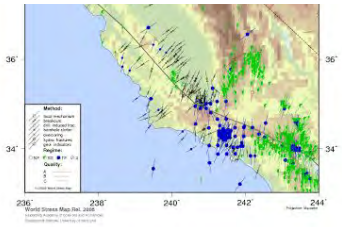
San Bernardino basin focal mechanisms reveal signals of interseismic loading and the 1812 Wrightwood earthquake

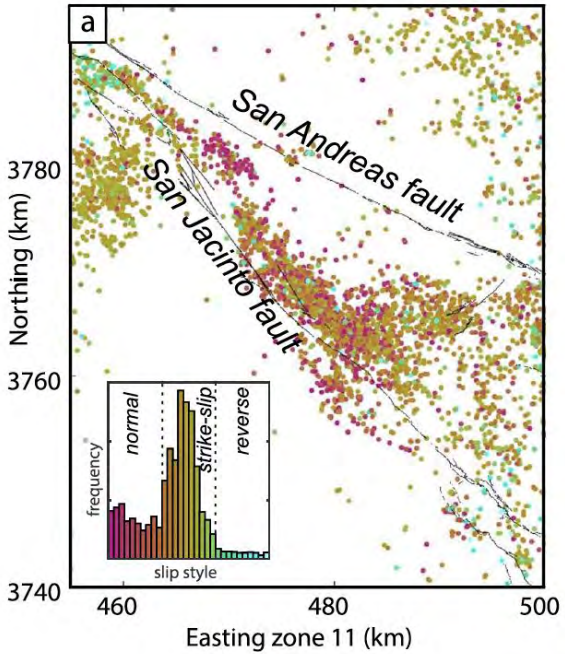
Michele L. Cooke, Jennifer L. Hatch and Hanna M. Elston

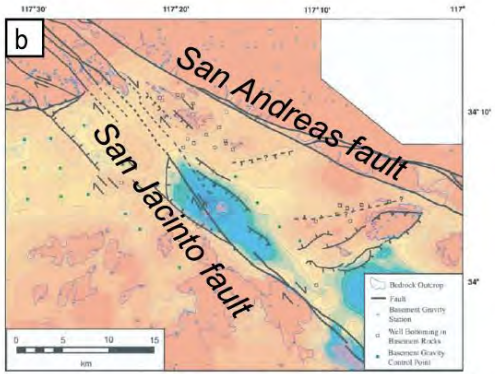
Cajon Pass EGA workshop 4 September 2020

Normal slip focal mechanisms?

Microseismicity (*Yang et al. 2012 and subsequent updates*) has unexpected normal slip events within the San Bernardino basin between two major strike-slip faults.







Forward interseismic models with 20 km locking depth predict strike-slip events at the locations of the observed microseismicity.

From Cooke and Beyer (2018)

Geophysical Research Letters

RESEARCH LETTER
10.1029/2018GL078932

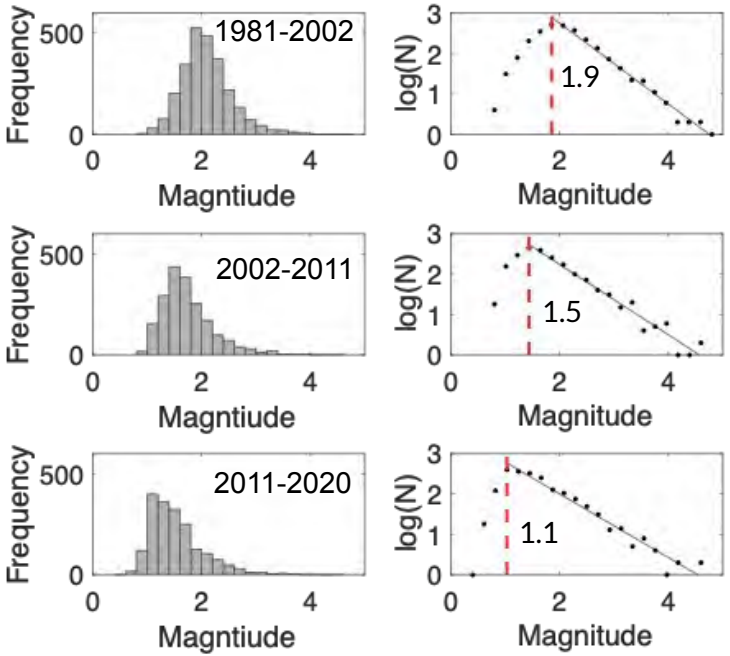
Key Points:
- Crustal deformation models demonstrate the plausibility of deep creep along the northern San Jacinto fault to account for nearby enigmatic normal slip mechanisms

