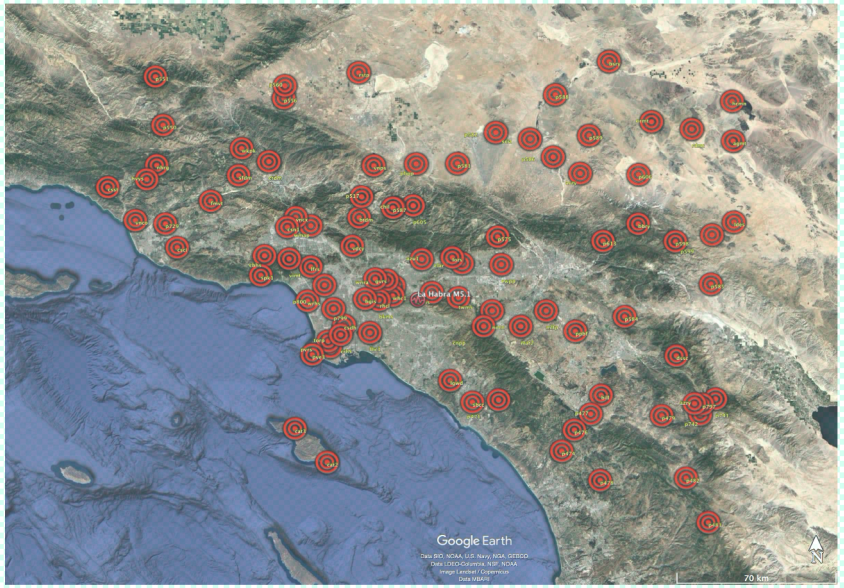
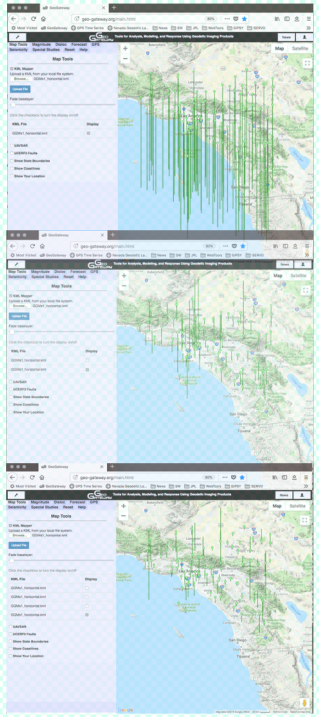
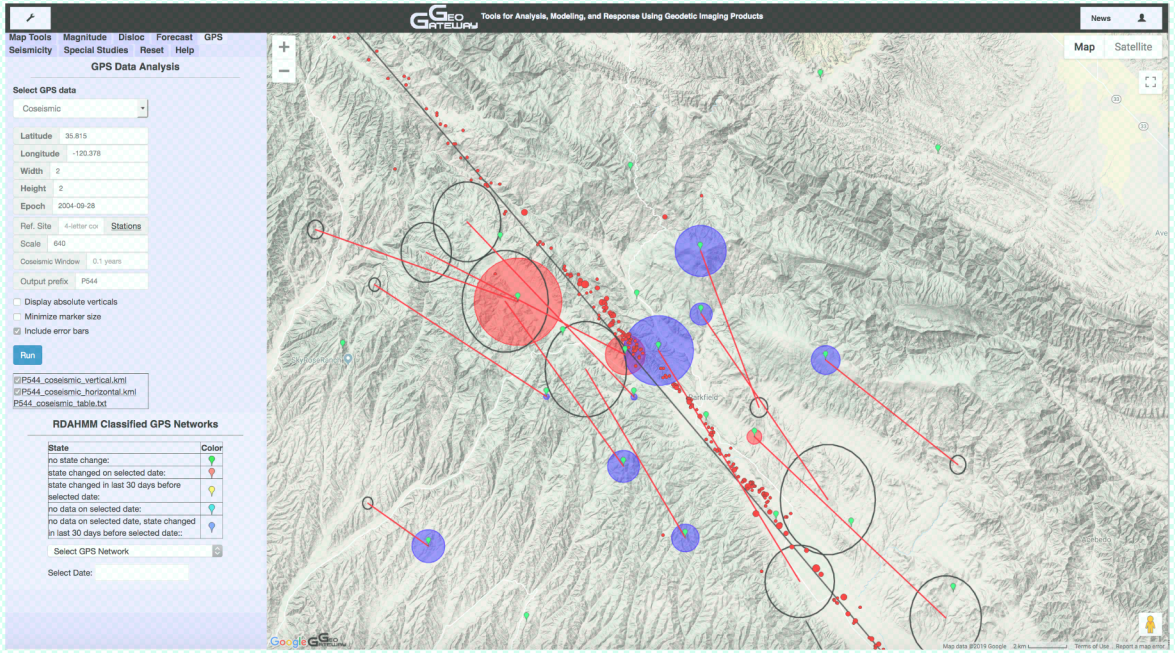
Deformation Model Inversion Dependency on GNSS Series Characteristics







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Jet Propulsion Laboratory/California Institute of Technology

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Topics

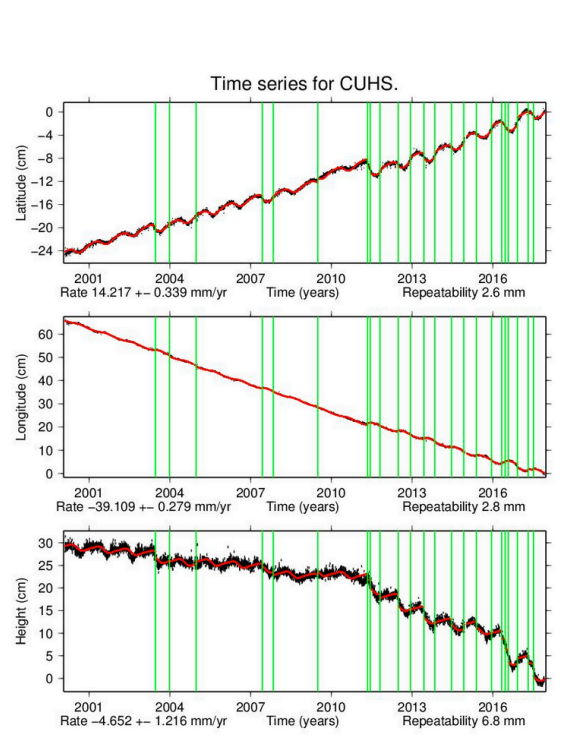
- GNSS daily series characteristics
- Analysis centers: places to download daily series
- RMS and Principal Component analysis by center
- Application to some California earthquakes (2004-2014)

