High resolution InSAR time series of transient creep on the Concord Fault, Eastern Bay Area

Ekaterina Tymofyeyeva, Heresh Fattahi, David Bekaert, Piyush Agram

Jet Propulsion Laboratory
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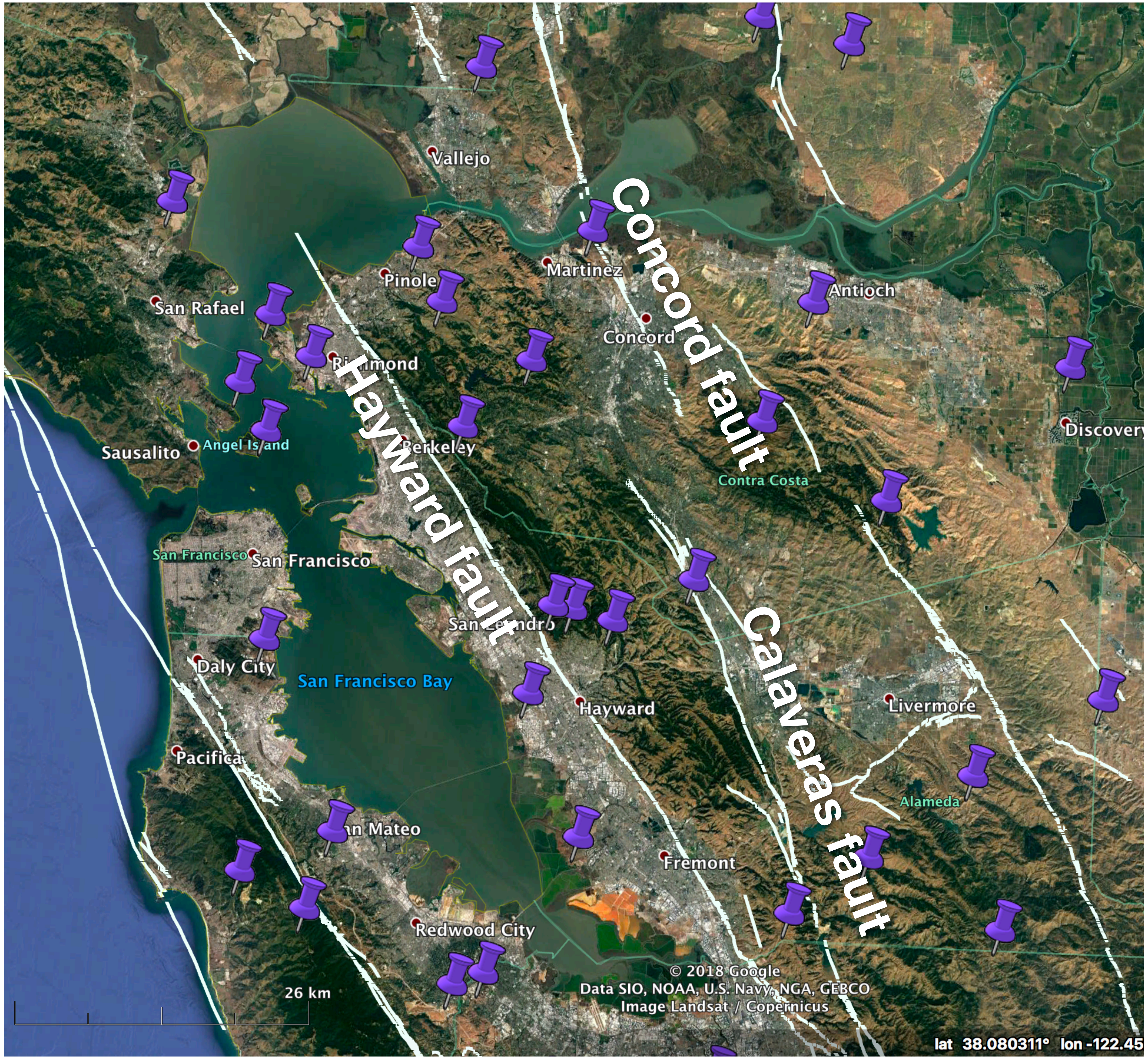
Vallejo
Martinez
Pinole
Antioch
San Rafael
Concord
Concord fault
Richmond
Hayward fault
Berkeley
Discovery
Sausalito
Angel Island
Contra Costa
San Francisco
San Francisco
San Leandro
Calaveras fault
Daly City
San Francisco Bay
Hayward
Livermore
Pacifica
Alameda
San Mateo
Fremont
Redwood City
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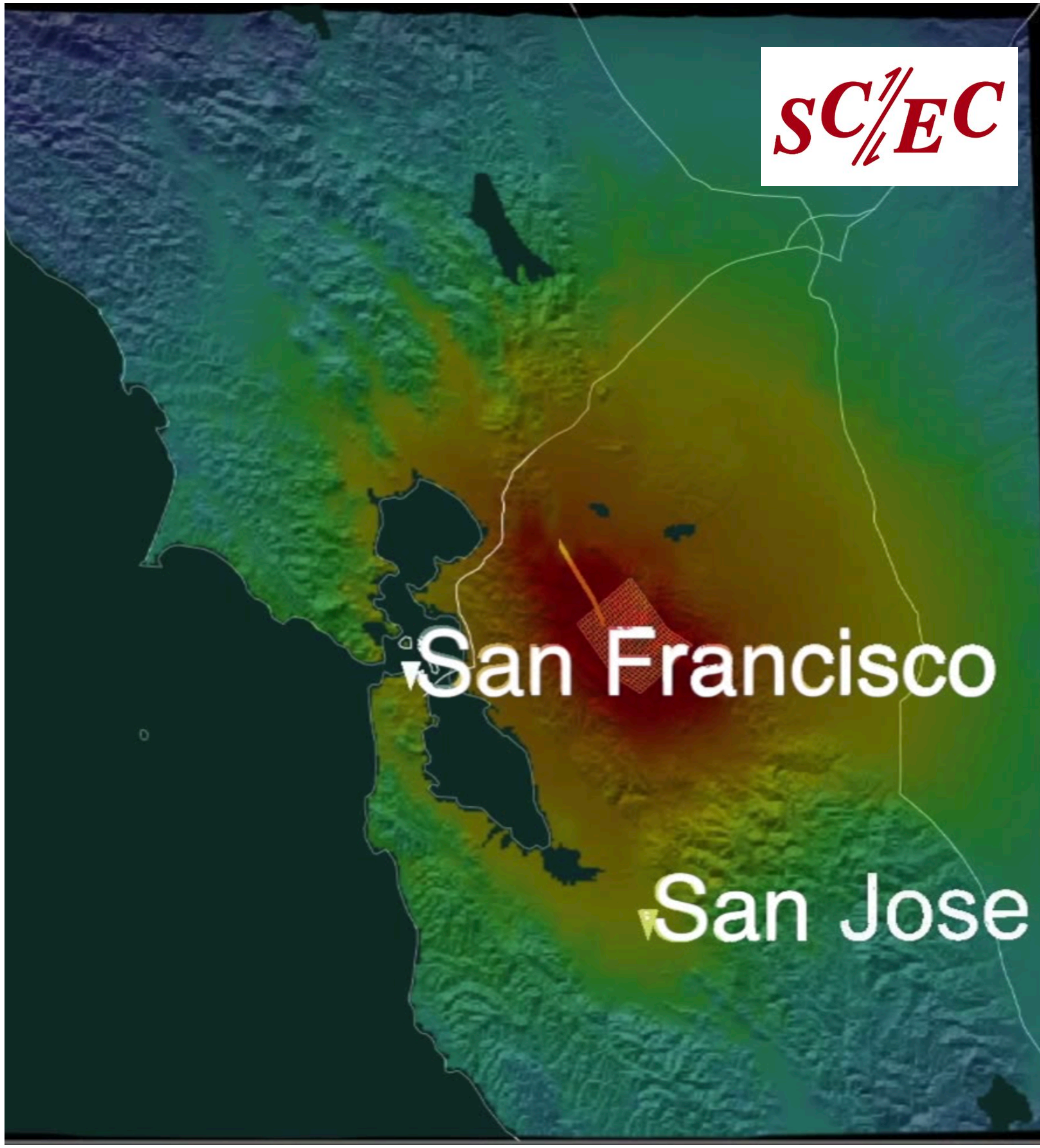
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
26 km
lat 38.080311° lon -122.45


