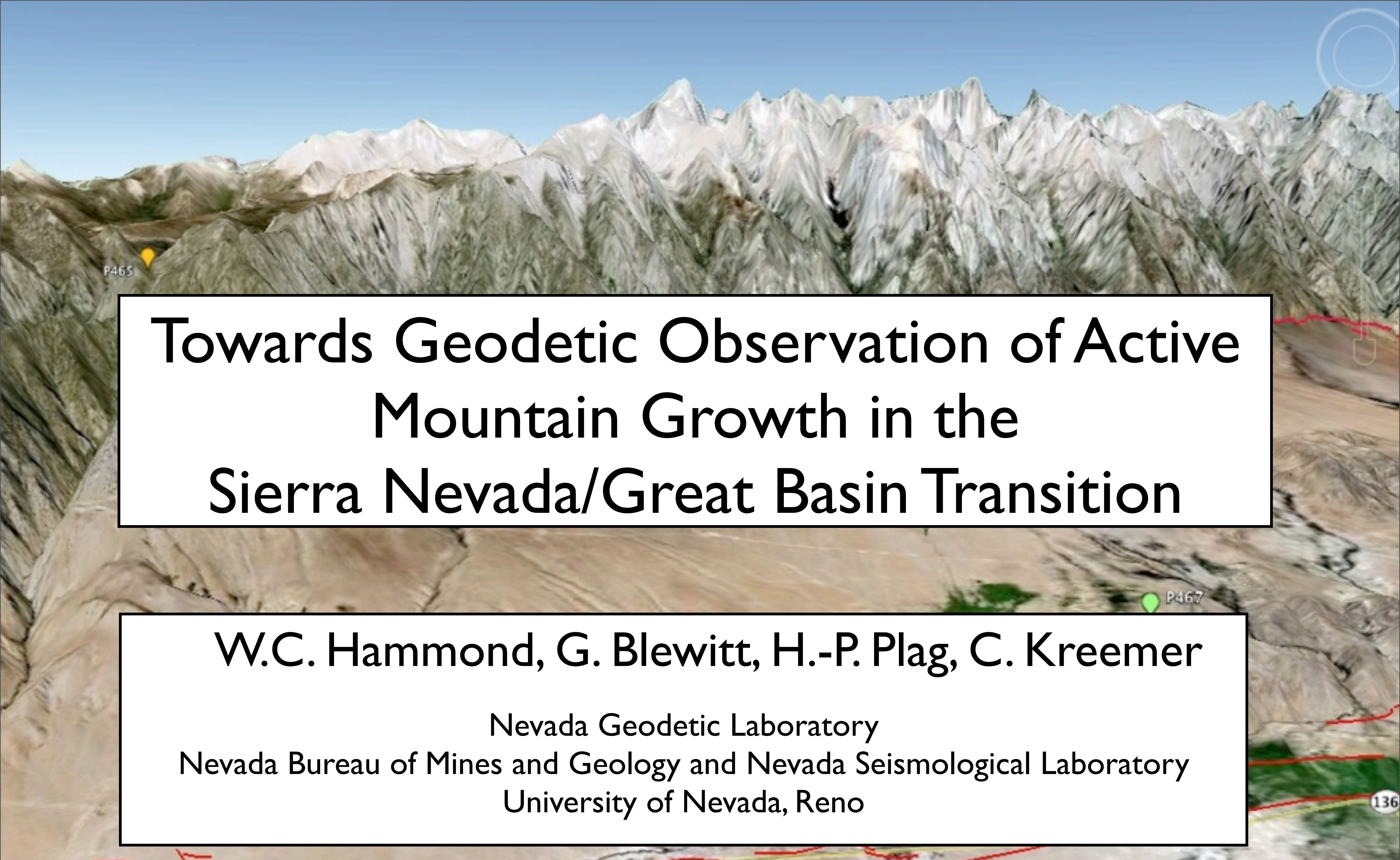

Towards Geodetic Observation of Active Mountain Growth in the Sierra Nevada/Great Basin Transition

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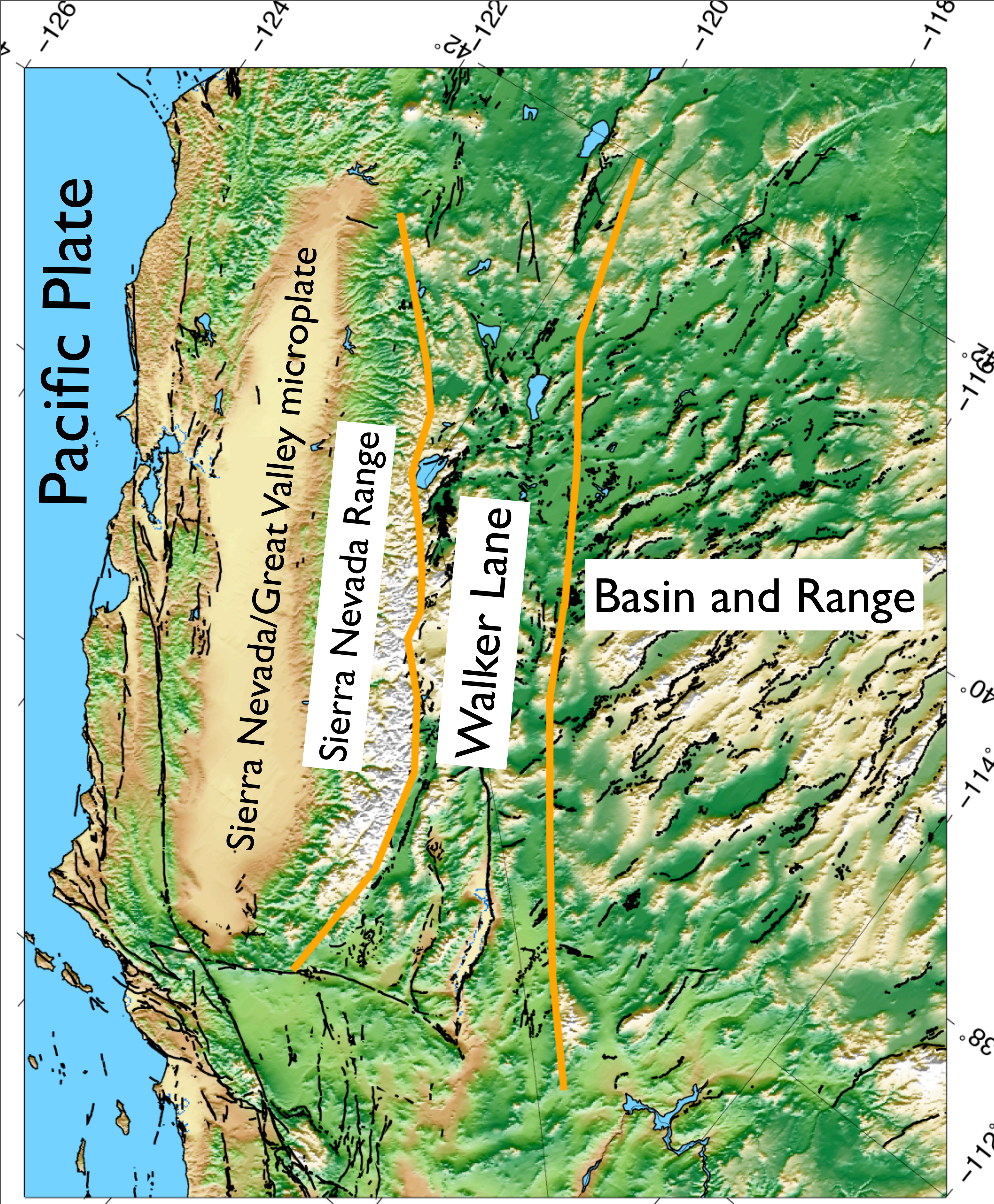
Nevada Geodetic Laboratory