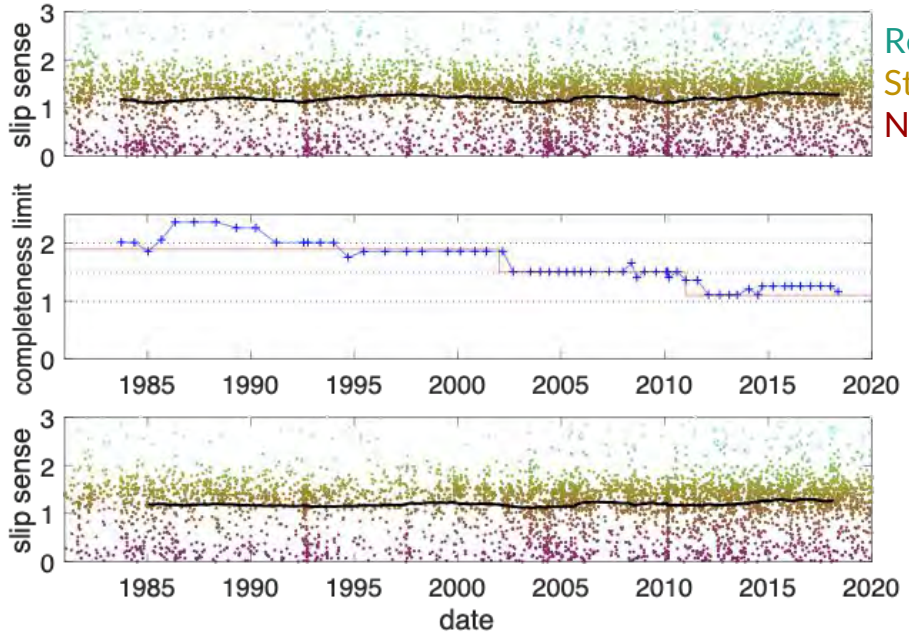
Off-Fault Focal Mechanisms Not Representative of Interseismic Fault Loading Suggest Deep Creep on the Northern San Jacinto Fault

