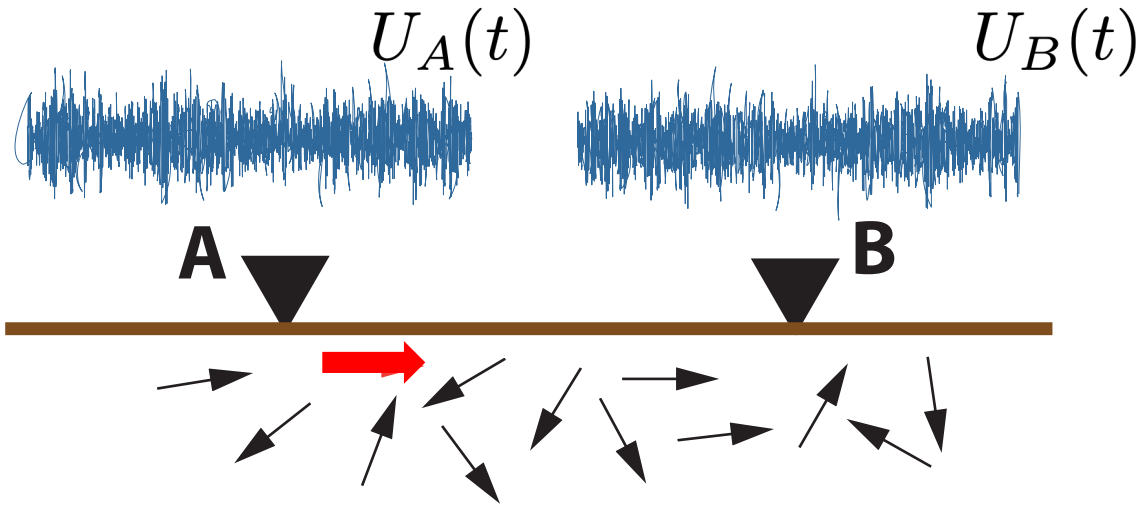
COSEG, March 23rd 2021

Marine Denolle, Tim Clements, Laura Ermert, Julian Schmitt

Groundwater monitoring using ambient noise seismology

Use ambient seismic waves to monitor the shallow structure

Window seismic noise at 2 stations



Cross-correlate noise windows between stations

$$G_{AB}(t) = U_A(t) * U_B(t)$$

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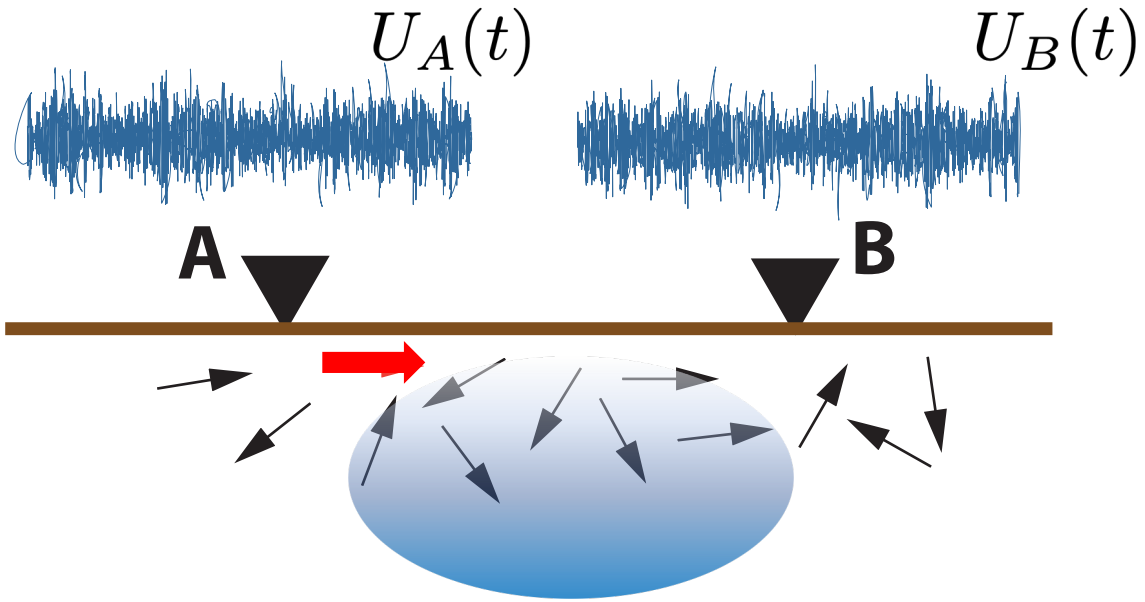

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Use ambient seismic waves to monitor the shallow structure