nbmg

NEVADA

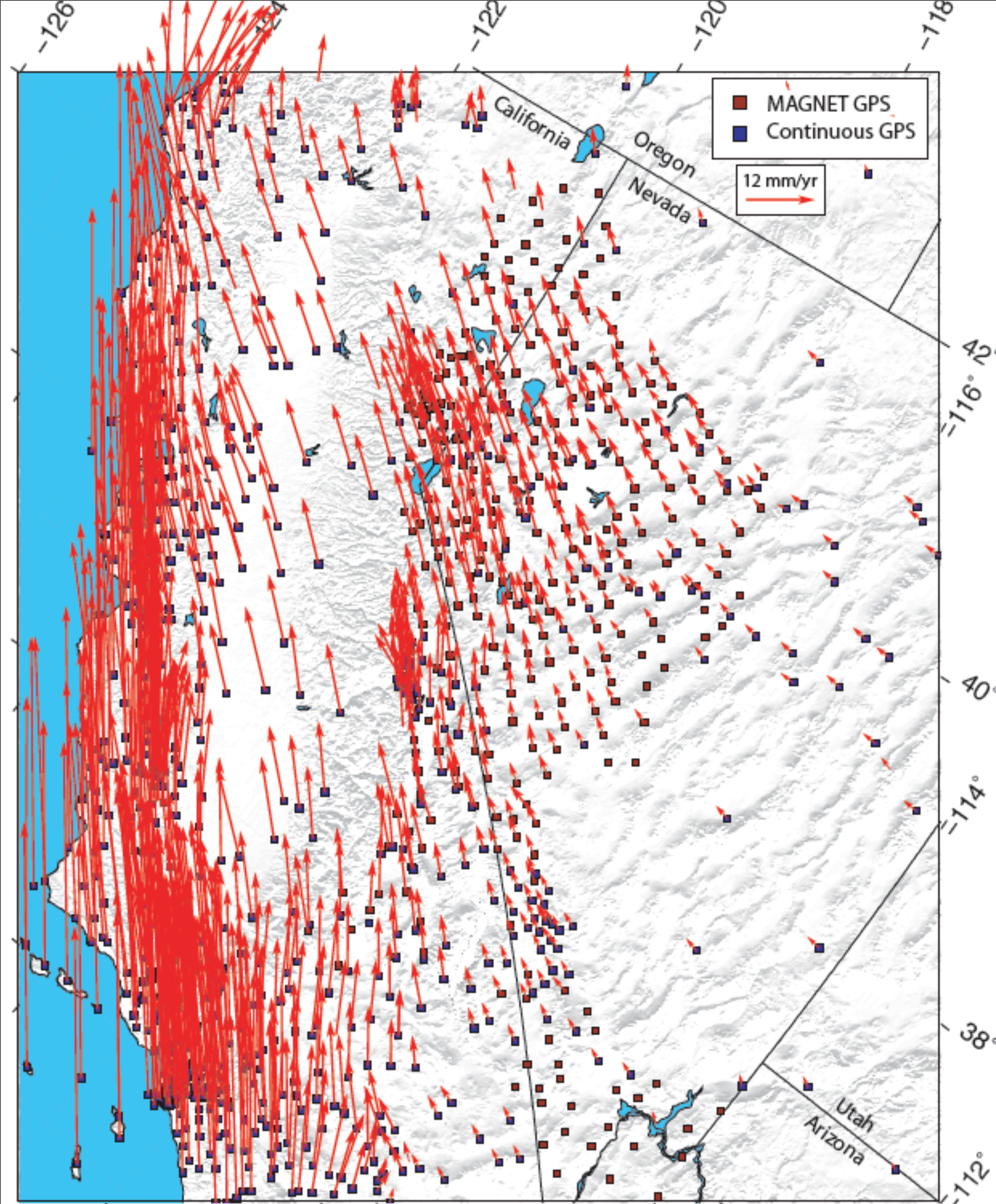
National Science Foundation
WHERE DISCOVERIES BEGIN