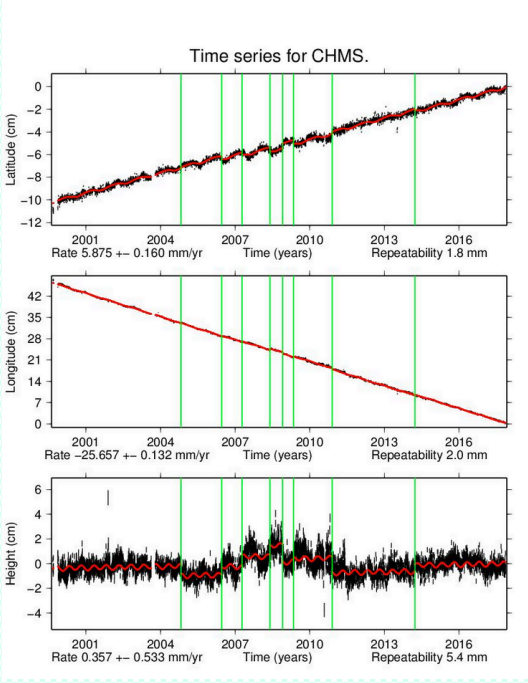
GNSS Daily Series Characteristics

- (continental) common mode error (CME)
- (series/continental) errors correlated in time
- (continental) patterns correlated in space
- (series) uncorrelated background noise

GNSS Daily Series Characteristics

- Detrended RMS: separates “interesting” from “quiet” stations.
- Keep “quiet” for systematic analysis via PCA
  - (similar to *Dong et al*, 2006, but here use SVD).
  - Generally use 3 x min(RMS) as threshold (test all e,n,u).





Analysis Centers:

places to download daily series

NASA Jet Propulsion Laboratory (JPL): **https://sideshow.jpl.nasa.gov/pub/usrs/mbh/point/**

Nevada Geodetic Laboratory - UNR (NGL) : **http://geodesy.unr.edu/gps_timeseries/tenv3/IGS08/**

Plate Boundary Observatory – UNAVCO (PBO): **ftp://data-out.unavco.org/pub/products/position/**

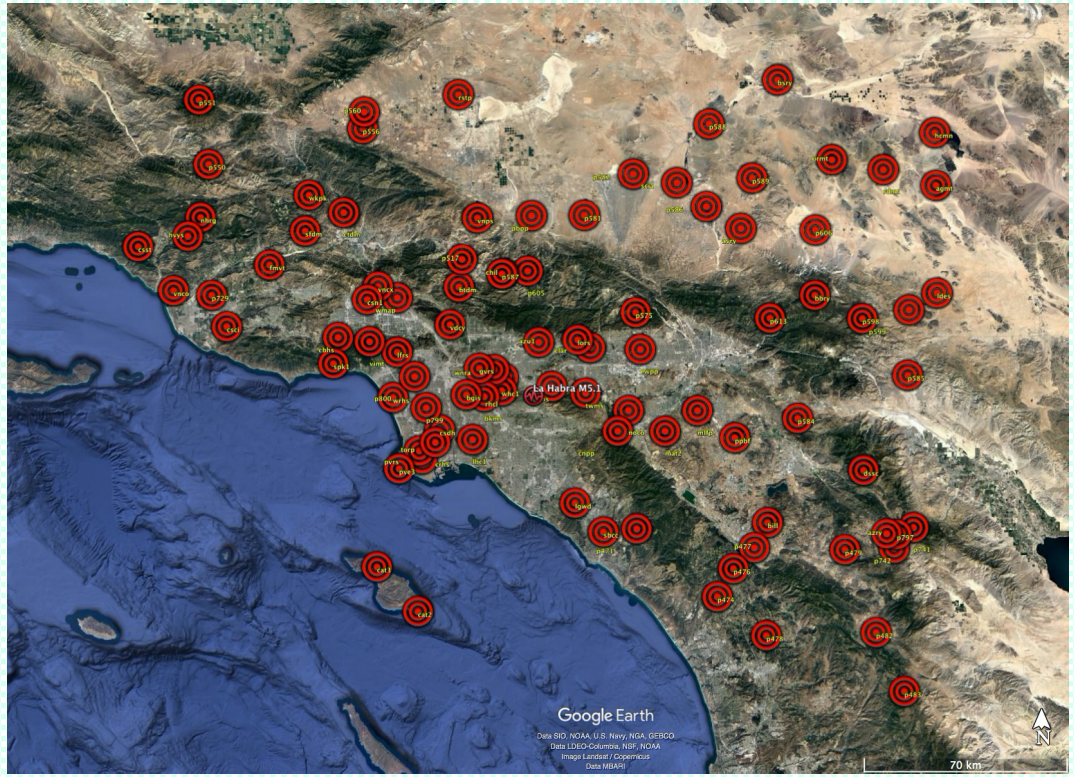
Scripps Orbit and Permanent Array Center- UCSD (SIO):

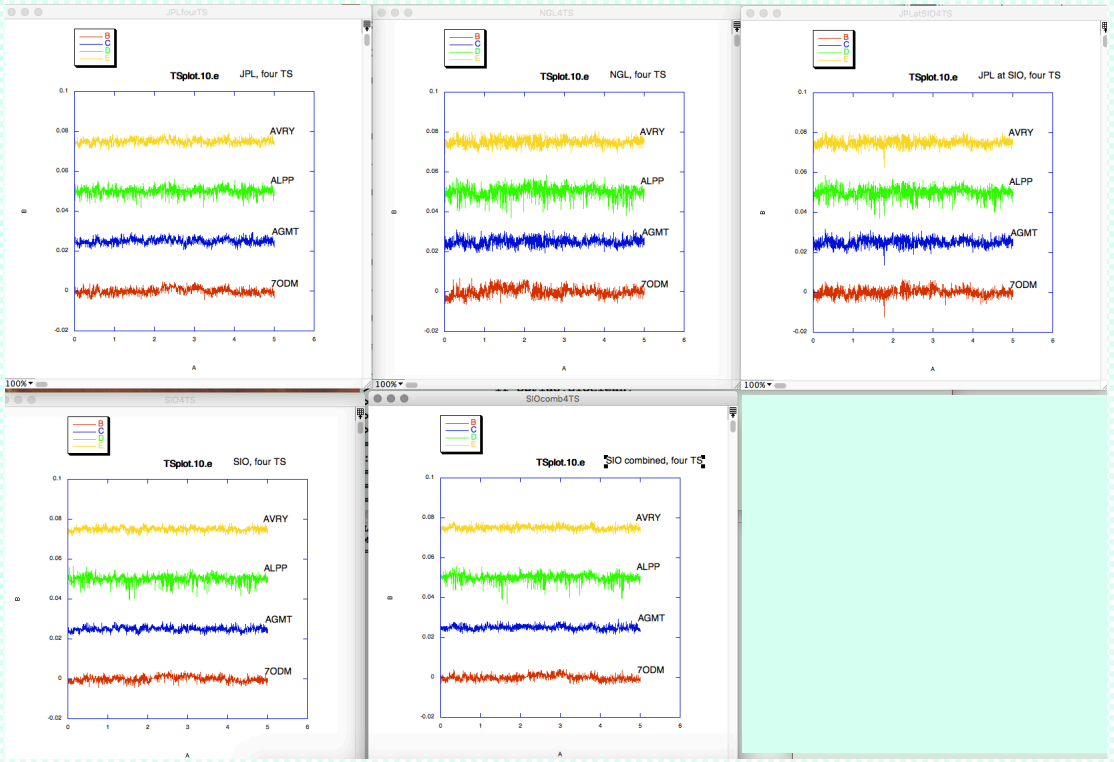
sopac-ftp.ucsd.edu:///pub/timeseries/measures/ats/WesternNorthAmerica/ *(or alts)*