SCEC
San Francisco
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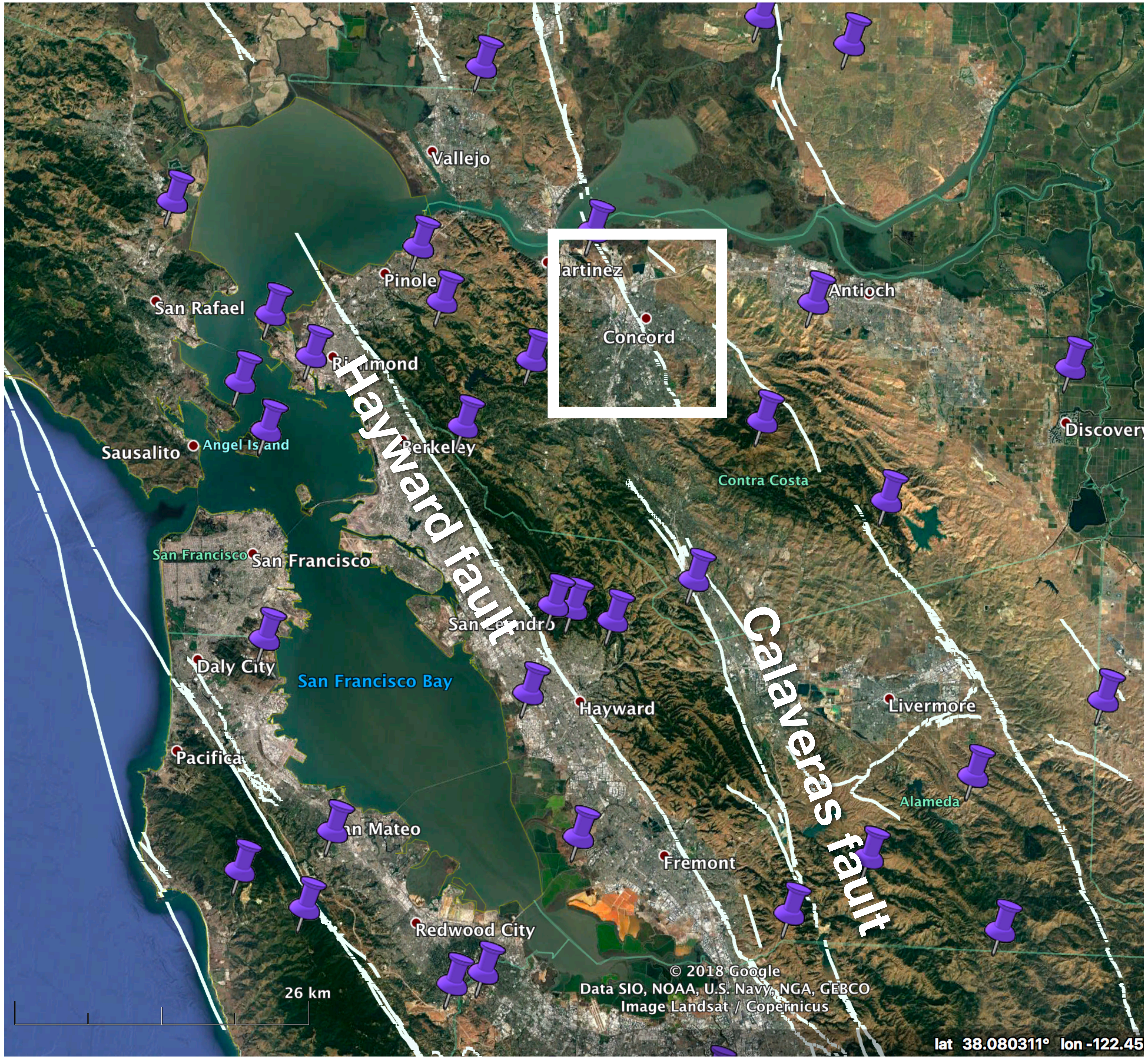
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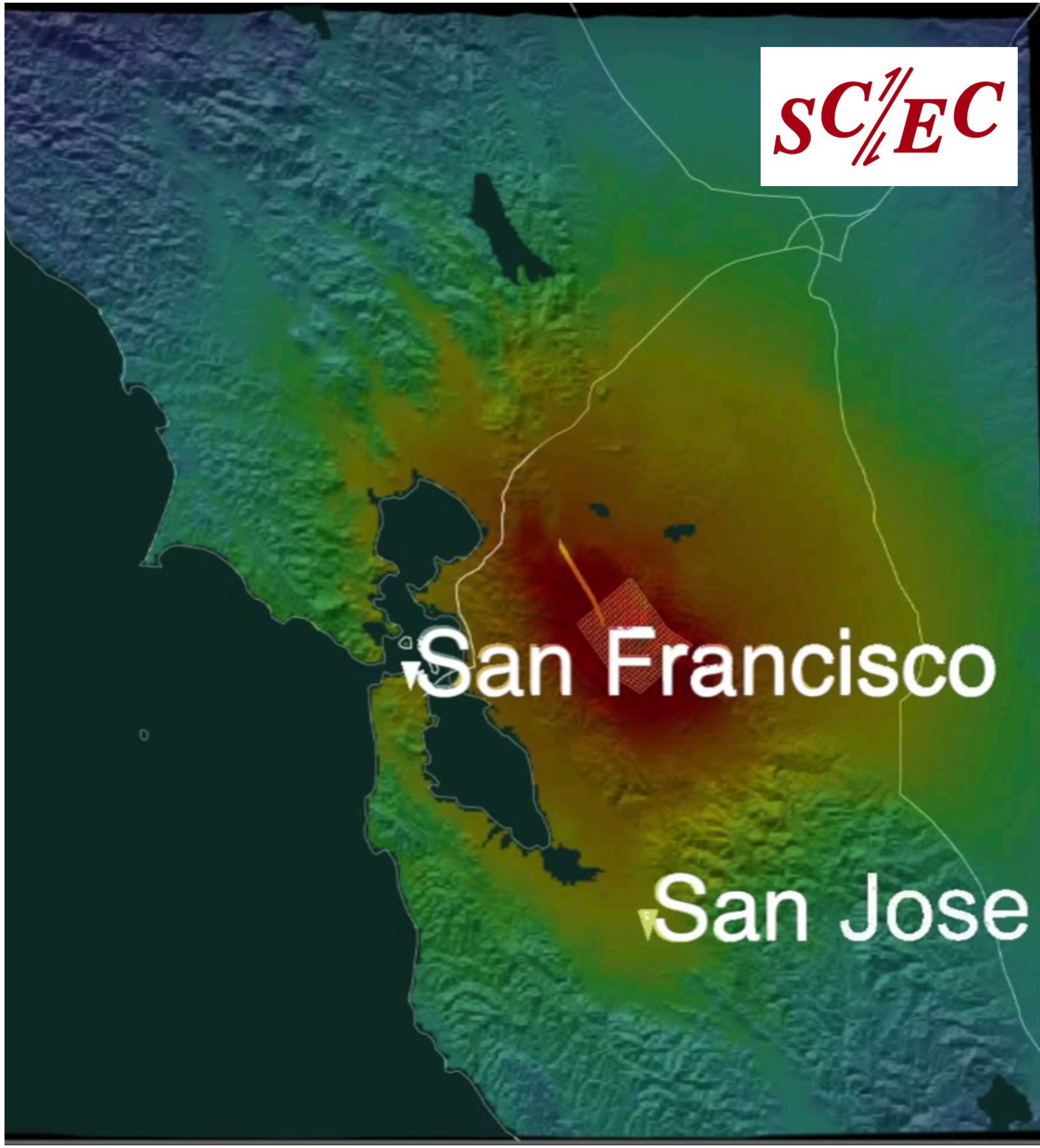
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San Francisco
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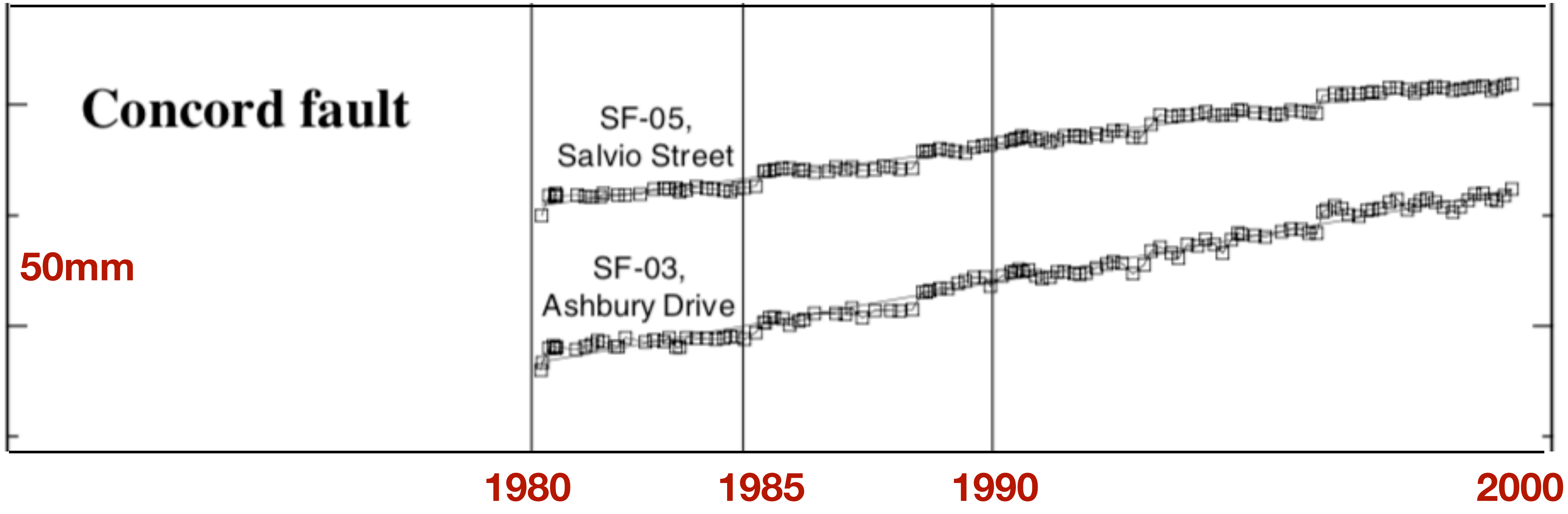
Alignment arrays:

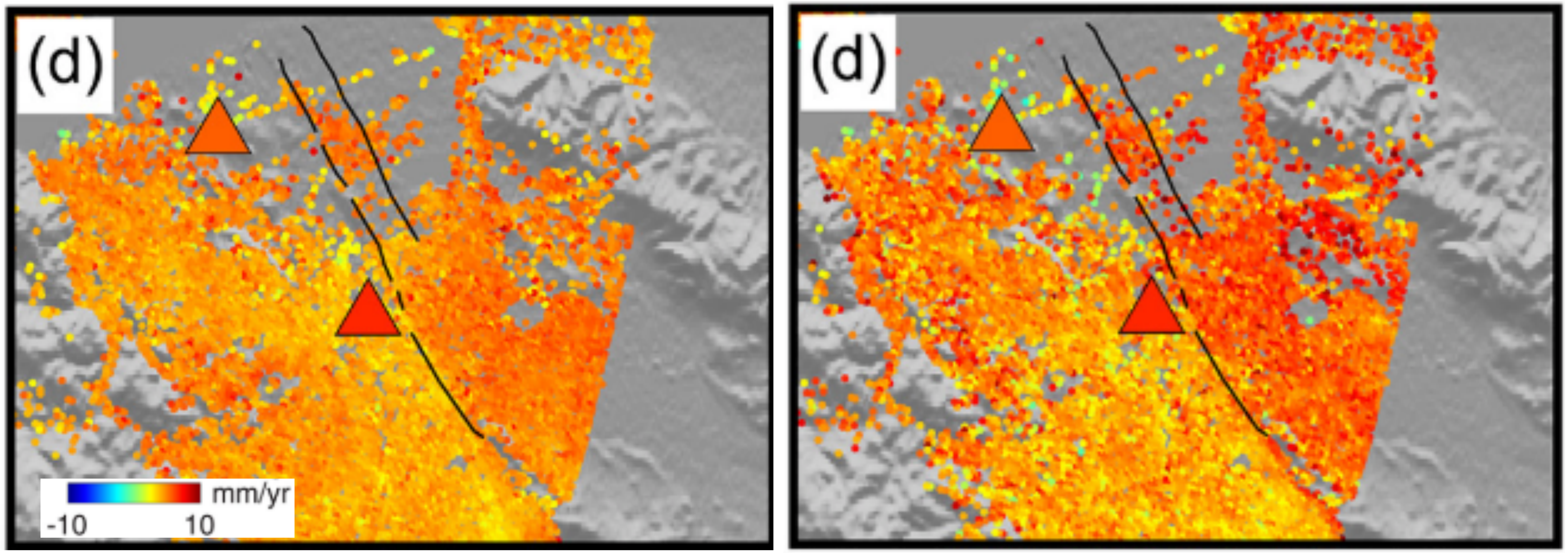


Galehouse and Liencamper, 2003

- Geologic slip rate: 2-5mm/yr
- Average creep rate: 3mm/yr
- Episodic creep events at shallow depths?