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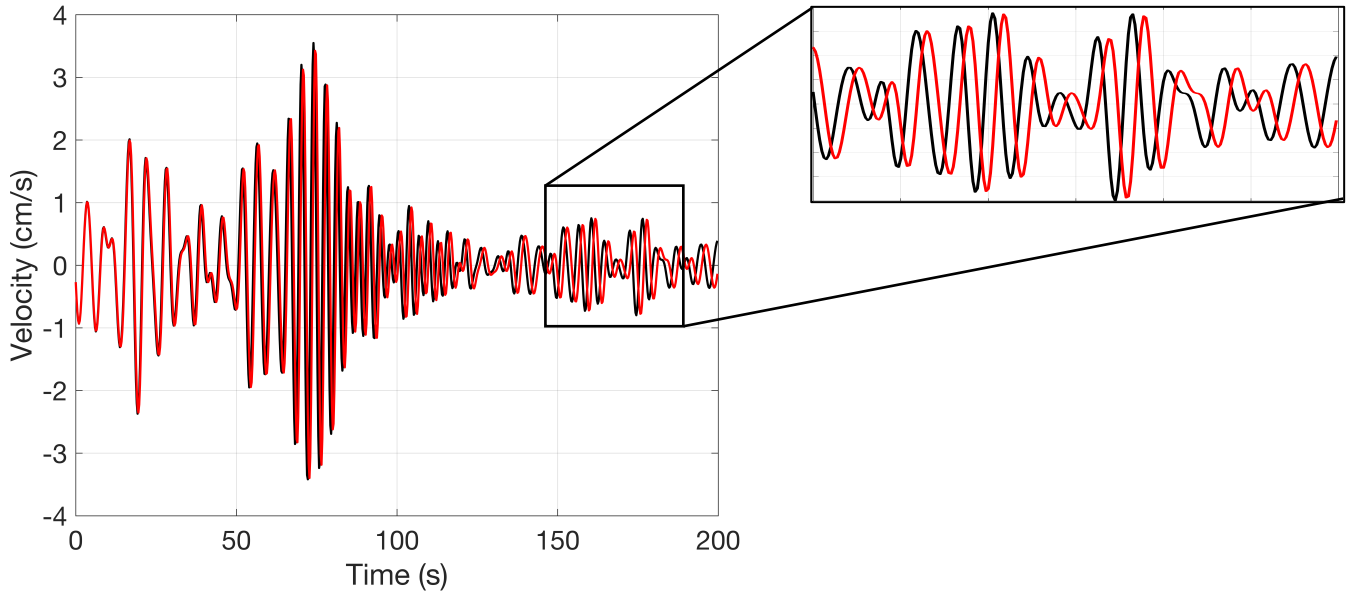
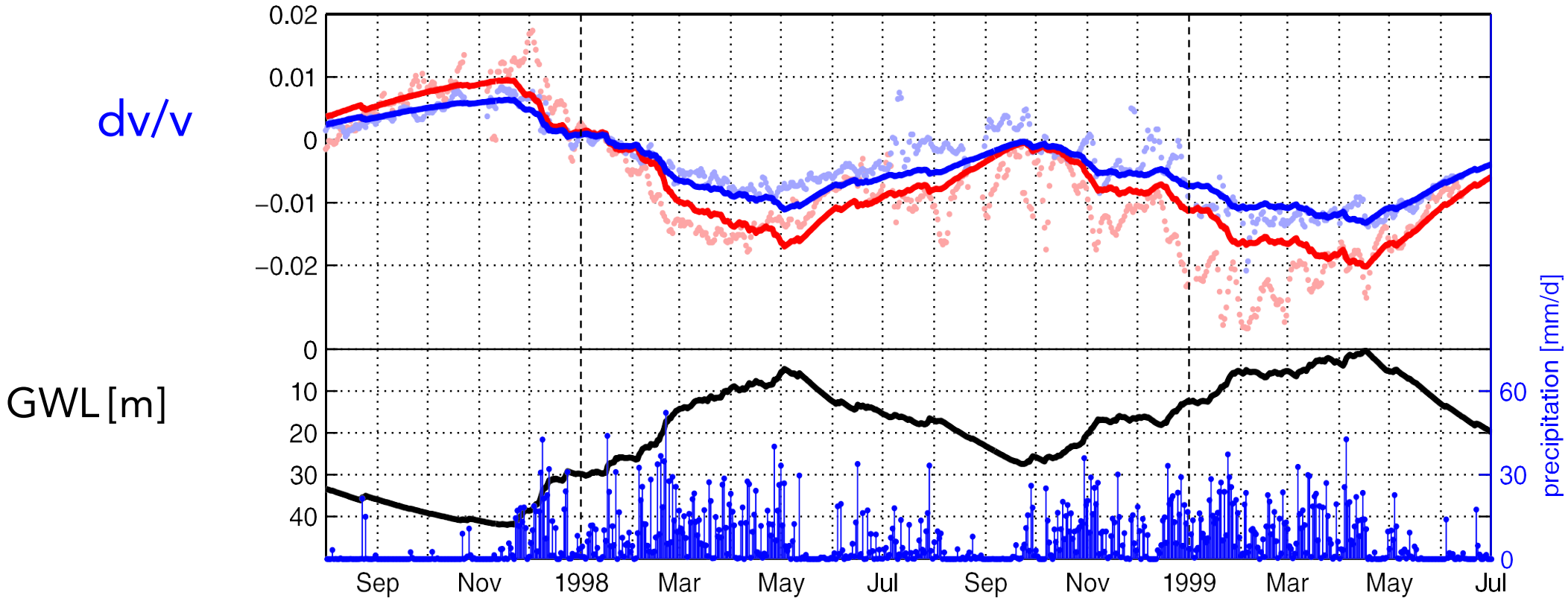
$$dt/t = -dv/v$$



Seismic velocities vary with groundwater levels

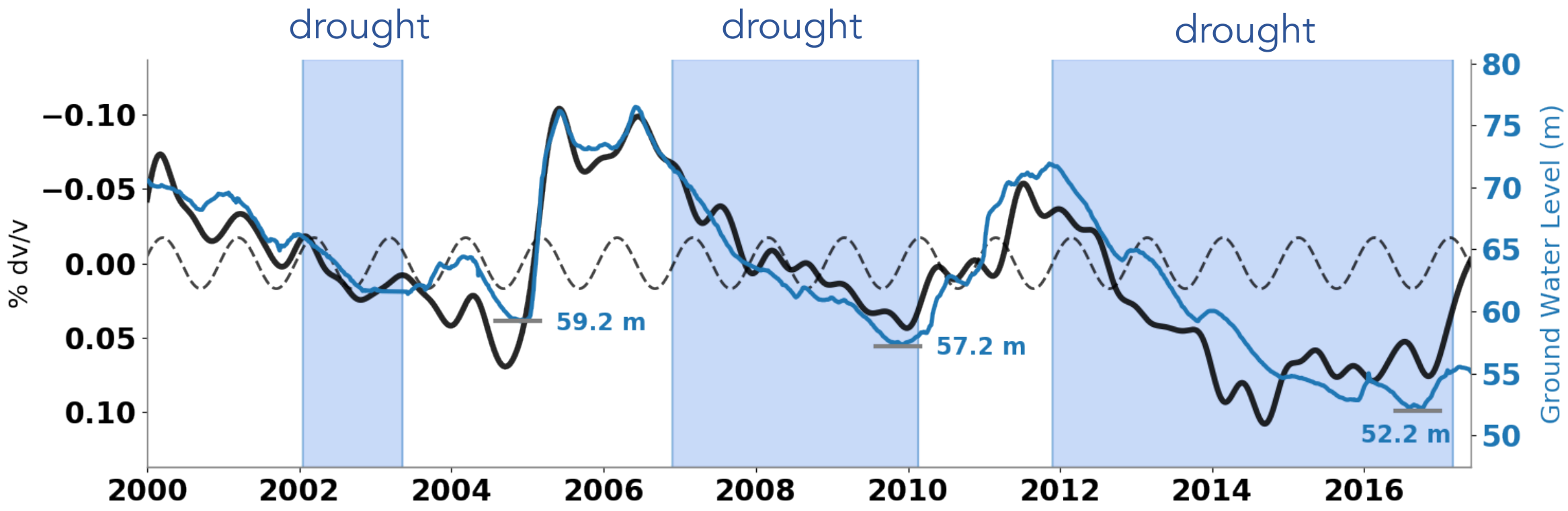
Merapi Volcano, Indonesia (Sens-Schonfelder and Wegler, 2006)



Monitoring ground water in California

Clements and Denolle (2018)

unconfined aquifer.
20m drop in the 2012-2016 drought. All-time low since 1932.