earth scope



Ideas About Sierra Nevada Elevation

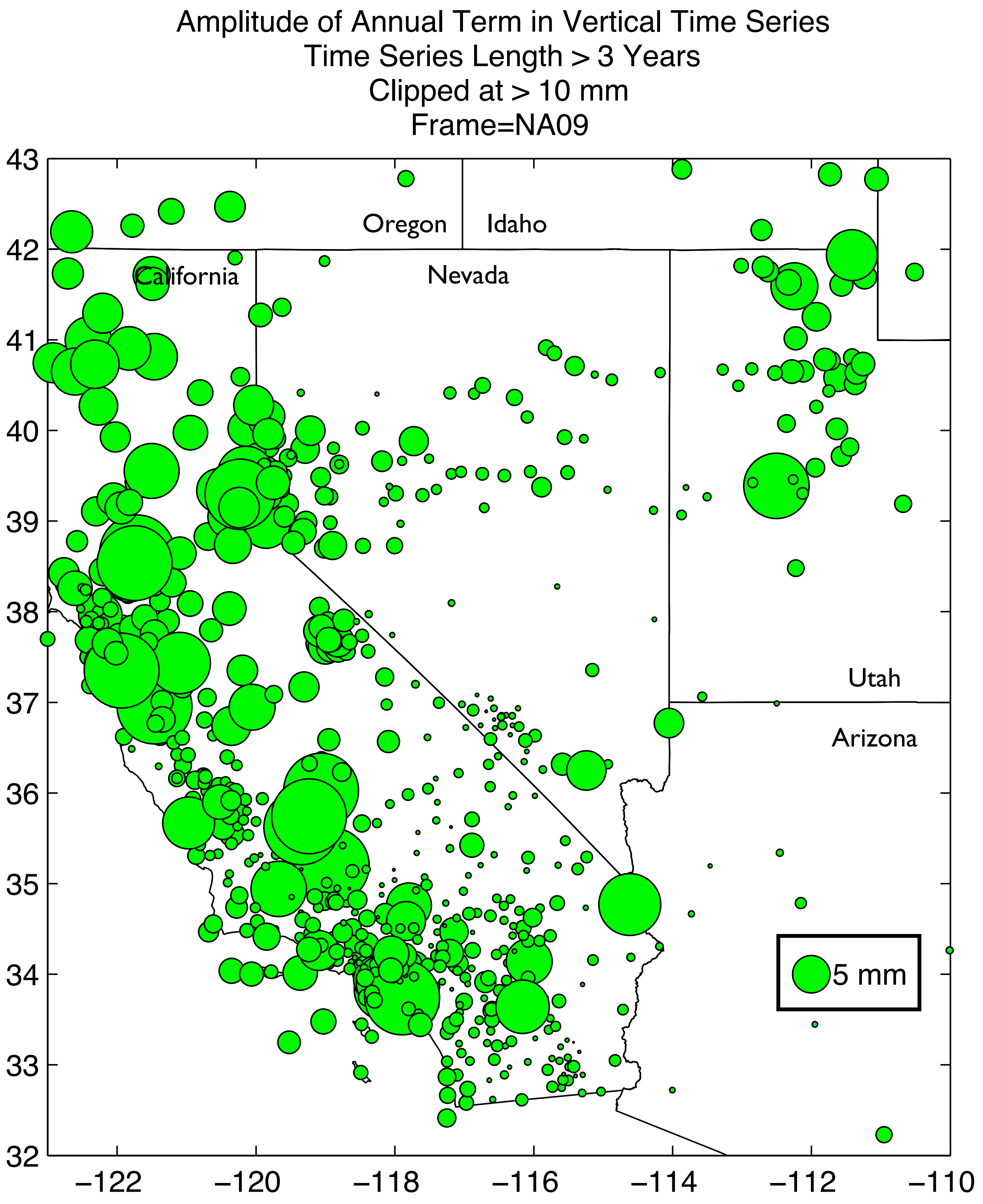
- Active tectonics drive normal faulting at 0.3 to 1.3 mm/yr normal slip rates on the eastern edge of the microplate (to form 2–3 km of relief).
- Westward tilting of the SNGV owing to a combination of loads, including:
- Denudation/unloading of High Sierra
- Sedimentation increases load on the Great Valley
- Lithospheric delamination, Isabella anomaly in southern Sierra, may explain higher elevations to the south
- Deglaciation, expected to have a small contribution
- Weakening of the plate at SNGV eastern edge
- Age: Young or Old? 40 Million or 3 millions years?