WNAM_Raw_TrendNeuTimeSeries_jpl: SIOj
WNAM_Raw_TrendNeuTimeSeries_sopac: SIOs
WNAM_Raw_TrendNeuTimeSeries_comb: SIOc

RMS and Principal Component Analysis

by center





- Selected stations in a box, time span:
- **29-Sep-2011 28-Sep-2016**
  - -with over 95 percent of days occupied
  - -separately for e, n, u:
    - Form array A with each column a daily time series, station:

Singular Value Decomposition (SVD
Adapted from Numerical Recipes in C, *Press et al*, p59, 1992)

Stations ->

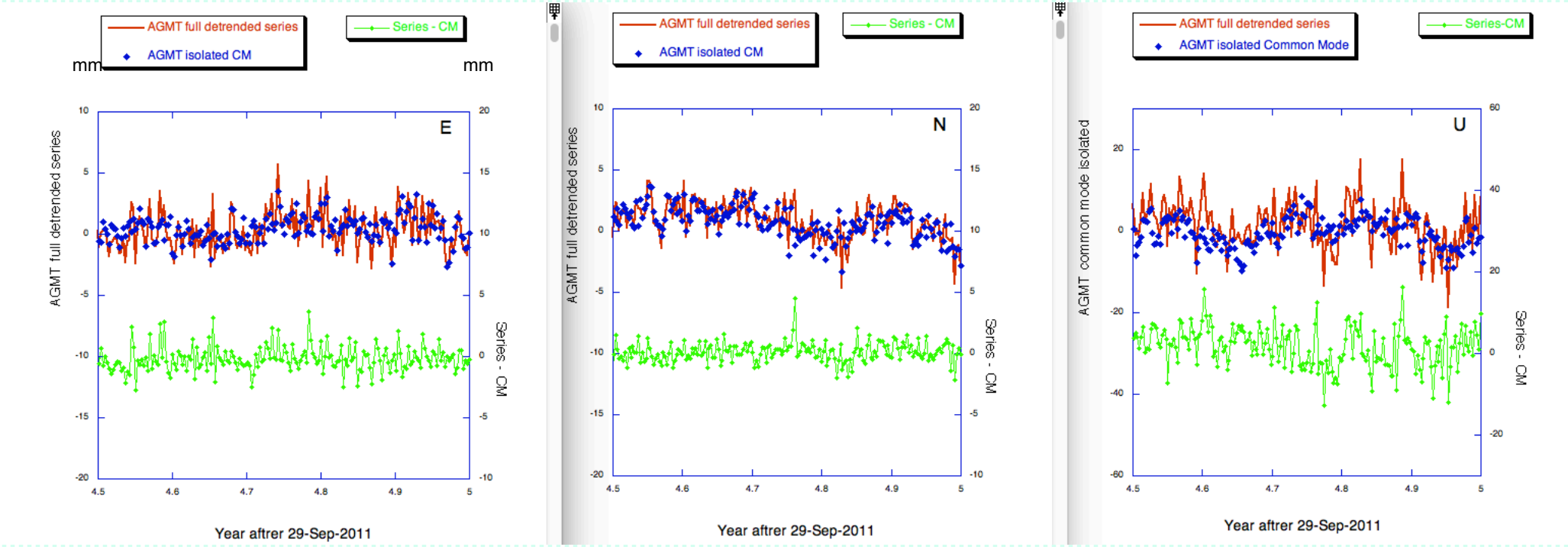
Days ->

$$\begin{pmatrix} & & \\ & \mathbf{A} & \\ & & \end{pmatrix} = \begin{pmatrix} & & \\ & \mathbf{U} & \\ & & \end{pmatrix} \cdot \begin{pmatrix} w_1 & & & \\ & w_2 & & \\ & & \cdots & \\ & & \cdots & \\ & & & w_N \end{pmatrix} \cdot \begin{pmatrix} & & \\ & \mathbf{V}^T & \\ & & \end{pmatrix} \tag{2.6.1}$$

RMS and Principal Component Analysis

by center

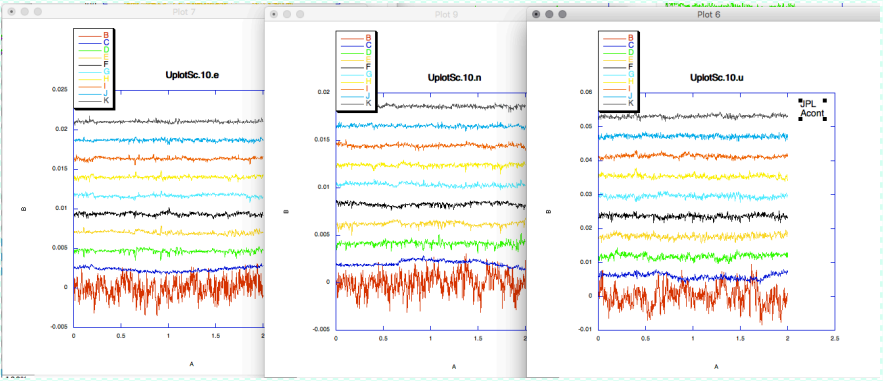
- ***Example from NGL center, AGMT station:***