M. L. Cooke[1] and J. L. Beyer[1]

[1]Geosciences Department, University of Massachusetts Amherst, Amherst, MA, USA

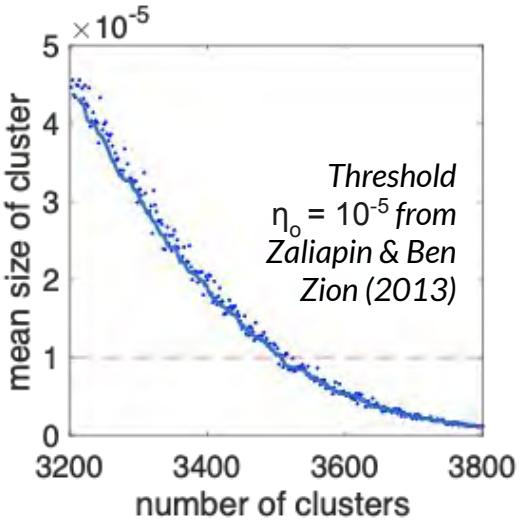
Catalog Completeness

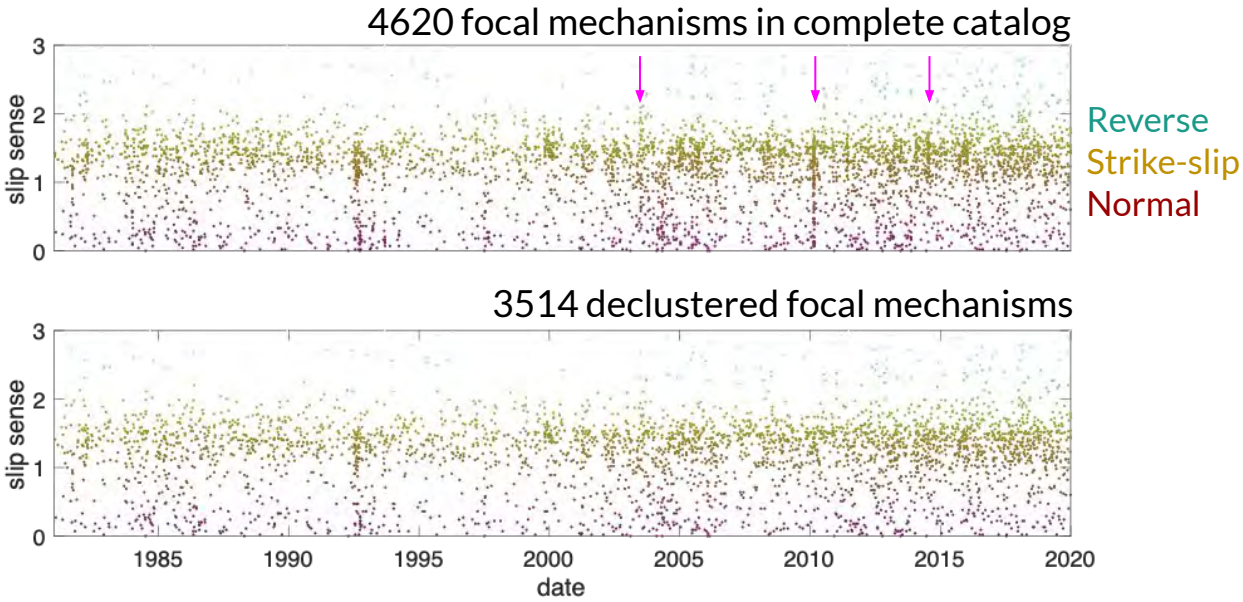




Reverse
Strike-slip
Normal

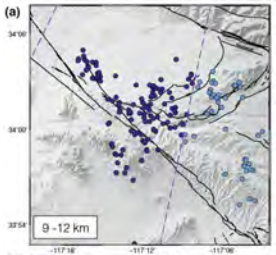
3514 declustered events

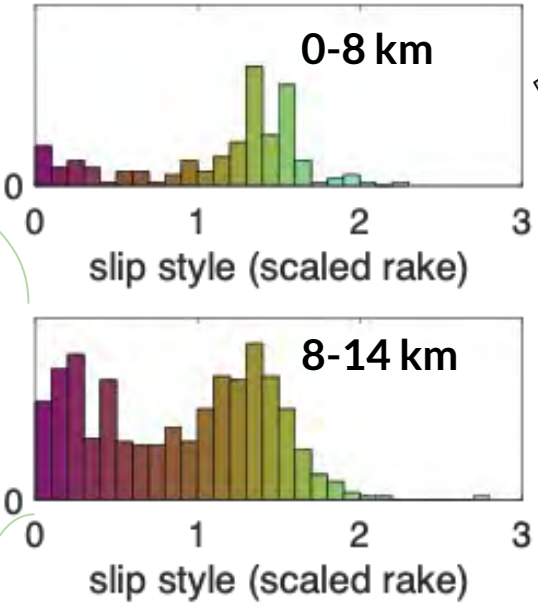




- Spatial and temporal rescaling following *Baiesi & Paczuski* [2004] using parameters from Zaliapin & Ben Zion (2013)
- K-means using squared Euclidean distance to identify clusters
- Choose largest magnitude event in each cluster