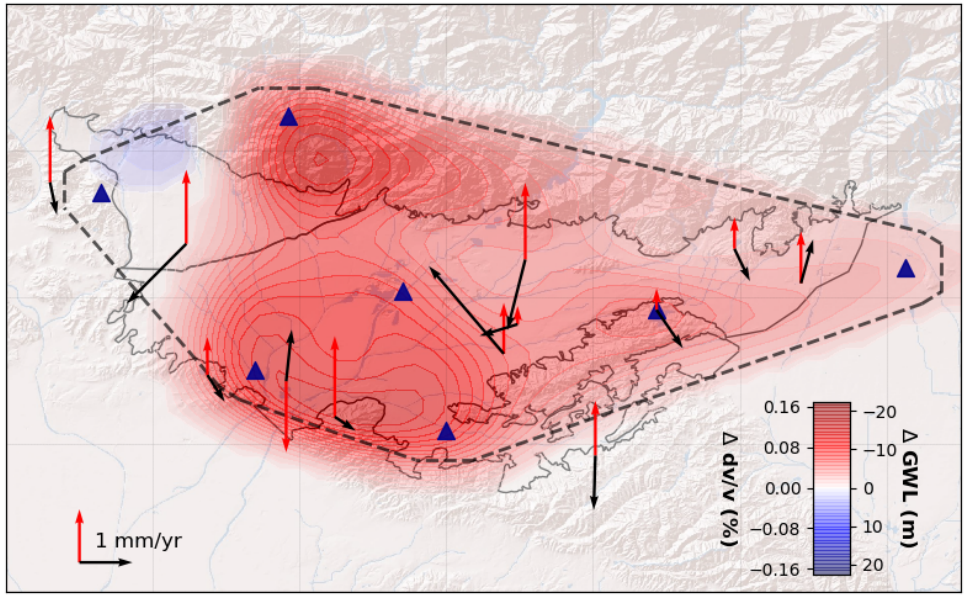
seismic velocity perturbation

groundwater level

Monitoring ground water in California

Clements and Denolle (2018)

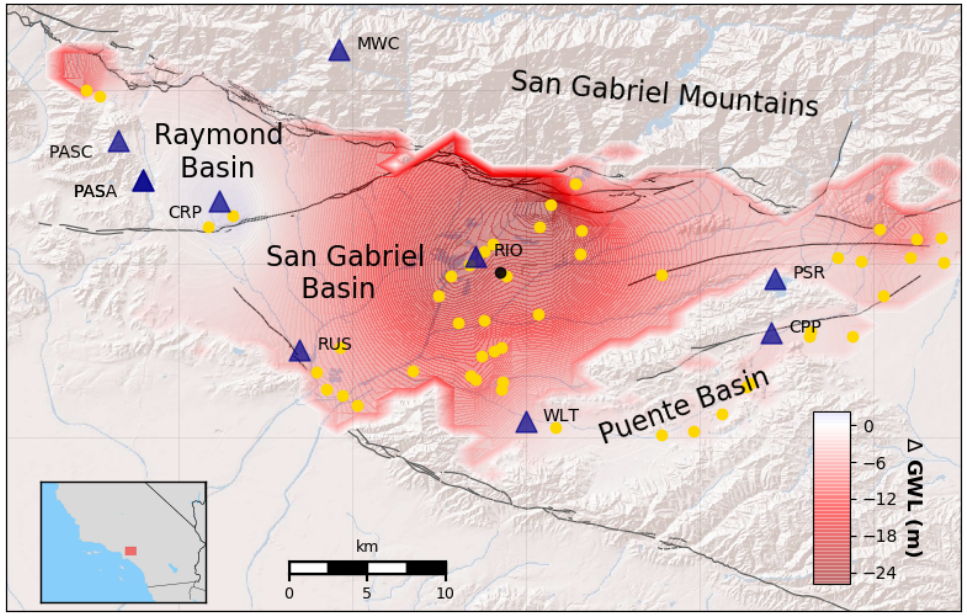
Predictions (dv/v)



Volume loss

V_W = 0.48 km^3

Observations (interpolated wells)