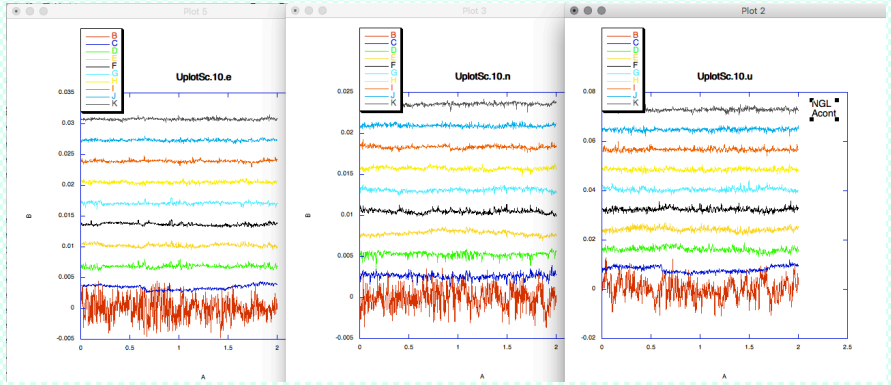


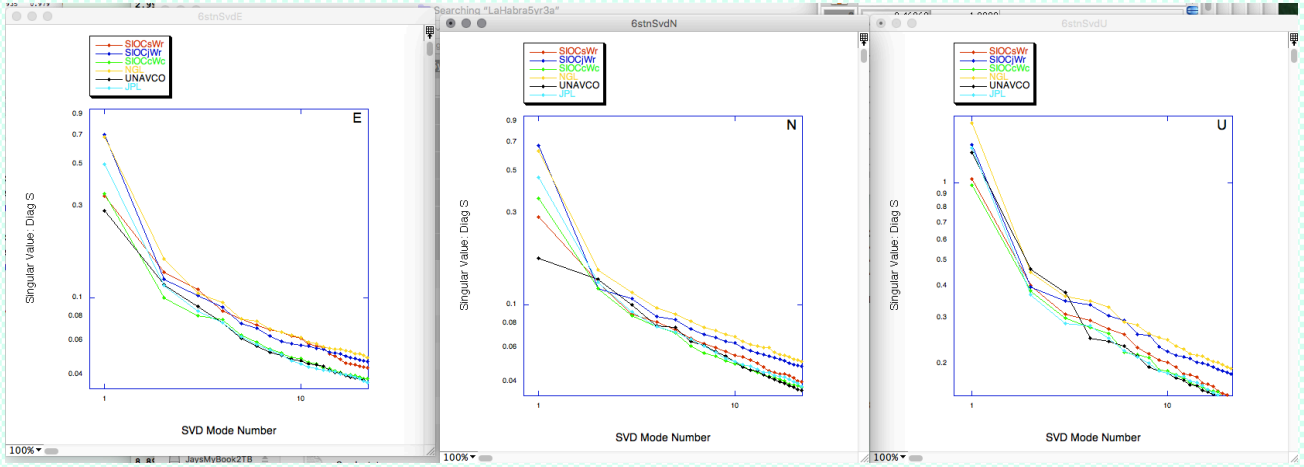
CM may arise from preliminary orbit/clock estimation:
At roughly 20,000km altitude, Estimates of GNSS satellite orbit are limited to few cm accuracy.