ERS 1/2, 1992-2002

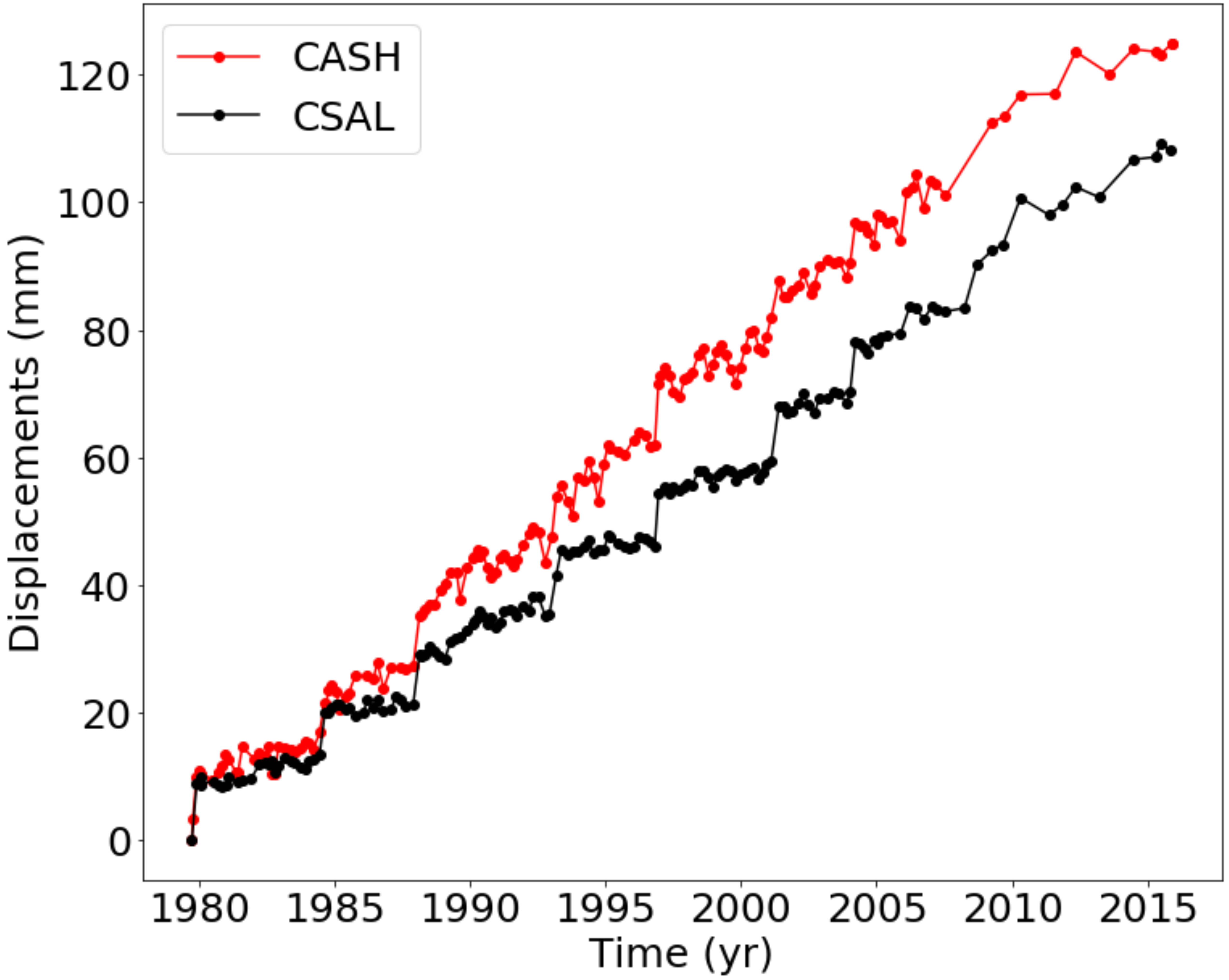
Envisat, 2006-2010



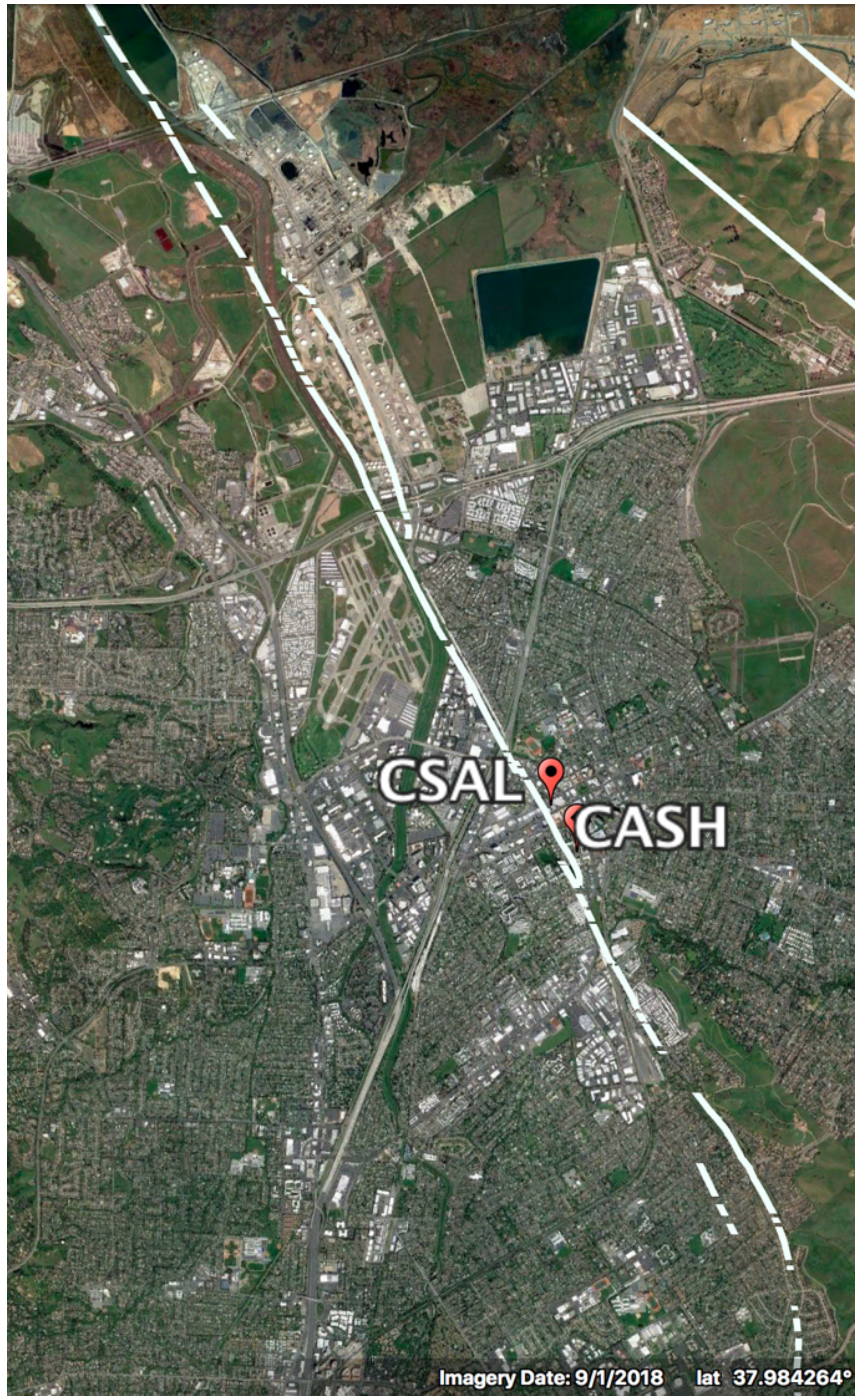
Xu et al, 2018

Alinement arrays

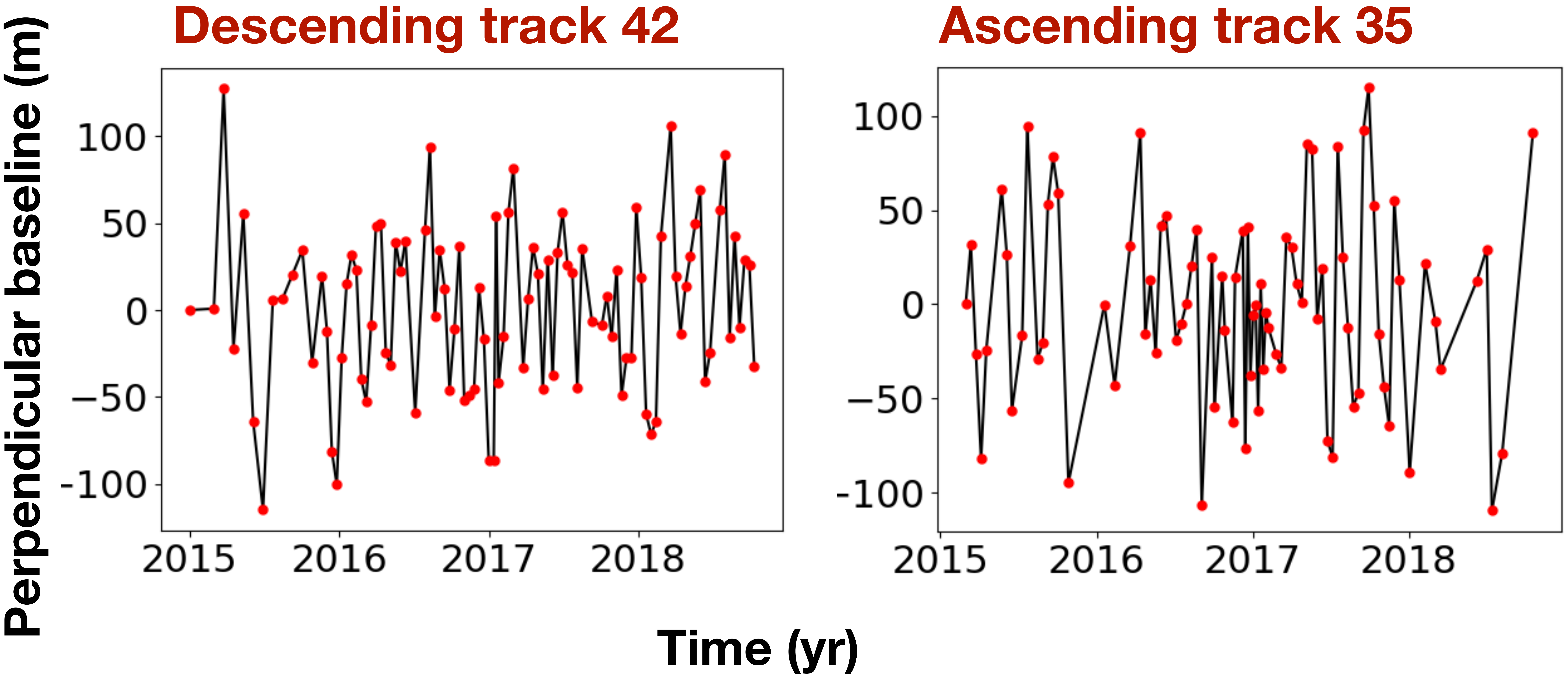
aperture: 100 m



distance: ~500 m



Sentinel-1: 2015 - 2019



Methods: summary

- Created coregistered SLCs with **ISCE processing software.**
- Used **adaptive multi-looking** for noise reduction and coherence estimation (similar to Ferretti et al., 2011).
- Processed data in batches using the **Sequential EVD** (inspired by Ansari et al., 2017)
- Applied **CANDIS atmospheric correction** (Tymofyeyeva and Fialko, 2015)
- Decomposed data from two lines of sight into **vertical and fault-parallel components** (e.g., Tymofyeyeva and Fialko 2018)