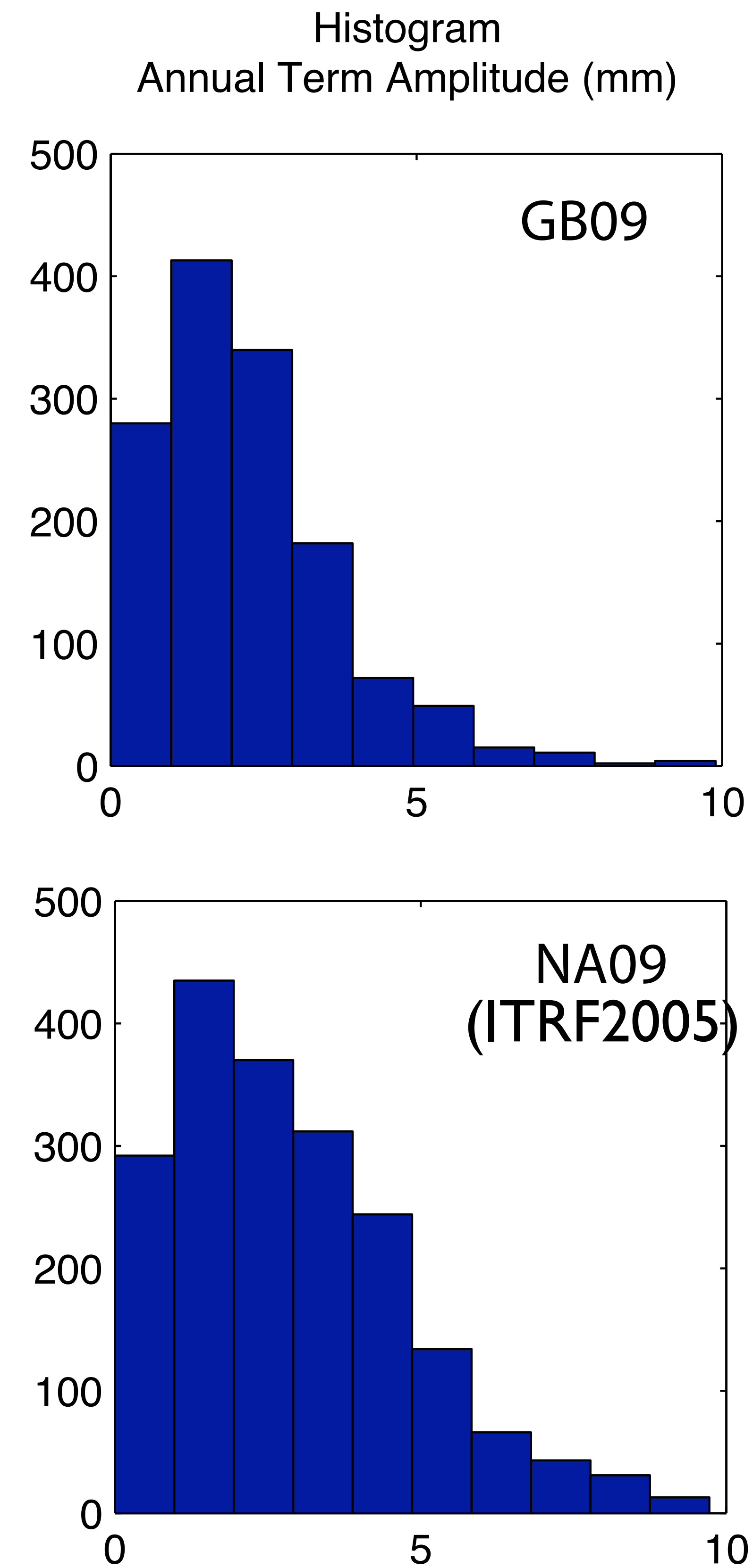


Geodetic Observation of Sierra Nevada Motion

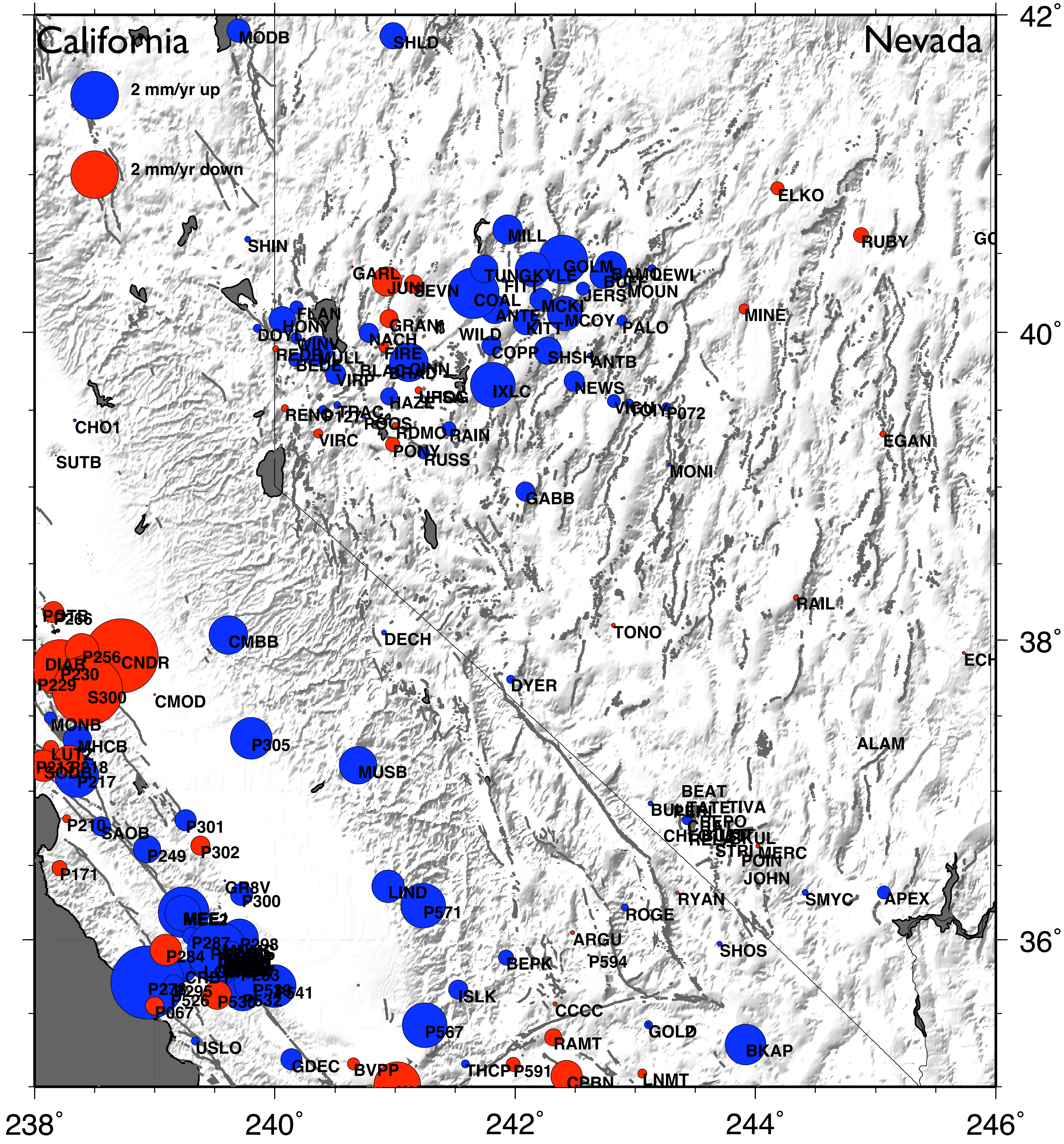
- Excellent GPS coverage across CA/NV with EarthScope PBO/PBO Nucleus/MAGNET. Have made lots of progress quantifying rate, pattern and style of deformation.
- Sierra Nevada/Great Valley microplate (SNGV) is quite rigid. Moves as a block to the level of 1 mm/yr.
- Subtle deformations inside microplate may be attributable to viscoelastic postseismic relaxation from historic earthquakes back to (e.g. 1857, 1872, 1906, 1952, 1993, 1999)
- If horizontal rigidity implies vertical rigidity, expect coherence of vertical motion associated with tectonic deformation

Seasonal Terms in Vertical GPS Time Series





Vertical GPS Velocities: California and Nevada



Attempt to focus on solid Earth by:

1) taking most reliable stations,
2) forming proxies that avoid non-tectonic signals e.g. associated with hydrology

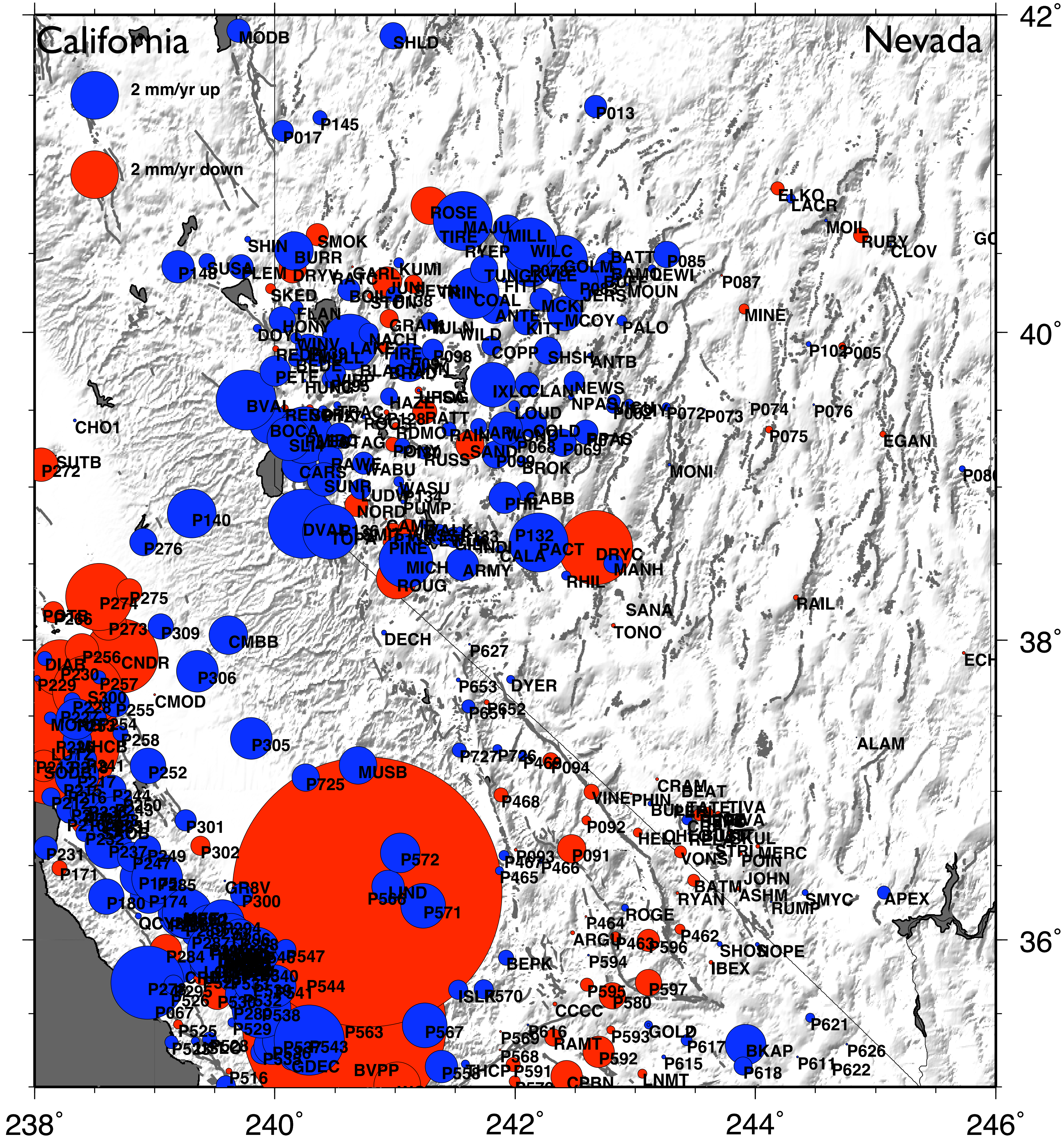
- Just EarthScope PBO, BARGEN, SCIGN, BARD networks
- Time Series 5 years or longer
- Seasonal (annual) oscillation amplitude < 4 mm
- Considered outlier if abs(rate) >15 mm/yr