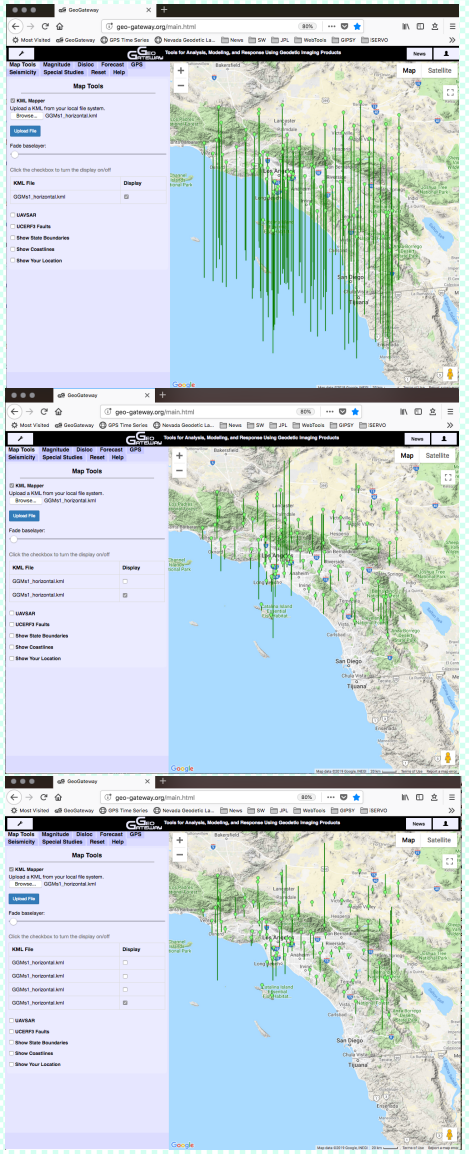
RMS and Principal Component Analysis

by center



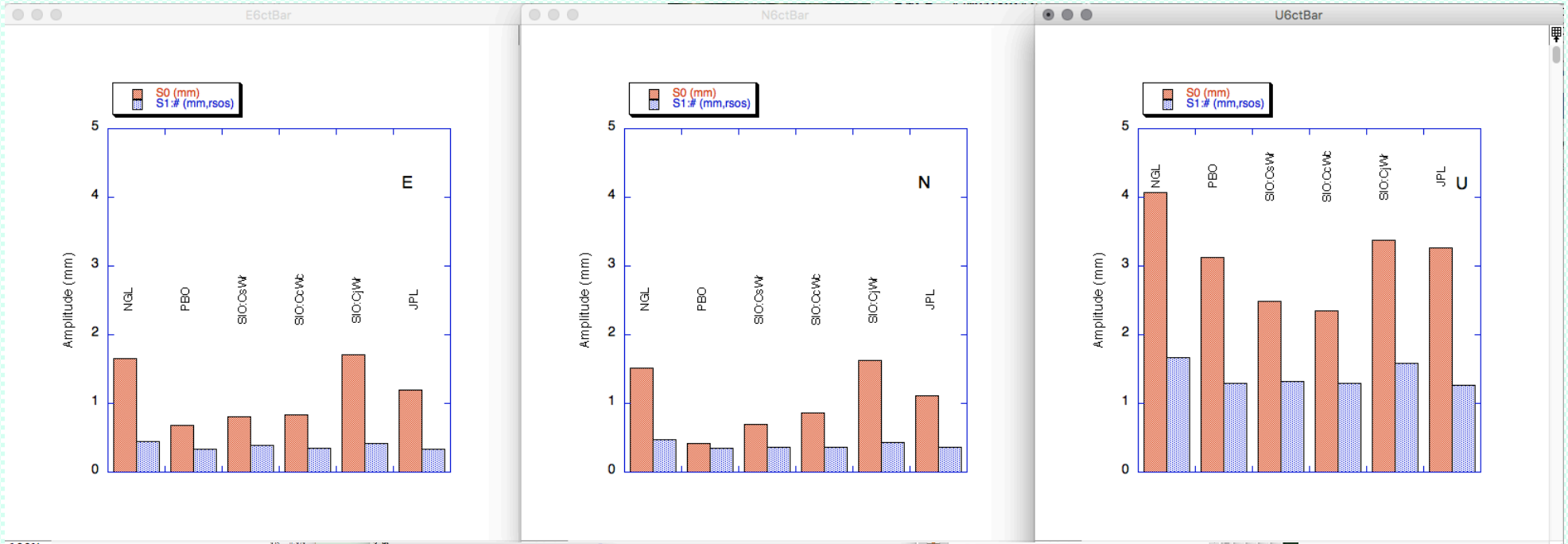


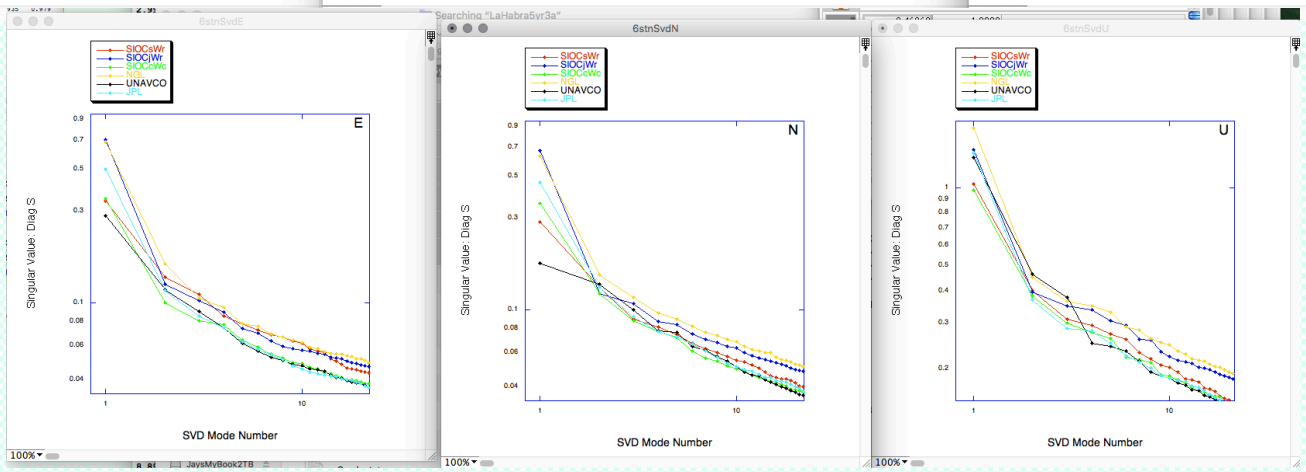




RMS and Principal Component Analysis

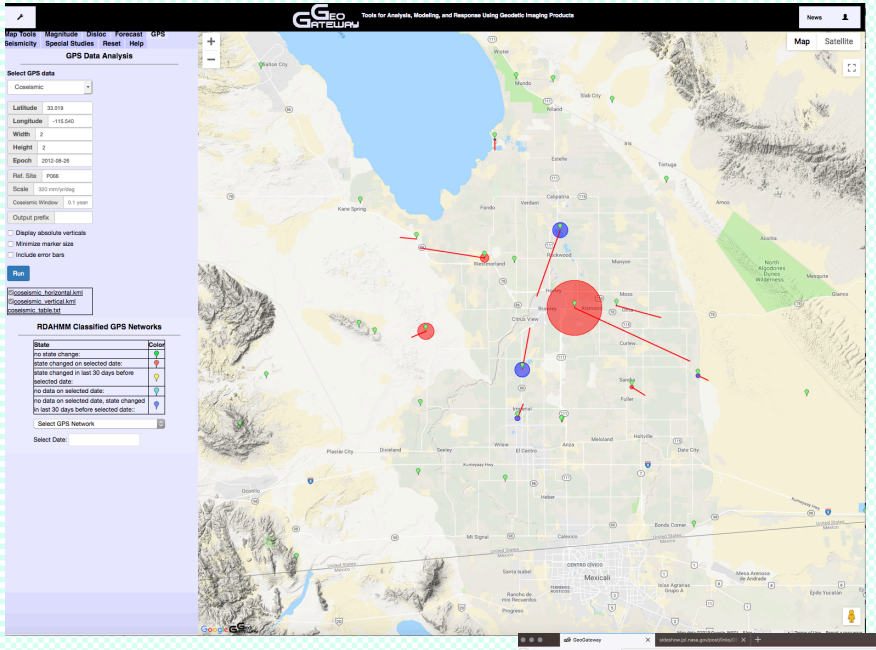
by center

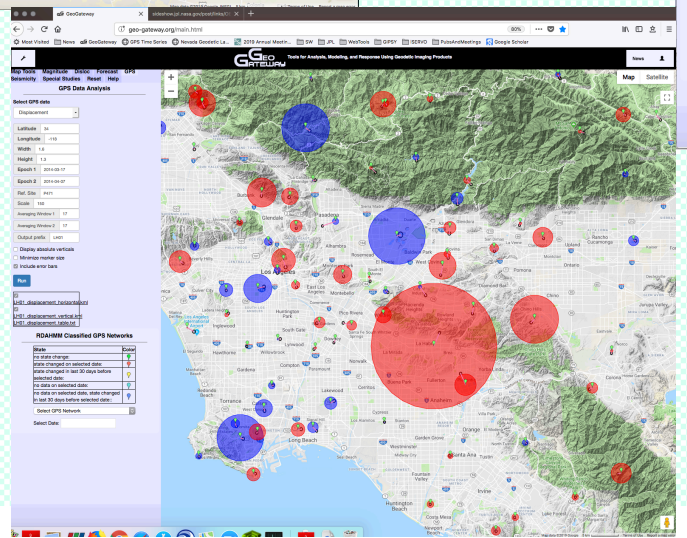


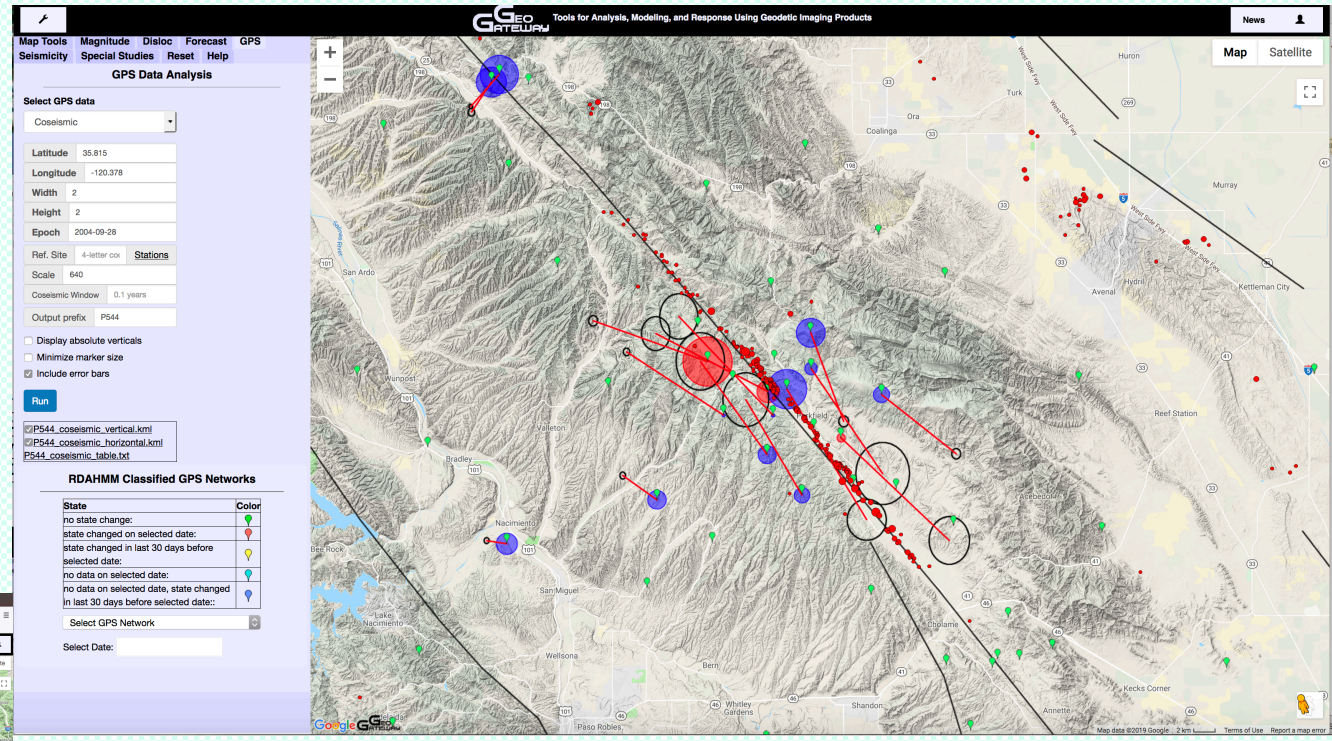


Application to Some California earthquakes

(2004-2014)

