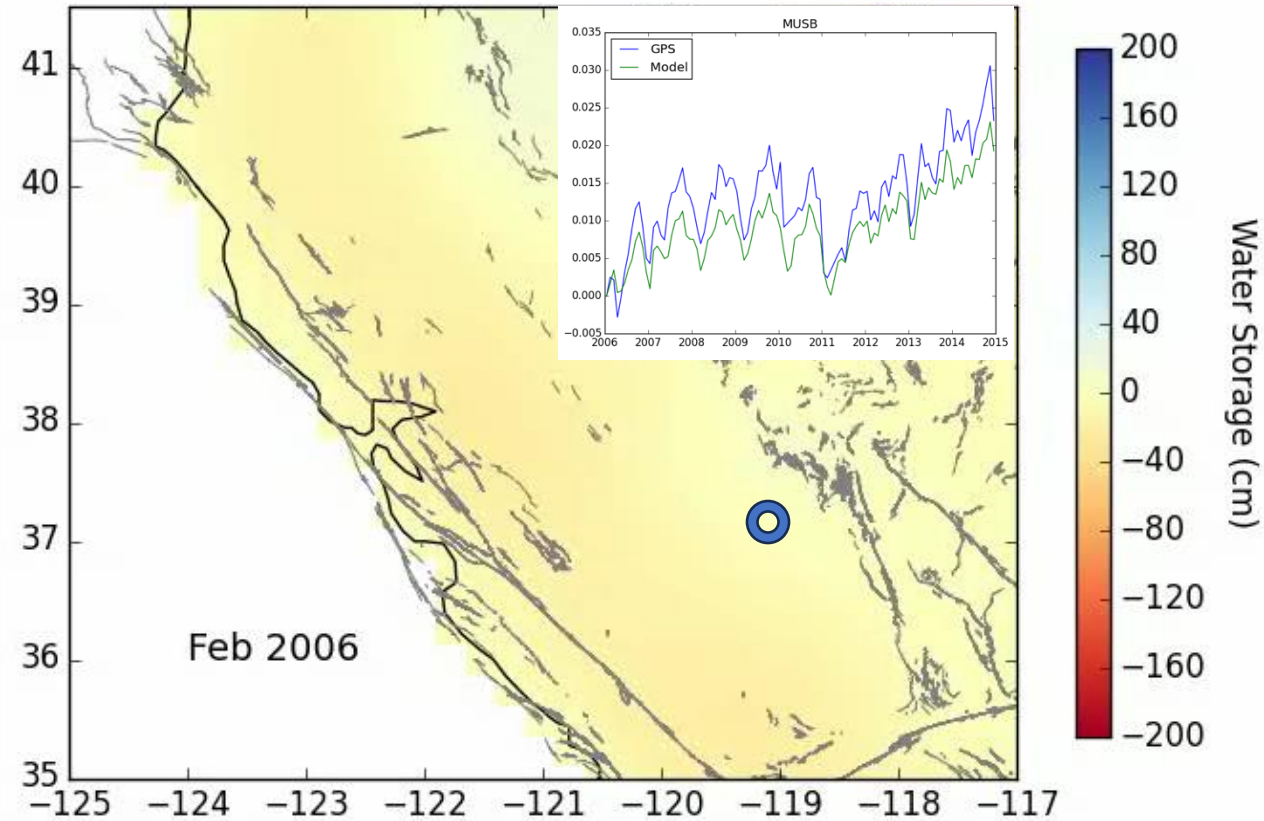




# ... Seasonal Uplift are Mostly Hydrological Deformation Transients

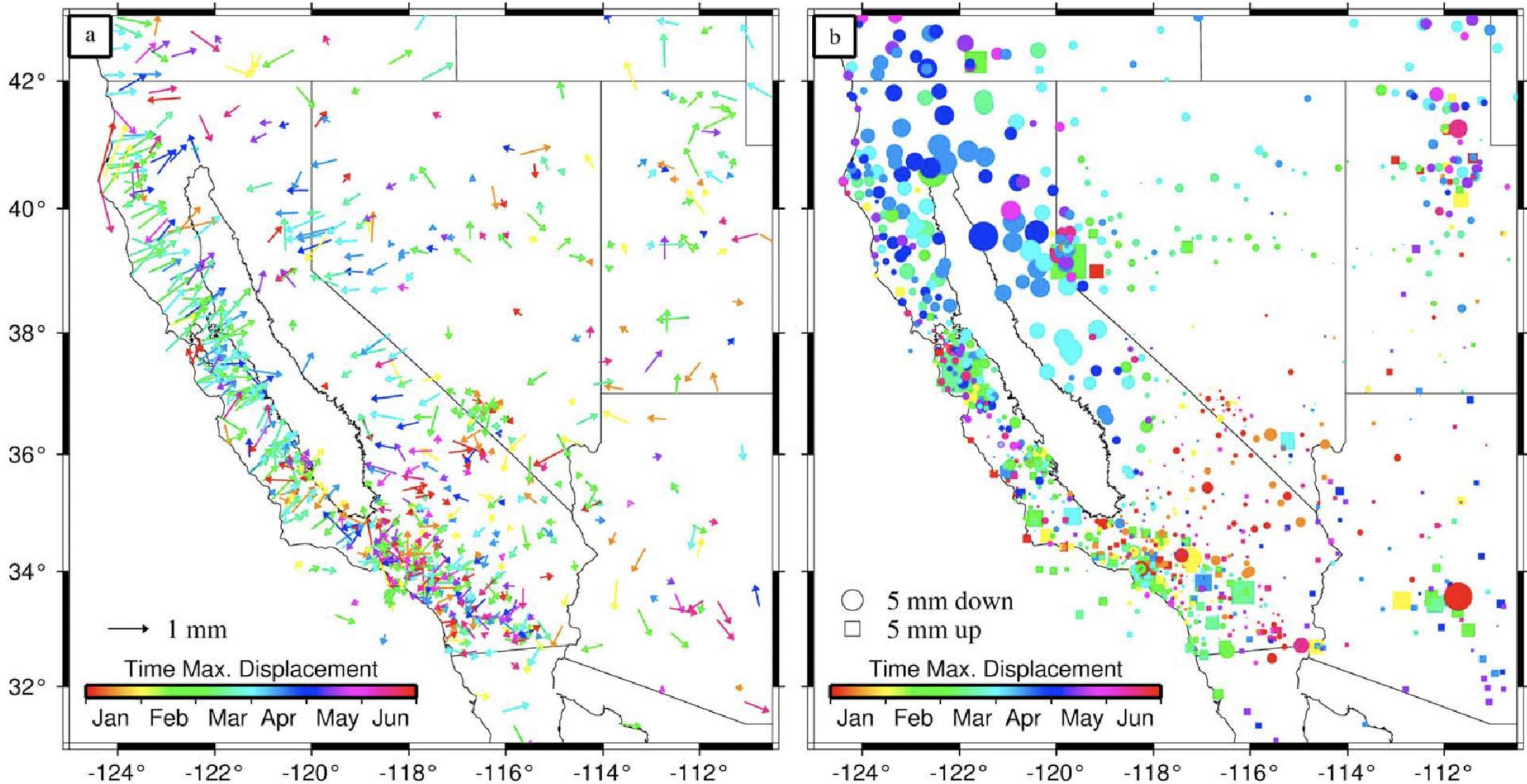


Amos et al., 2014 Nature