Specifically omitting a few sites near:

- Long Valley Caldera magmatic area
- Coso geothermal area

(note Blue is Up, Red is Down)

Vertical GPS Velocities: California and Nevada



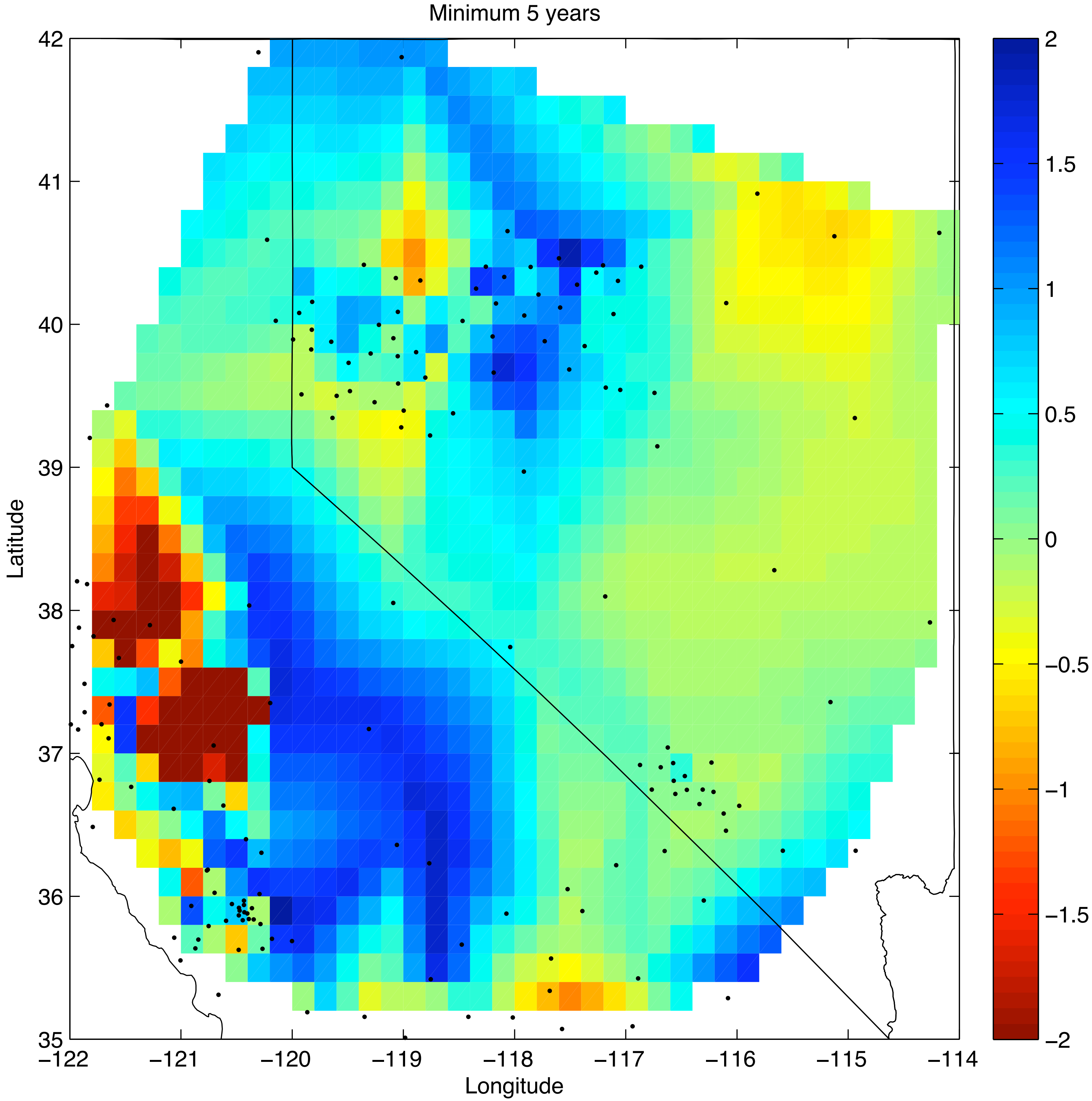
- Time Series **3** years or longer
- Frame is GB09, similar to ITRF2005, but regionally filtered on scale of Great Basin.

We See:

- Extremely stable eastern NV, RMS of ~0.2 mm/yr
- Larger uplift rates near Central Nevada Seismic Belt ~2 mm/yr
- Complexity in Walker Lane where crustal deformation rates are higher
- Generally upward rates on west slope of Sierra Nevada Range near 1-2 mm/yr
- Though consistent still skeptical of Great Valley down motion

Rates similar to what others have shown (e.g. Fay et al., 2008; Bennett et al., 2009; Dong et al., Meertens et al.)