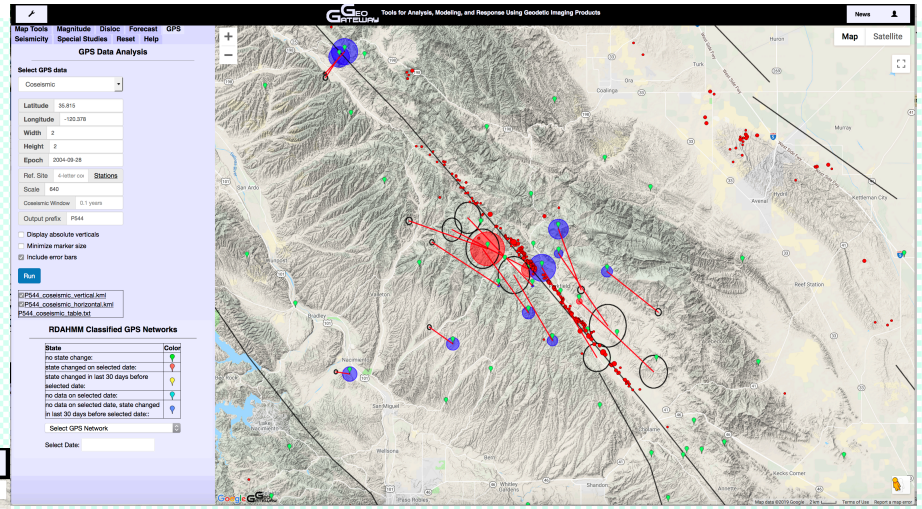


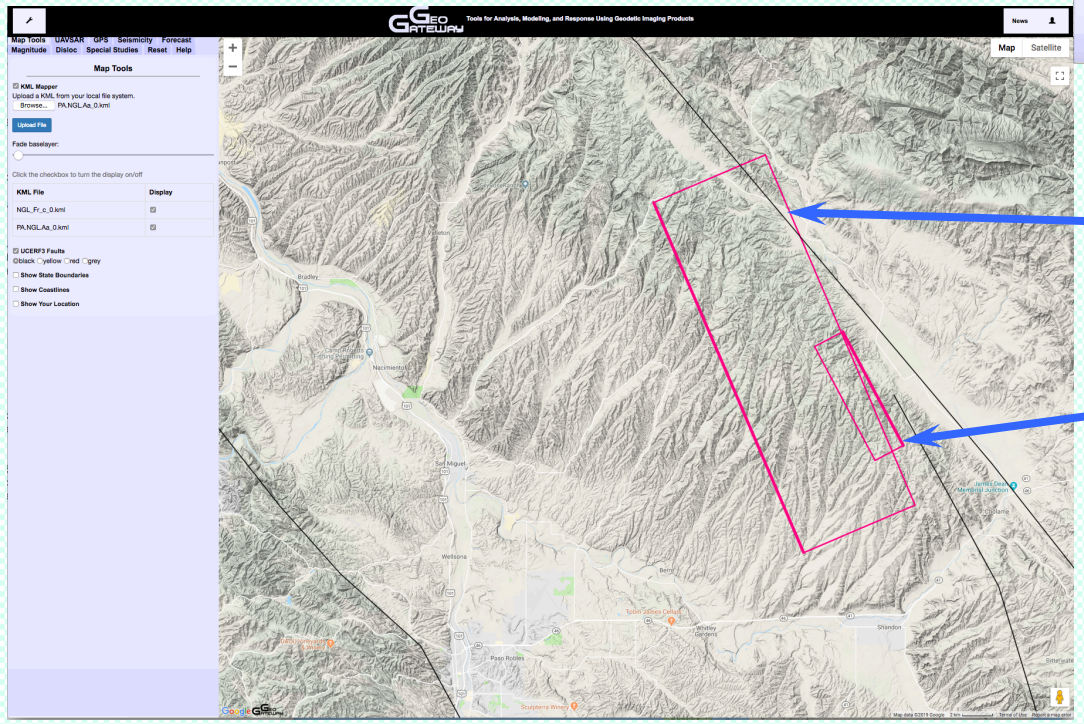




Application to Some California earthquakes (2004-2014)

