Comparative analysis of transform fault evolution from seismic anisotropy along the San Andreas system

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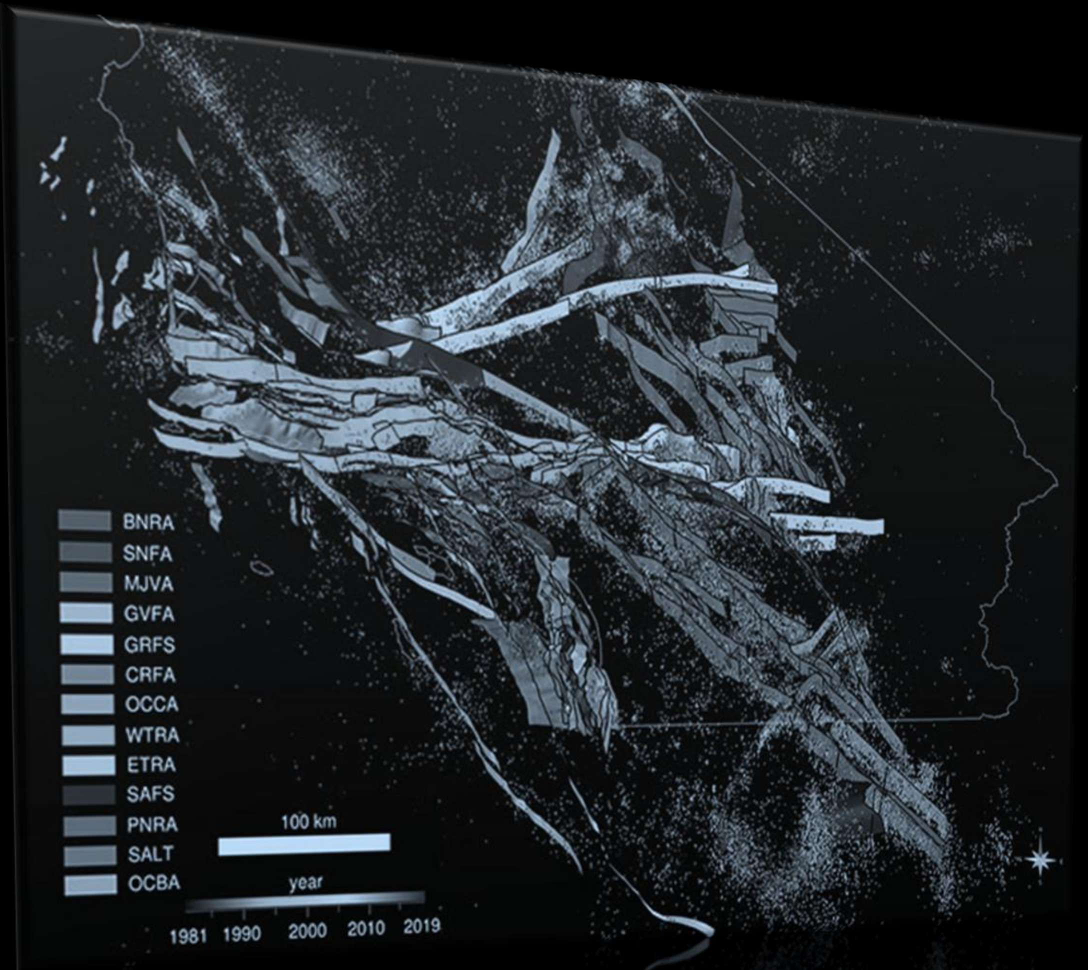
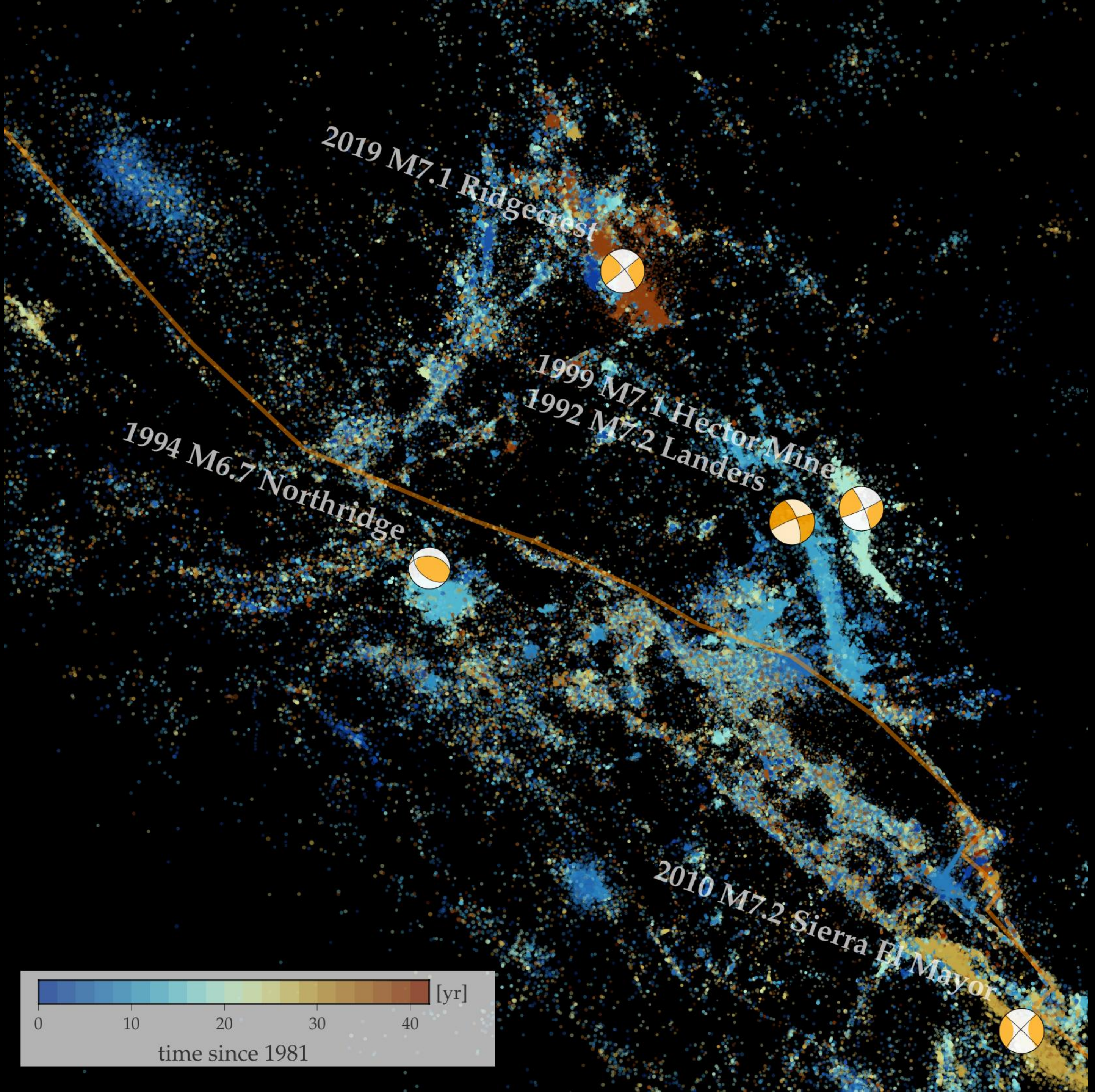
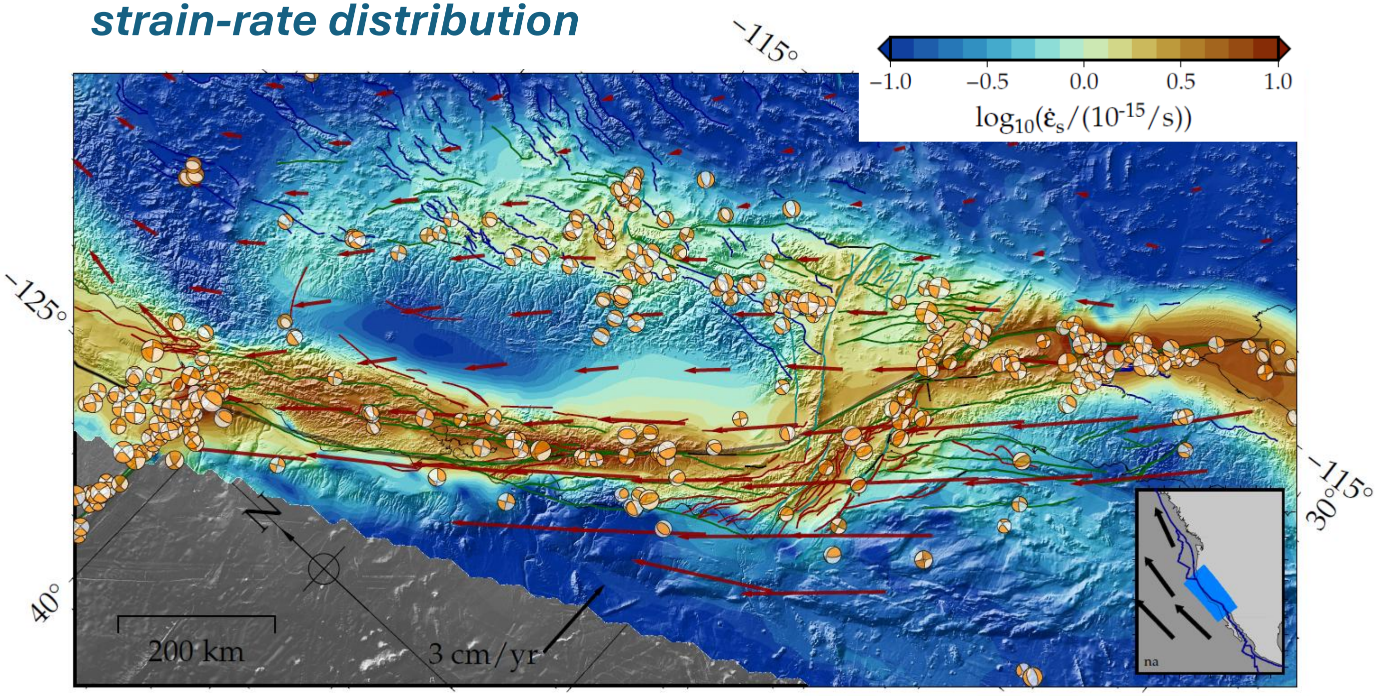

BNRA
SNFA
MJVA
GVFA
GRFS
CRFA
OCCA
WTRA
ETRA
SAFS
PNRA
SALT
OCBA
100 km
year
1981 1990 2000 2010 2019

SCEC CFM v. 7

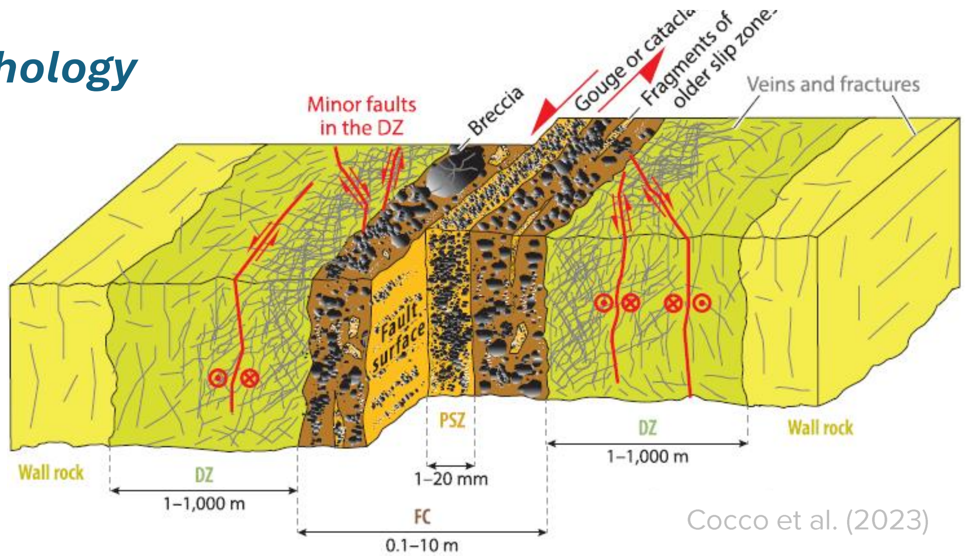

2019 M7.1 Ridgecrest
1999 M7.1 Hector Mine
1992 M7.2 Landers
1994 M6.7 Northridge
2010 M7.2 Sierra El Mayor
[yr]
0 10 20 30 40
time since 1981