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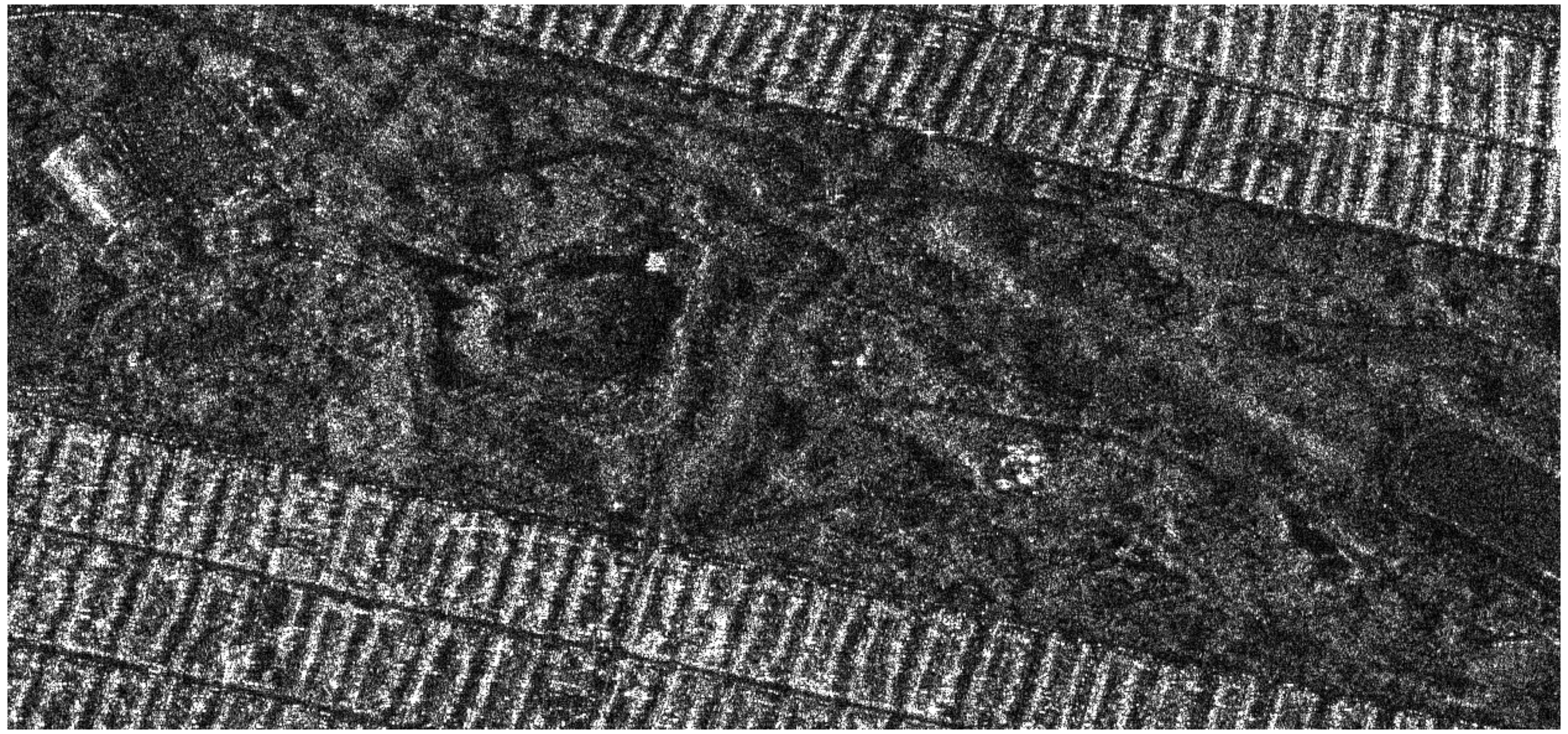
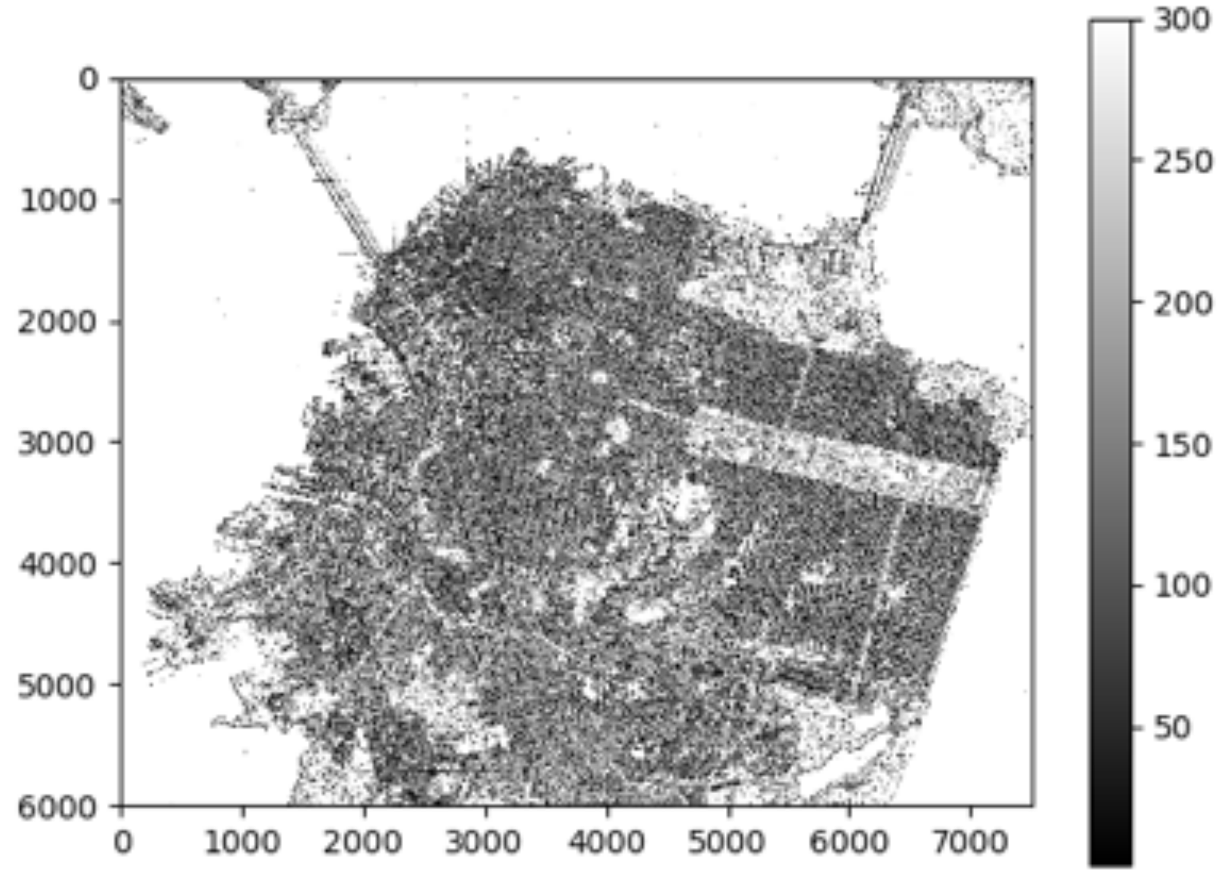
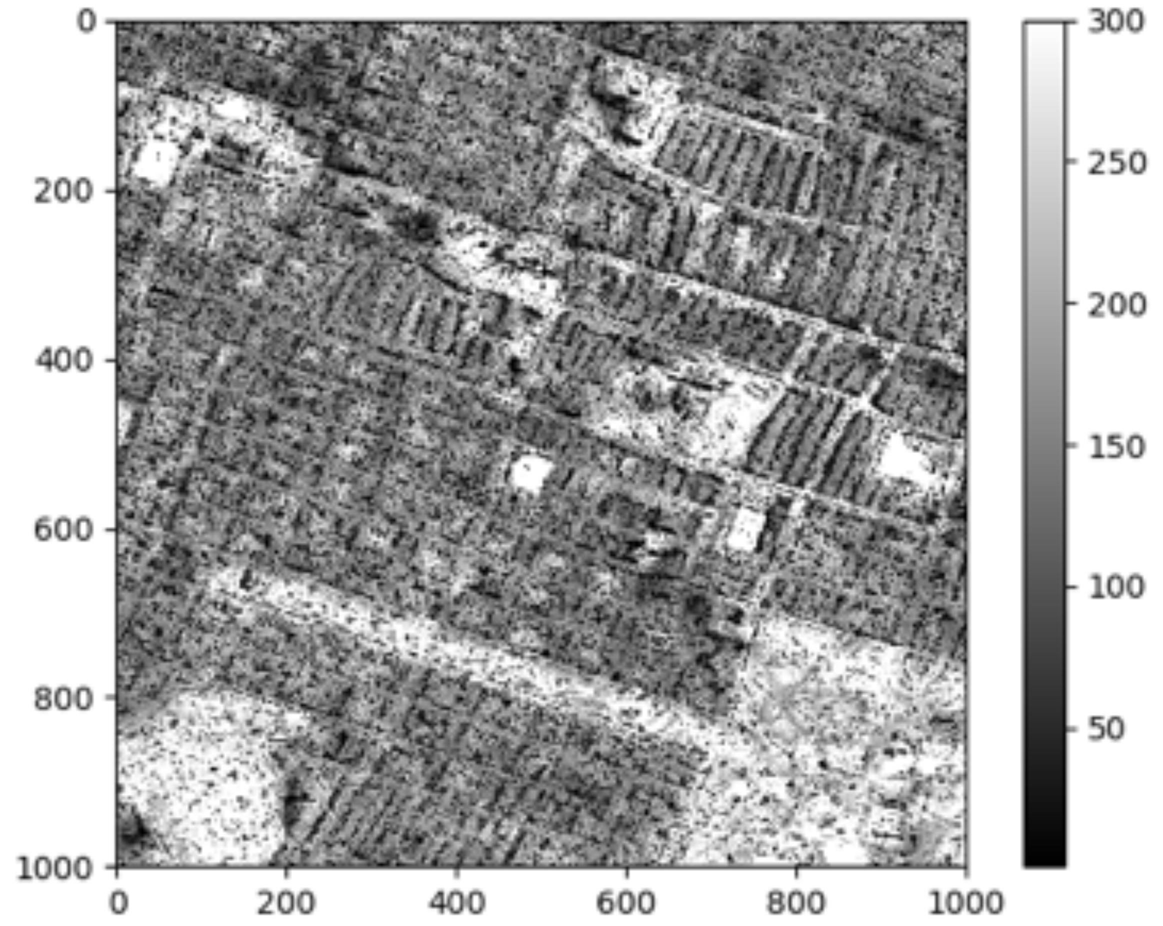
Methods: adaptive multilooking

- For each pixel, **identify a family of distributed scatterers** that belong to the same structure

- **Compute coherence matrix and average** for each pixel based on the identified families