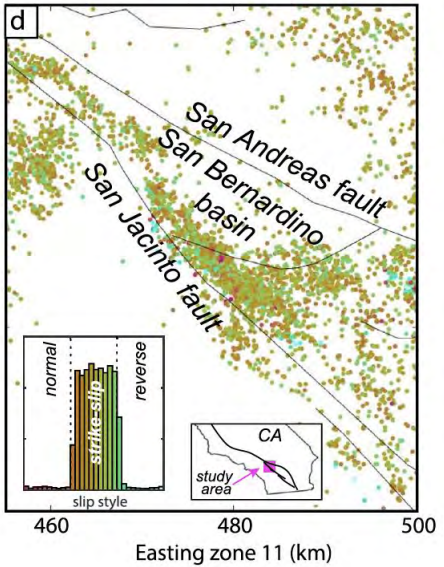
Depth variation within the San Bernardino basin





Within the depths of 8-14 km normal slip events are as prevalent as strike-slip events.

Interseismic loading produces strike-slip stress state above the locking depth.

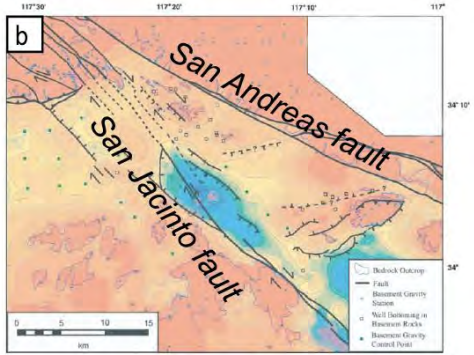


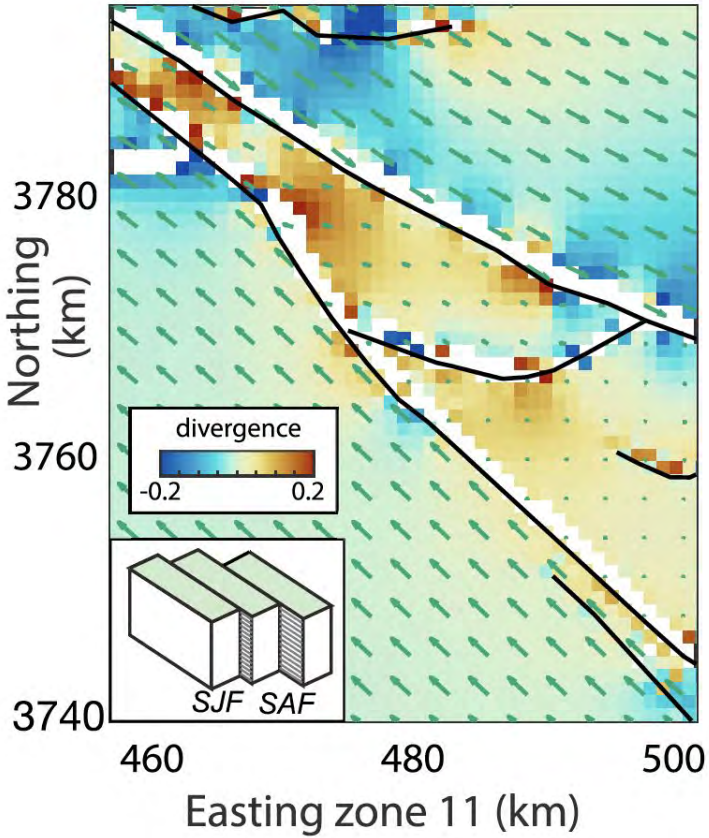
From Abolfathian et al 2018

Long-term basin extension

Long term deformation over multiple earthquake cycles shows dilation within the San Bernardino basin.