Fault system evolution

strain-rate distribution

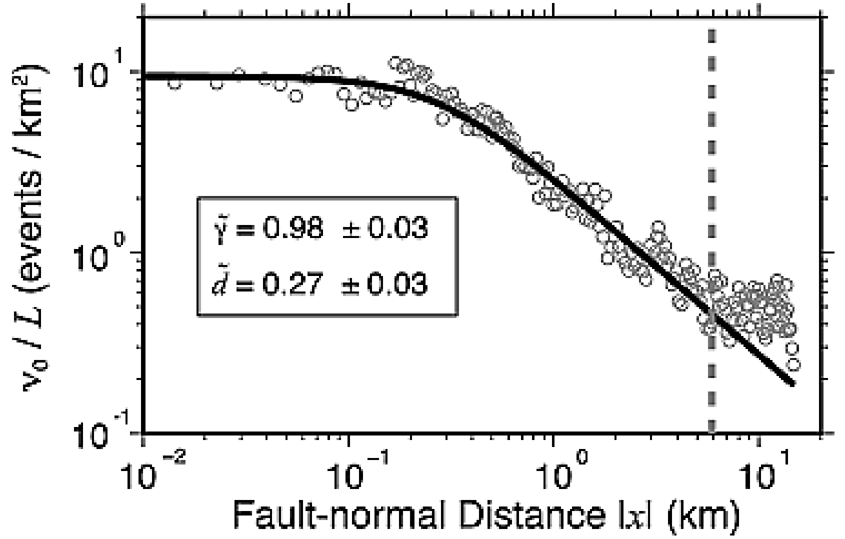


lithology



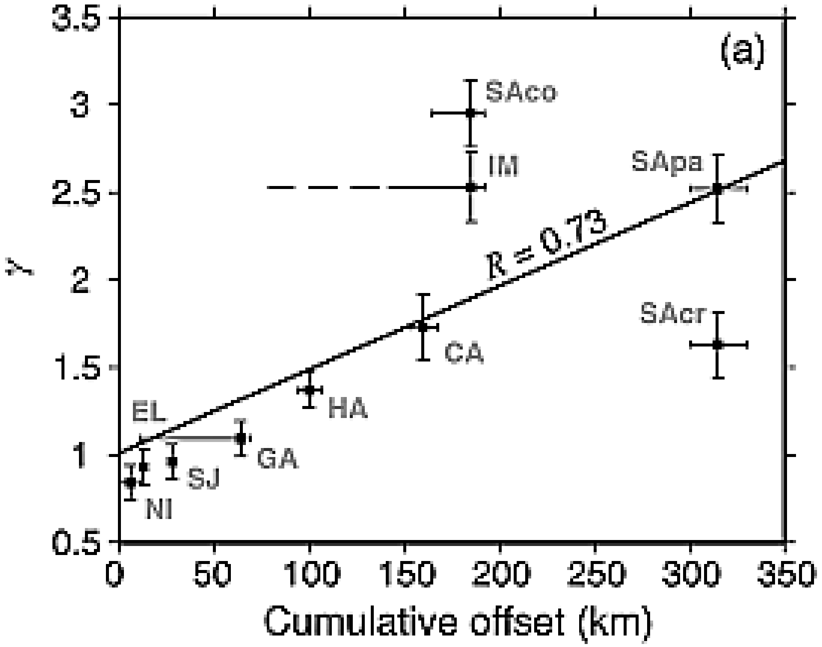
Cocco et al. (2023)

Off fault seismicity



seismicity distribution

off fault seismicity
rate of decay



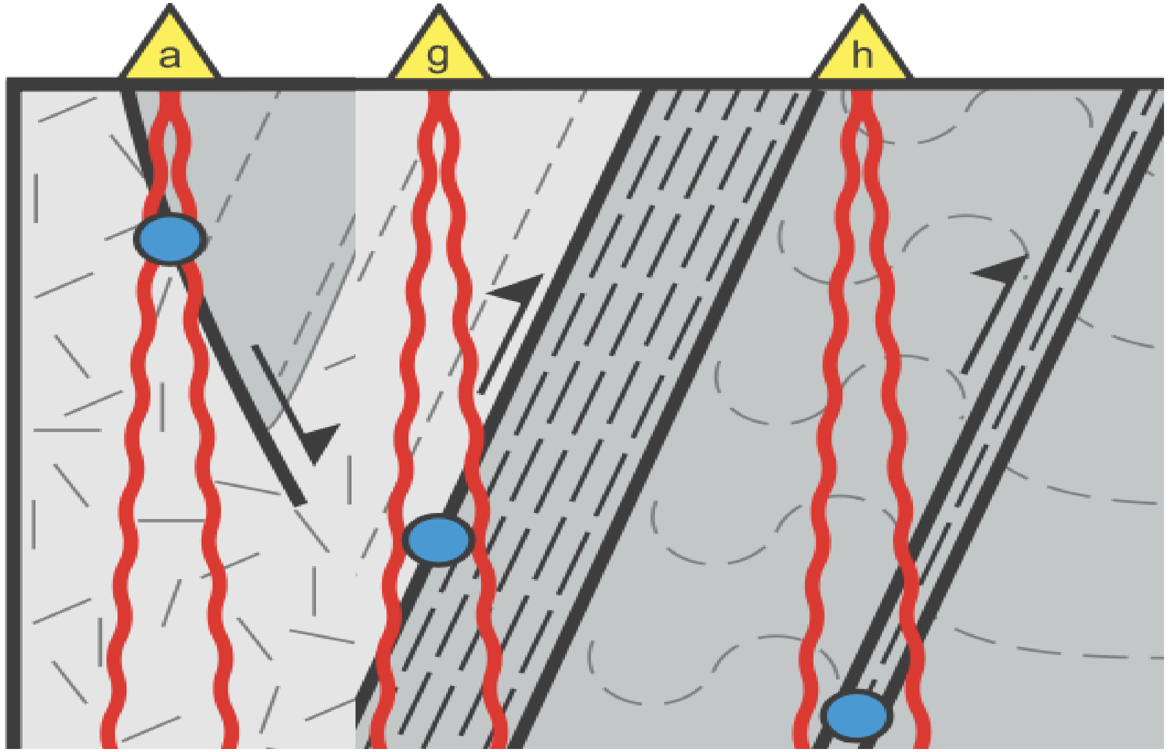
Puster and Jordan (2010)

Fault and shear zone imaging with receiver function anisotropy

seismic station

conversions from this depth vary with azimuth

teleseismic rays



Frothingham et al. (2022)

faults

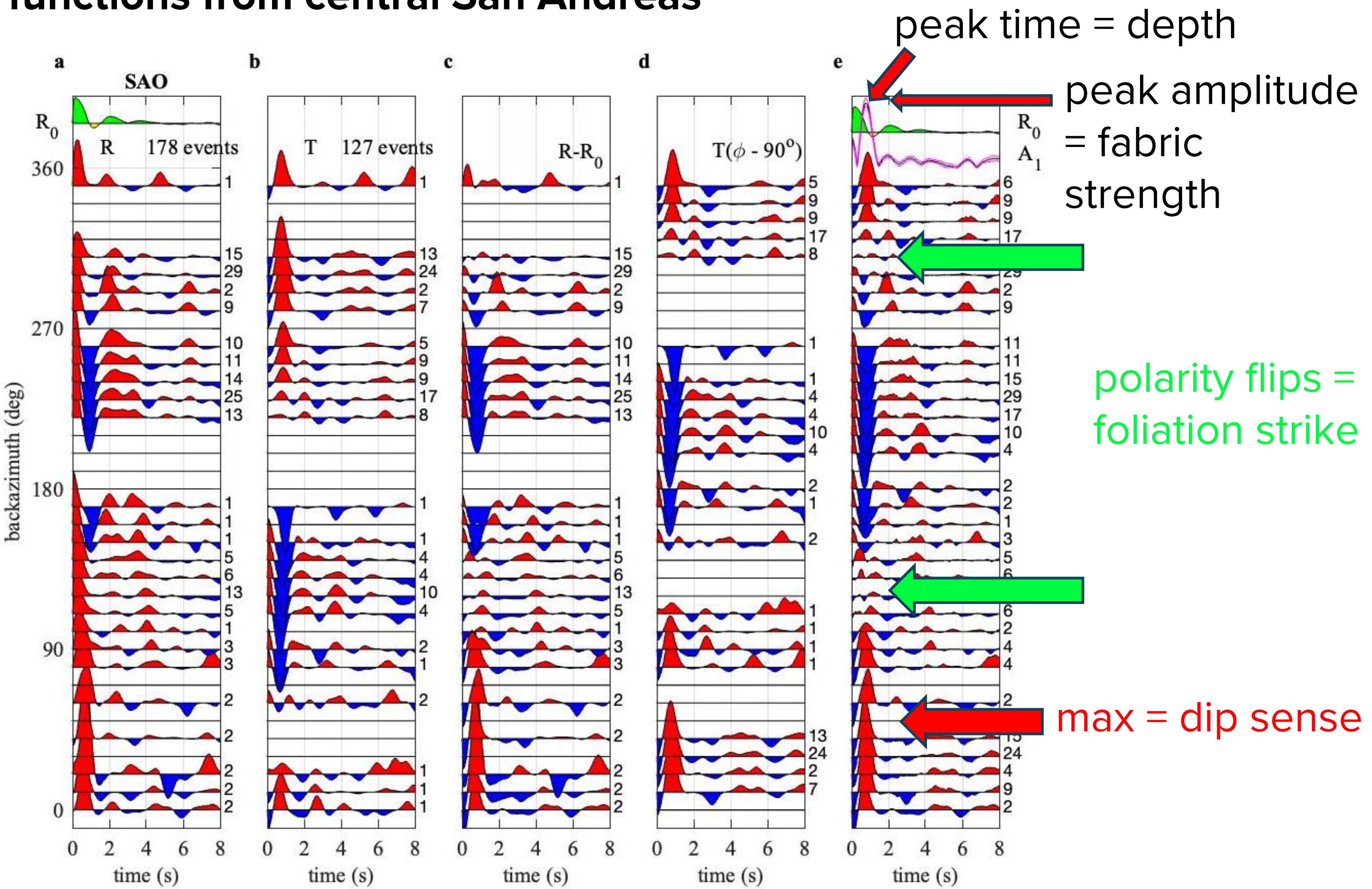
shear zones

Example receiver functions from central San Andreas

Station SAO

2 km from SAF surface trace

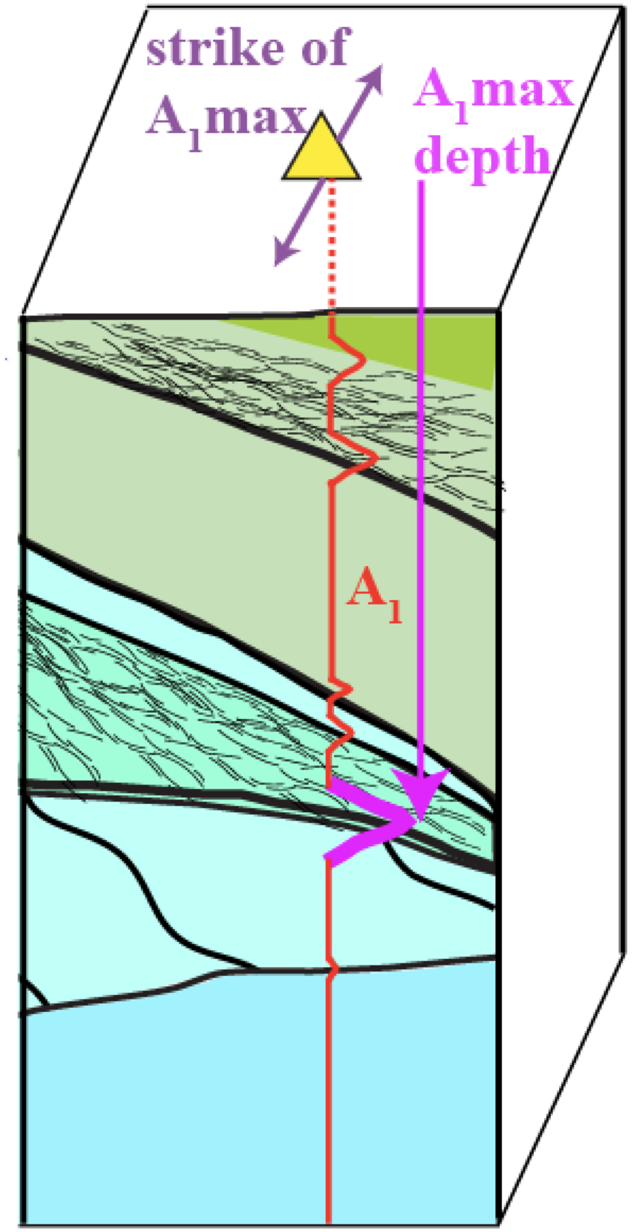
Large conversion from ~6 km depth



e.g. Schulte-Pelkum et al. (2020)

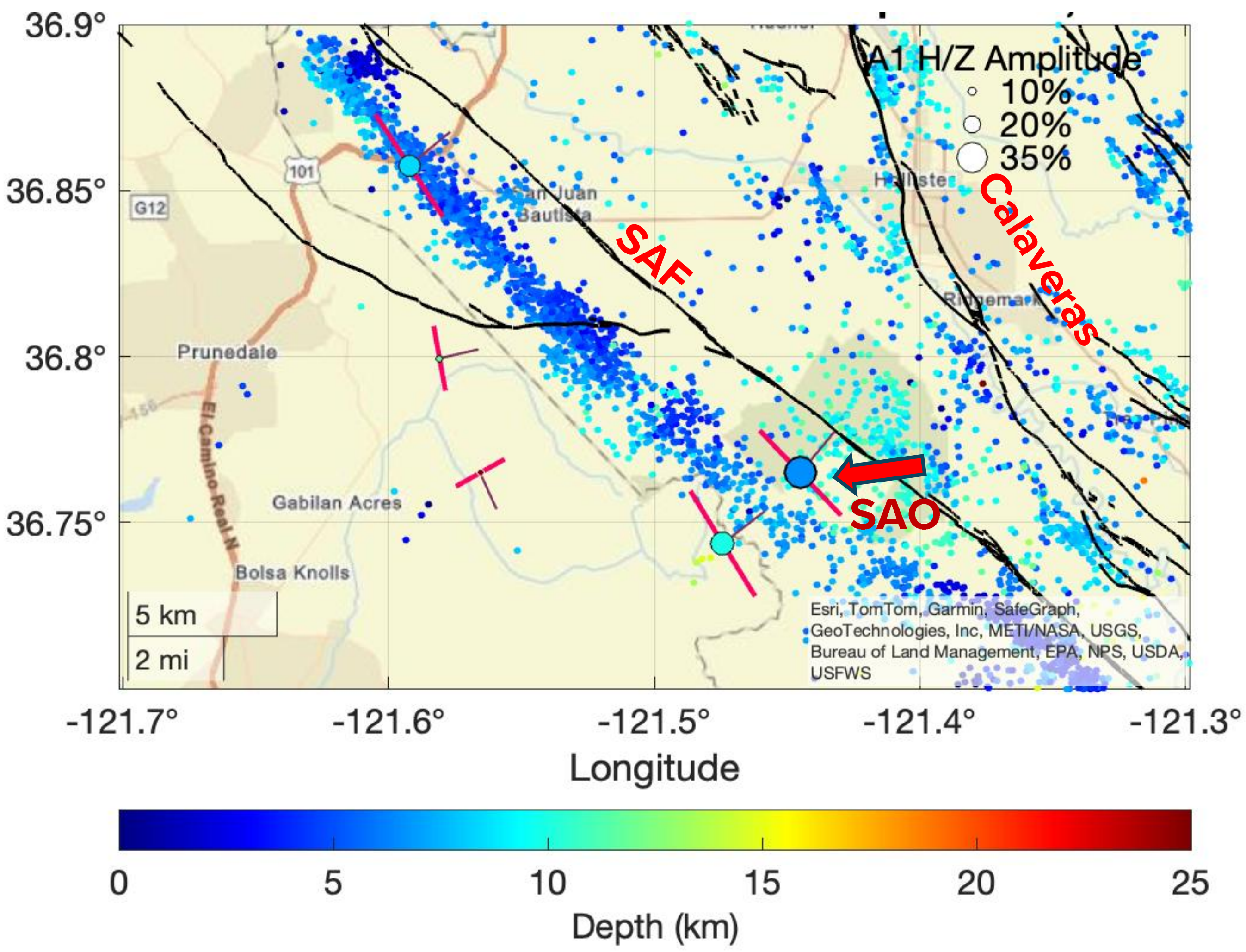
Imaged fabric contrasts: Receiver function (RF) anisotropy parameters