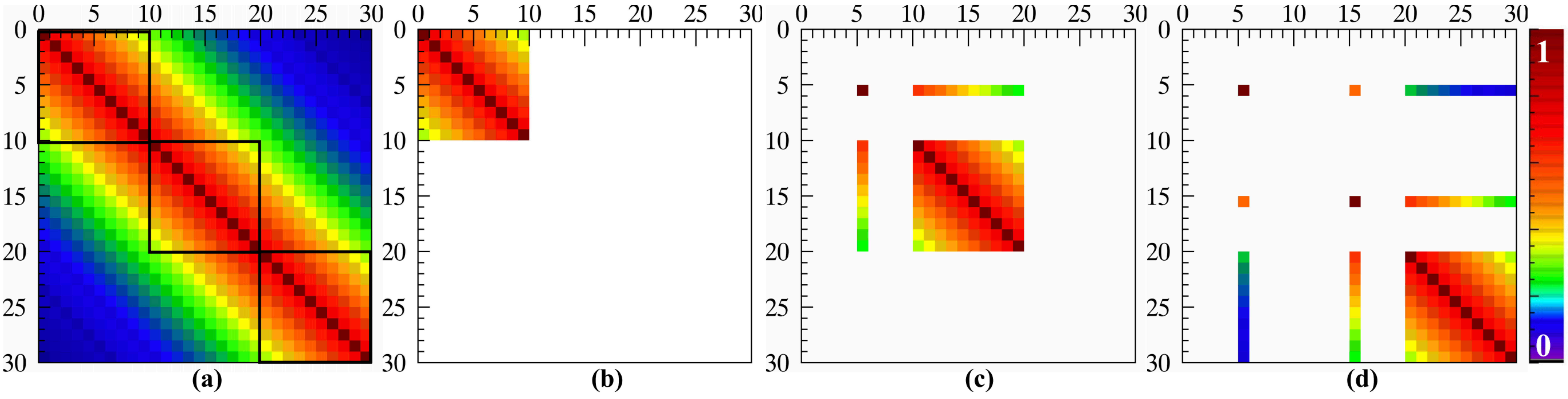




(similar to SqueeSAR™, Ferretti et al., 2011)

Methods: Sequential EVD

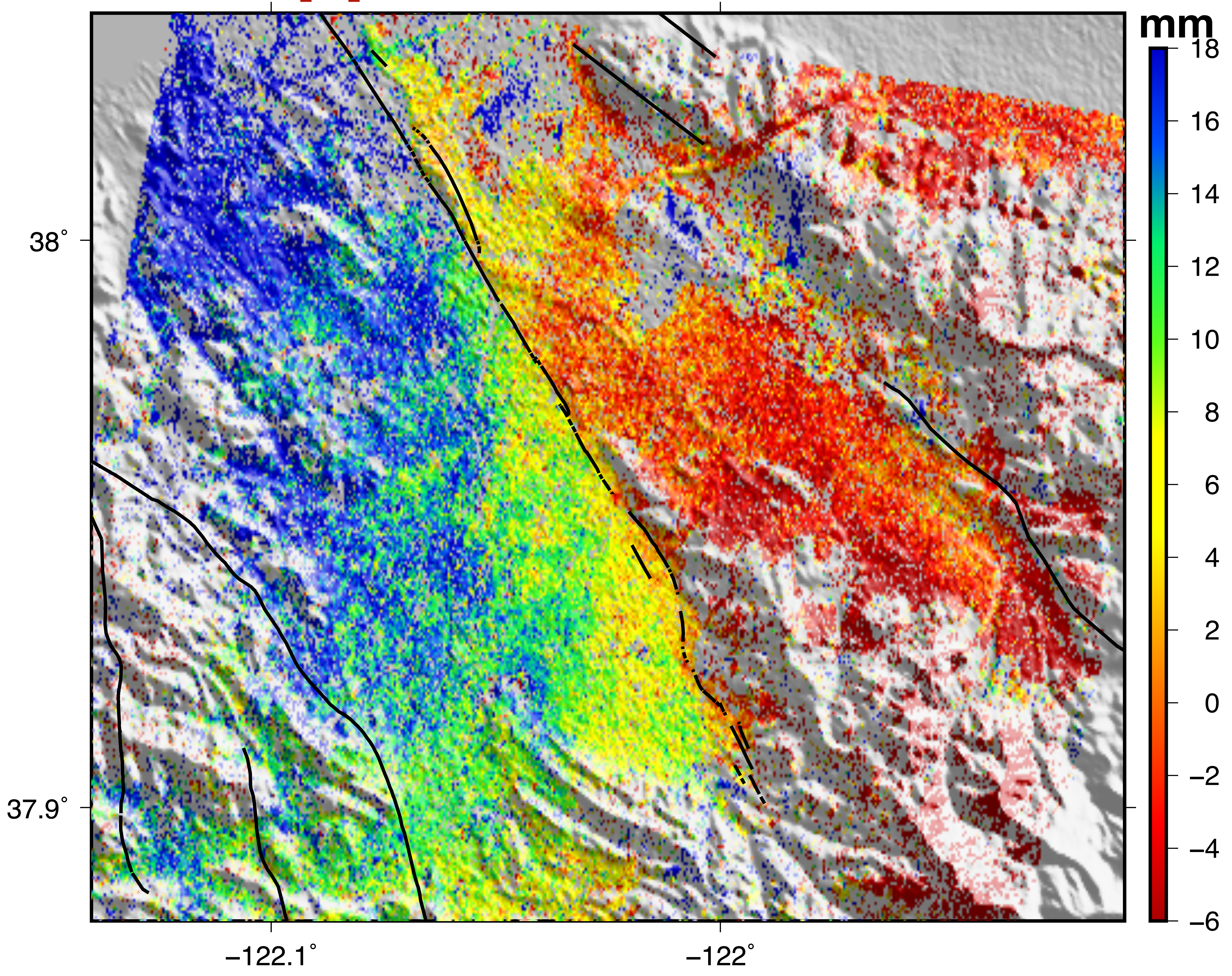
- Data are divided into **mini stacks**
- Mini stacks are compressed using **eigenvalue decomposition**
- **New data are added** without recalculating the full coherence matrix



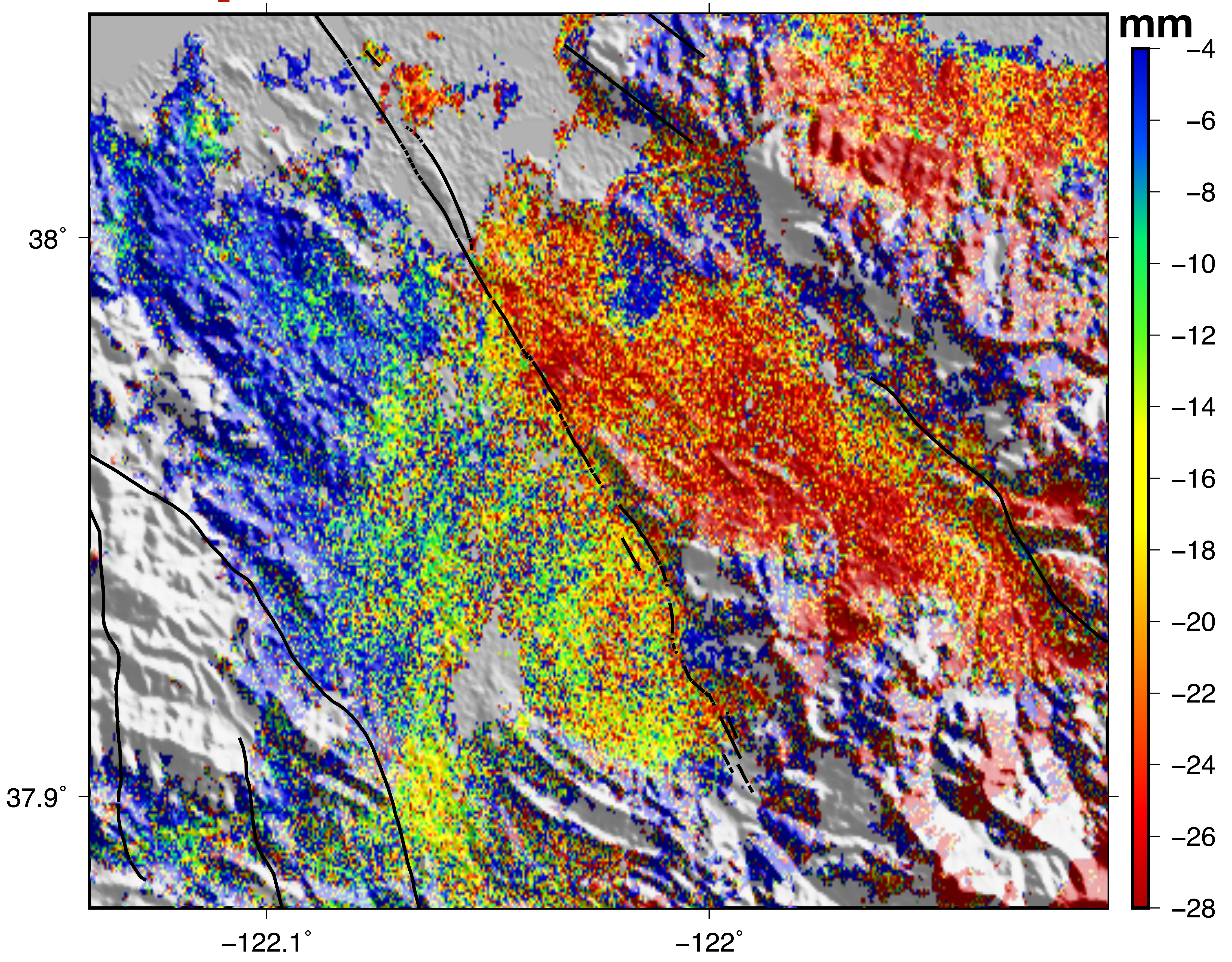
(Ansari et al., 2017)

Track 42: comparison

Our approach:

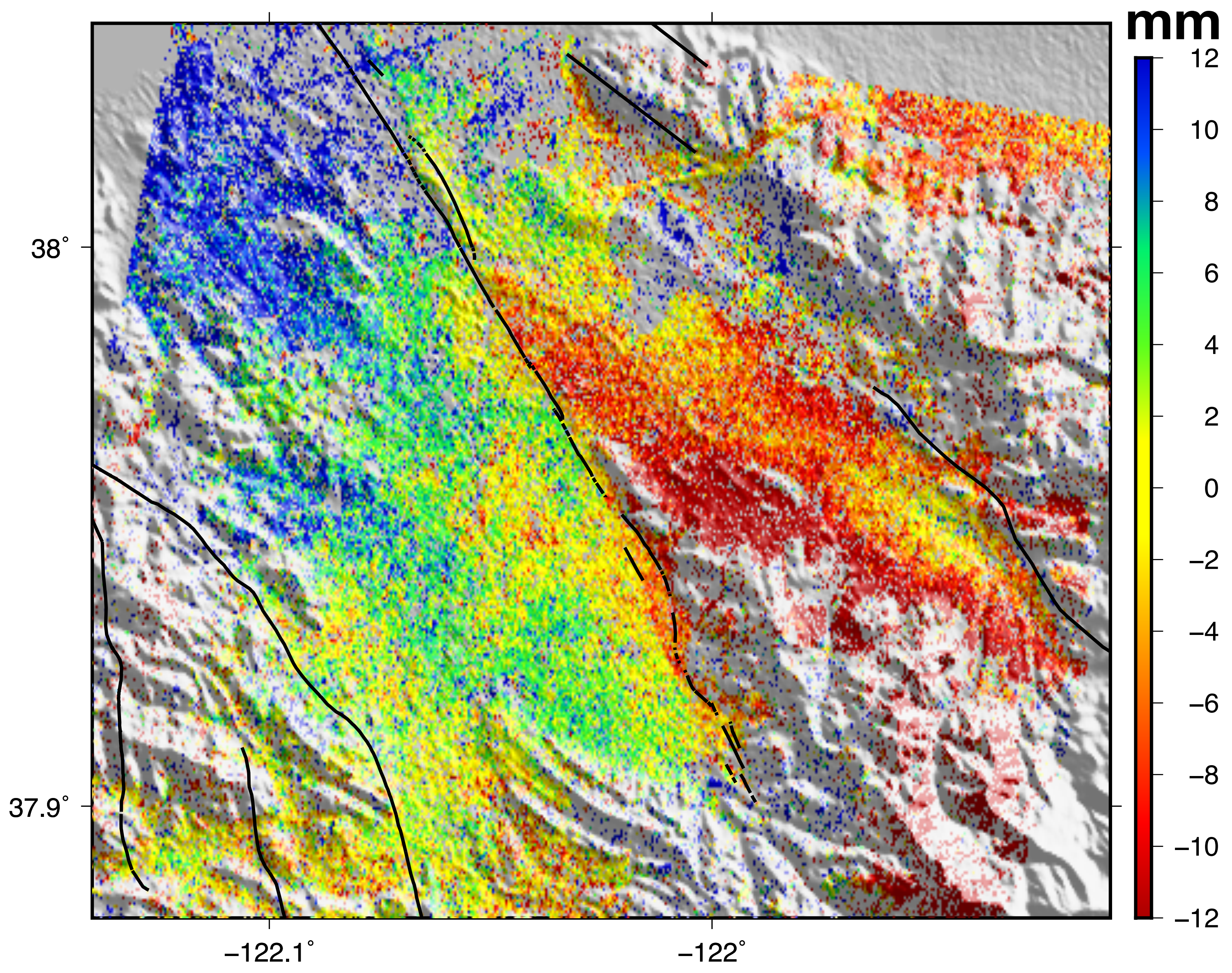


Sequential time series:

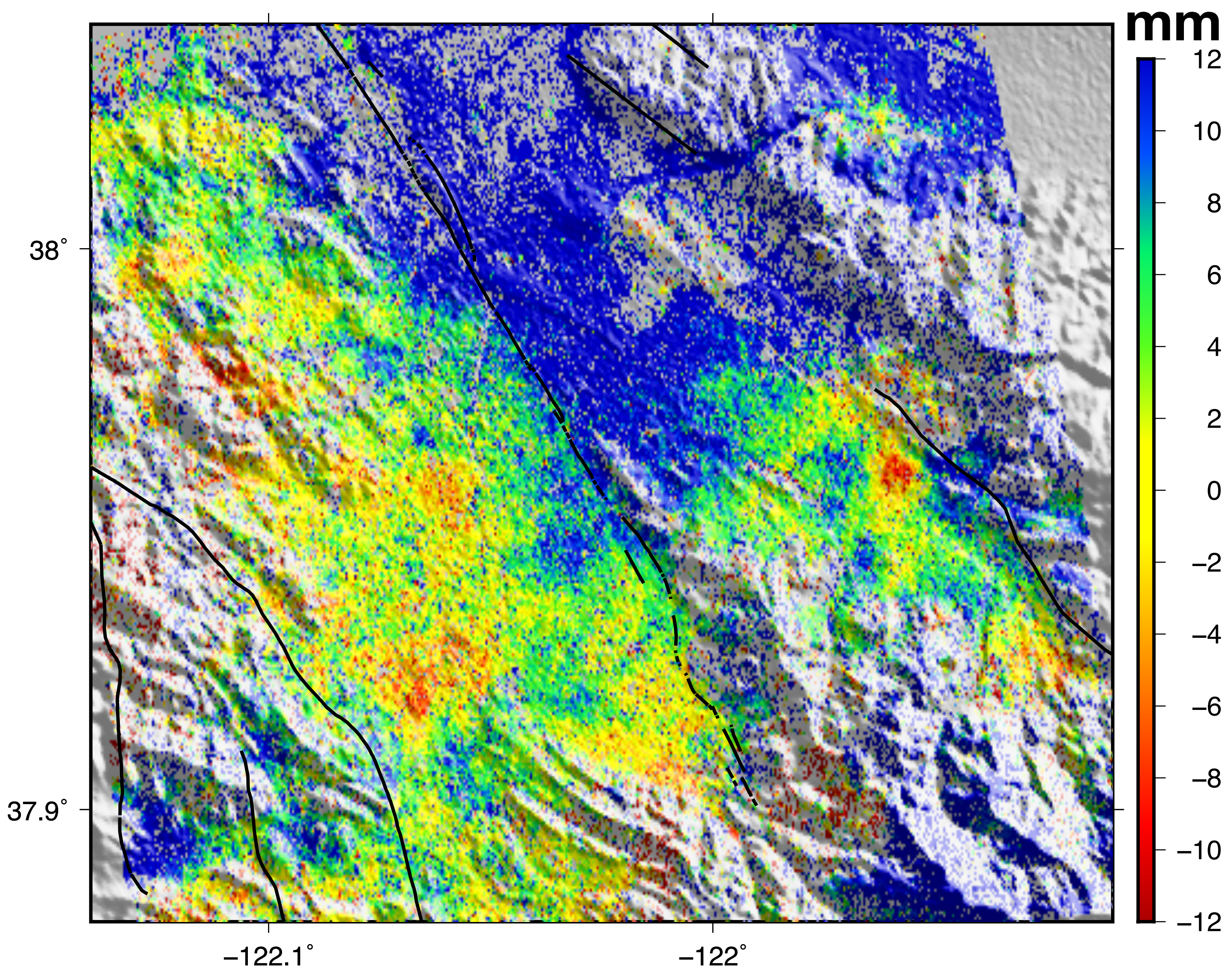


Sentinel-1 tracks with different look geometries

Descending track 42



Ascending track 35



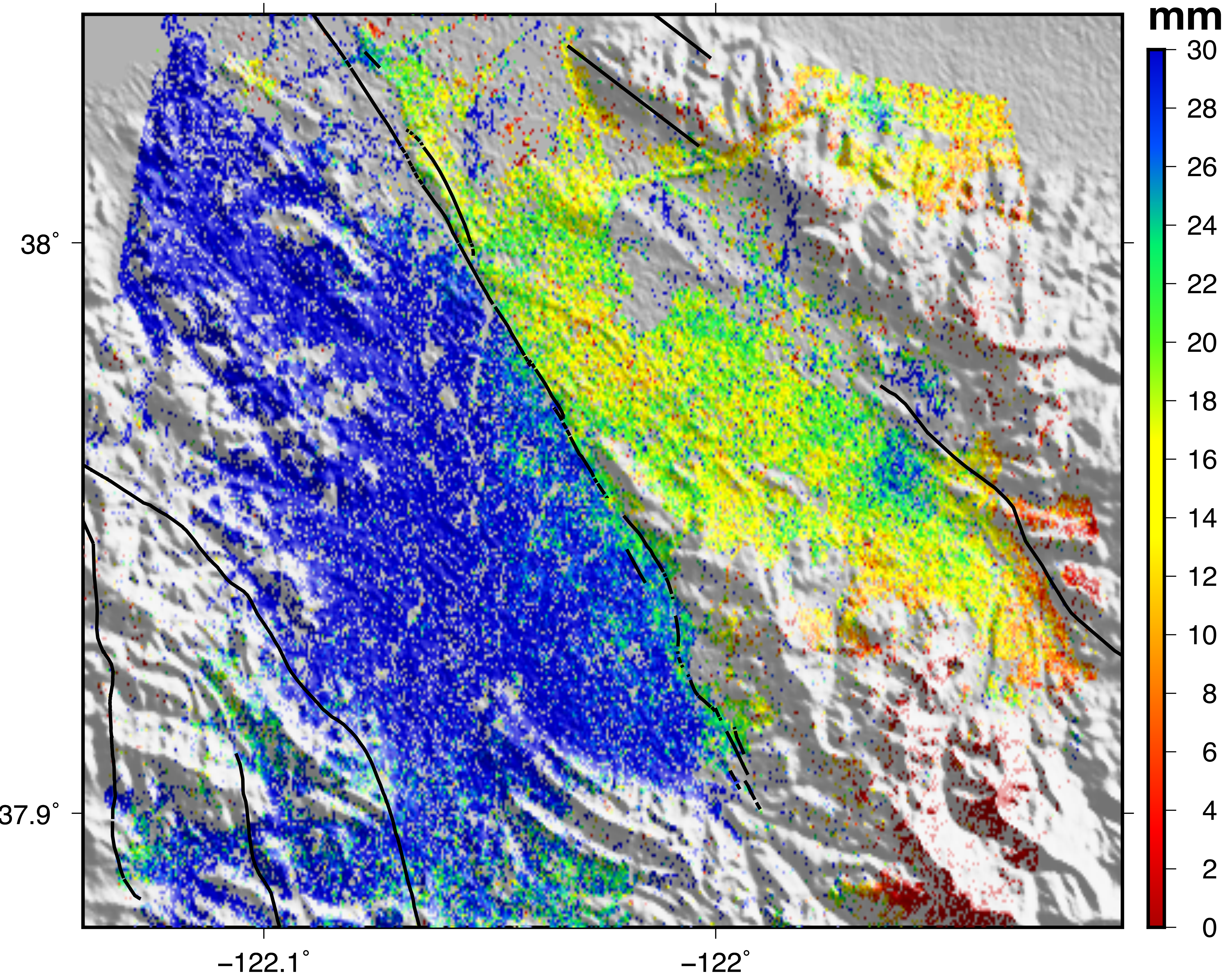
Decomposition:

$$\begin{bmatrix} e_a \sin(\alpha) + n_a \cos(\alpha) & u_a \\ e_d \sin(\alpha) + n_d \cos(\alpha) & u_d \end{bmatrix} \begin{bmatrix} D_H \\ D_V \end{bmatrix} = \begin{bmatrix} D_a \\ D_d \end{bmatrix}$$