Parkfield 2004 M6.0 event





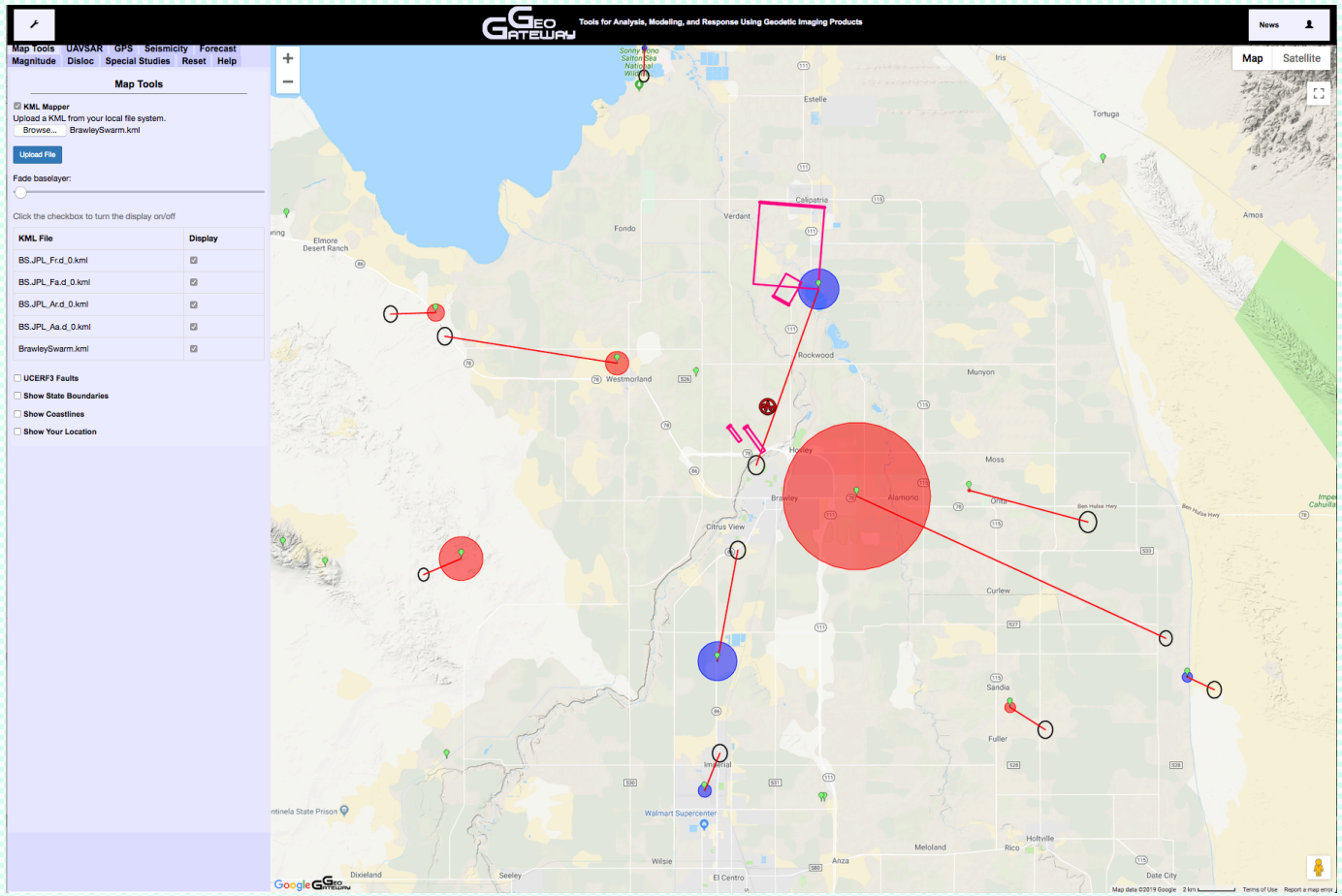
Overly simple jump, sigma estimates

Jump, sigma estimates with leading mode removed (in this case, not CME)

Application to Some California earthquakes
(2004-2014)

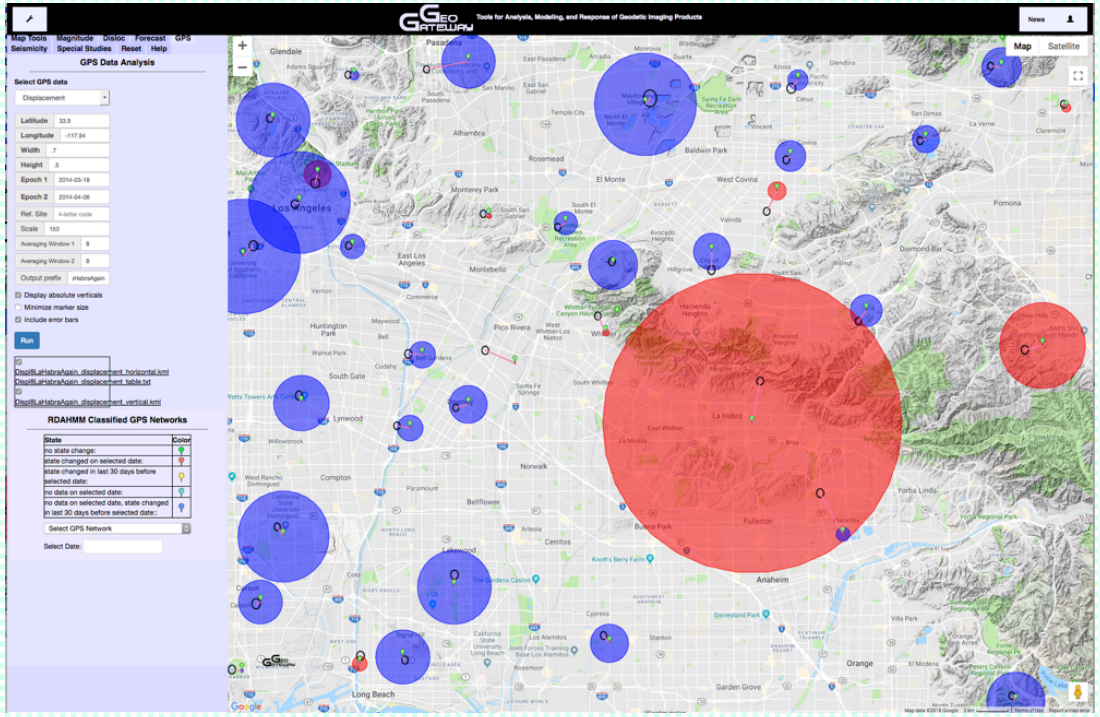
Brawley Swarm Lead Event:

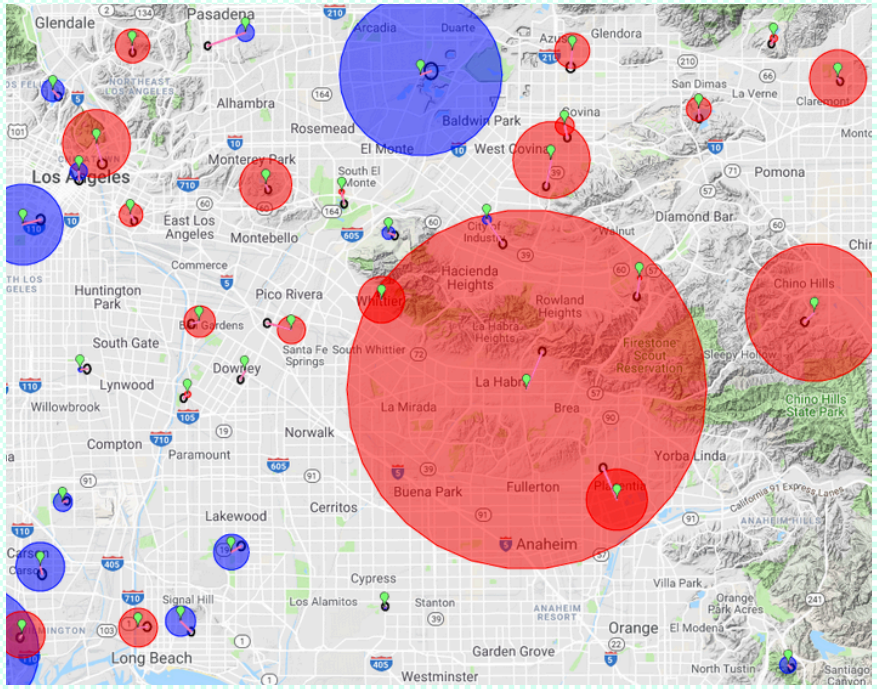
Date 26-Aug-2012
Lon -115.540
Lat 33.019
Depth 5.0
Magnitude 5.41
Strike 238
Rake -9
Dip 85
url https://earthquake.usgs.gov/earthquakes/eventpage/ci15200401/moment-tensor