- Depth (from time)
- Fabric strike at contrast (from first azimuthal harmonic phase)
- **Strength of fabric at contrast** (from harmonic amplitude), $\mathbf{A_1}$
- Dip sense of dipping fabric (from phase)

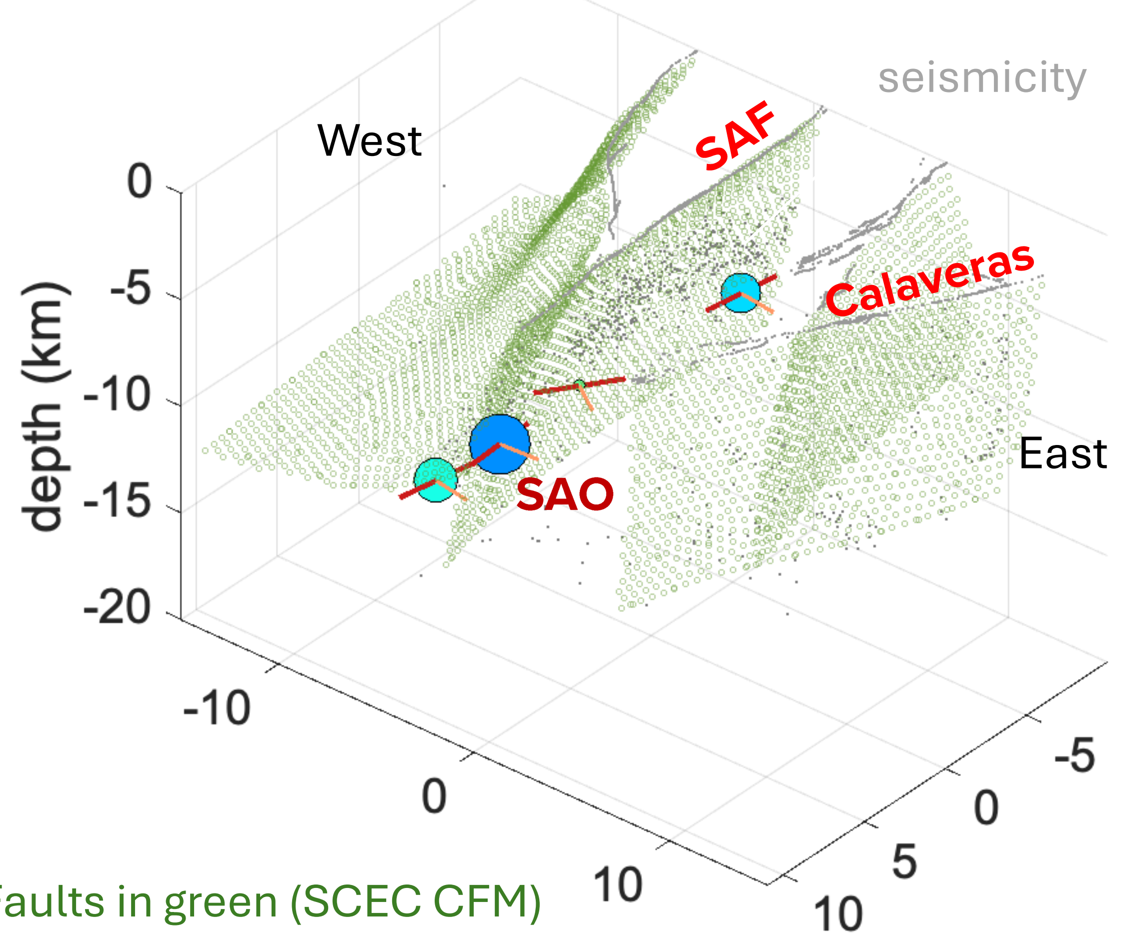


RF results: San Andreas (SAF) near Calaveras fault junction

Station SAO from waveform example

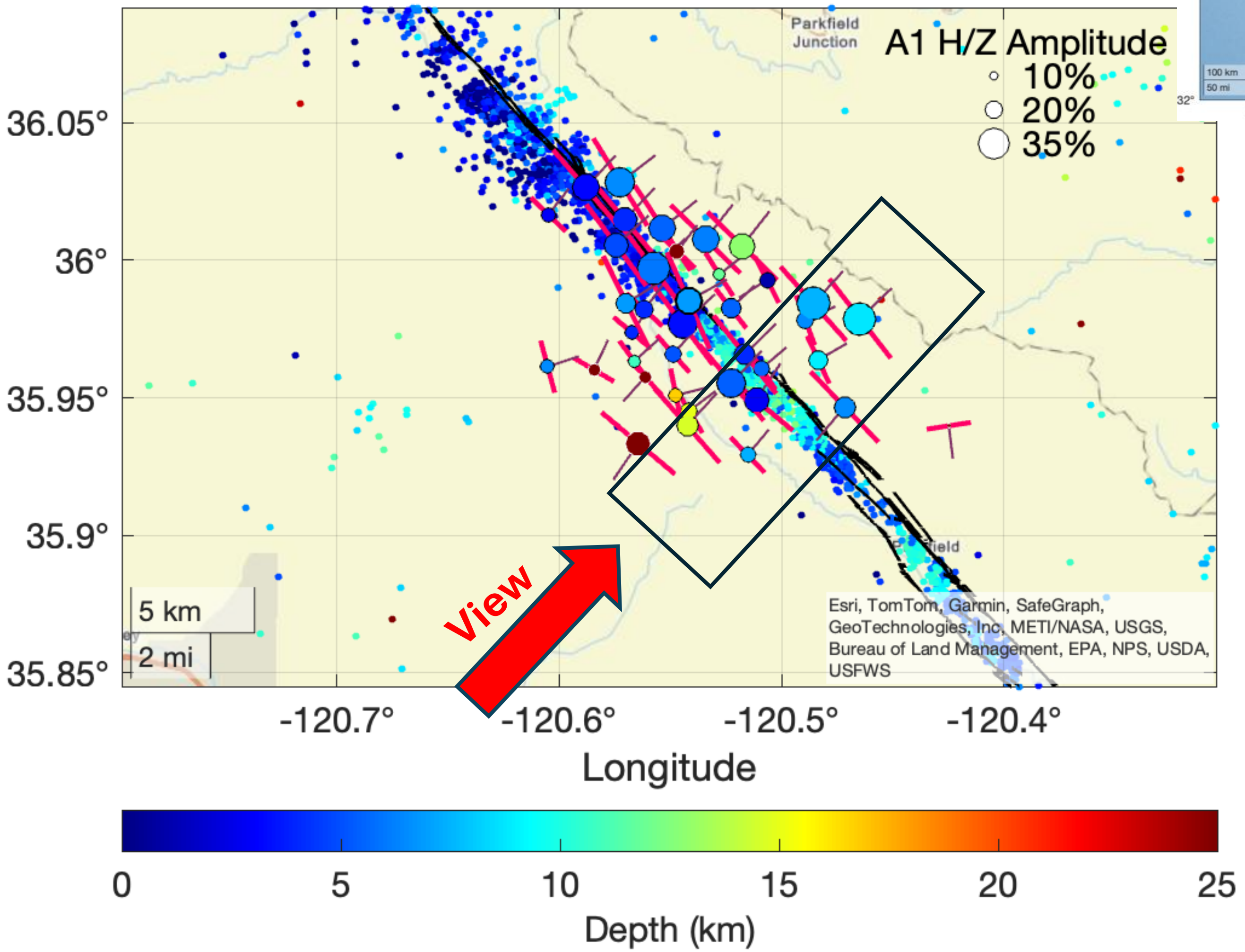


- strike || SAF
- conversion depth just below seismicity

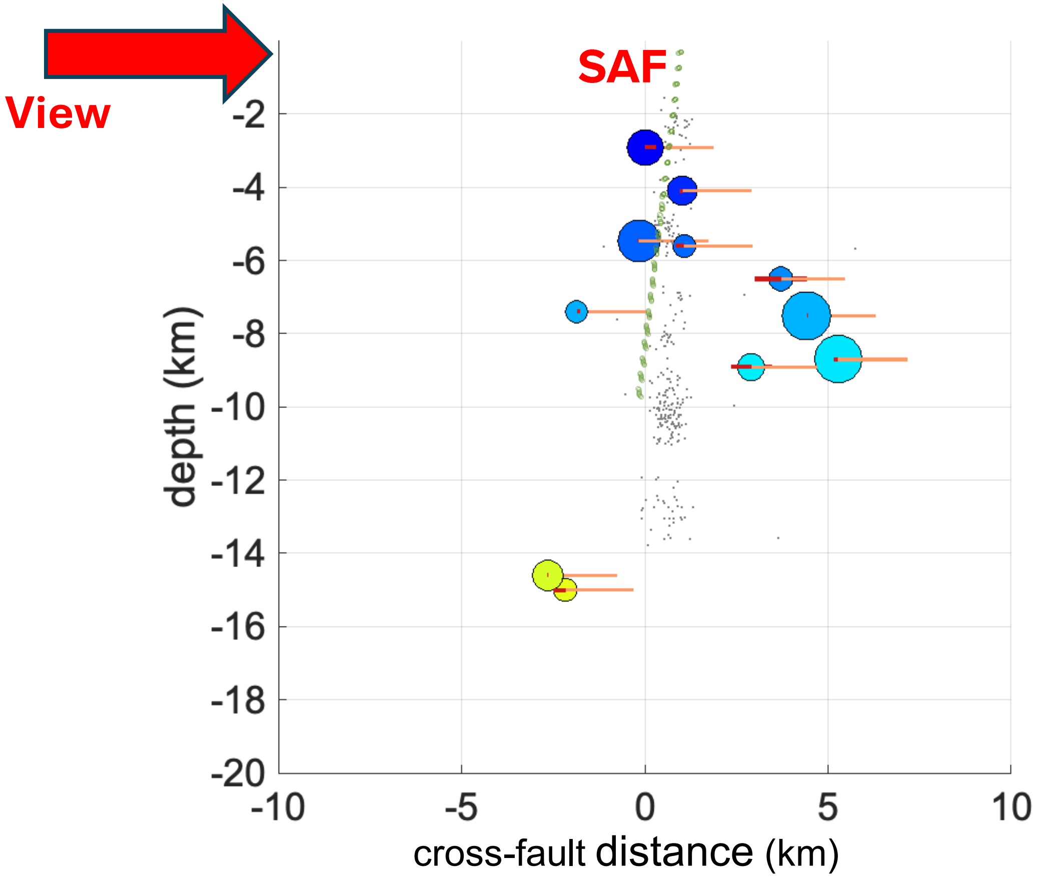


Faults in green (SCEC CFM)