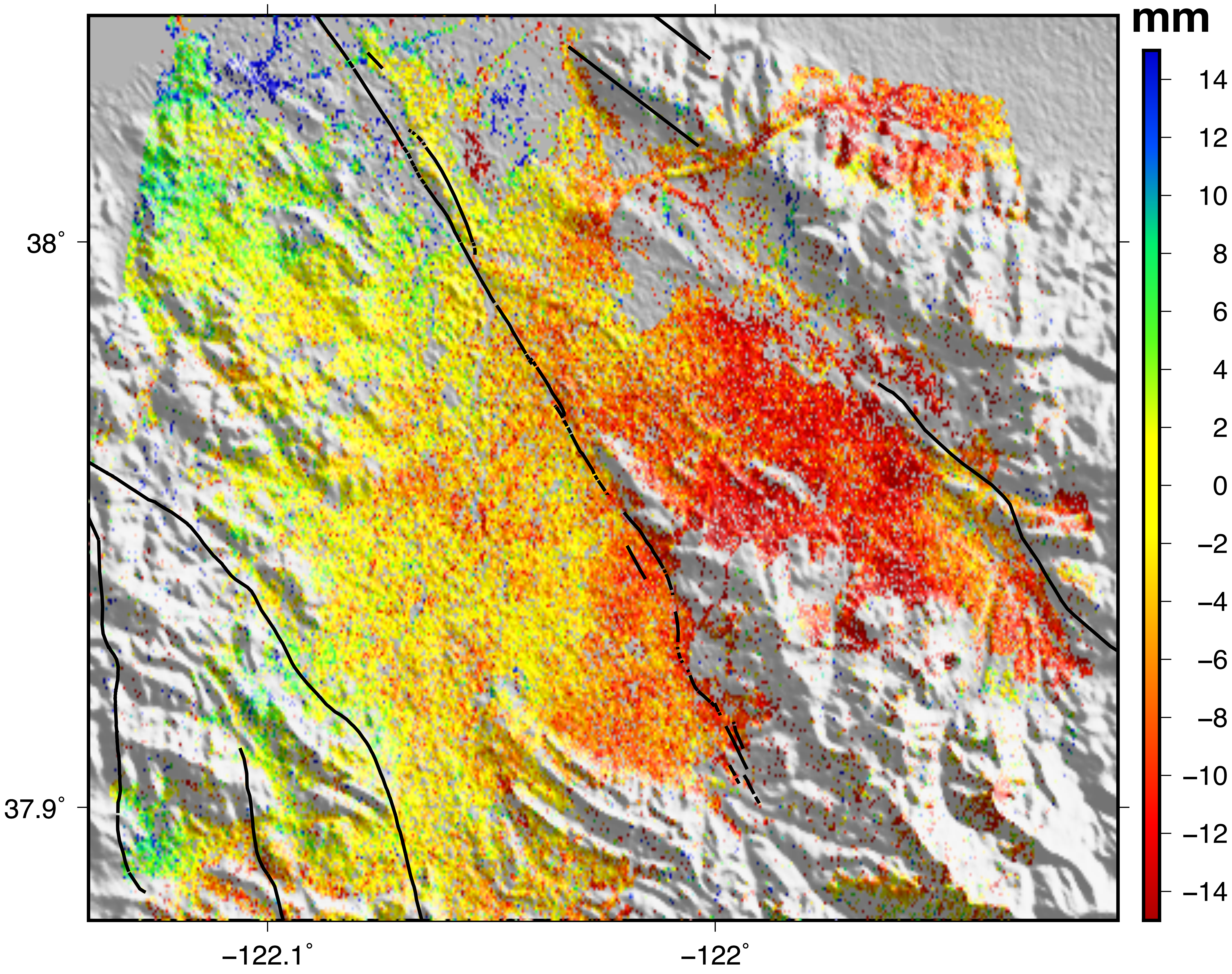
$$\alpha = N28W$$

- Applied **CANDIS atmospheric correction** (Tymofyeyeva and Fialko, 2015)