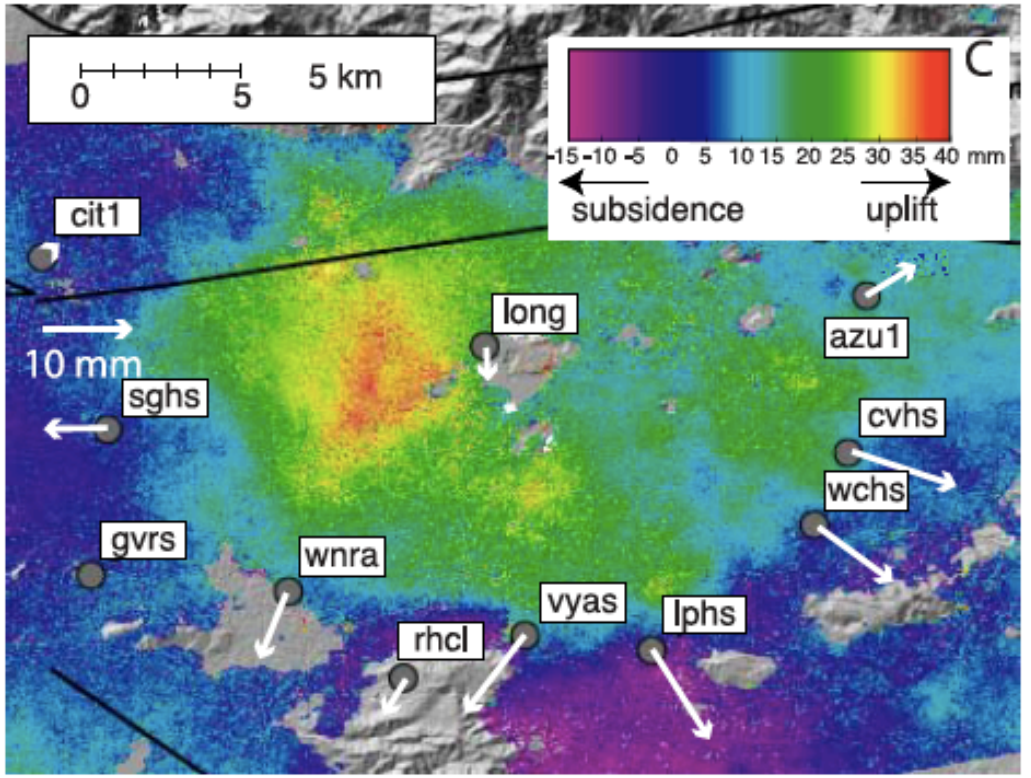
Volume pumped

V_W = 0.45-0.5 km^3

San Gabriel Aquifer

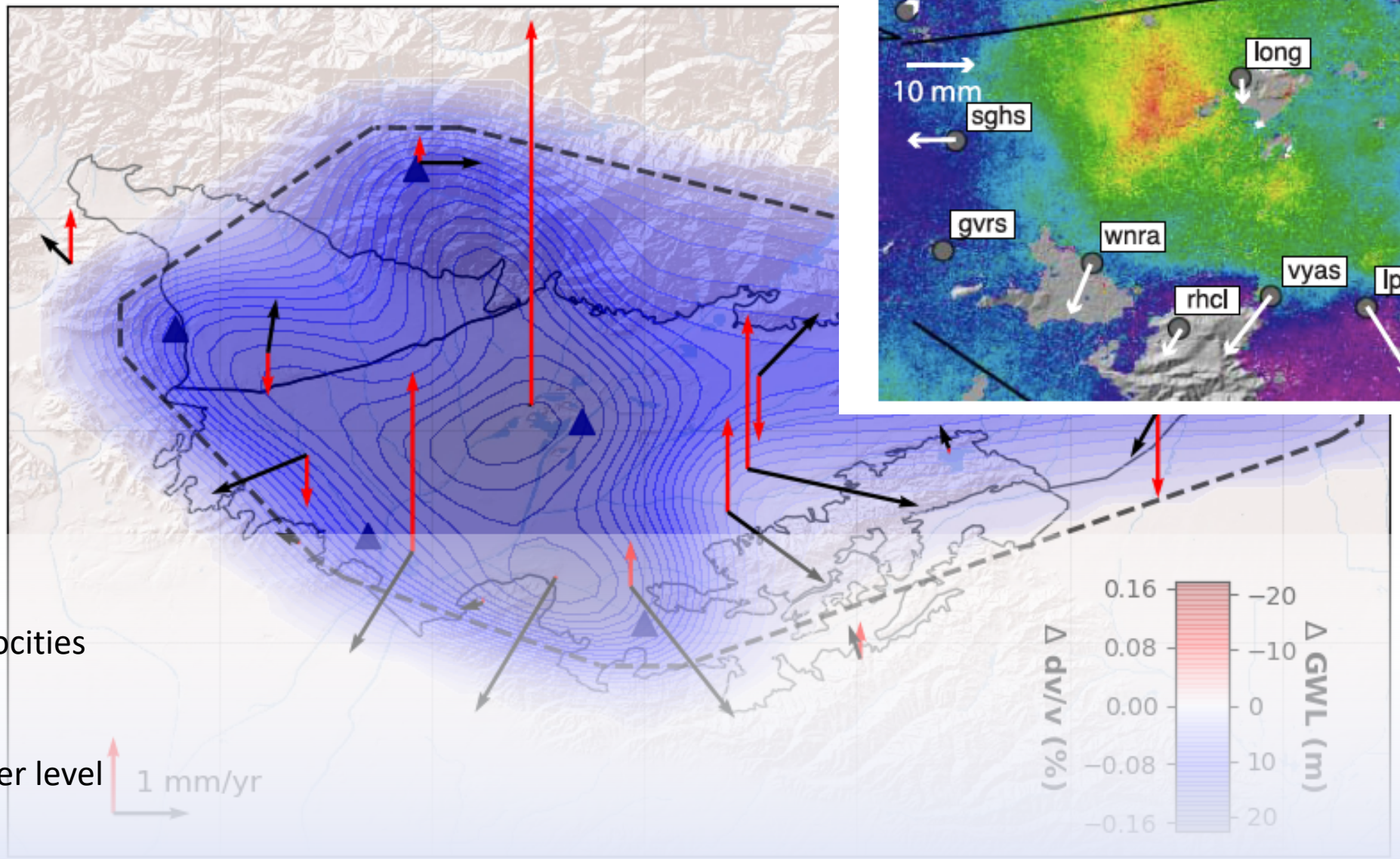
Winter 2005

1m of rainfall
4cm of uplift

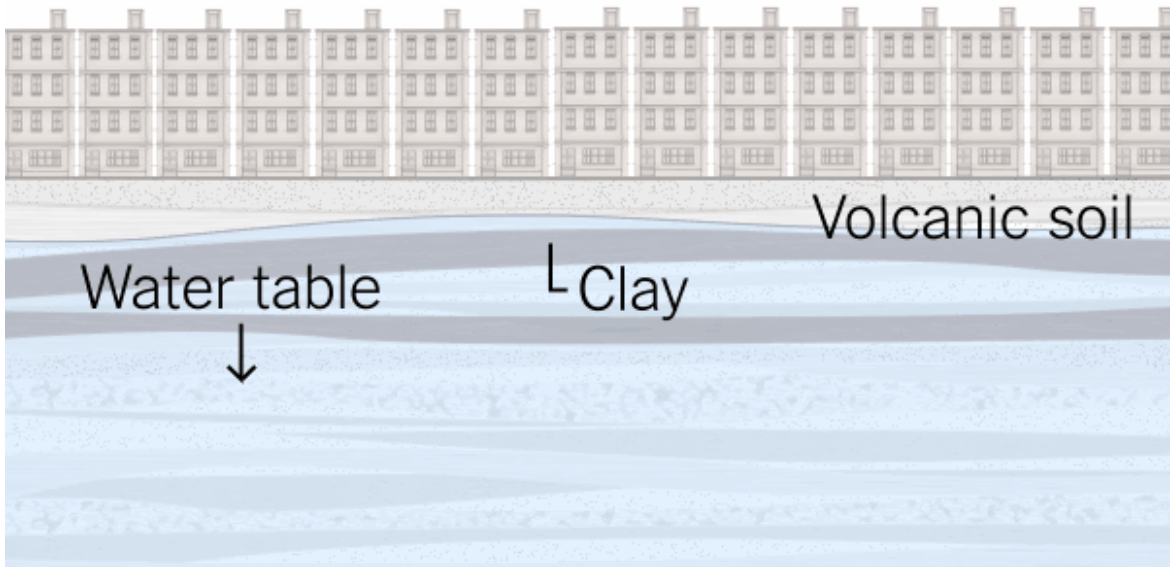


King et al, 2007

Seismic velocities
GNSS
InSAR
Groundwater level



Monitoring site effects in Mexico City



Laura Ermert

Estelle Chaussard

Enrique Cabral-Cano

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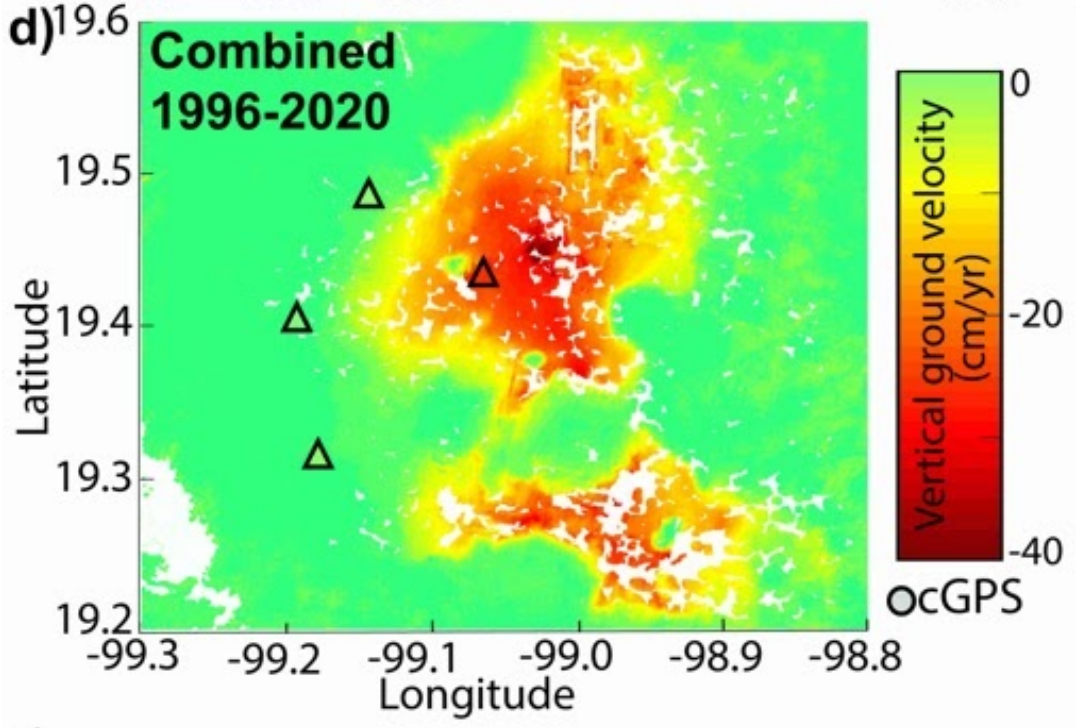