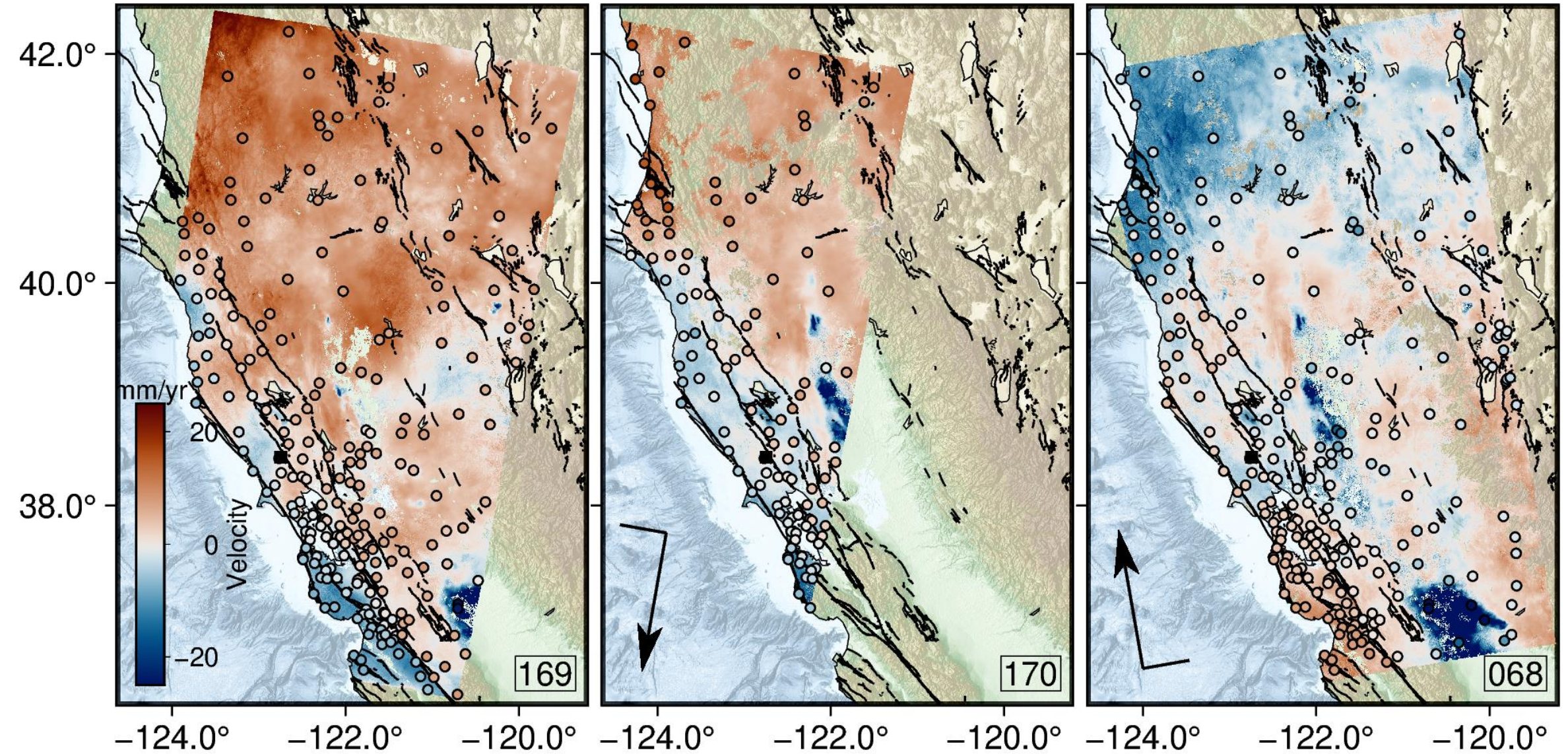
Johnson et al., 2017 Science

# Load Transients in Both Horizontal and Vertical Components



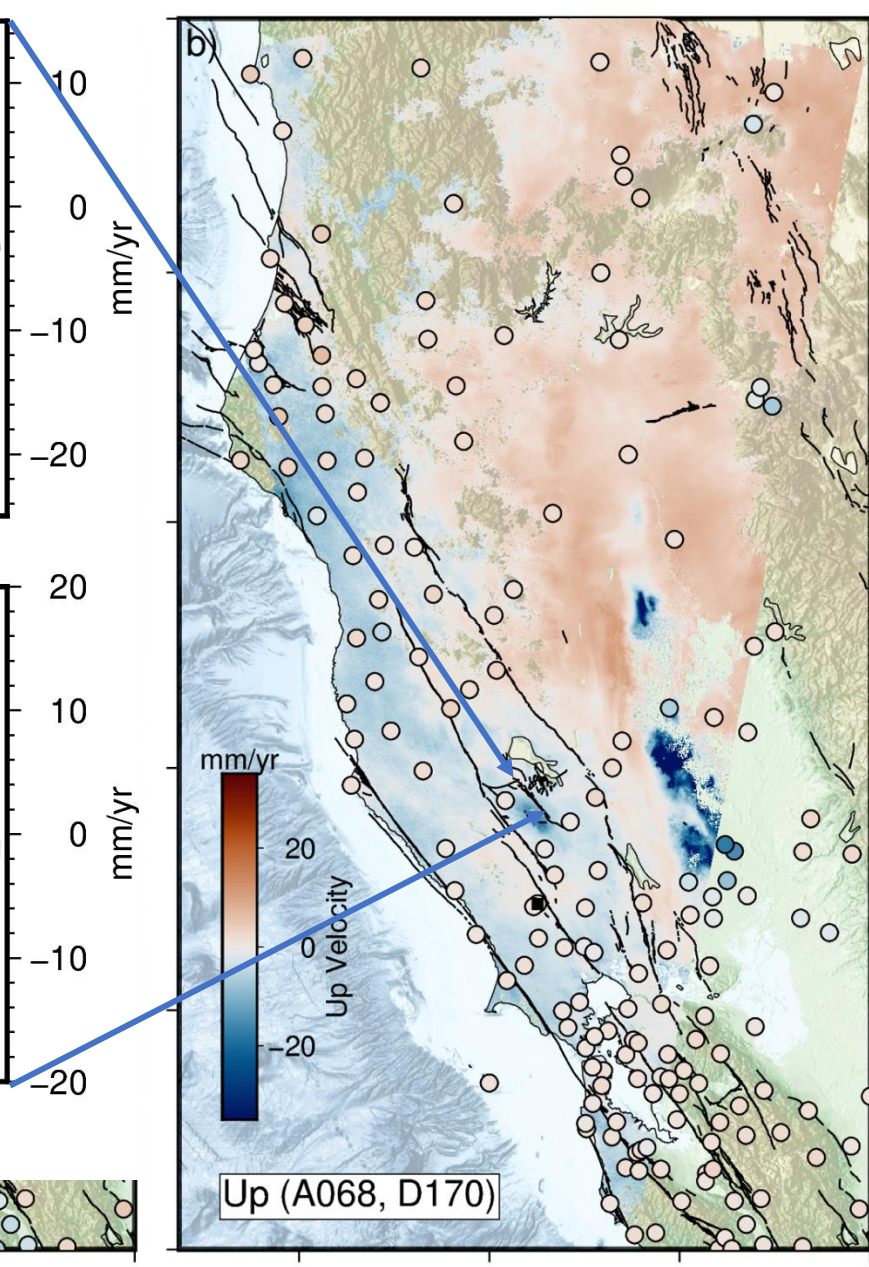