Since normal slip events occur primarily below 8 km depth could the San Jacinto have creep below this depth?

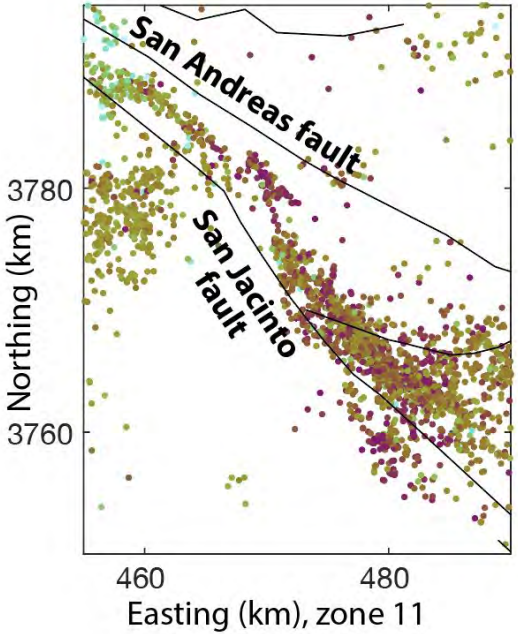




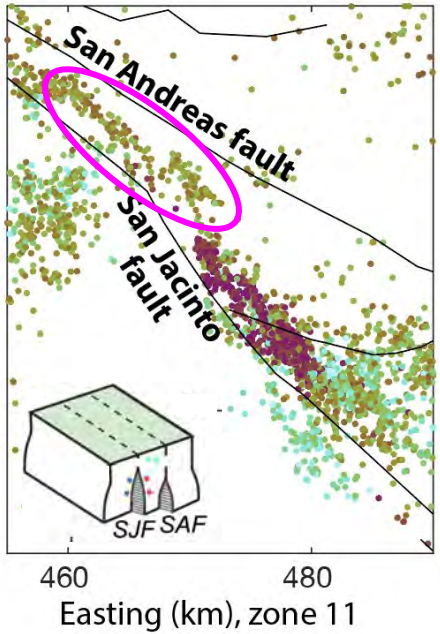
From Cooke and Beyer (2018)

With SJ locking depth 10km SA 20 km

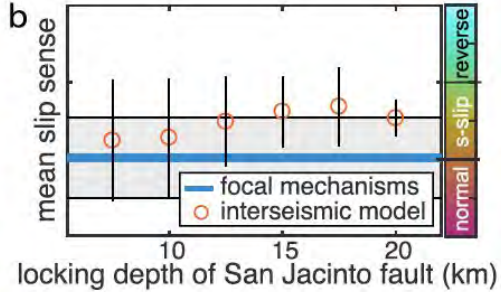
Complete & declustered focal mechanisms

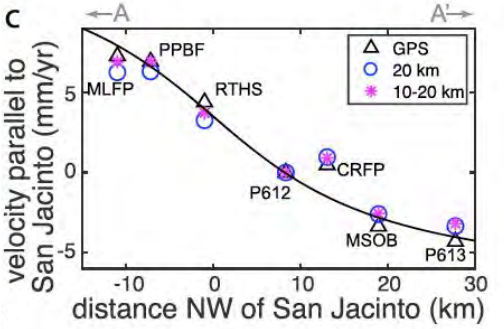


Interseismic forward model predictions



uniform random noise (+/- 0.5) added to the model predictions to account for heterogeneity