Chaussard et al (in review in JGR)

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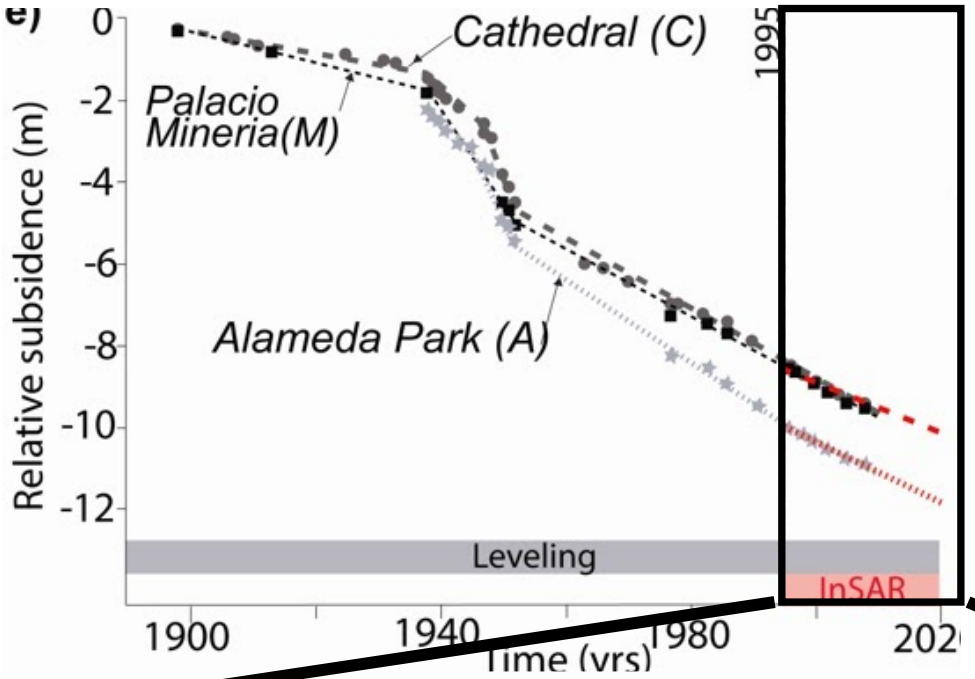