Vertical GPS Velocities Interpolated



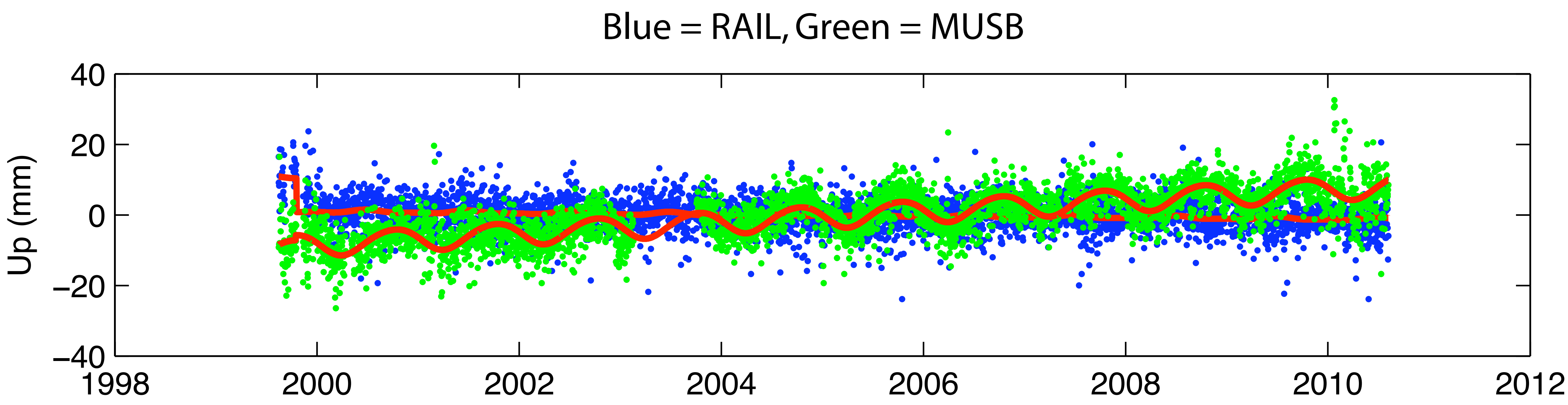
- Time Series **5** years or longer
- Frame is GB09, similar to ITRF2005, but regionally filtered on scale of Great Basin.

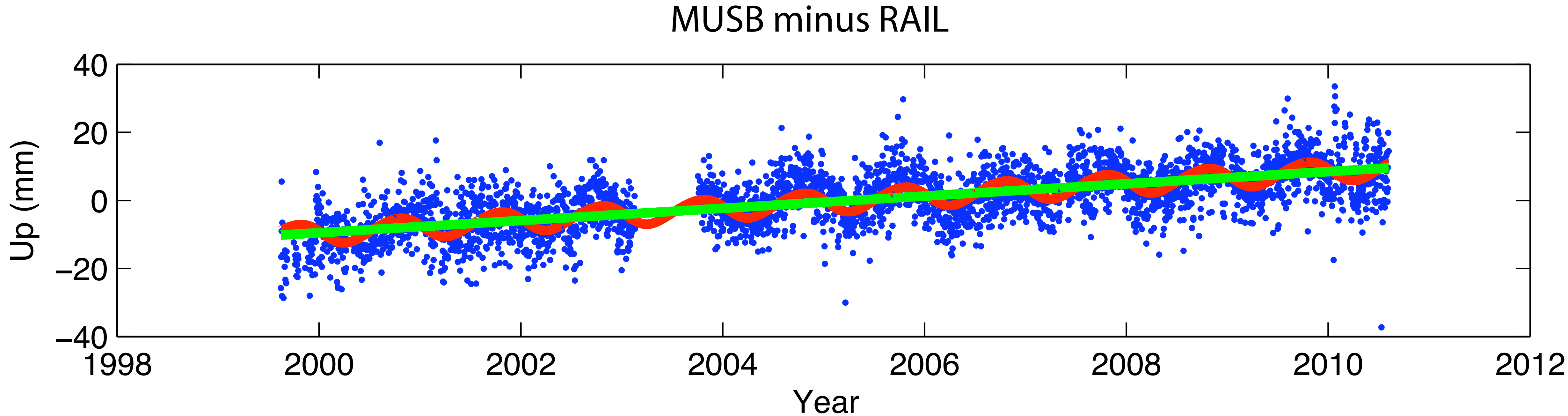
We See:

- Extremely stable eastern NV, RMS of ~0.2 mm/yr
- Larger uplift rates near Central Nevada Seismic Belt ~2 mm/yr
- Complexity in Walker Lane where crustal deformation rates are higher
- Generally upward rates on west slope of Sierra Nevada Range near 1 mm/yr

Rates similar to what others have shown (e.g. Fay et al., 2008; Bennett et al., 2009; Dong et al, 2009)