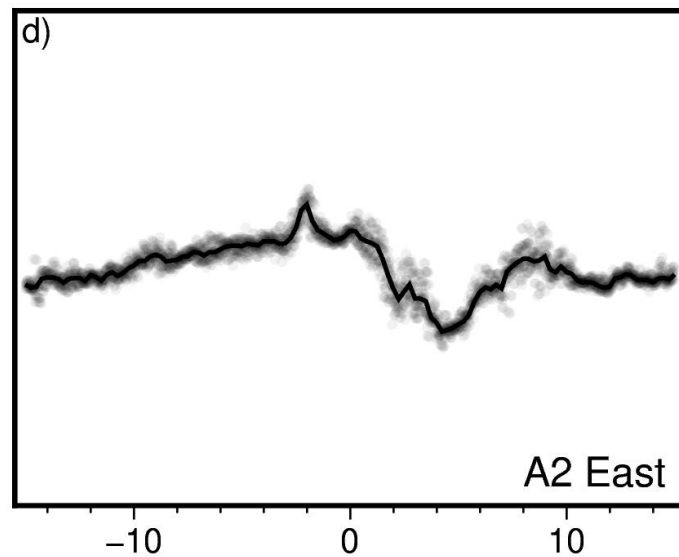
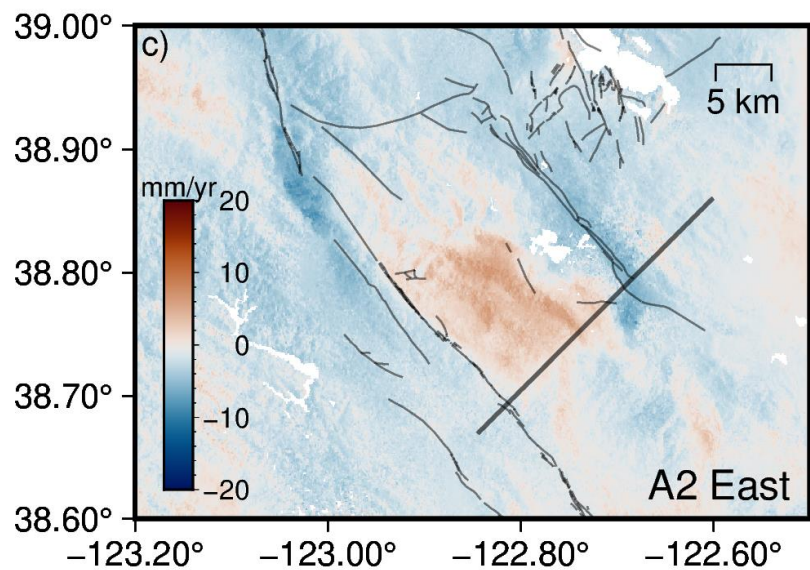
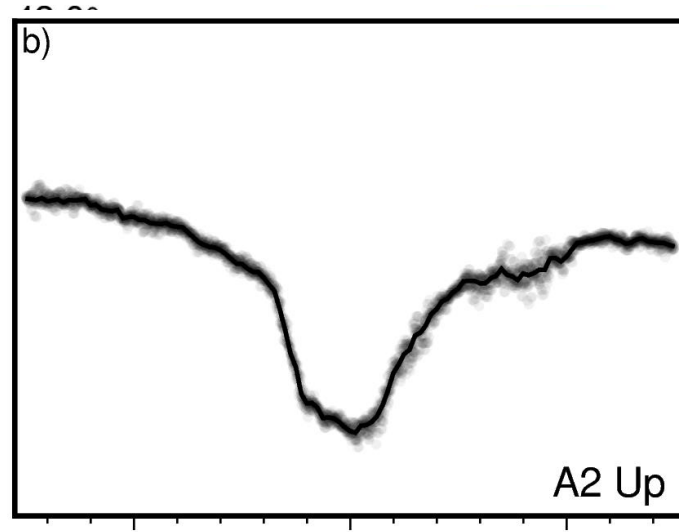
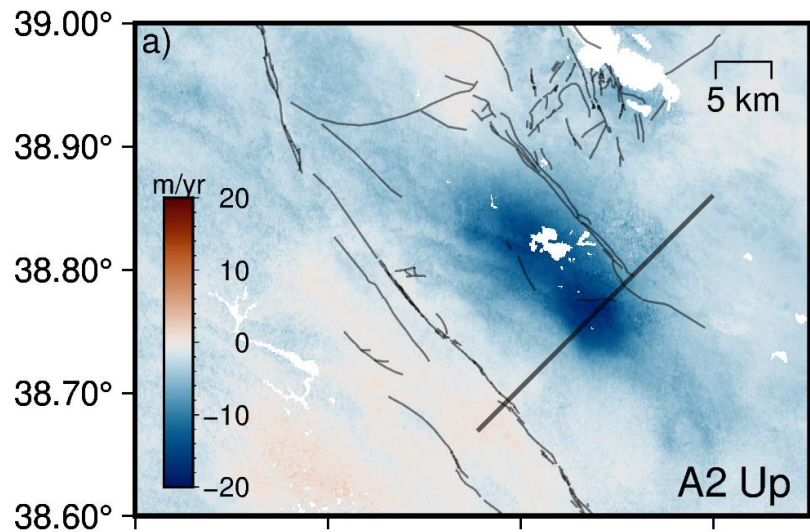