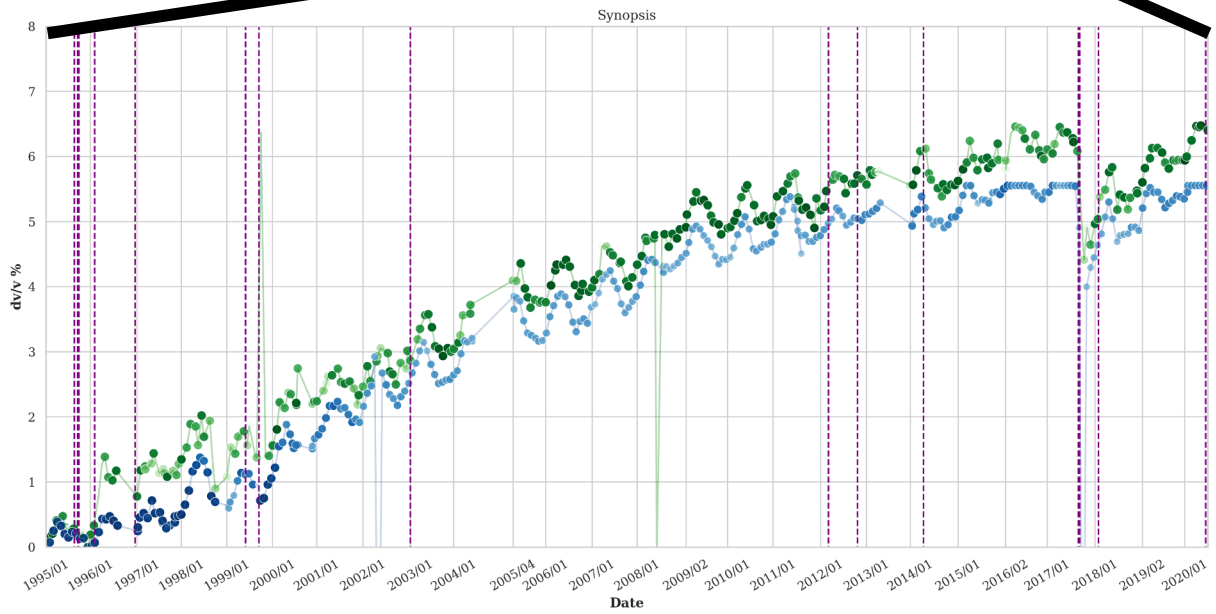

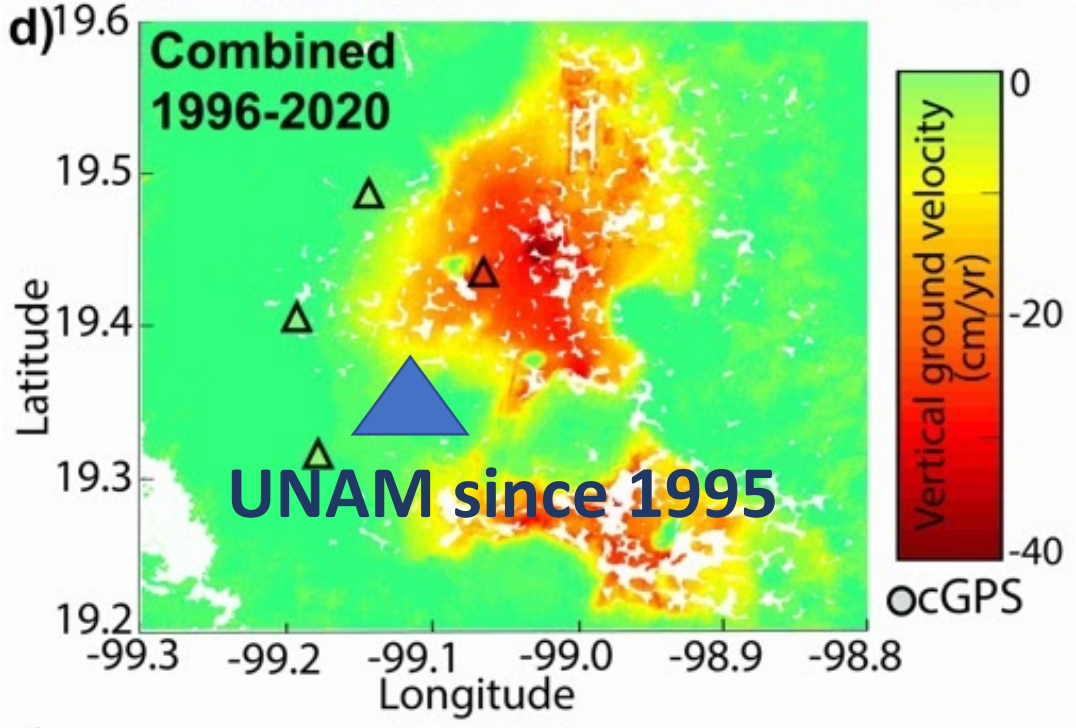

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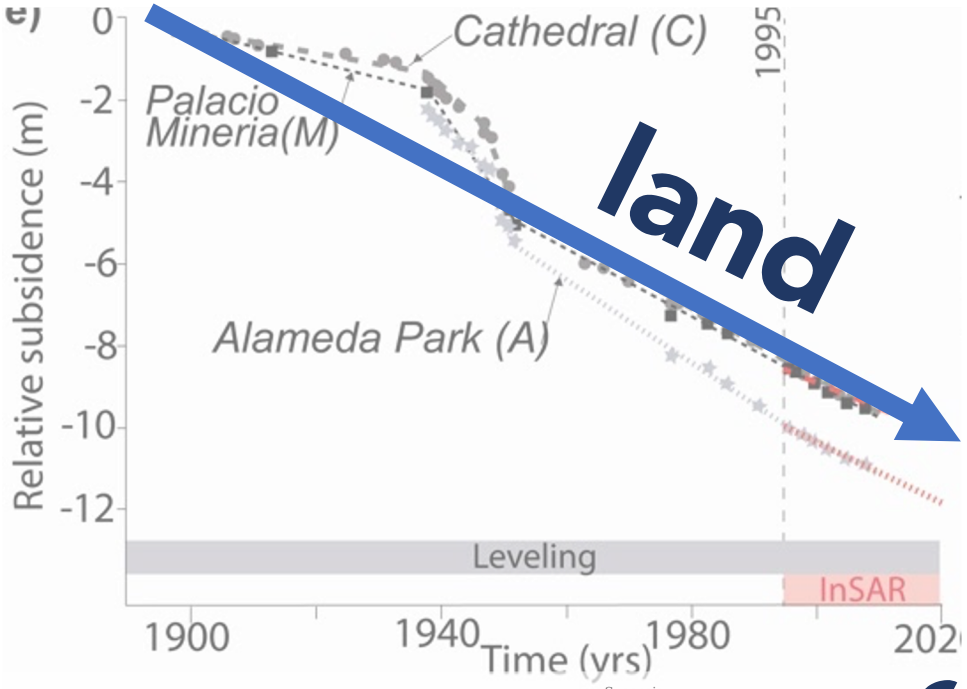
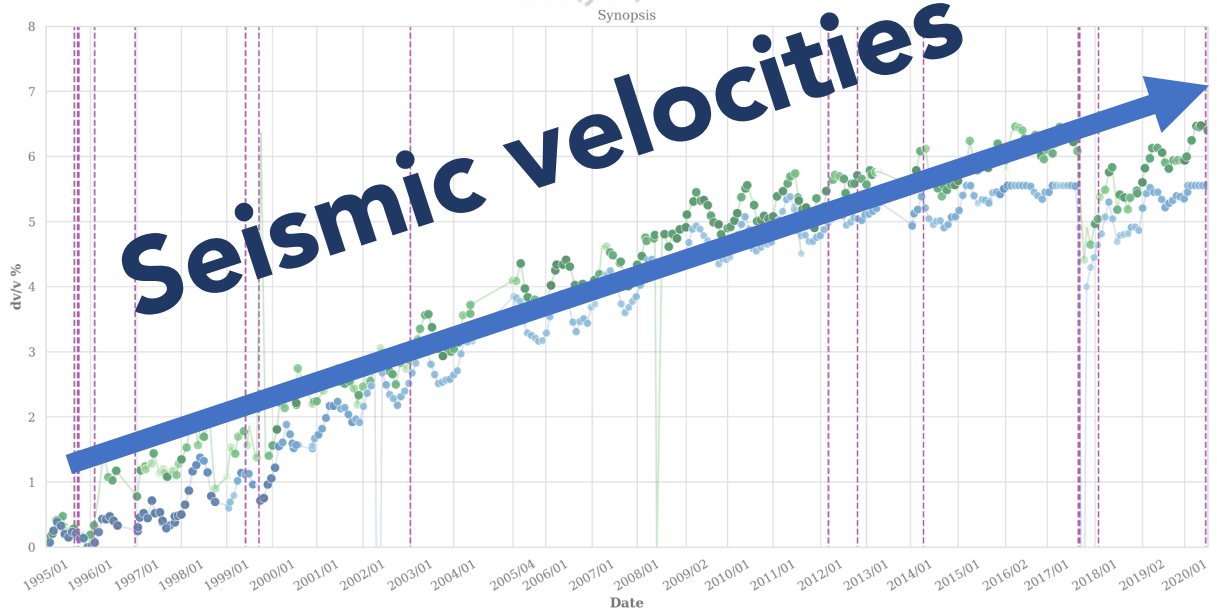
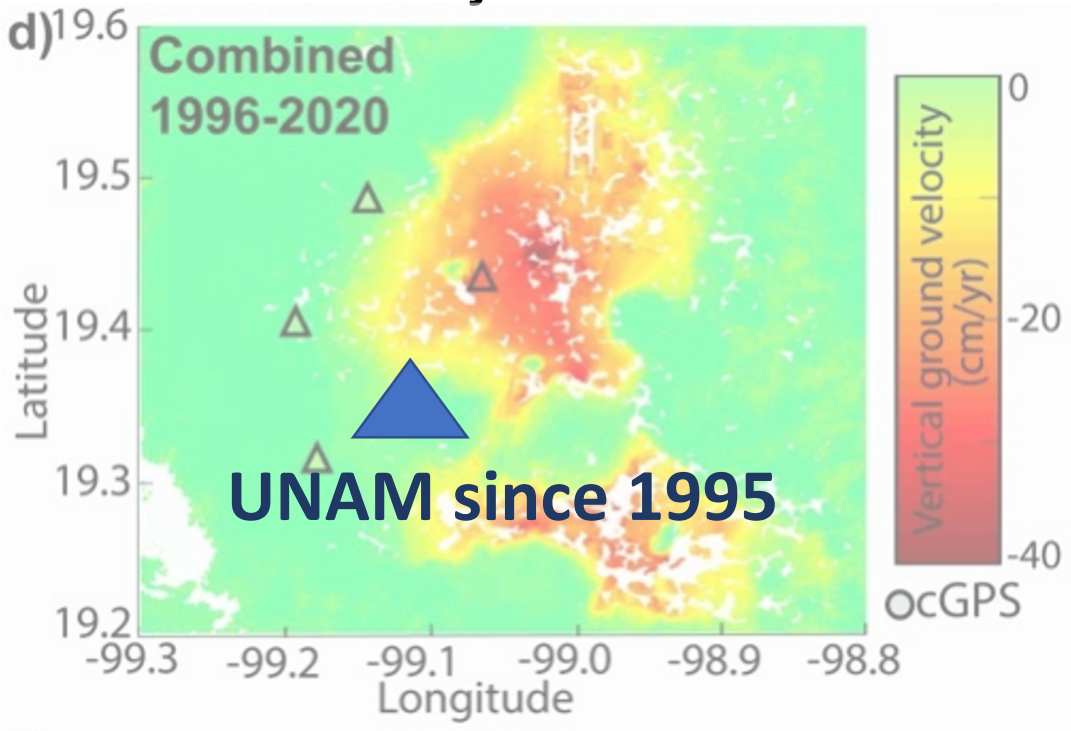
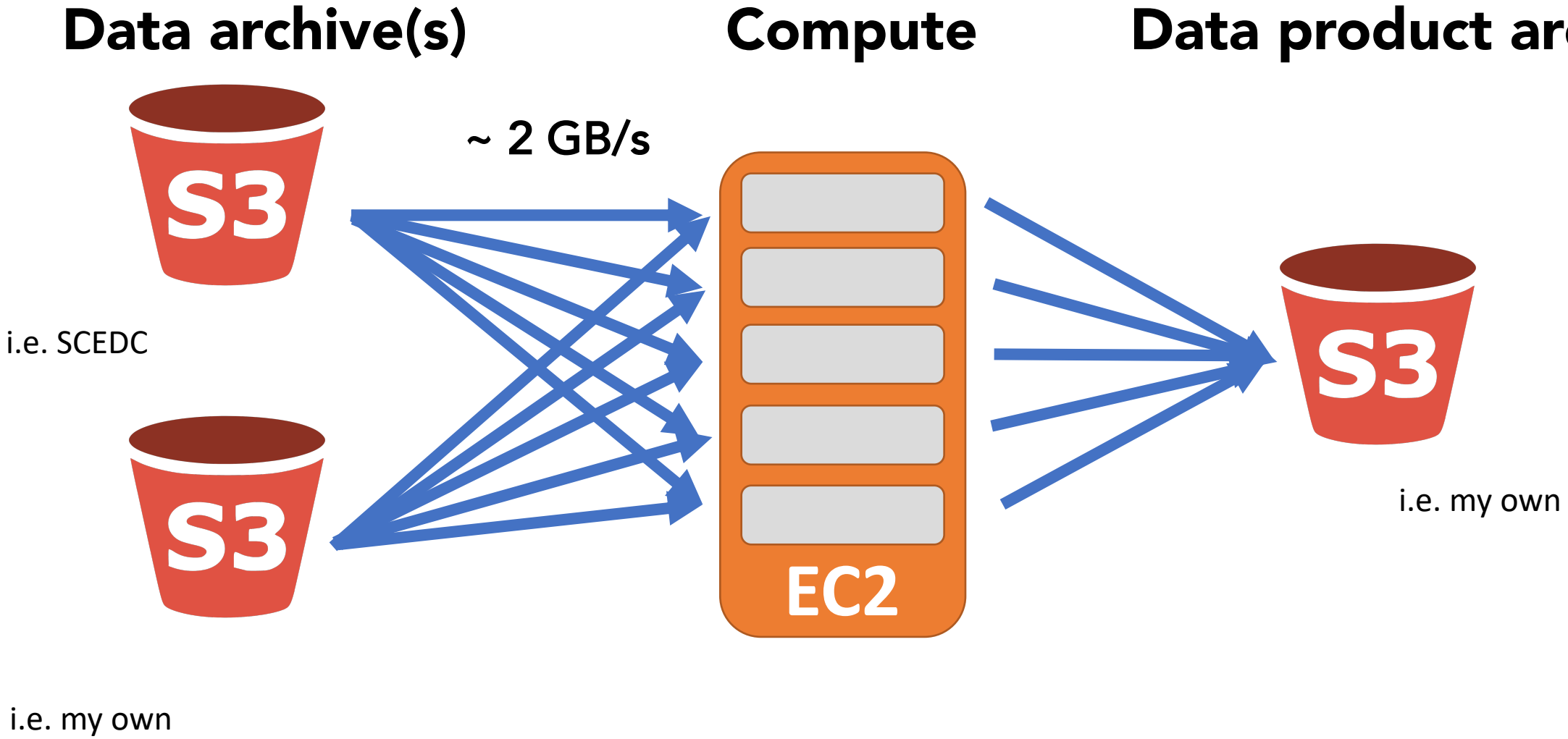