RF results: SAF near Parkfield/SAFOD

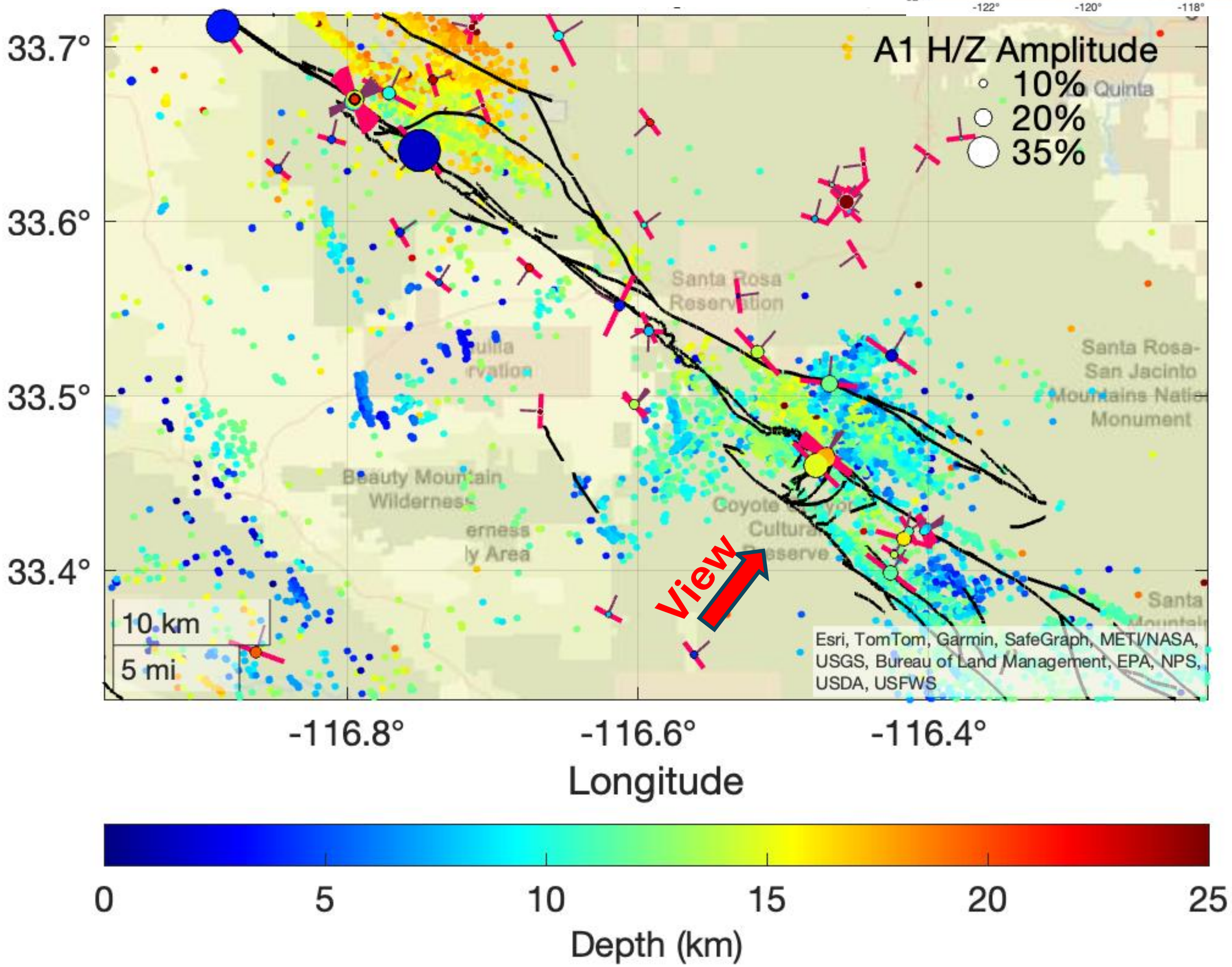


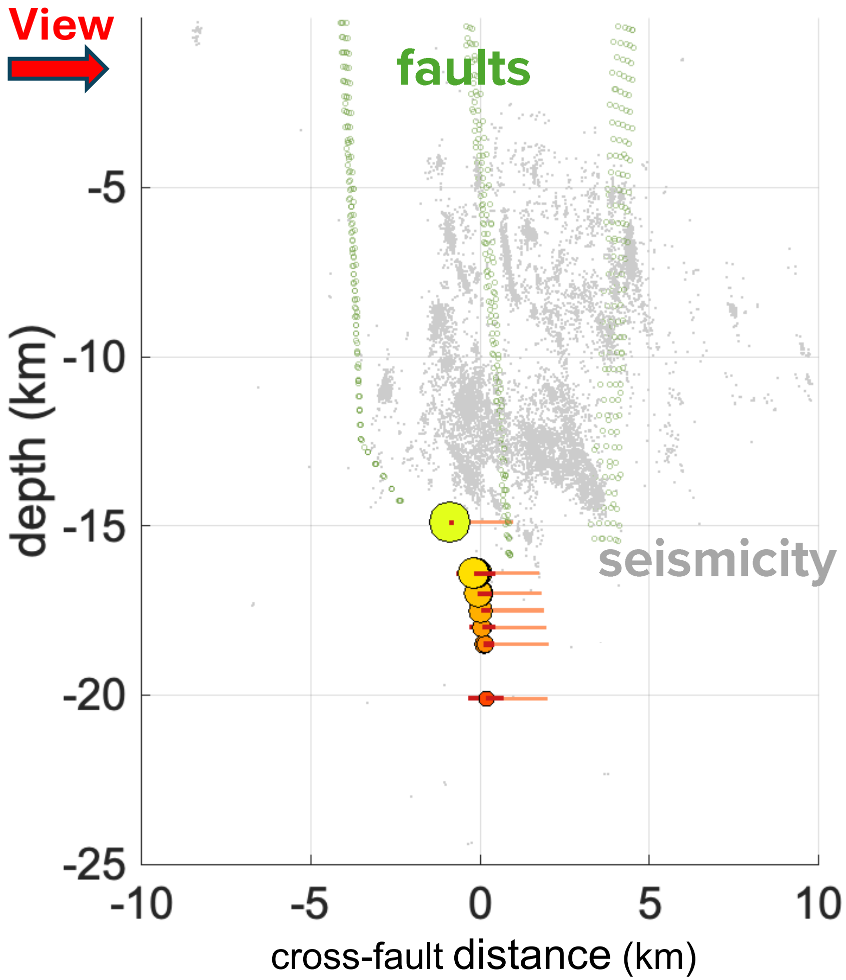
- strike || SAF
- dip sense to NE on both(!) sides of fault
- contrasts deepen away from fault



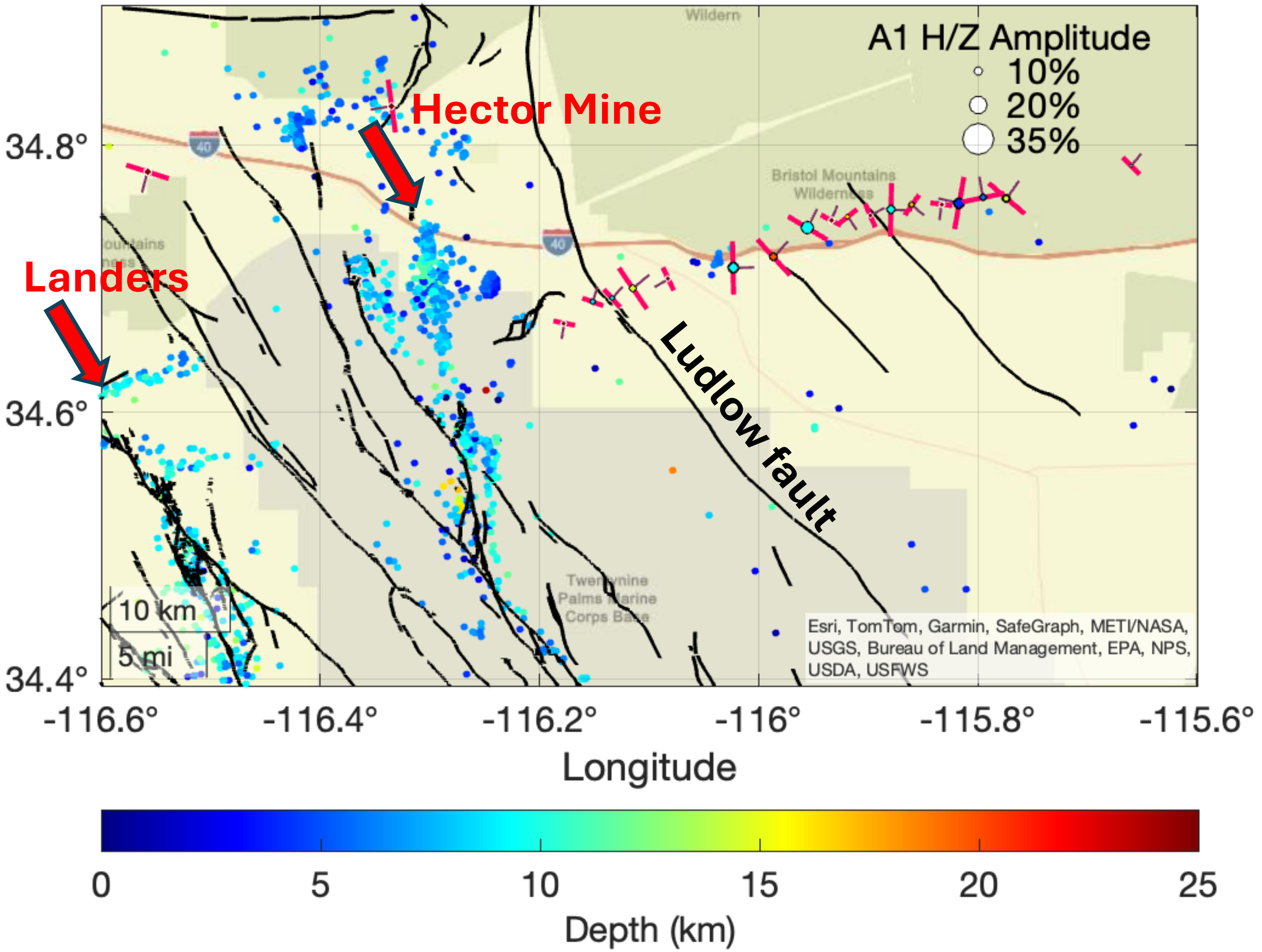
RF results:
San Jacinto fault zone

- dense station line in trifurcation
- strike || fault strands
- conversions below seismicity
- amplitudes decrease below brittle ductile transition