# 2015 – 2024 ALOS-2 InSAR and GNSS for 3D N Cal Deformation





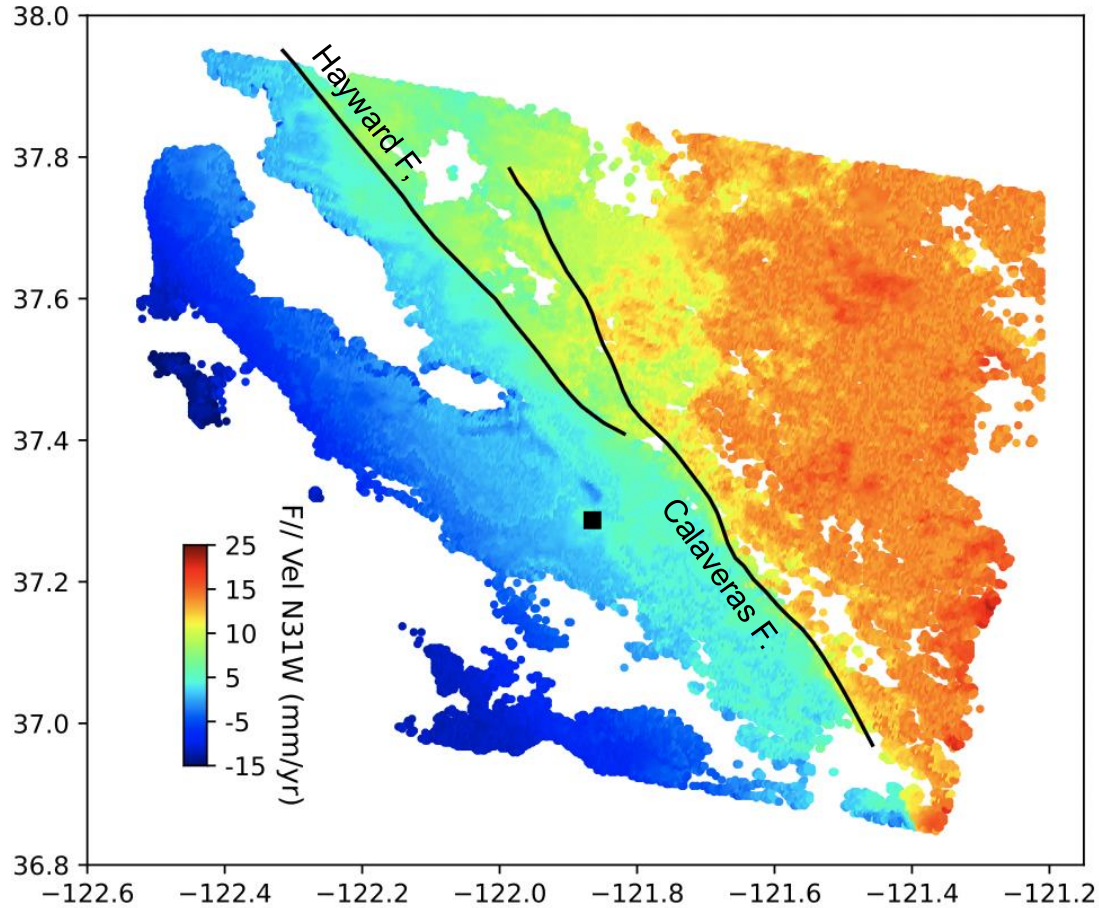
# Tectonic and Non-Tectonic Vertical Land Motions



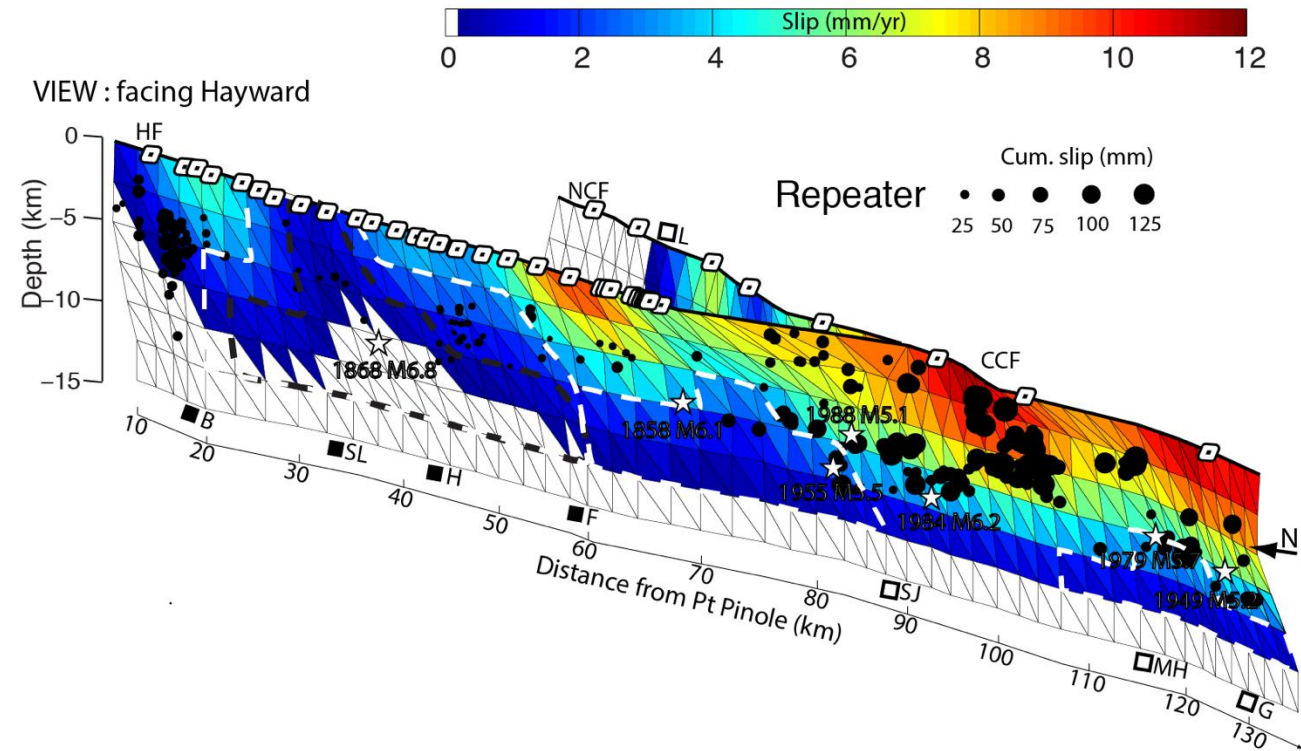


# “Interseismic” Fault Coupling

ERS/Envisat (1992-2011)