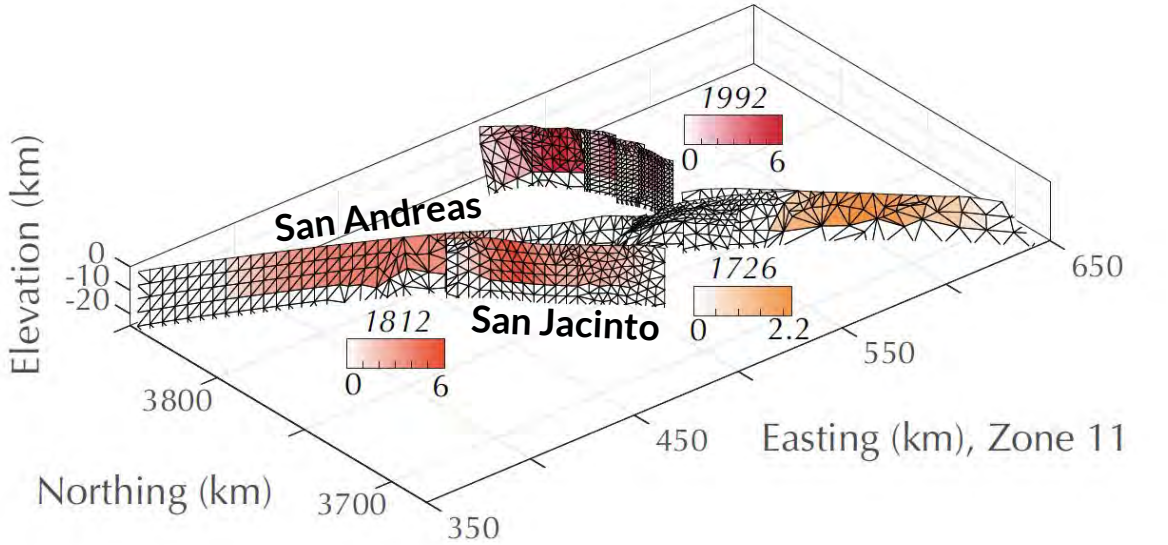




From Cooke and Beyer (2018)