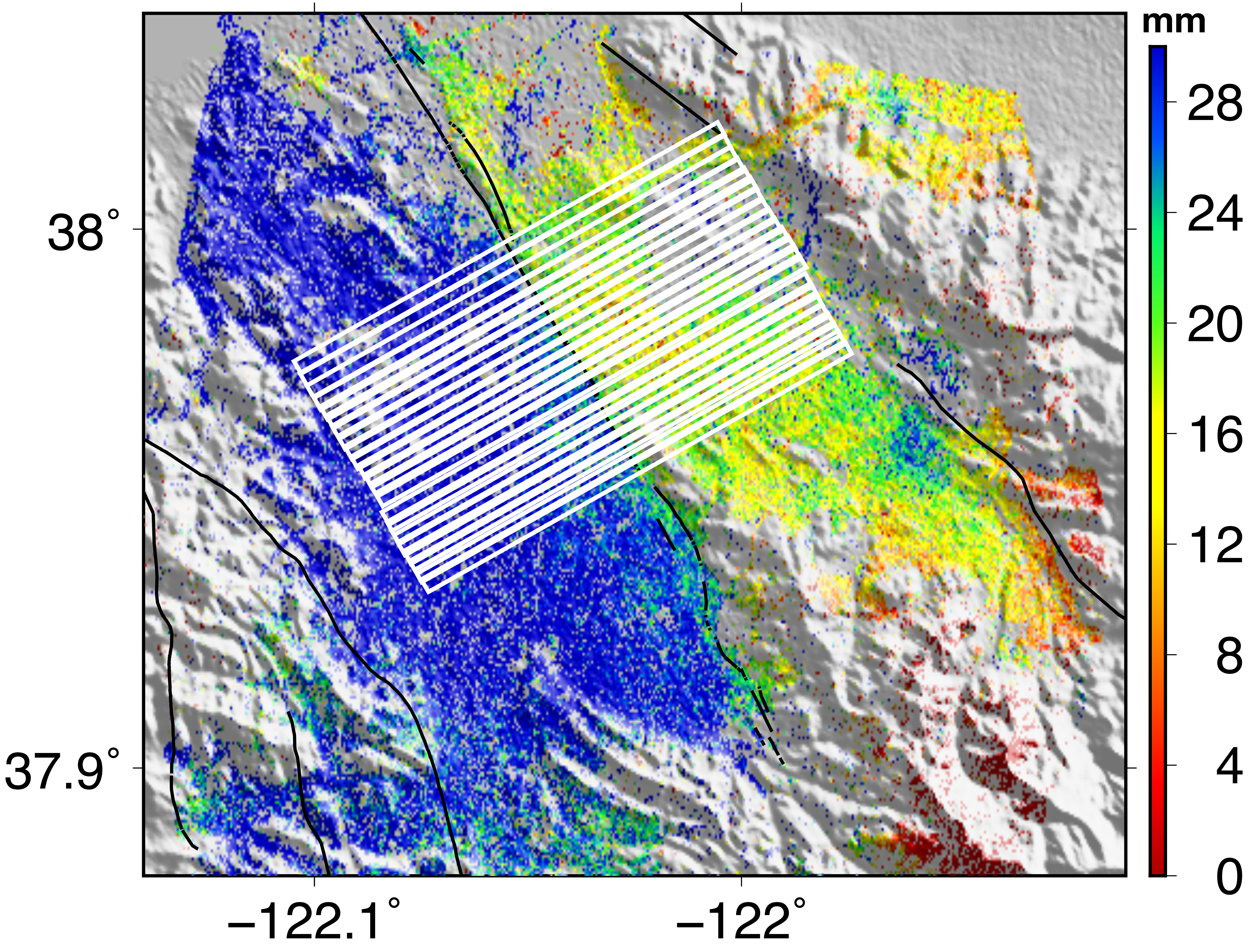
Fault parallel displacements

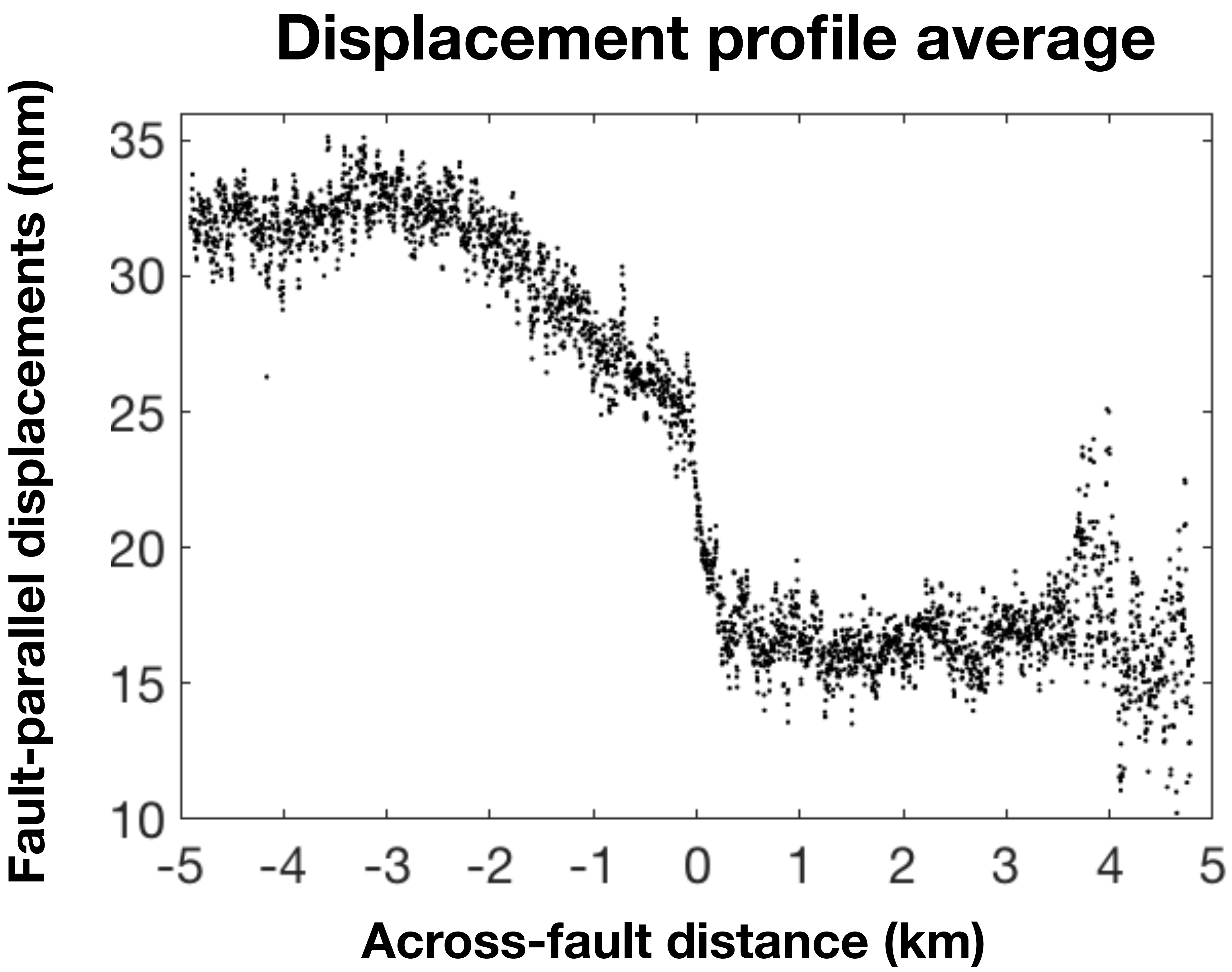


Vertical displacements



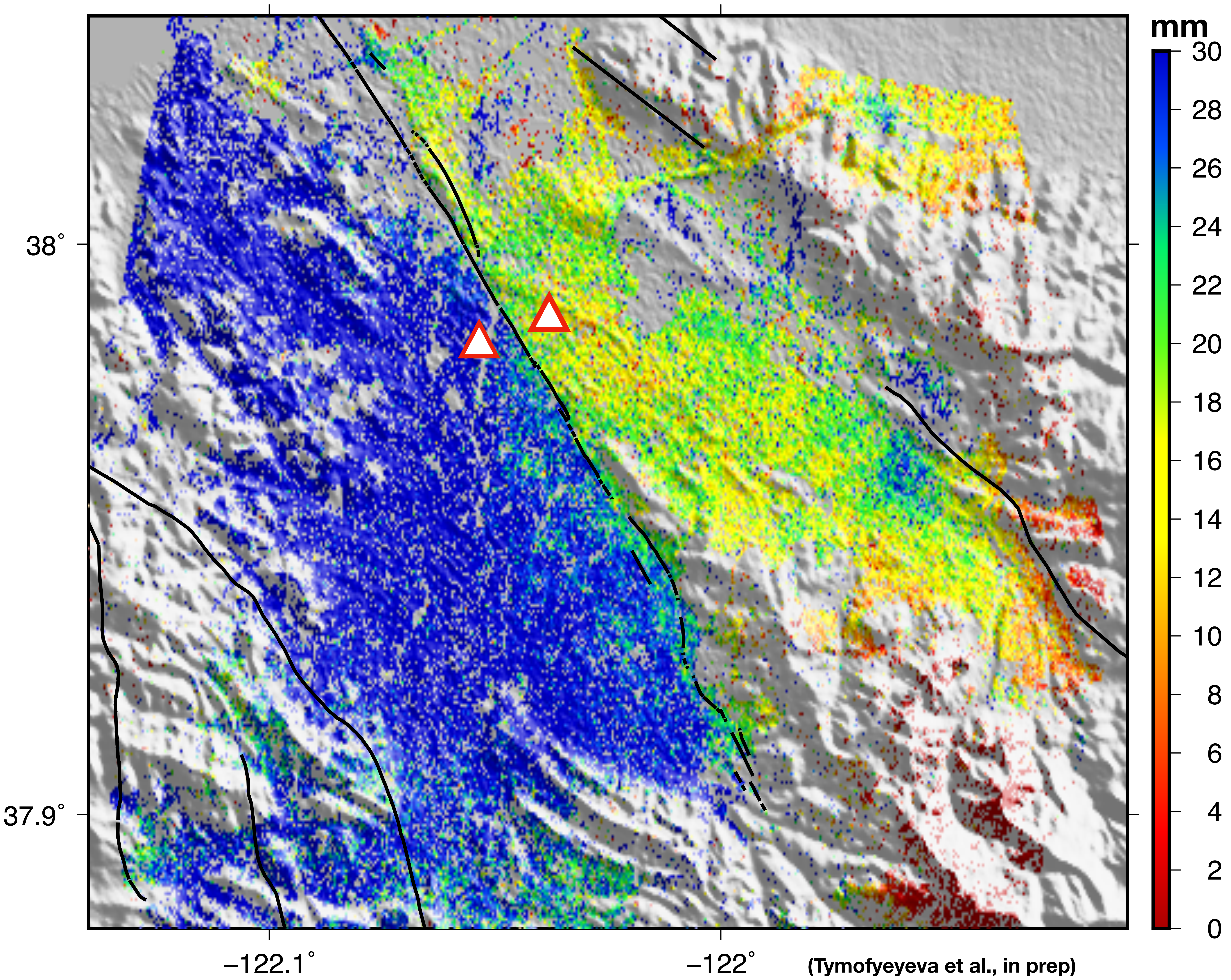
Fault-parallel displacements: 2015-2018





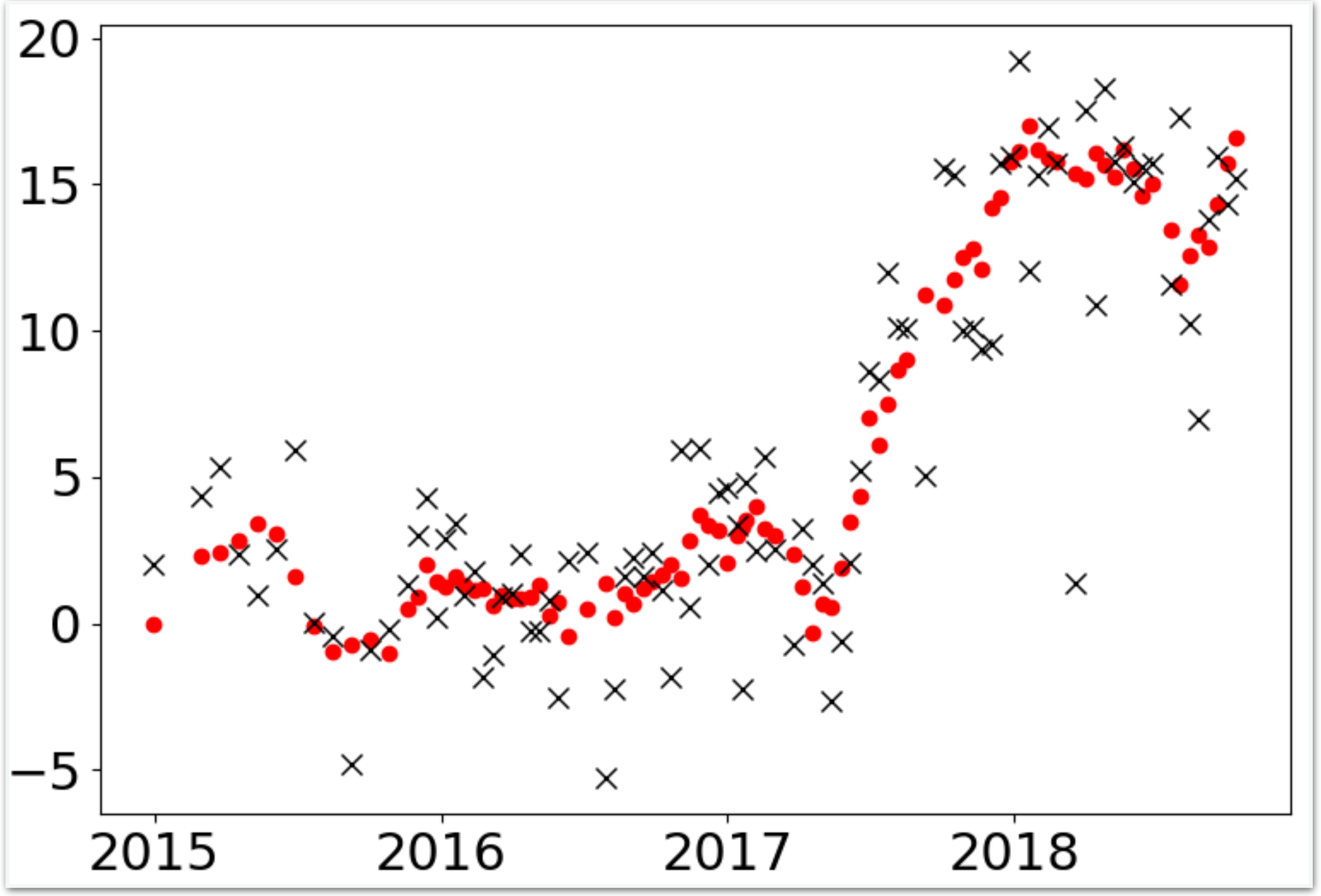
(Tymofyeyeva et al., in prep)

Fault-parallel displacements: 2015-2018

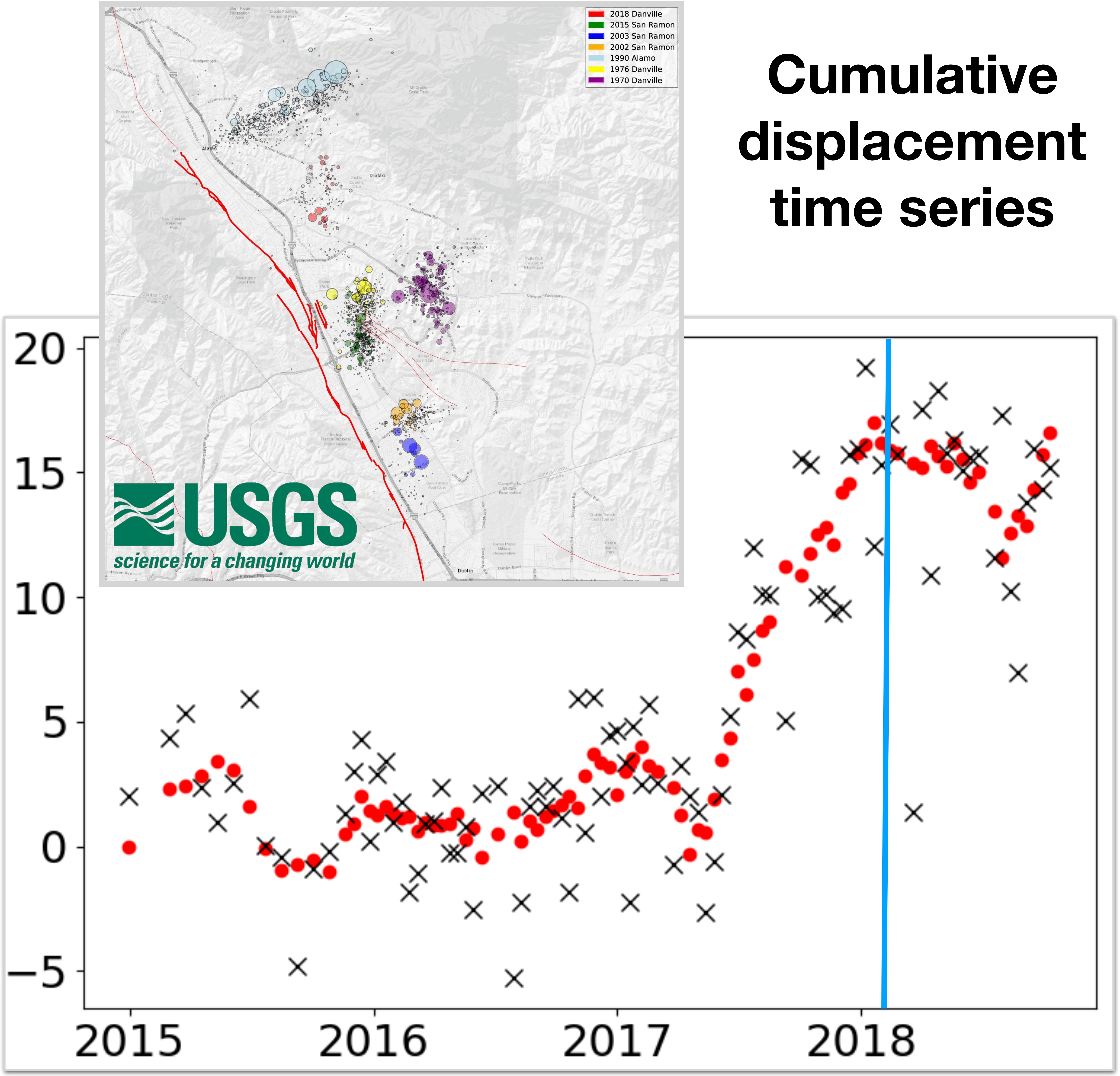


(Tymofyeyeva et al., in prep)

Cumulative displacement time series



Cumulative displacement time series



Conclusions

- We apply adaptive multilooking and sequential EVD methods to the study of shallow fault creep on the Concord Fault in the Eastern San Francisco Bay Area, where continuous GPS stations and other geodetic instruments are not available close to the fault.

- We use data from the European Sentinel-1 mission to observe a transient shallow creep event on the Concord fault.

- We are able to determine that the event began in the summer months of 2017, with variable slip along the fault, and a peak cumulative slip amplitude of approximately 12 mm in the direction parallel to the fault trace.

References

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