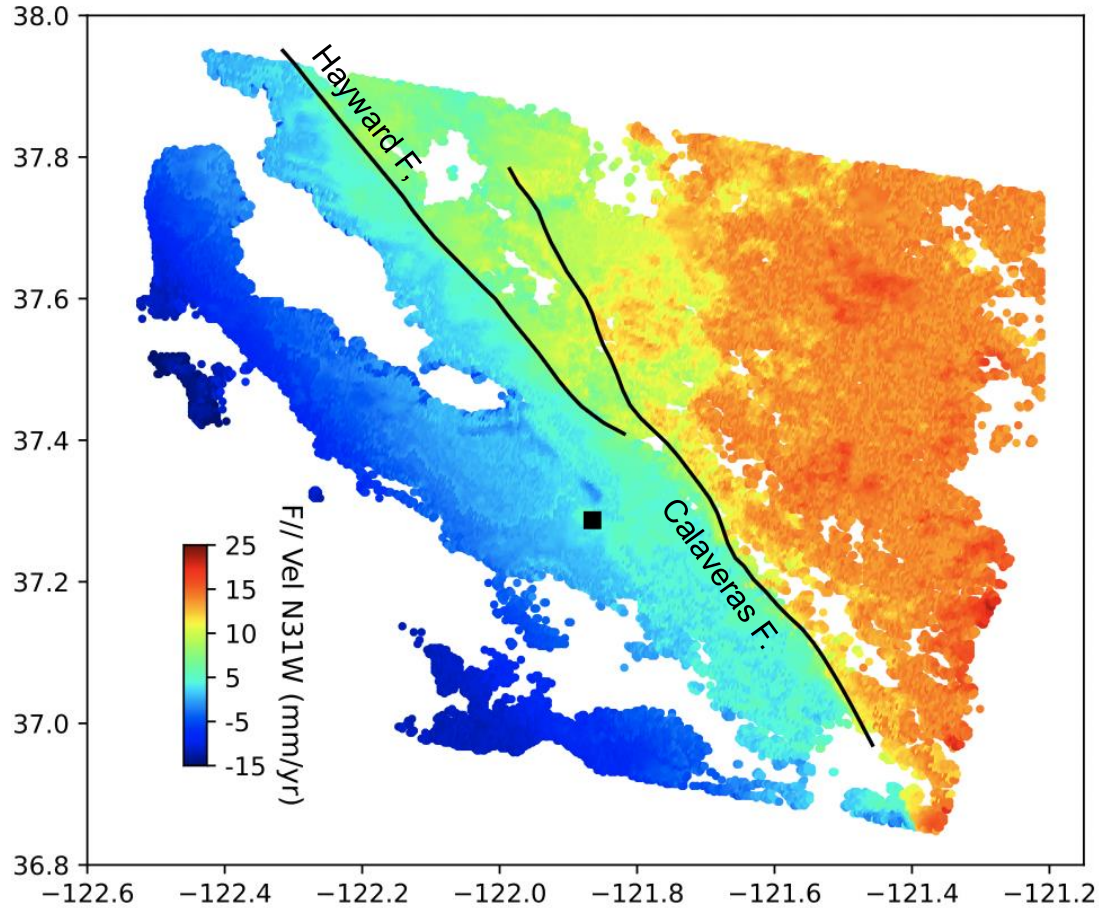


Data from Chaussard et al., 2015



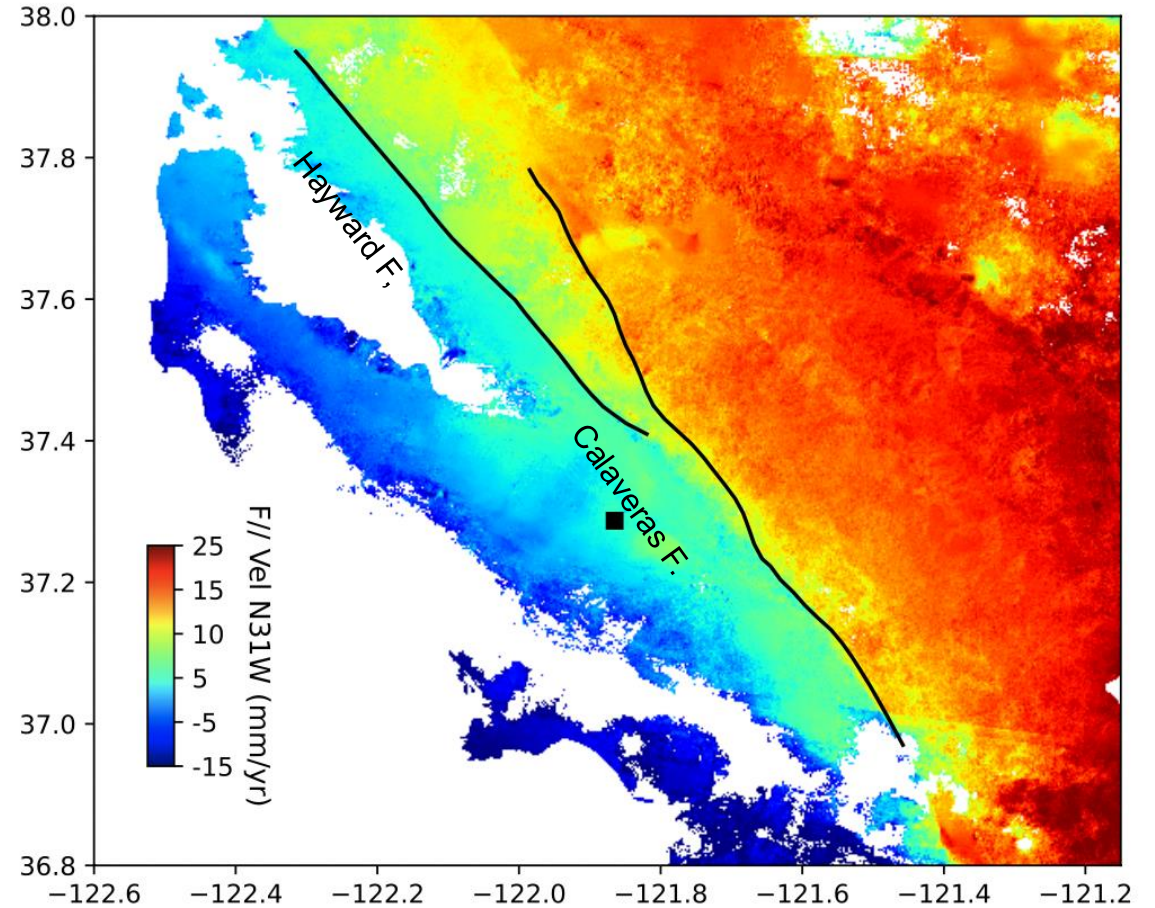
# Decadal Changes in Fault Coupling?