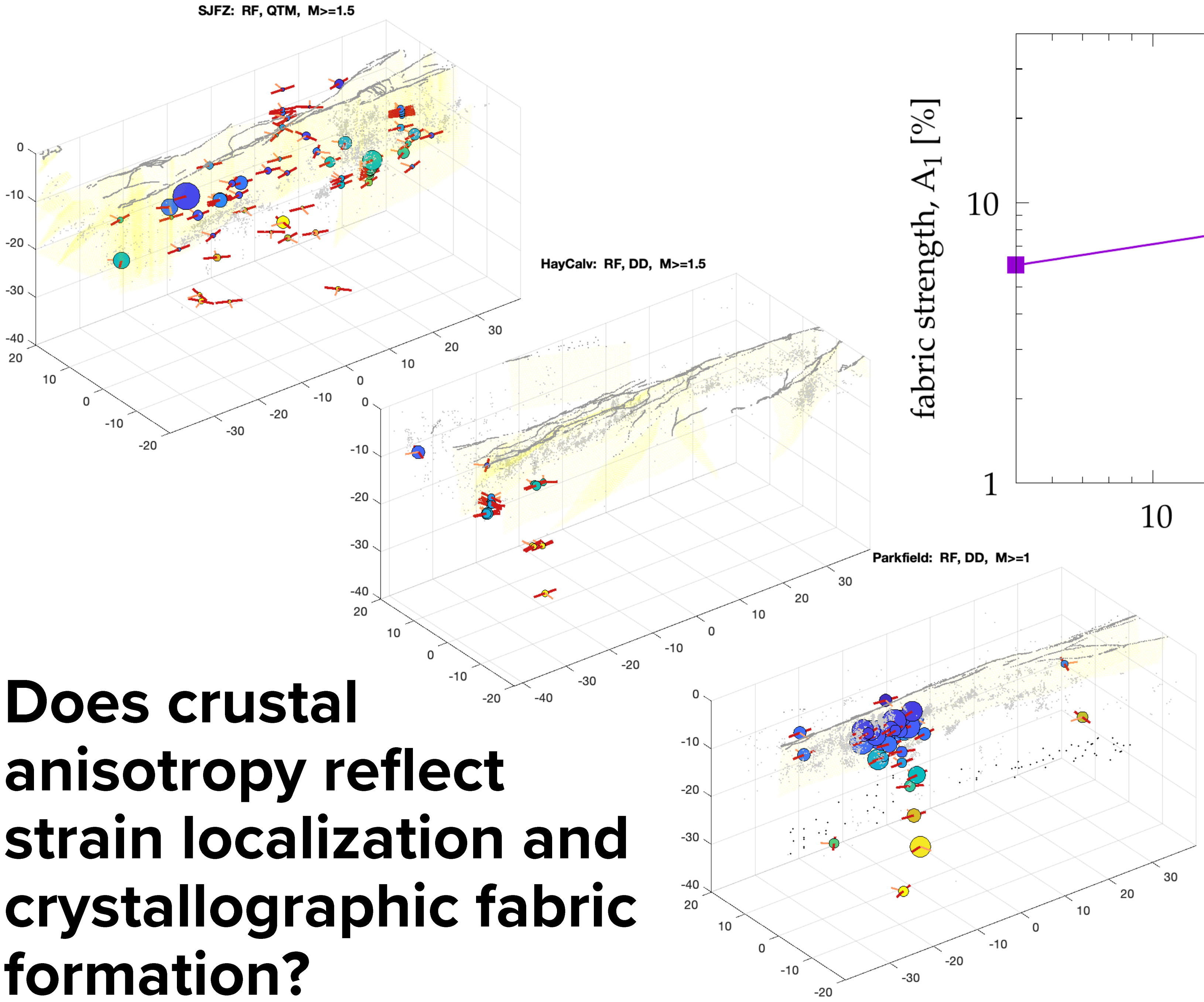


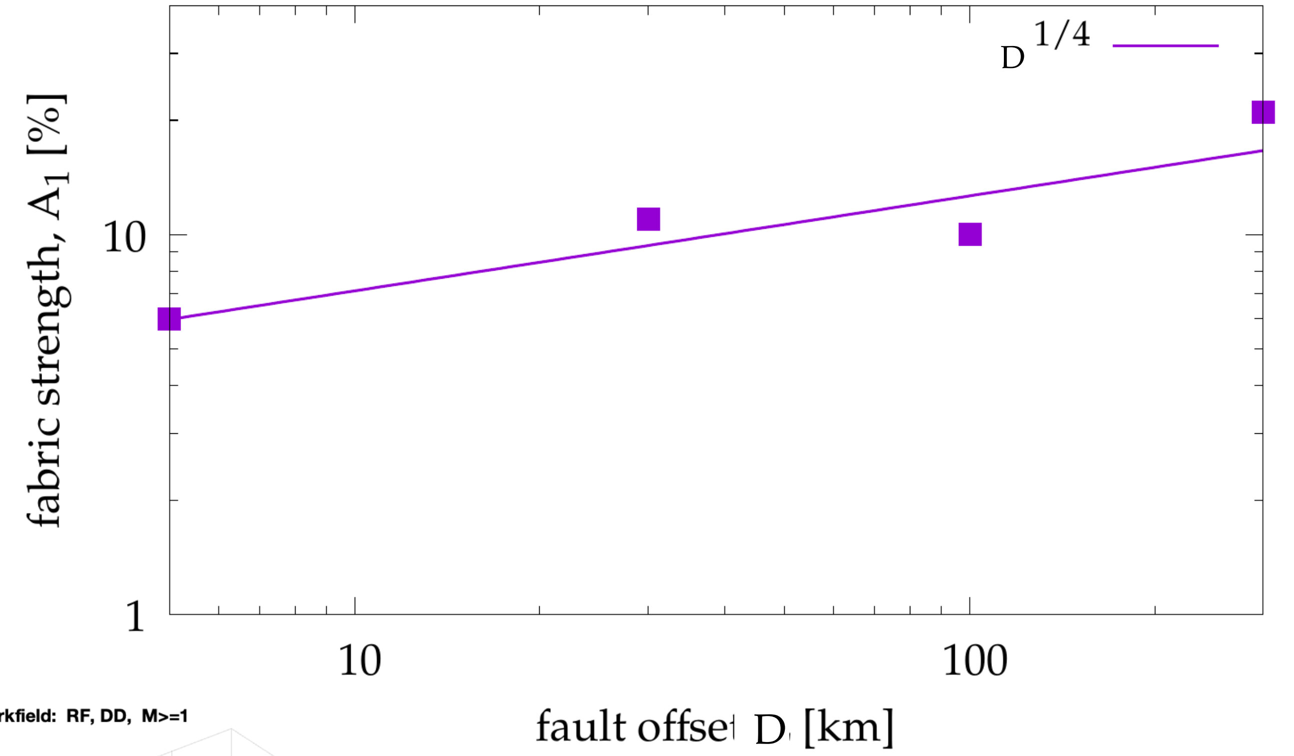
RF results: Mojave – Eastern California shear zone



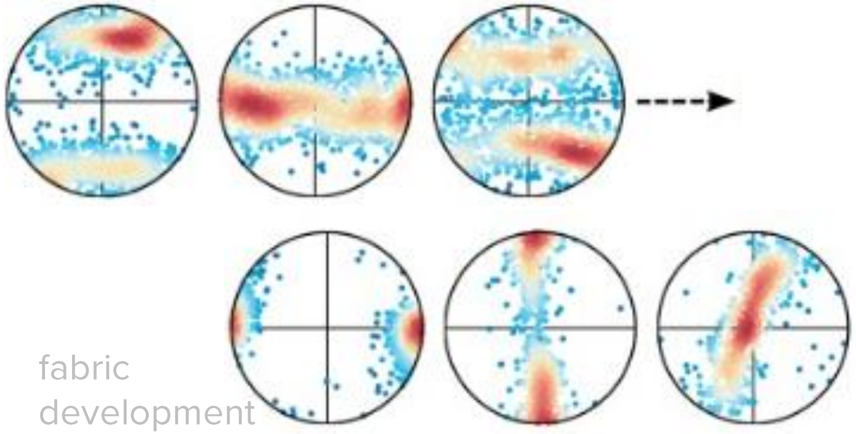
- very small amplitudes, dips to NE
- somewhat fault-parallel, more scatter

UTIG broadband seismometer deployment (2018 – 2021)





Does crustal anisotropy reflect strain localization and crystallographic fabric formation?

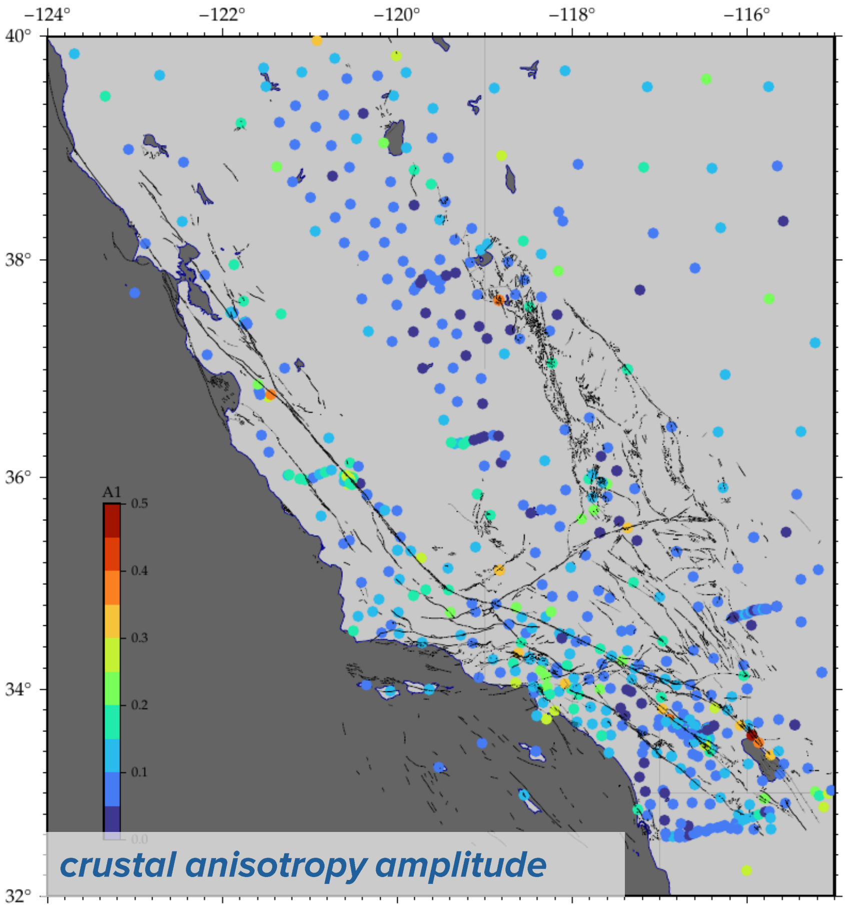


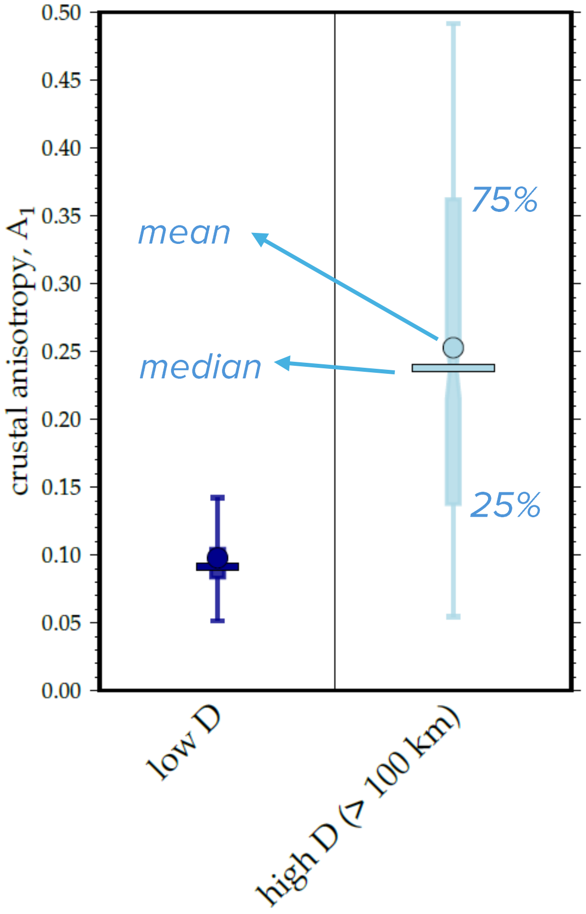
fabric development under shear

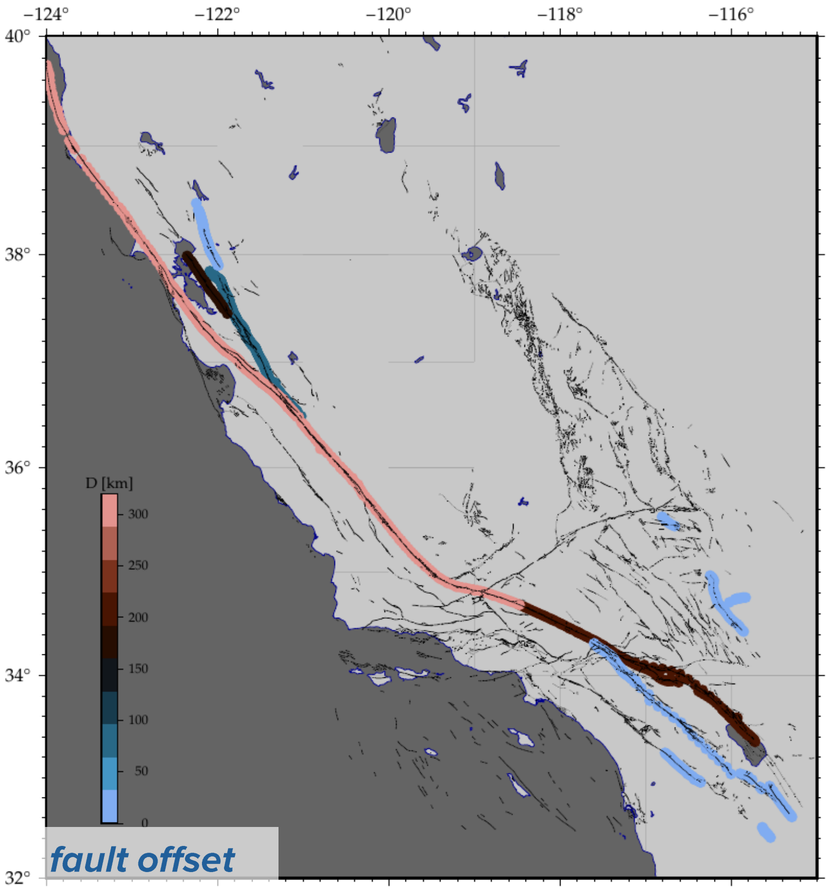
Hansen et al. (2016)

Crustal anisotropy versus fault offset

distribution of crustal anisotropy strength (within 5 km of fault) for low and high age/offset (D) regions