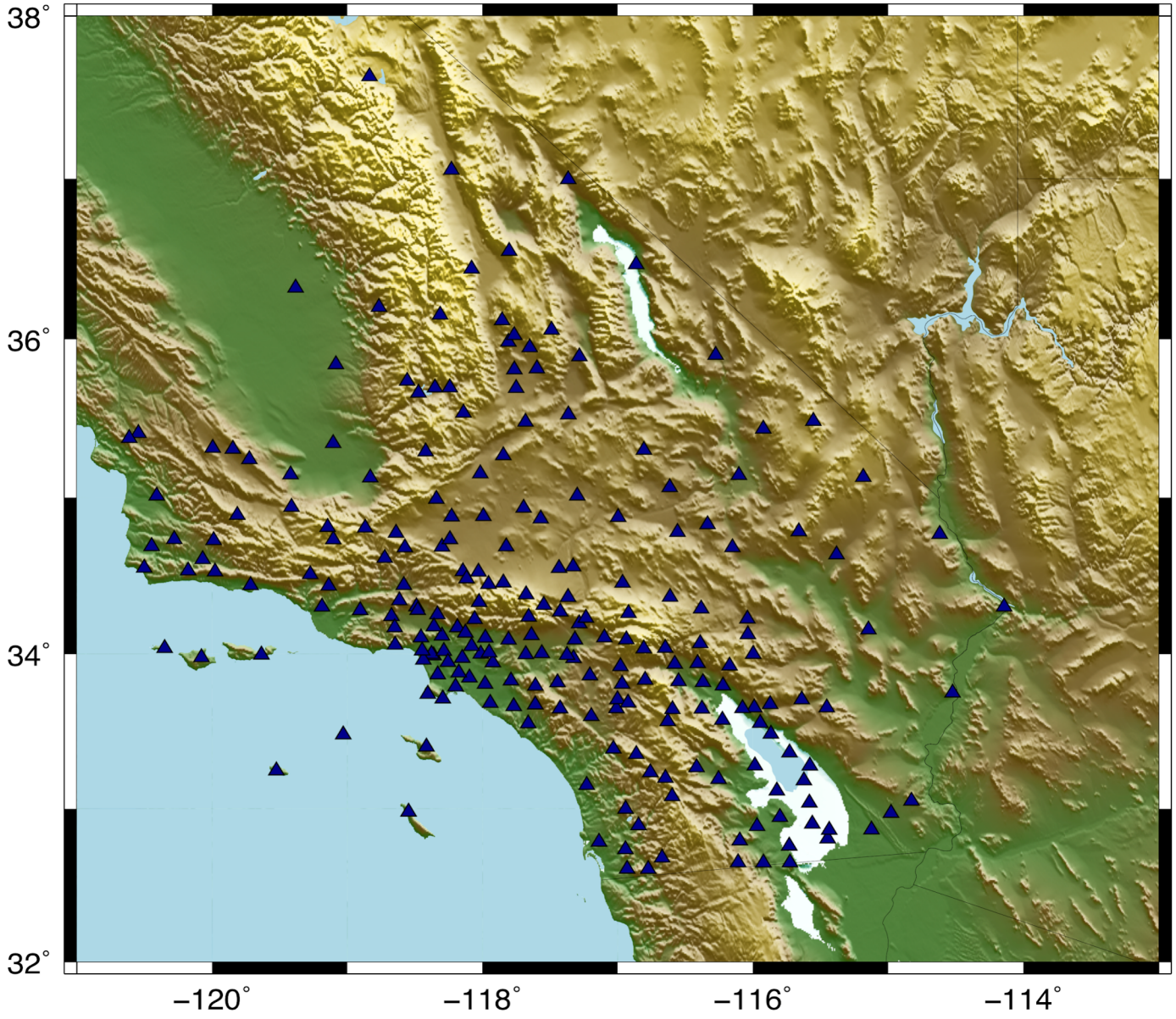
Chaussard et al (in review in JGR)