ERS/Envisat (1992-2011)



Data from Chaussard et al., 2015

Sentinel-1 (2015-2023)

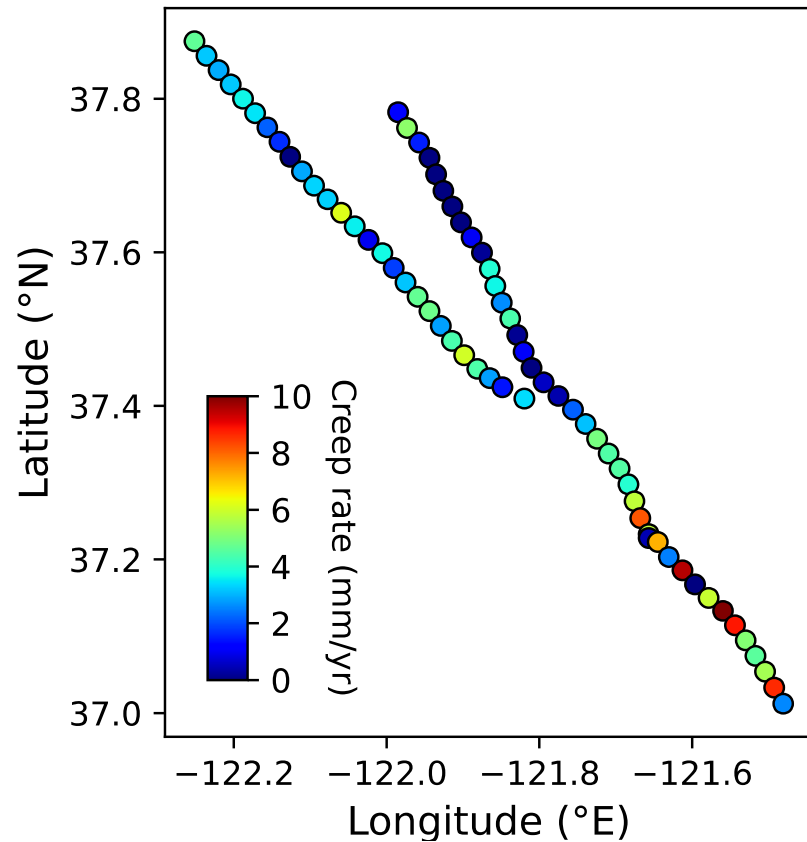


Data from JPL ARIA products

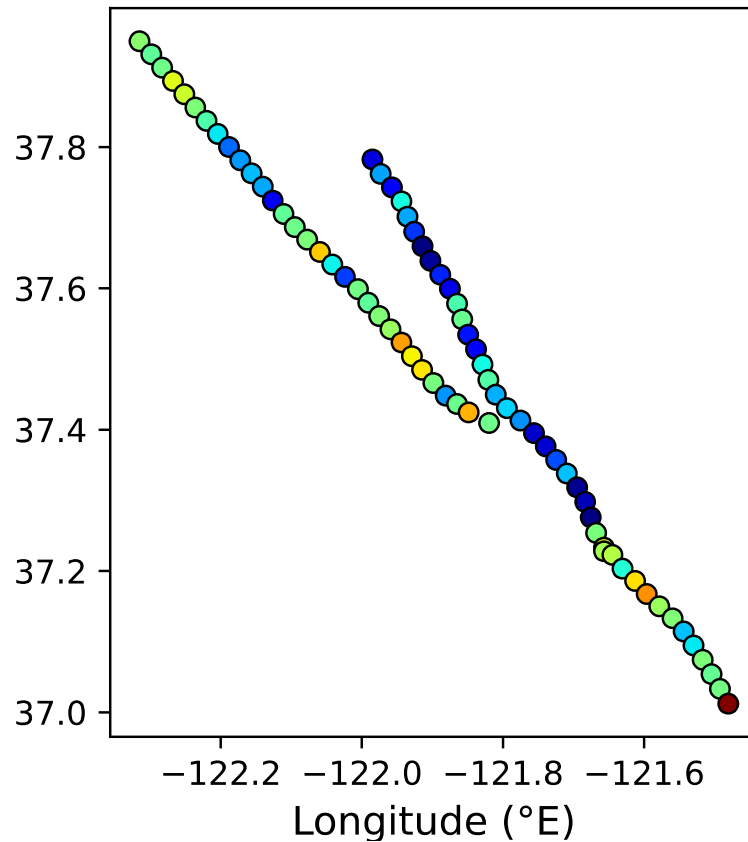


# Decadal Changes in Fault Coupling?

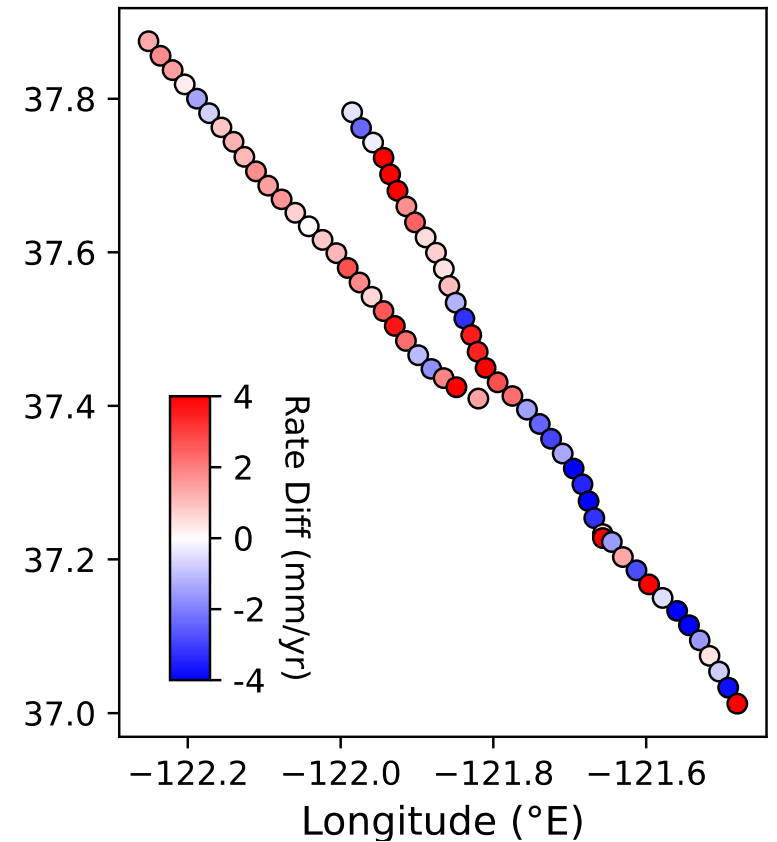
ERS/Envisat (1992-2011)