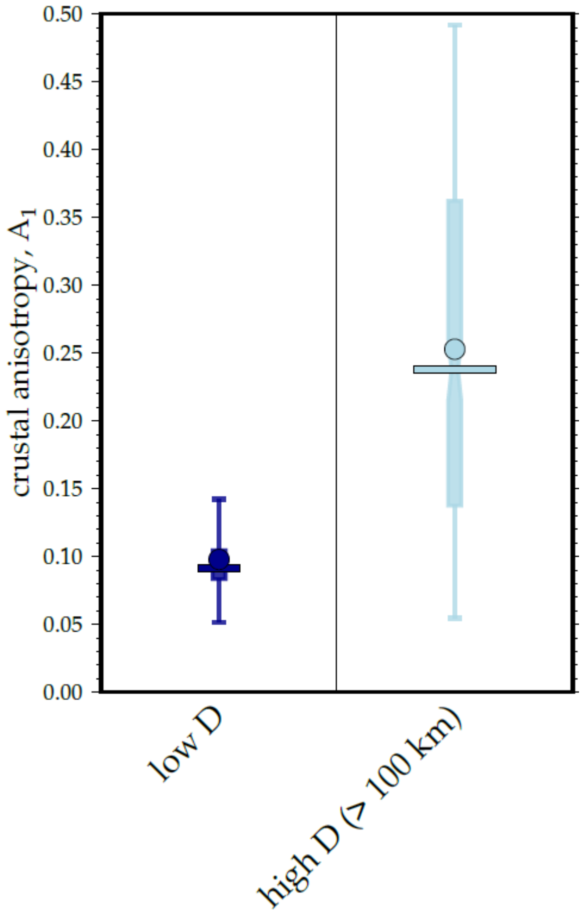




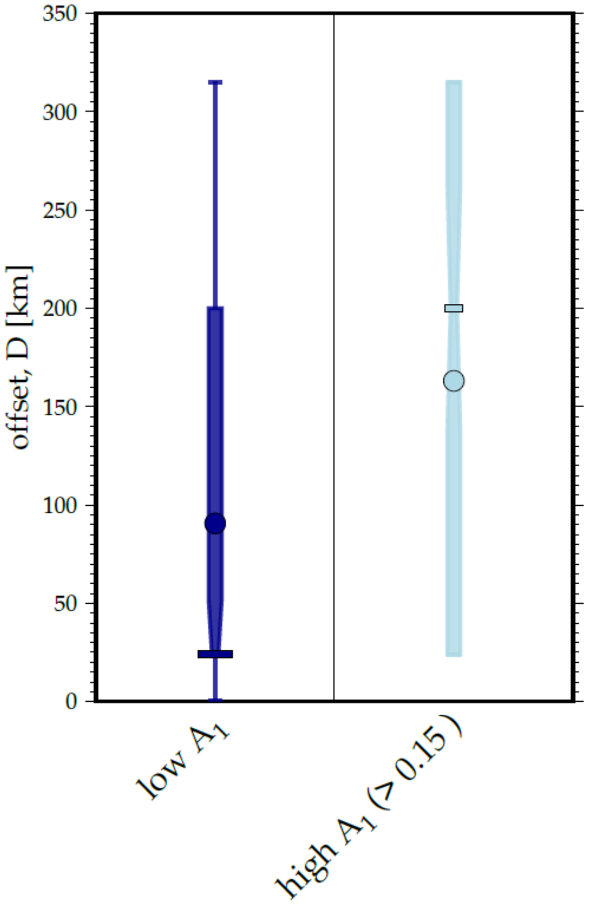


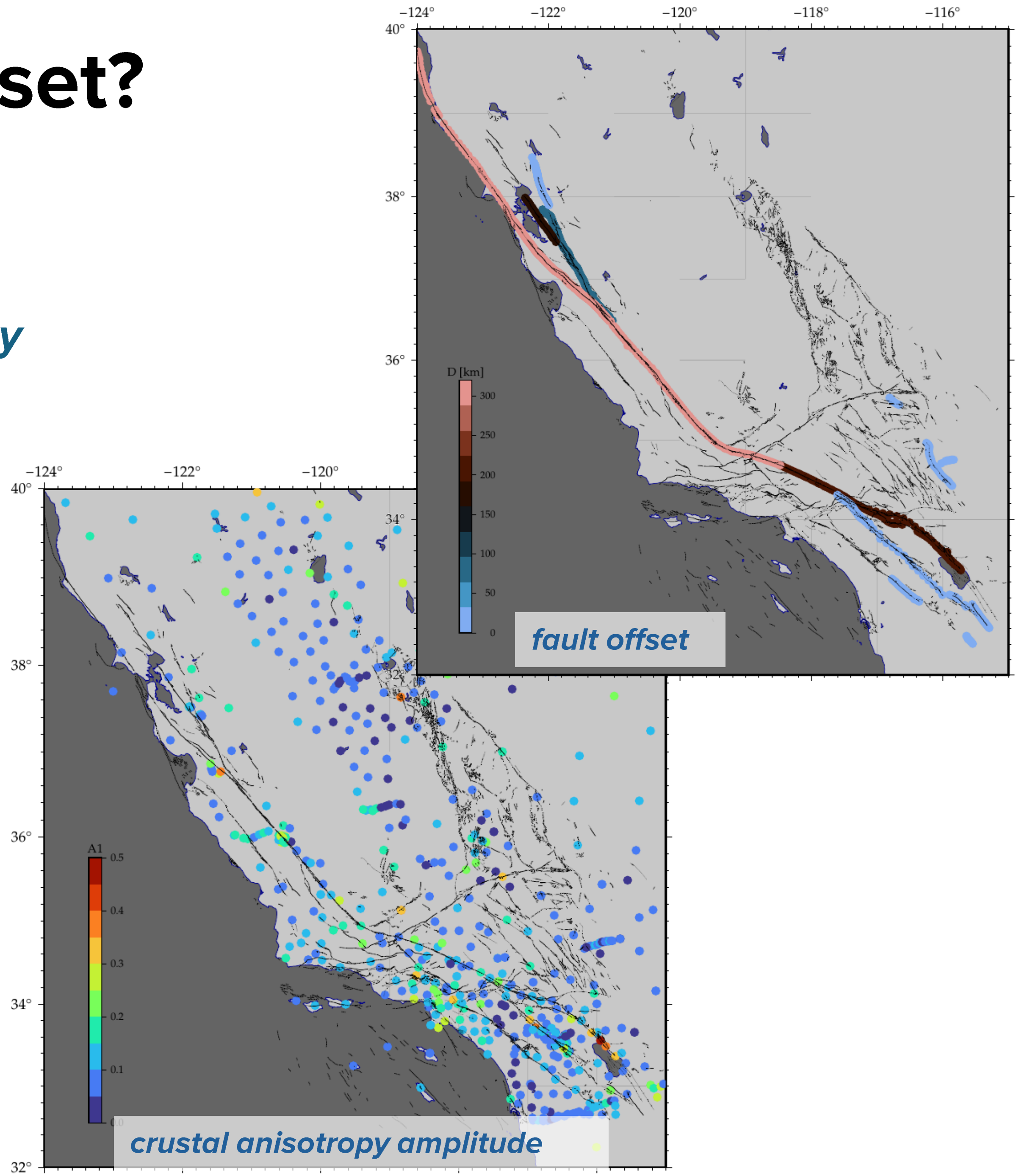
Crustal anisotropy vs. fault offset?

crustal anisotropy strength for low and high offset

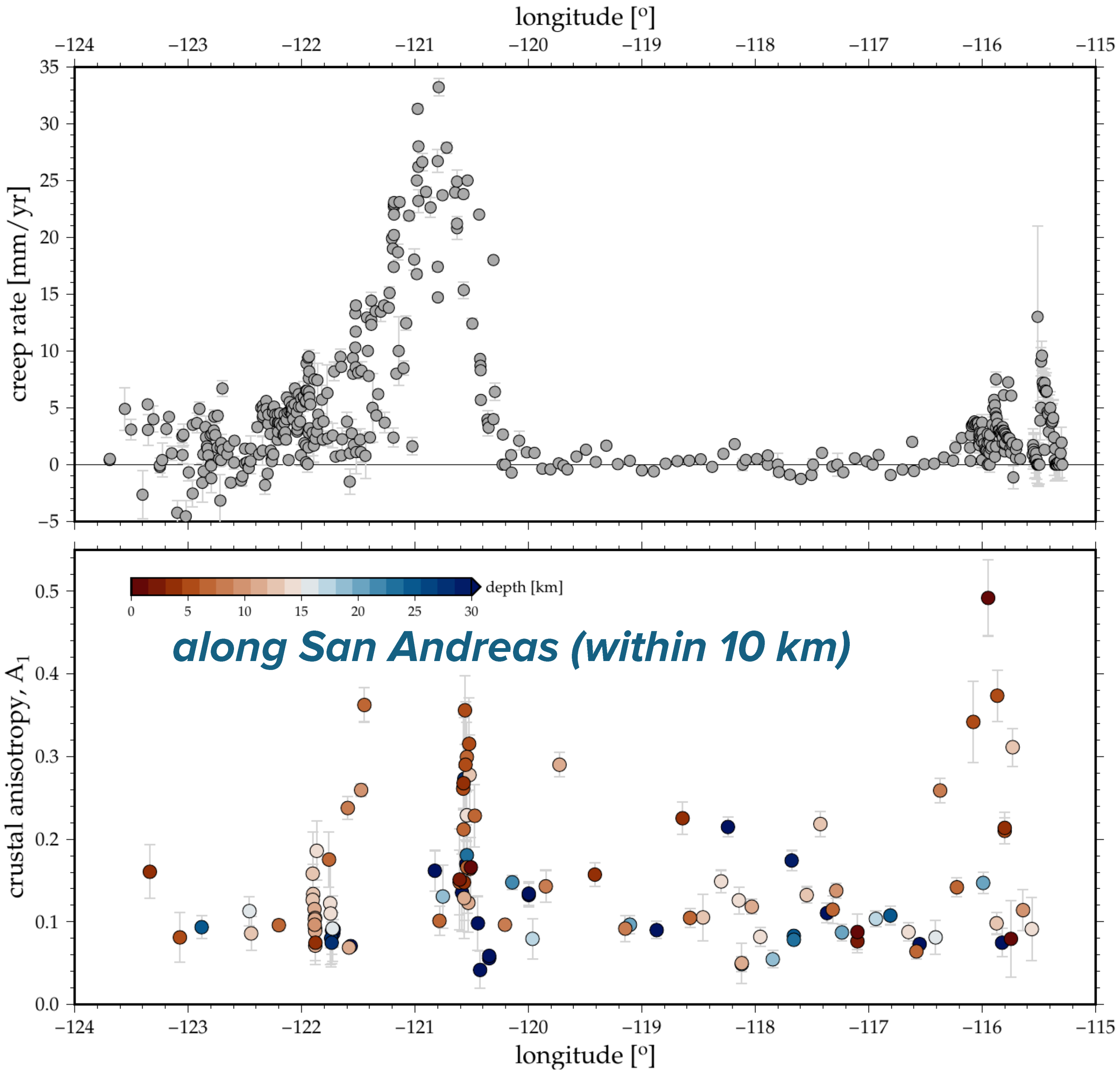


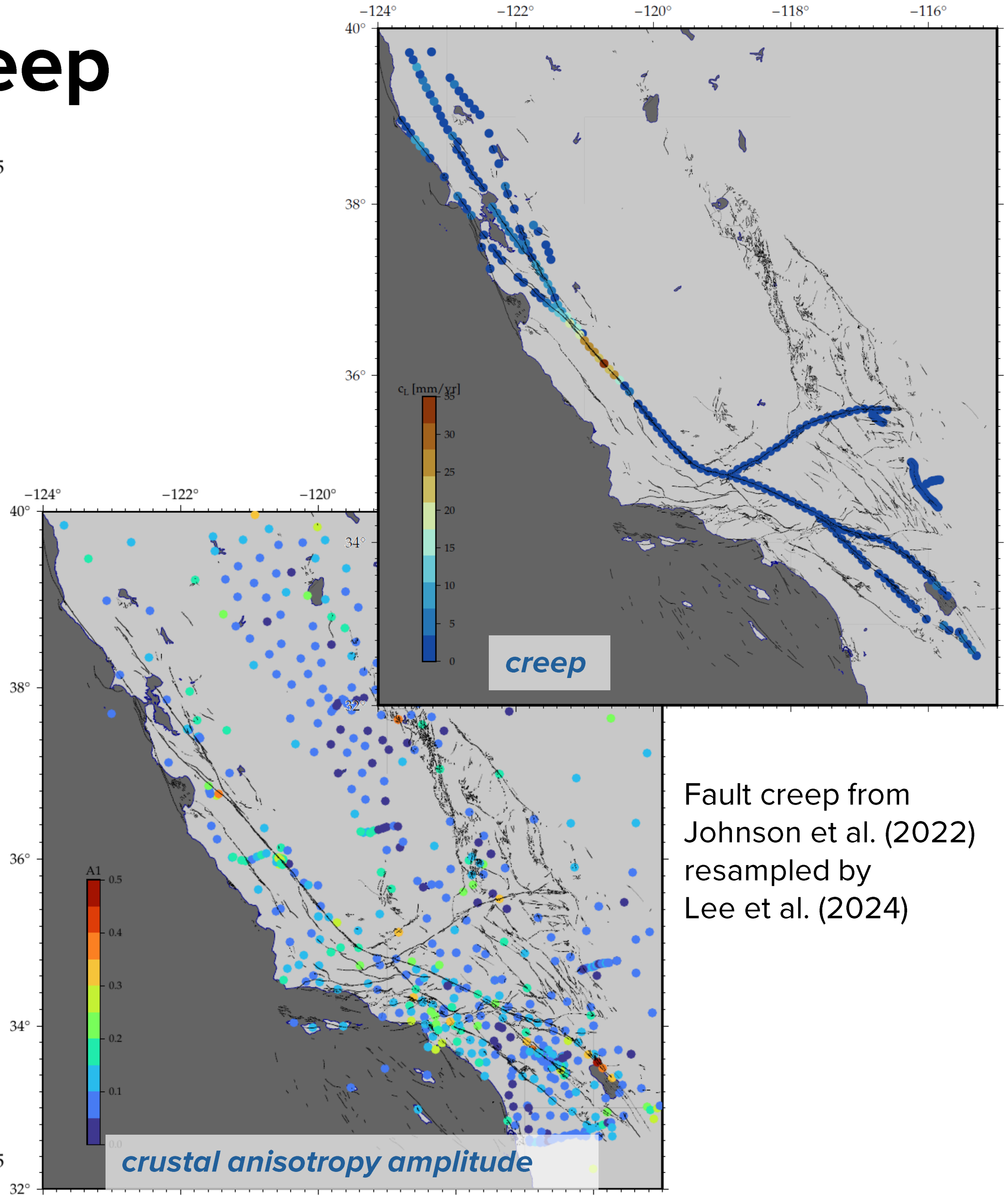
offset for low and high anisotropy





Crustal anisotropy vs. fault creep

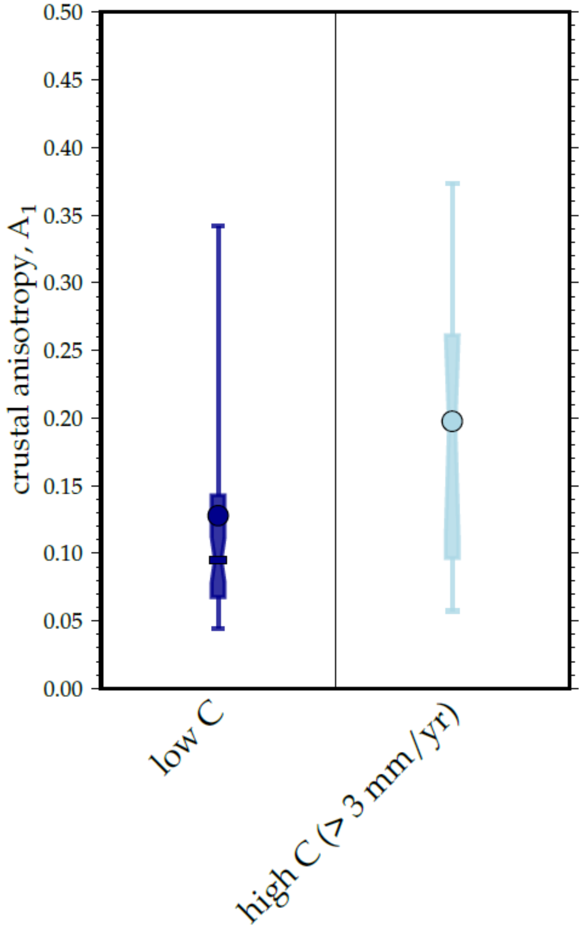




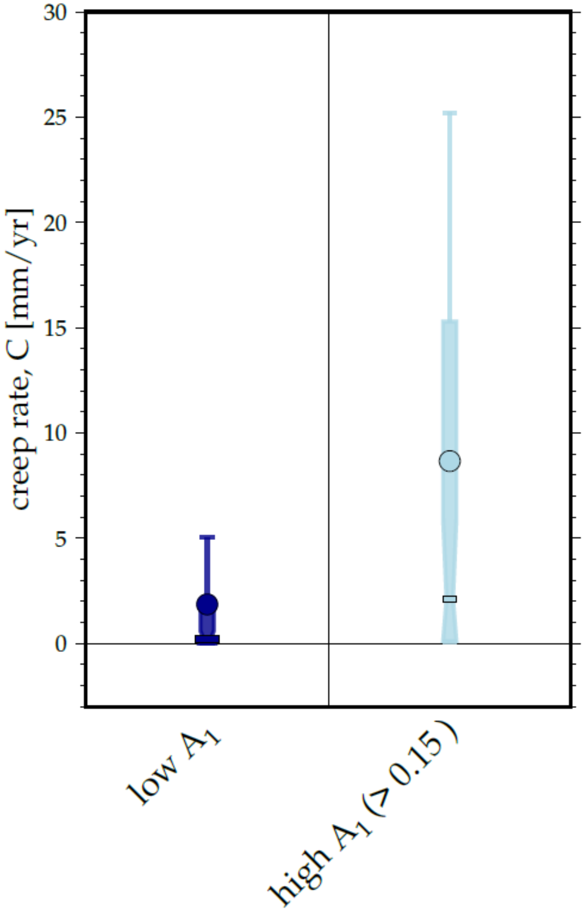
Fault creep from Johnson et al. (2022) resampled by Lee et al. (2024)