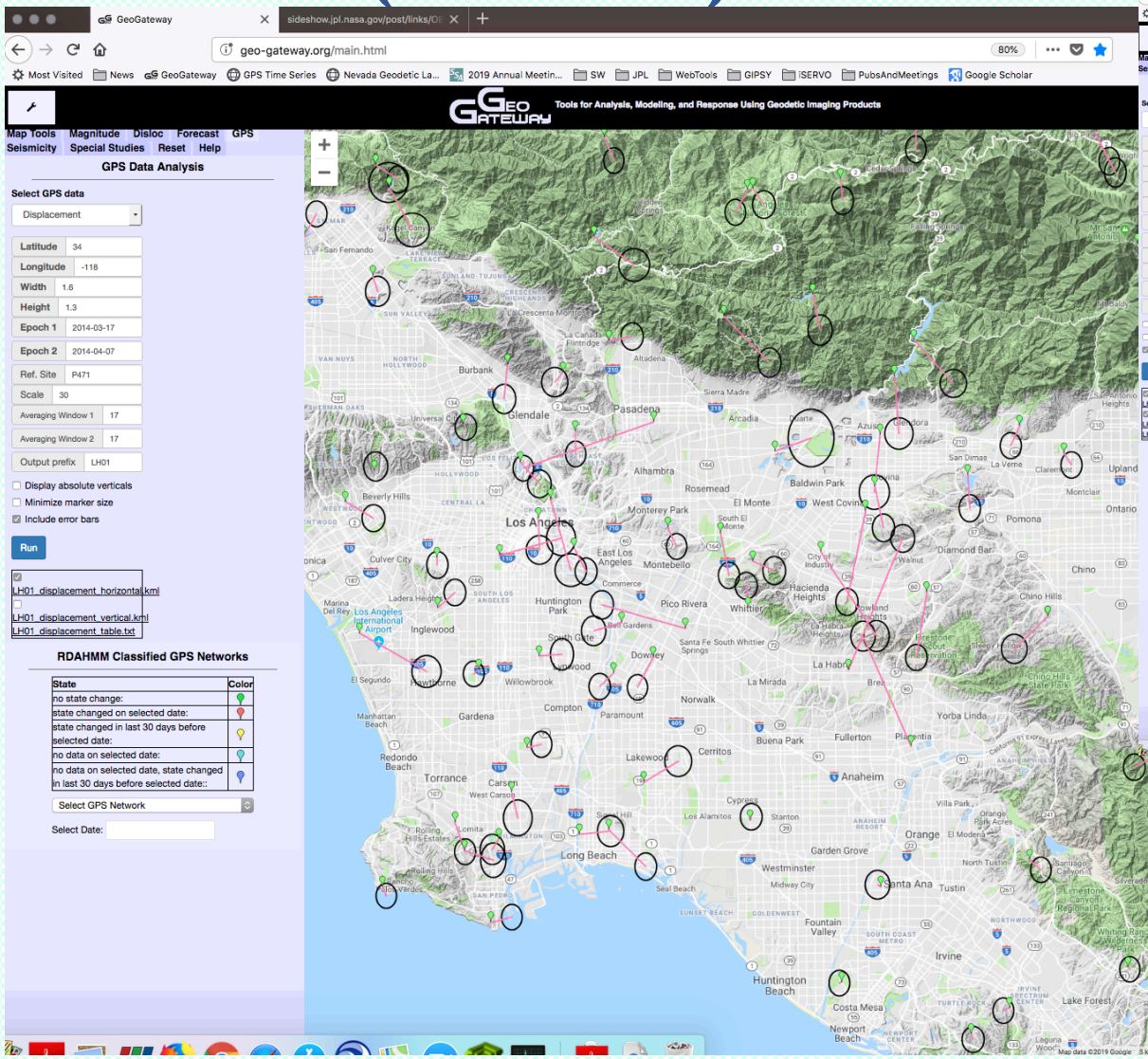
Application to Some California earthquakes (2004-2014)

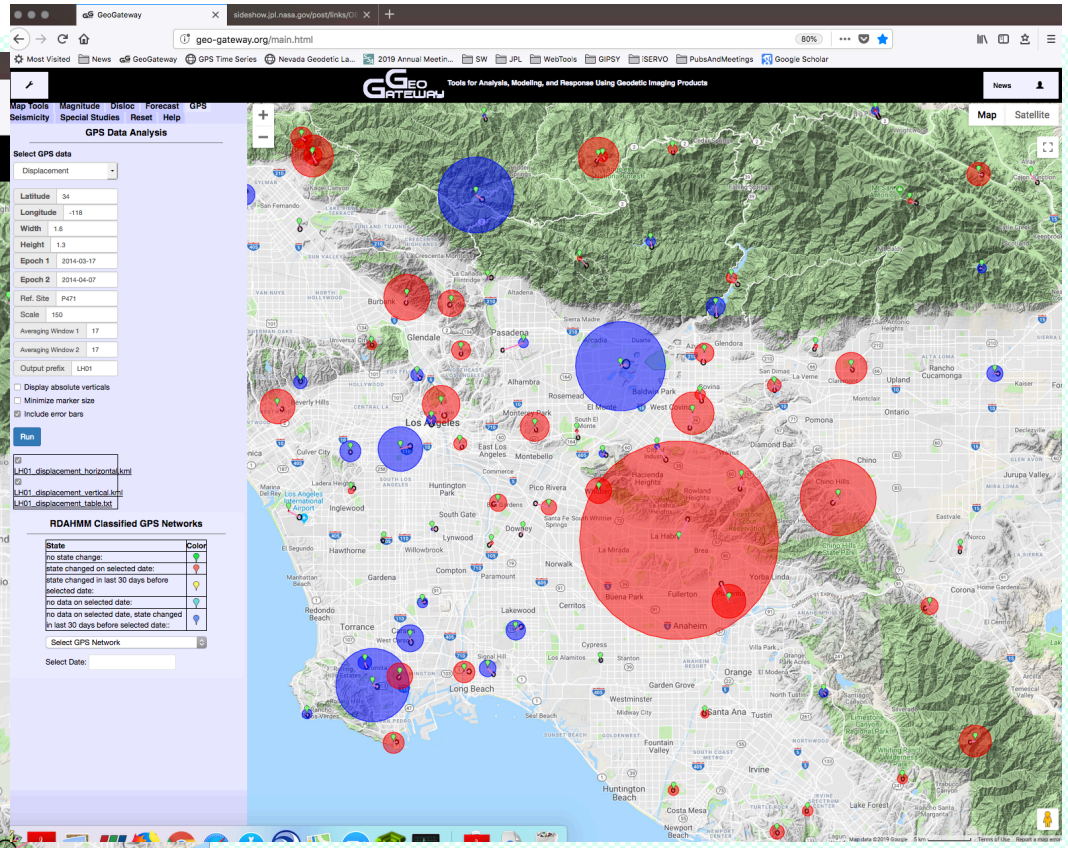
Left: jump in presence of CME
Right: jump with CME removed





Application to Some California earthquakes (2004-2014)





Conclusions and next steps

- Western North America Common Mode present in products of all four centers, eg. 2-4 mm vertical.
- CME can dominate quiet periods, skew regional displacement from small events.
- Parkfield uniform slip model is challenging: few, close-in stations, CME small but hard to remove.
- Brawley, La Habra events inversion improves with removing CME, correcting measurement sigmas.