Sentinel-1 (2015-2023)

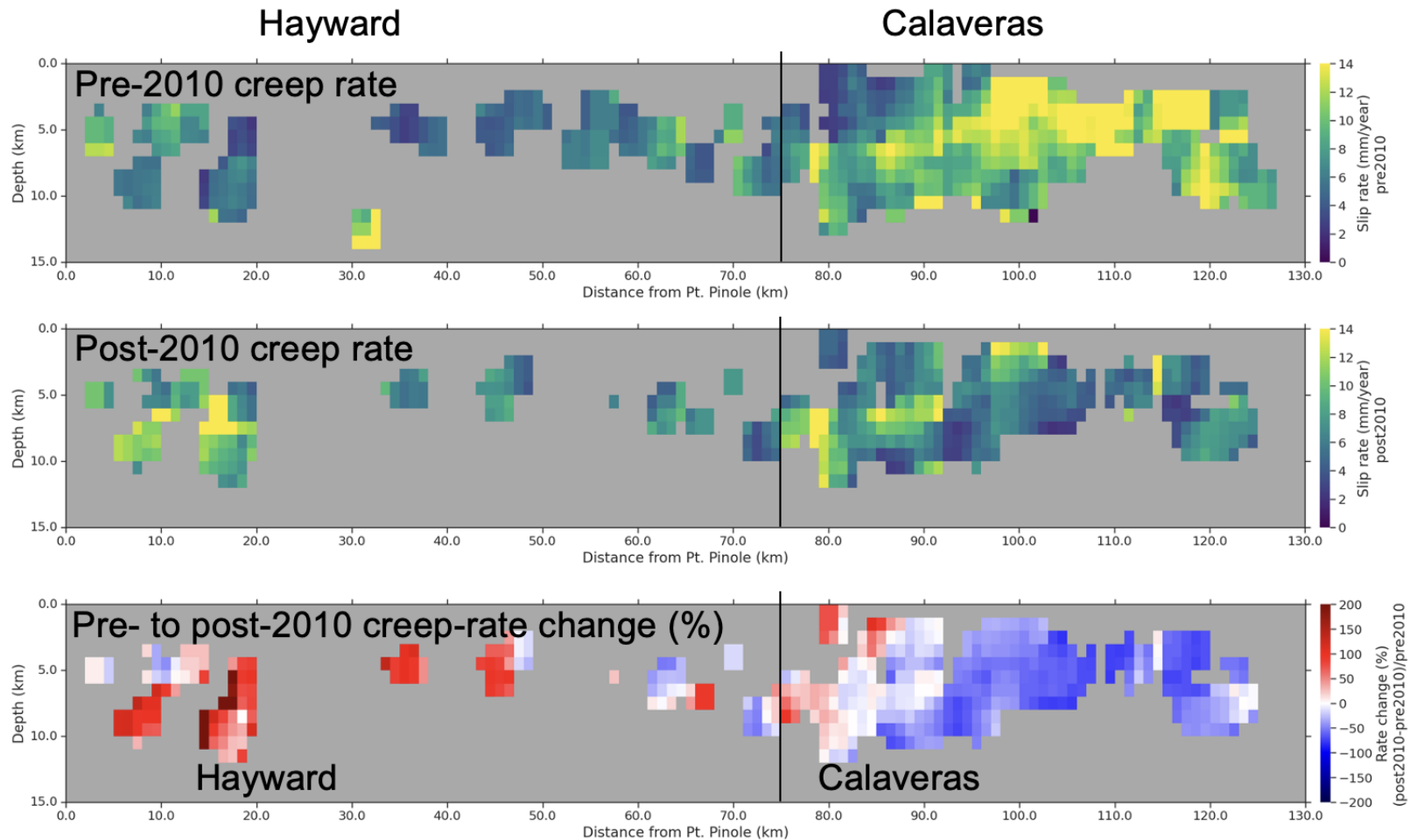


Sentinel-1 – ERS/Envisat

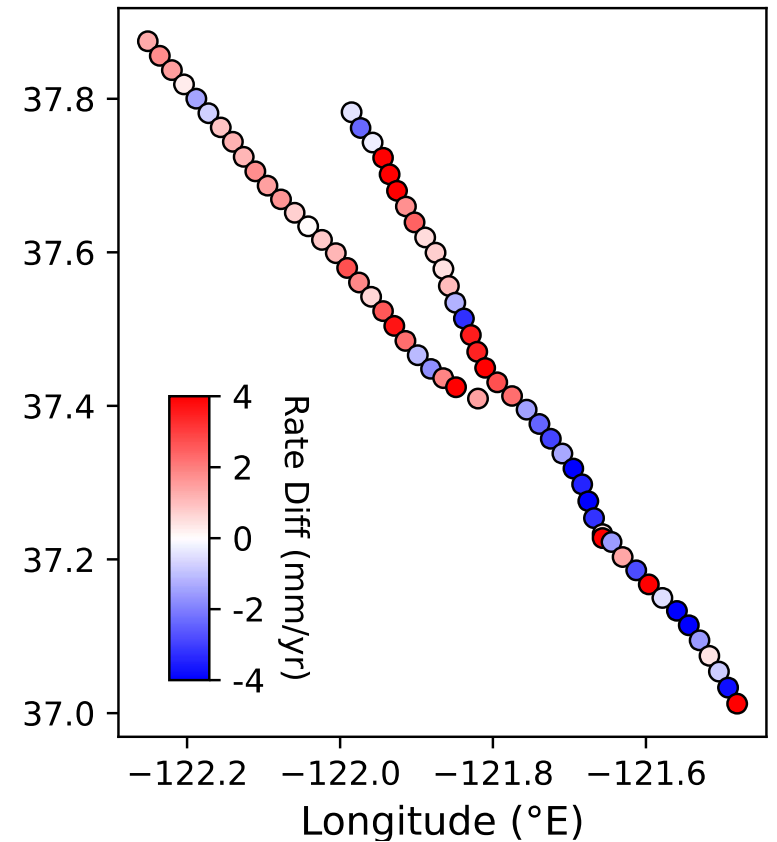


# Decadal Changes in Fault Coupling

1992 – 2010 vs. post-2010 creep rate from repeating earthquakes



Sentinel-1 – ERS/Envisat

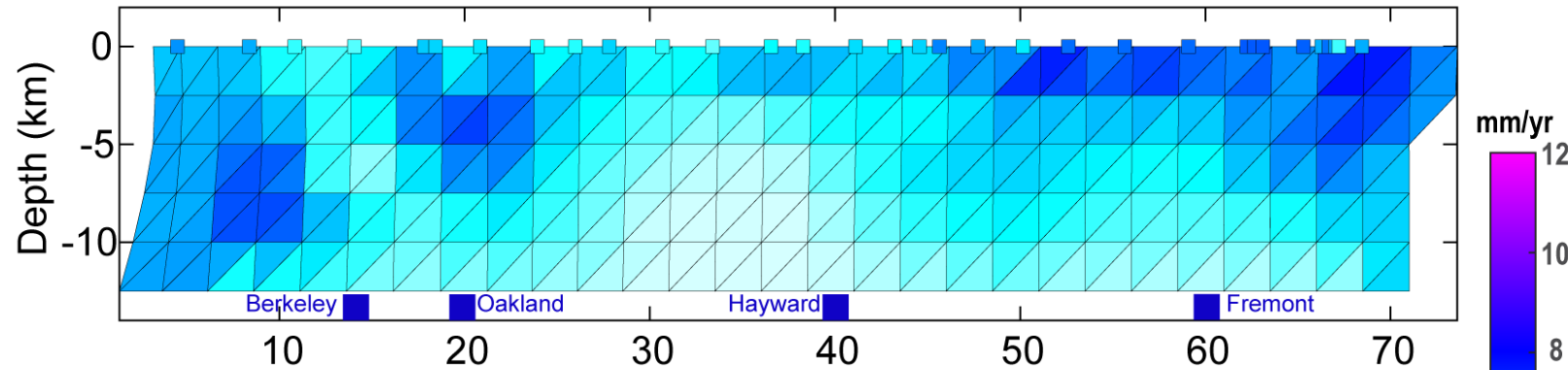




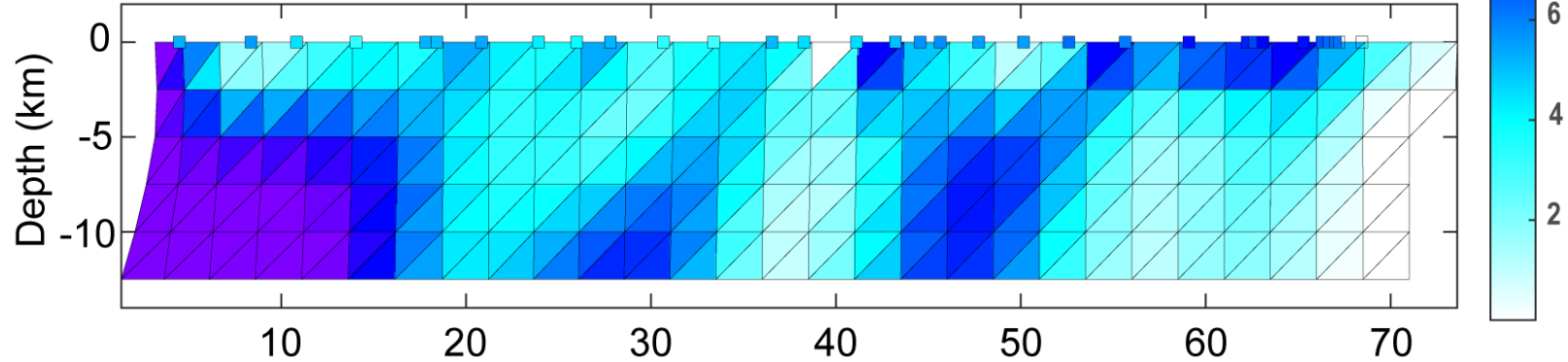
# Decadal Changes in Fault Coupling

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