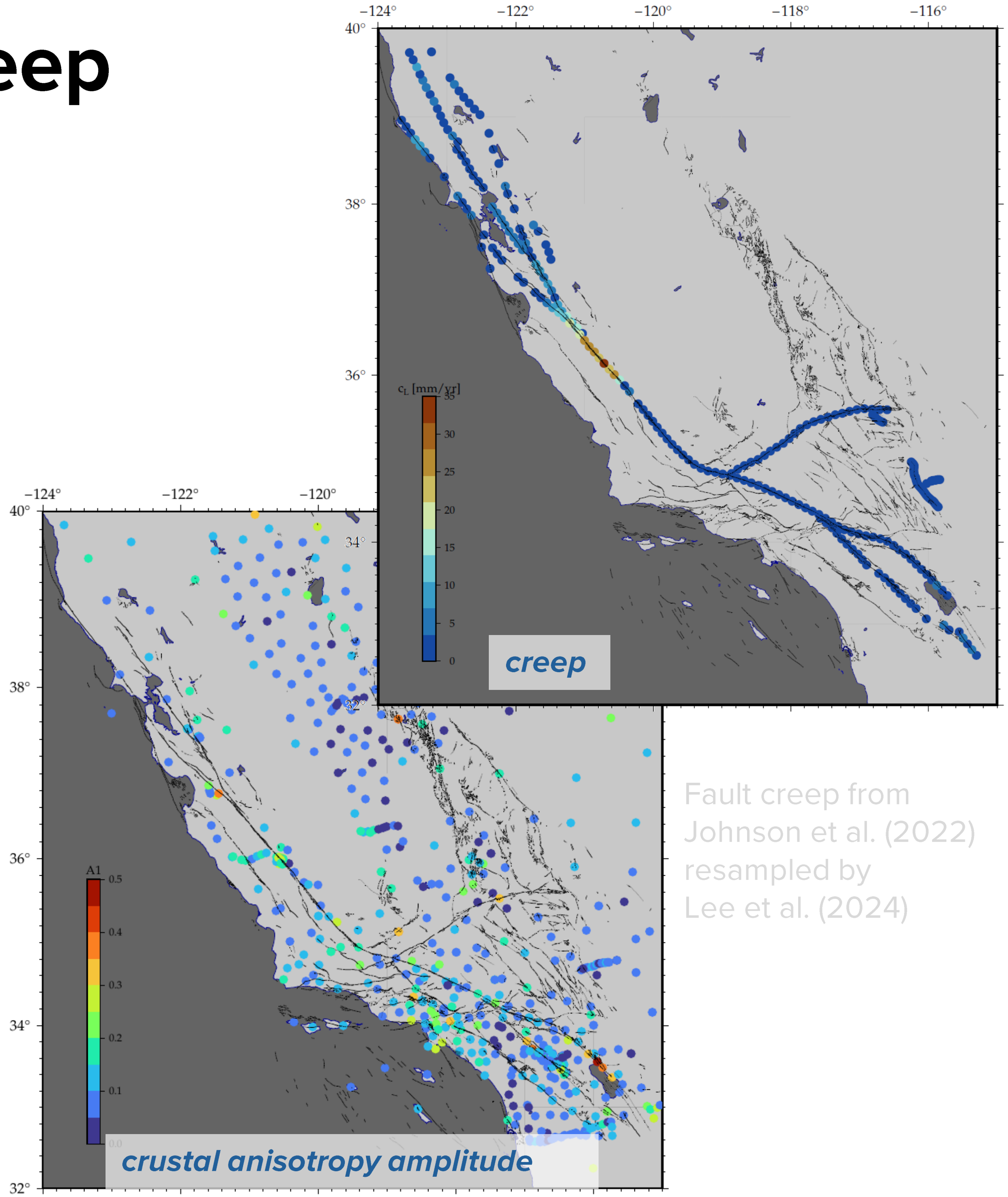
Crustal anisotropy vs. fault creep

crustal anisotropy strength for low and high creep



creep for low and high anisotropy





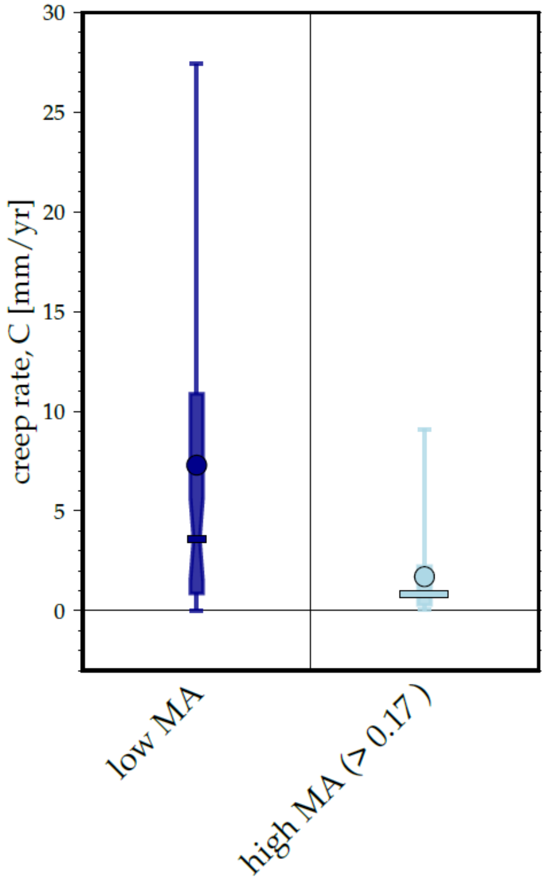
Fault creep from Johnson et al. (2022) resampled by Lee et al. (2024)

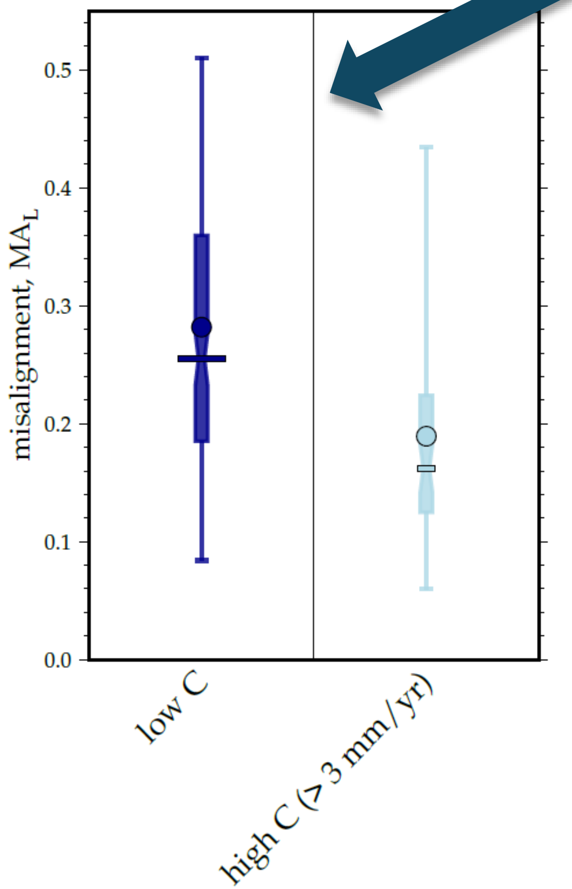
Fault misalignment vs. creep

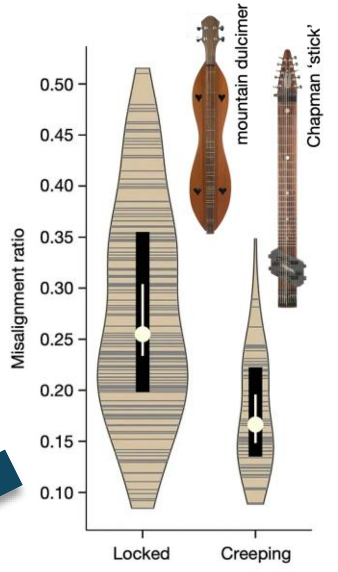
Bradley & Hubbard (2024) version of Lee et al.'s figure