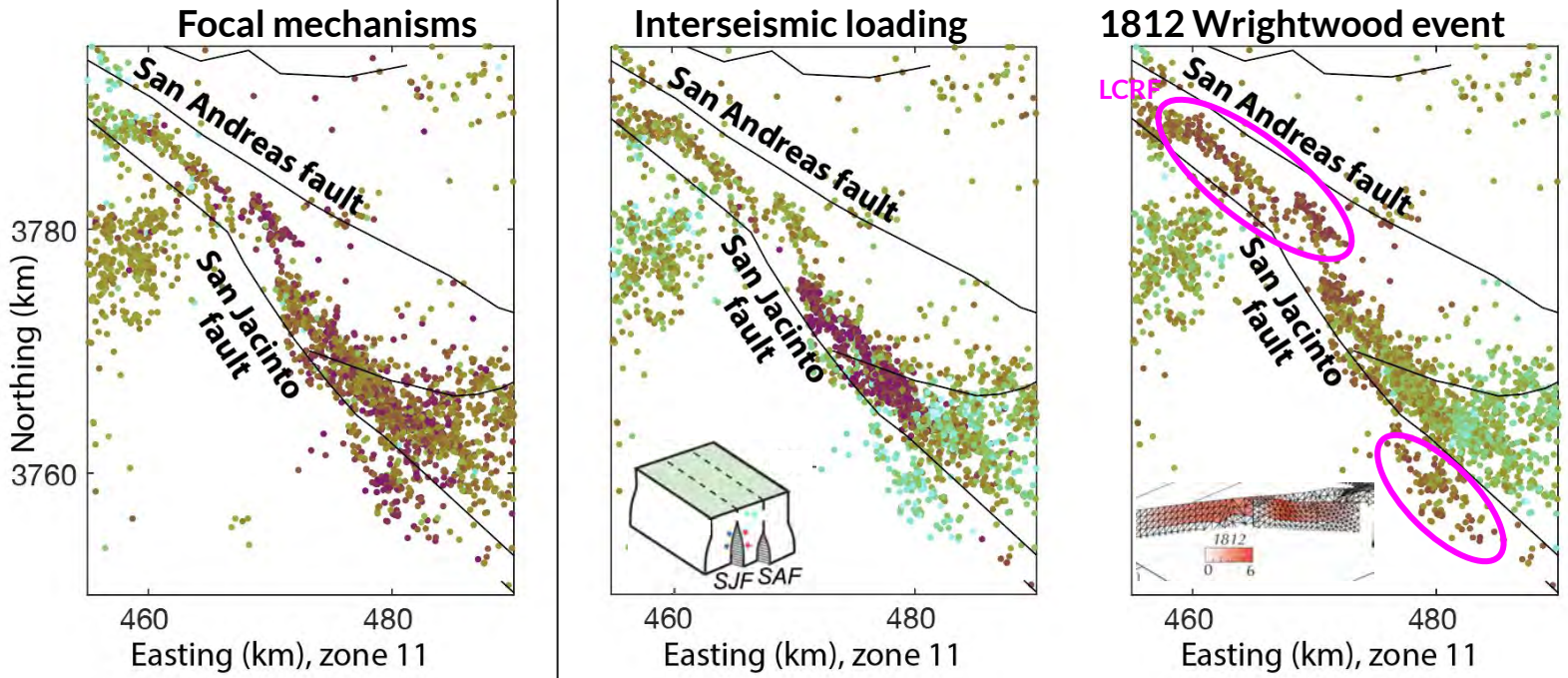
Wrightwood 1812 earthquake

Rupture extent and slip distribution based on Onderdonk et al., (2013 & 2015) Rockwell et al. (2016) and Lozos (2016)



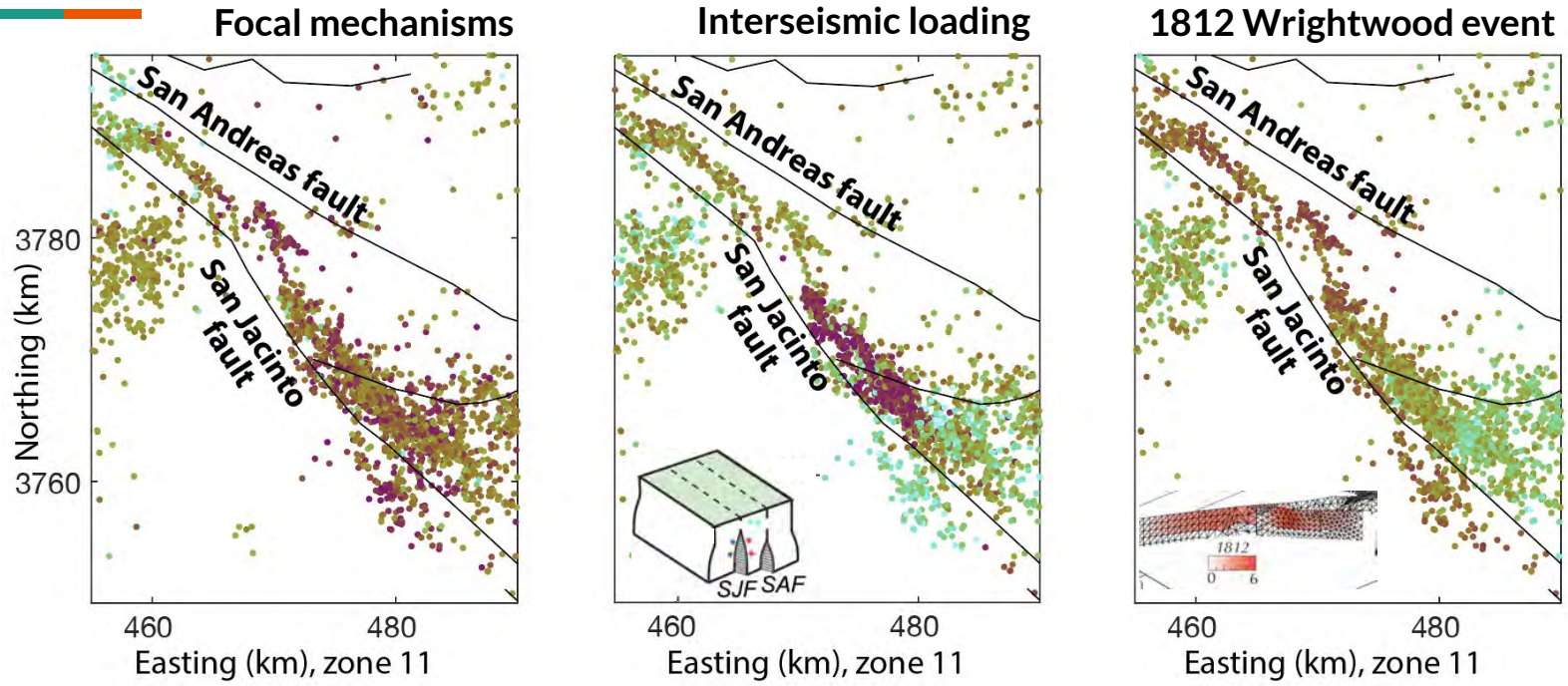
Hatch et al. (2020) show that recent earthquakes contribute to total stress state on nearby faults