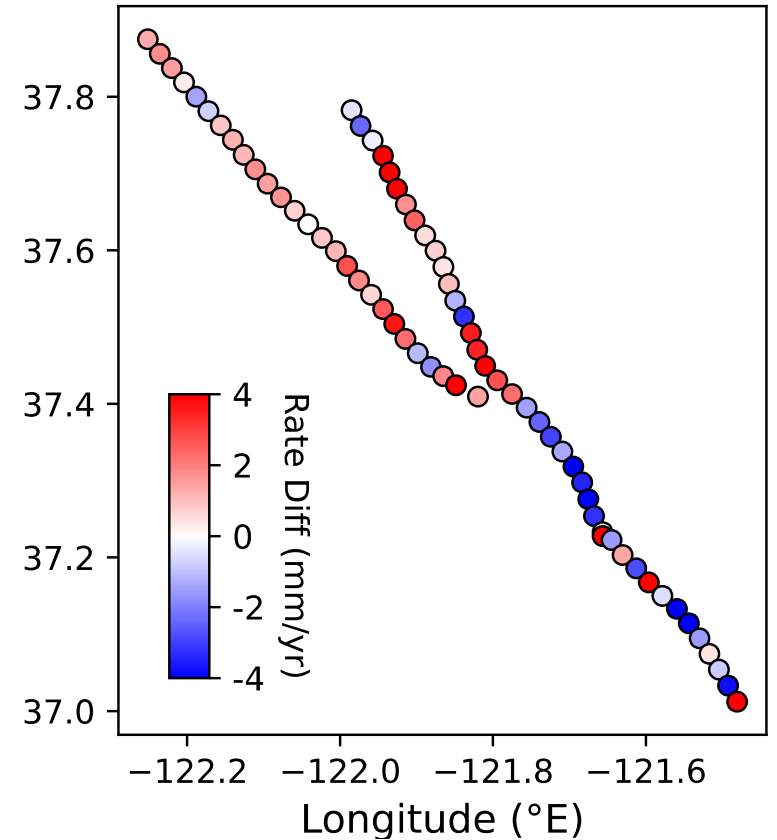
A) Creep rate (1992-2010)



B) Creep rate (2015-2023)



Sentinel-1 – ERS/Envisat



# Decadal Rate Changes from ~30-Year cGNSS & InSAR Records

## Case for exploration of decadal variations in 3D deformation:

- Earthquake cycle ghost transients
- Climate-driven load deformation transients
- Tectonic vs. non-tectonic vertical land motions
- Long-term evolution of fault coupling