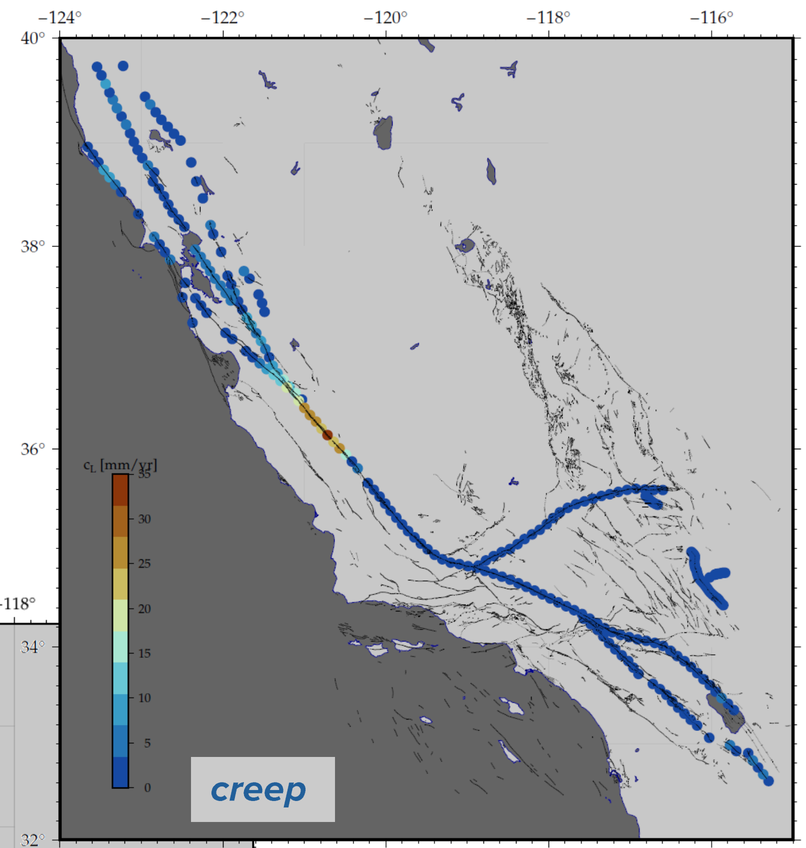
creep for low and high misalignment

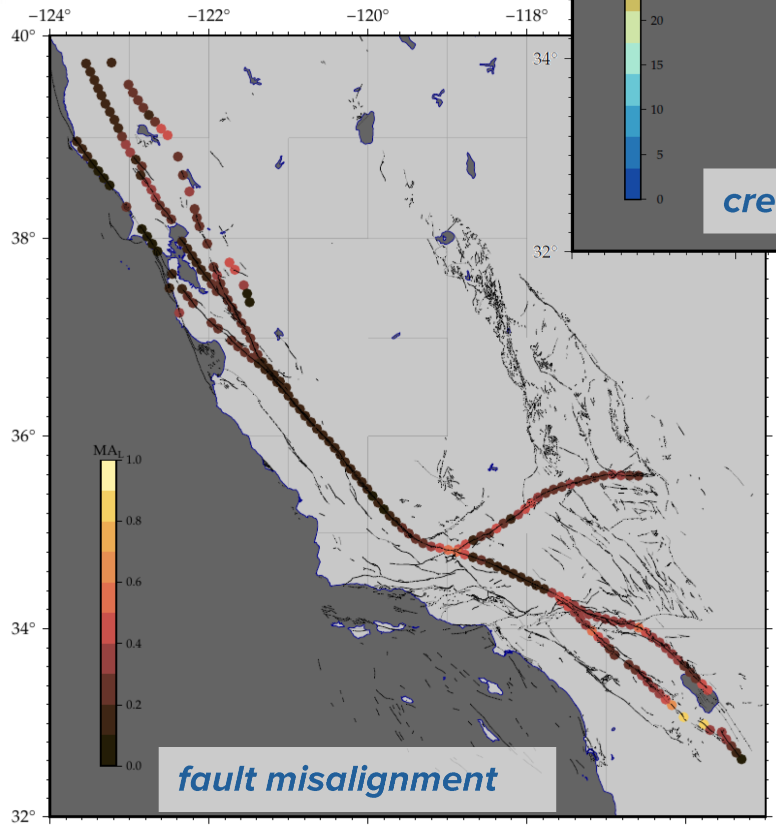
misalignment for low and high creep







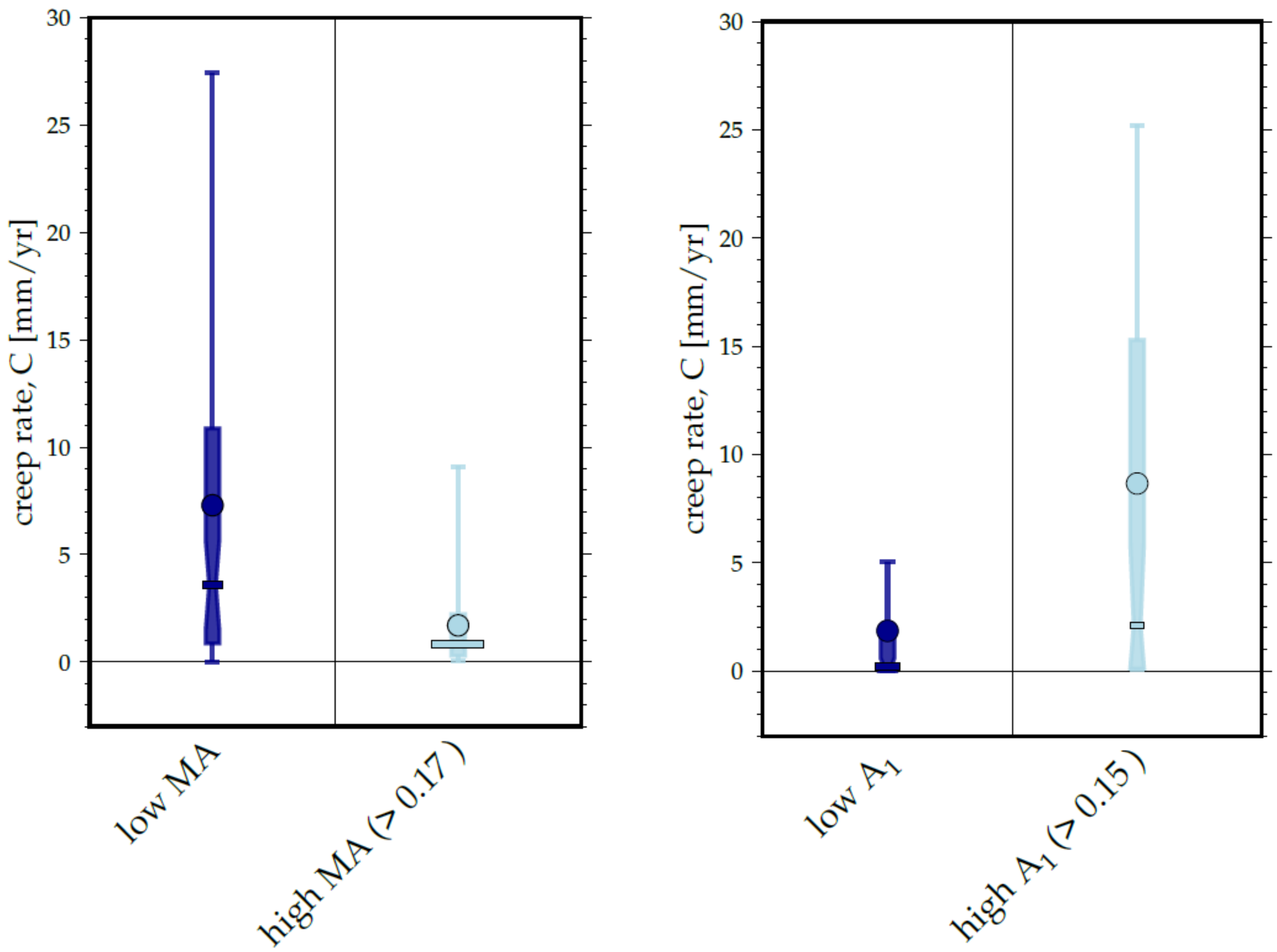




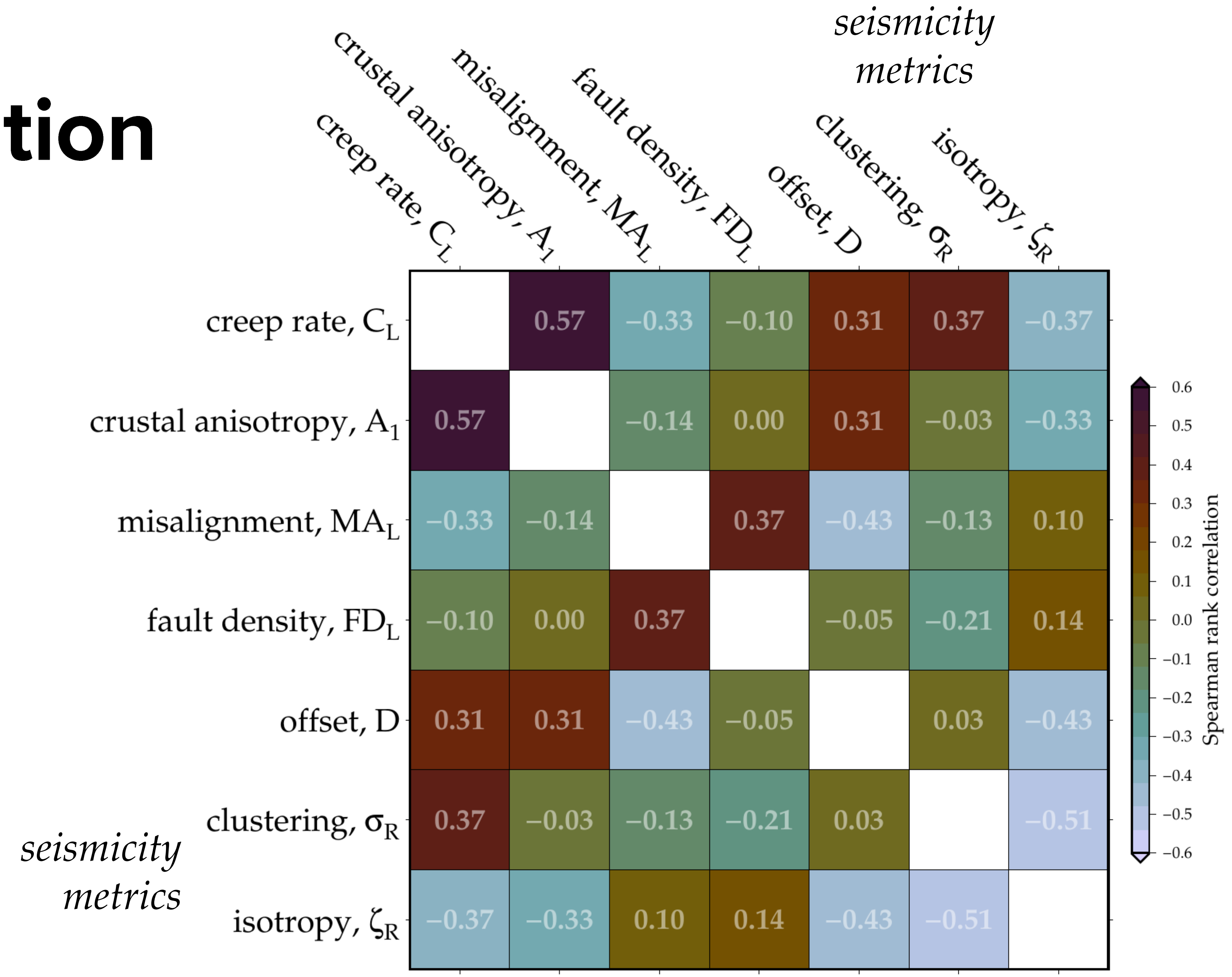
Fault creep from Johnson et al. (2022)

Misalignment analysis by Lee et al. (2024)

Crustal anisotropy better predictor of creep than fault misalignment?

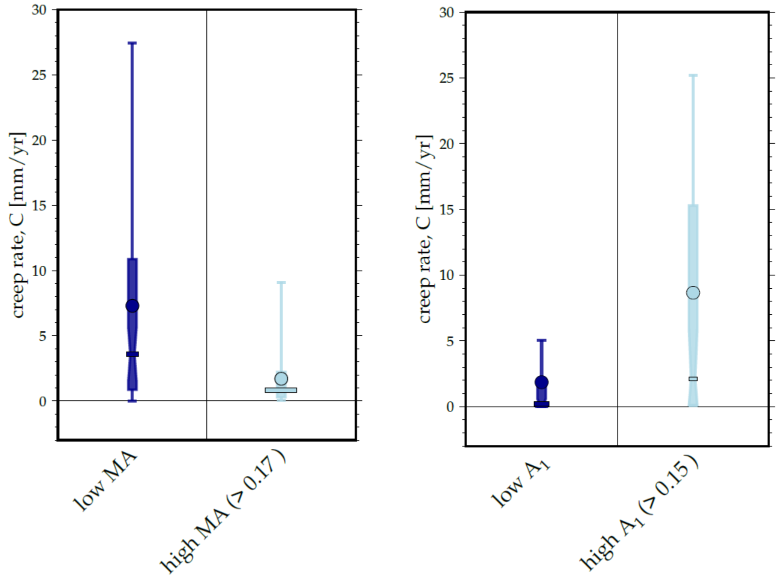


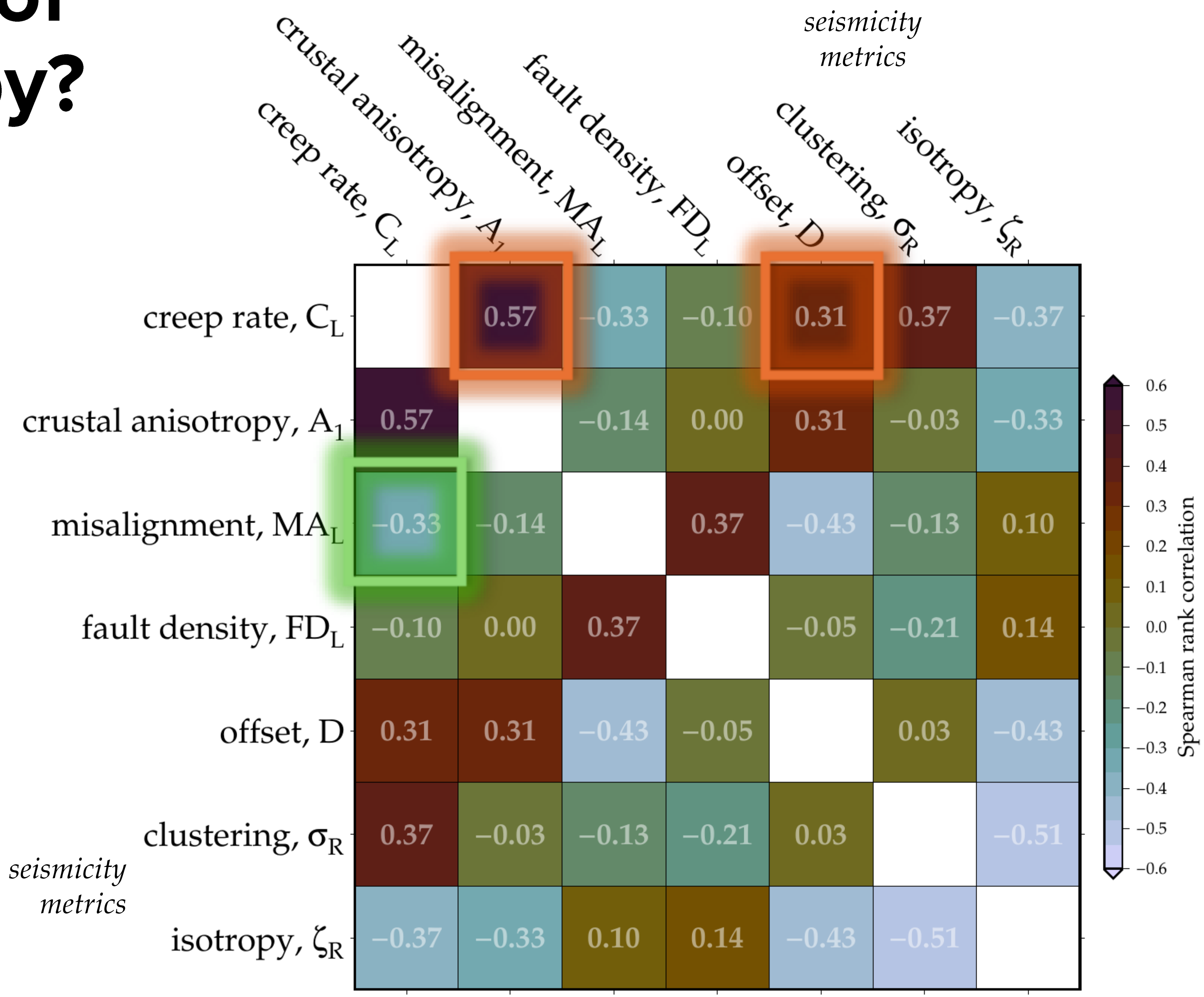
Cross correlation



Ross et al. (2022) seismicity parameters

Lithological control of creep and anisotropy?





Conclusions

- fault creep along the San Andreas correlates with
  - crustal anisotropy (A_1 from receiver functions),
  - clustering of seismicity, and
  - to a lesser degree, with misalignment (cf. Lee et al., 2022)
- crustal anisotropy reflects a mix of
  - fault zone evolution (correlation with offset) and
  - geological history (via creep, i.e. likely rock type controlled)
- expanded set of constraints for plate boundary evolution, to be integrated in constitutive laws