Two contributions to stress state



Uniform random noise added to model results +/- 0.5

Recent events & interseismic loading -> stress state

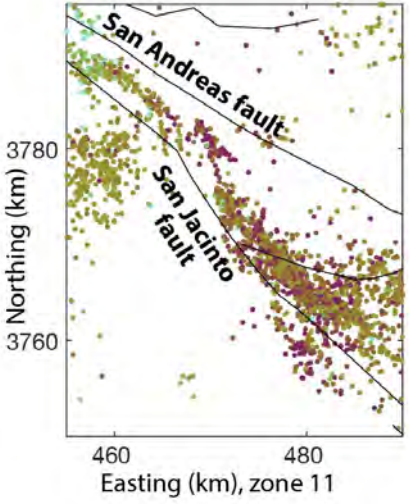


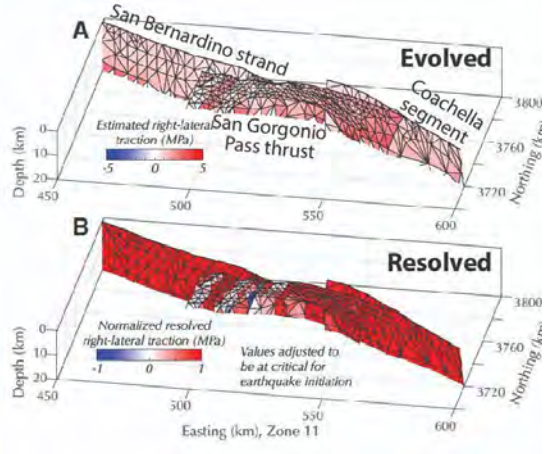
Regional stress state unreliable where fault behavior and geometry are complex

The regional stress state inaccurately predicts strike-slip microseismicity in the San Bernardino basin.

Stress state depends on interseismic loading & recent earthquakes ← on and off of faults

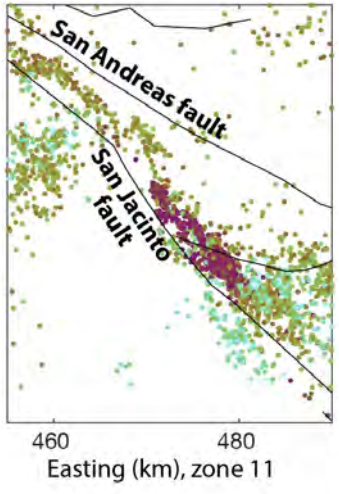
Focal mechanisms





From Hatch et al. (2020)

Interseismic loading



1812 Wrightwood