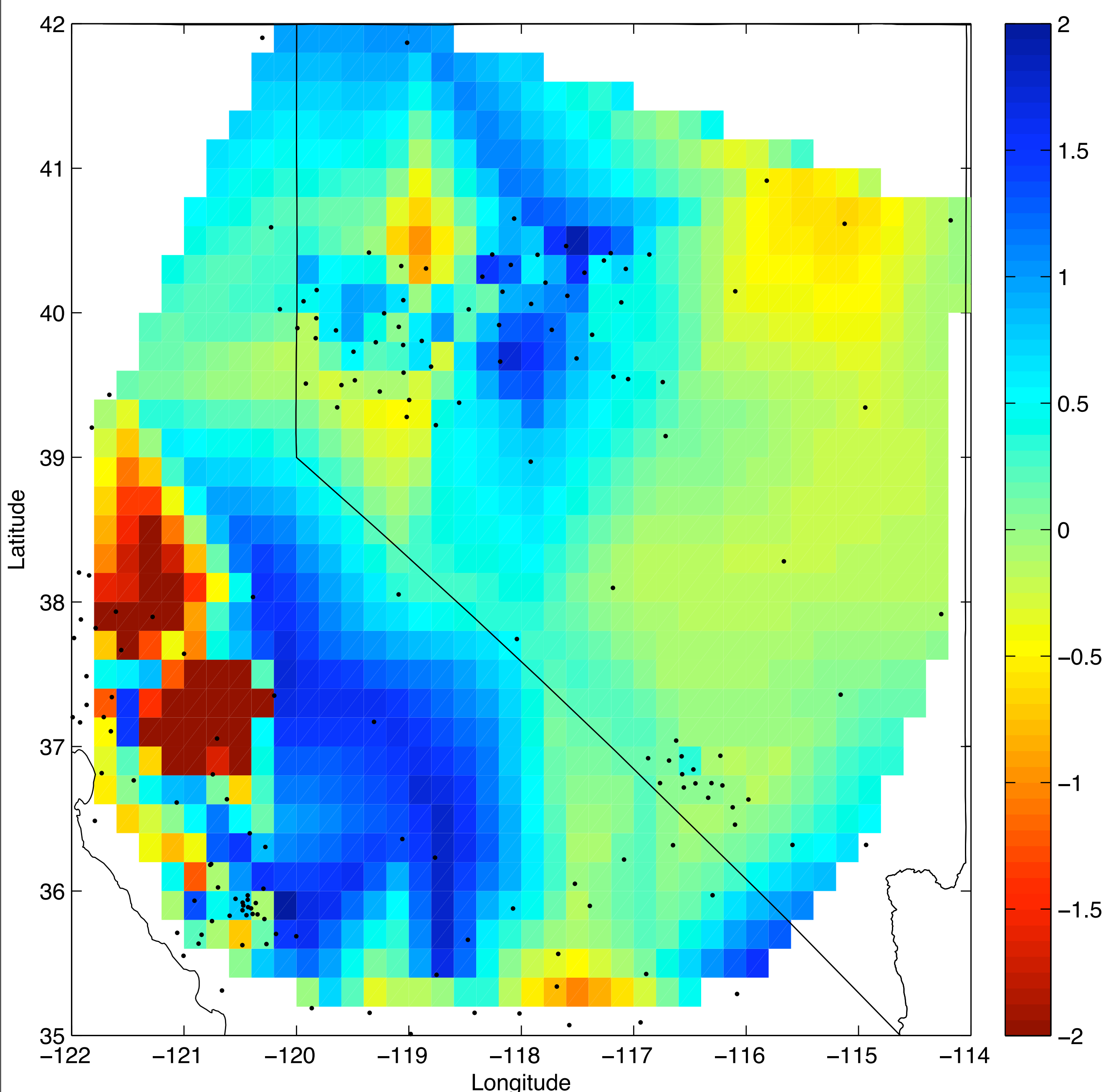
Relative Motion Between Two Stations





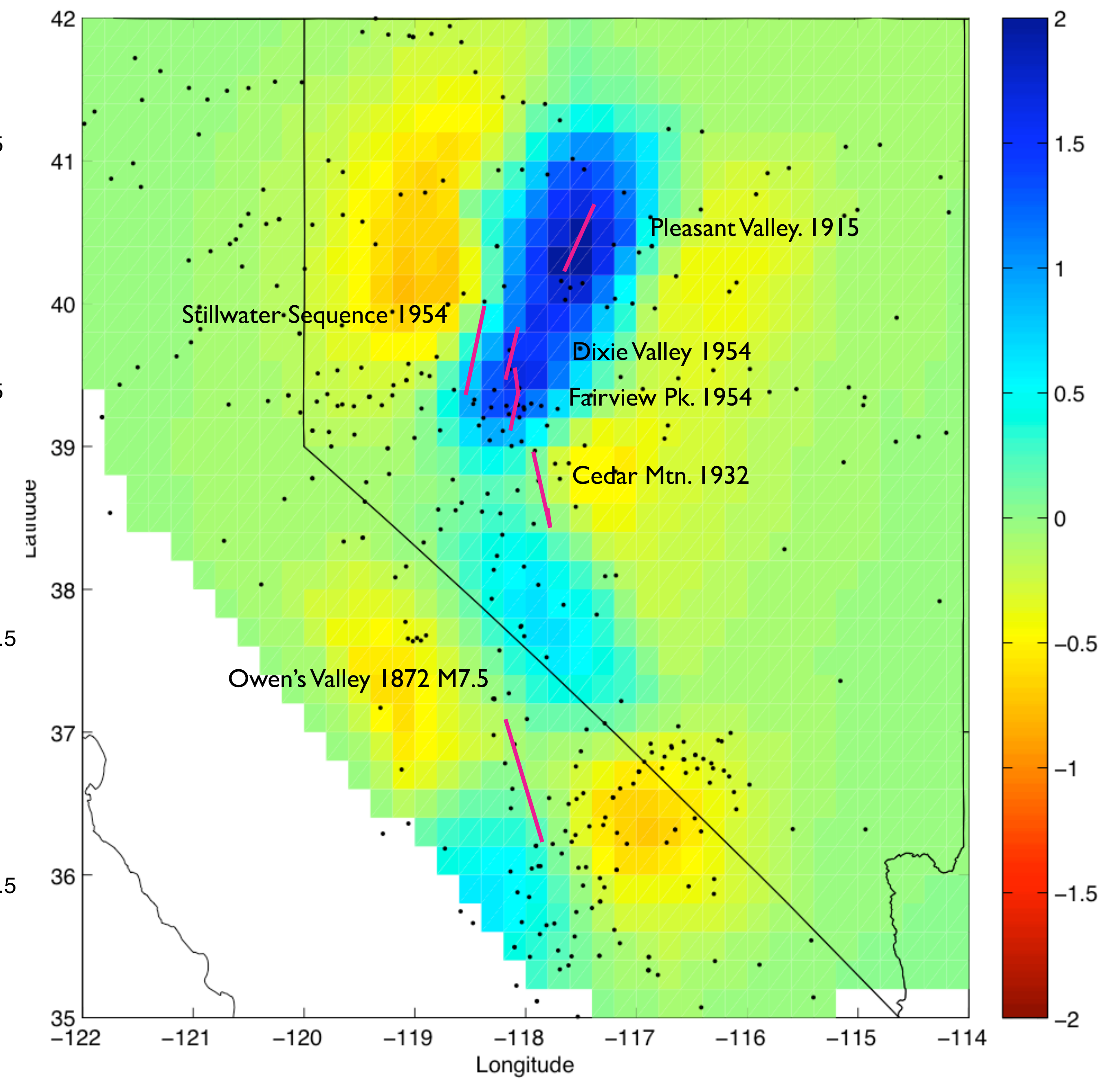
Why Do We Need Earthquake Cycle Models?
Central Nevada Postseismic Viscoelastic Relaxation

Observation



dT>5 Years

Model

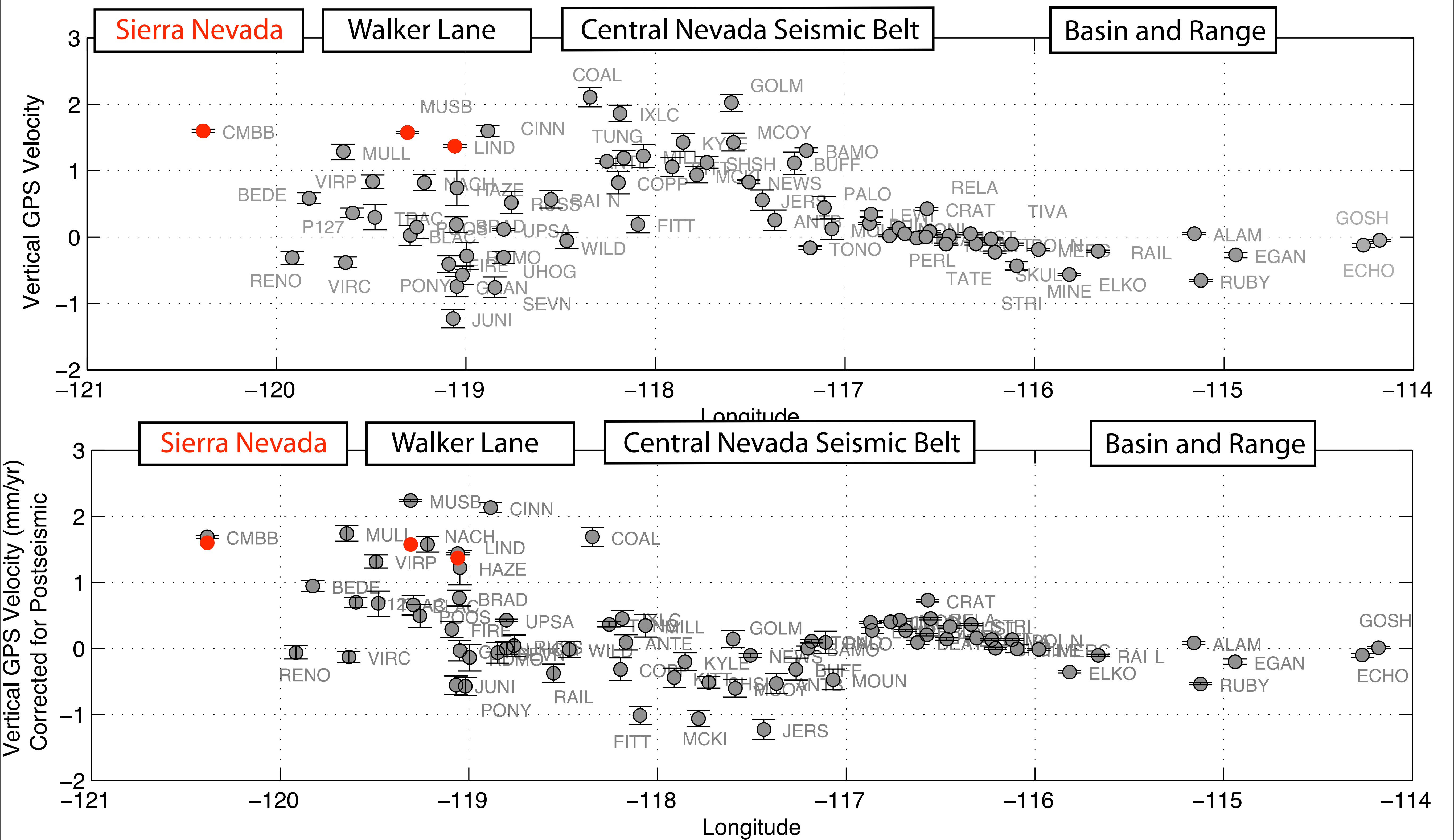


Hammond et al., (2009) using VISCO1D software of Pollitz, (1997) - Vertical GPS not used to constrain model

Profile of Vertical GPS Velocity:

Uncertainty in Rate Near 0.2 mm/yr

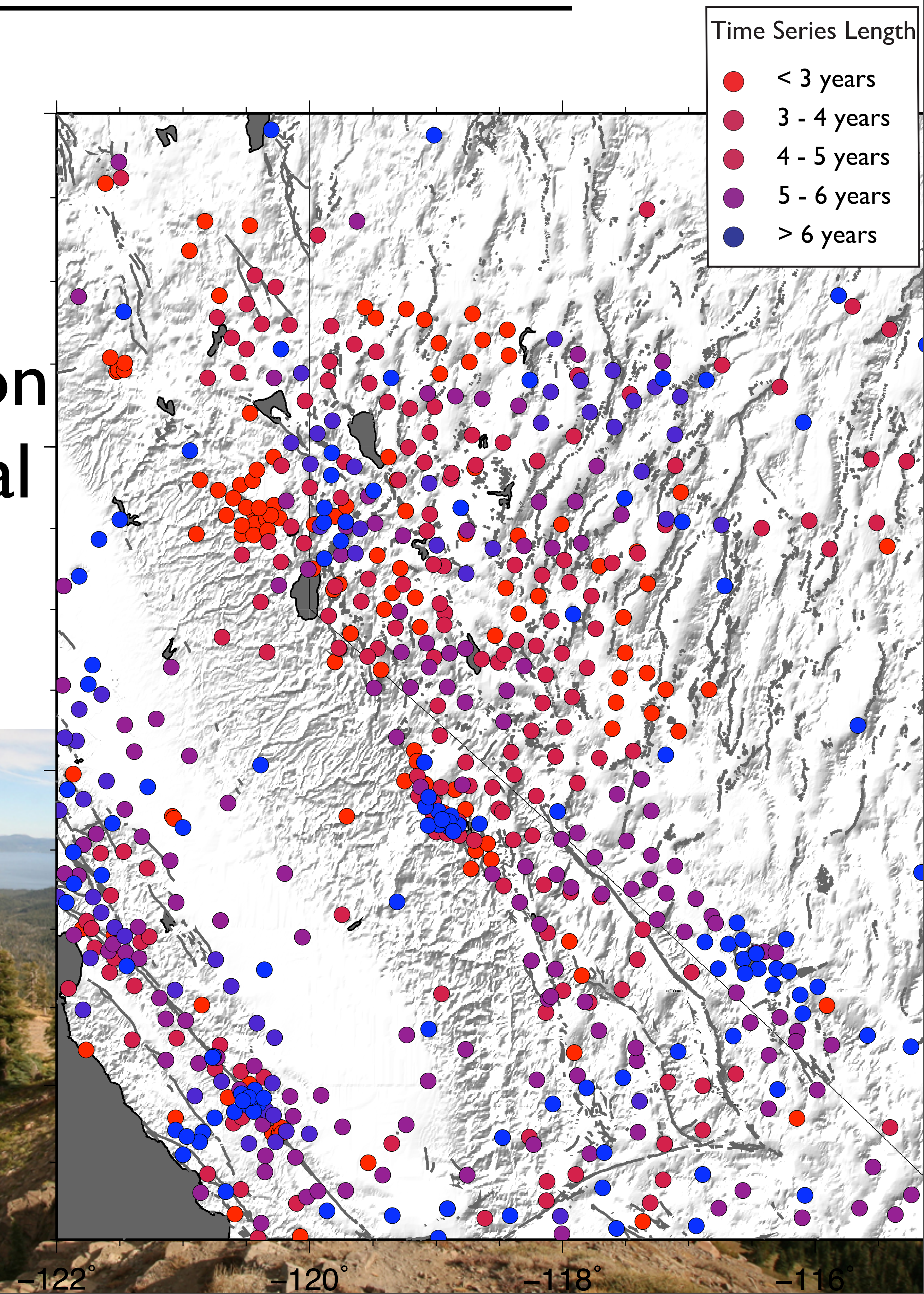
Effect of Viscoelastic Correction



The Future of Sierra Nevada GPS

PBO & MAGNET

- Will provide longer time series, and better constraint on geographic variation of vertical motion



Implications and Conclusions

- Sierra Nevada stations are rising 1-2 mm/yr where observations are good, i.e. subject to aggressive screening criteria accepting only long time series with small seasonal terms.
- This result implies SNGV tilting rates of 0.5° to 2°/ Ma, depending on width of tilting plate and true (solid Earth) vertical motion in Great Valley.
- Consistent with geologic slip rates on SN range front faults (eastern Sierra), 10 of which vary from 0.3 -1.3 mm/yr.
- This motion can generate modern relief and SNGV structural tilt in <3 Ma. From the perspective of geologic history these rates are relatively high and imply a fairly young modern range.

Block Modeling the Vertical Dimension