Cloud Computing is perfect for processing ambient noise data



Memory need is usually low
Workflow is sequential with channels and/or time

Monitoring 20 years of seismic velocities in California

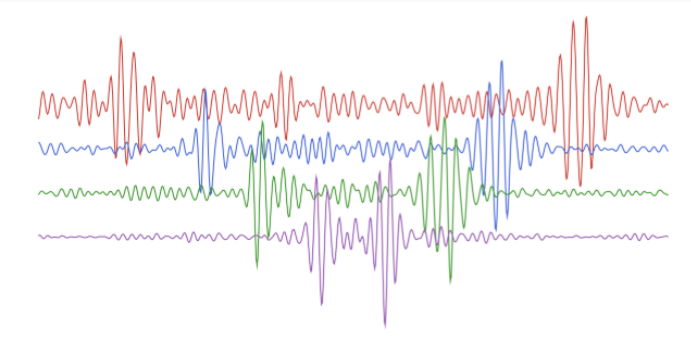


Registry of Open Data on AWS

Southern California Earthquake Data

earth observation | earthquakes | seismology

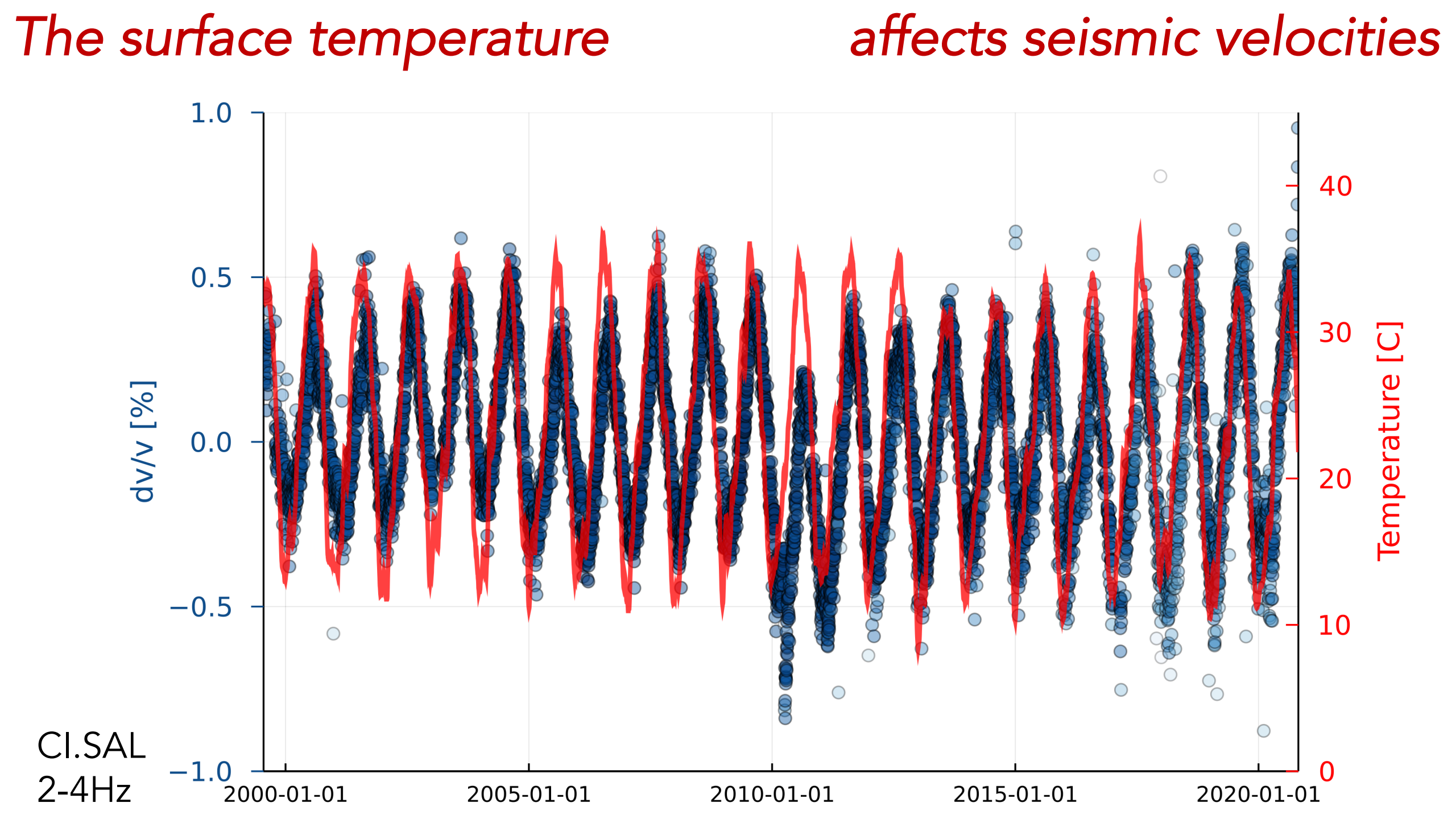
100 TB Southern California
30 TB Northern California



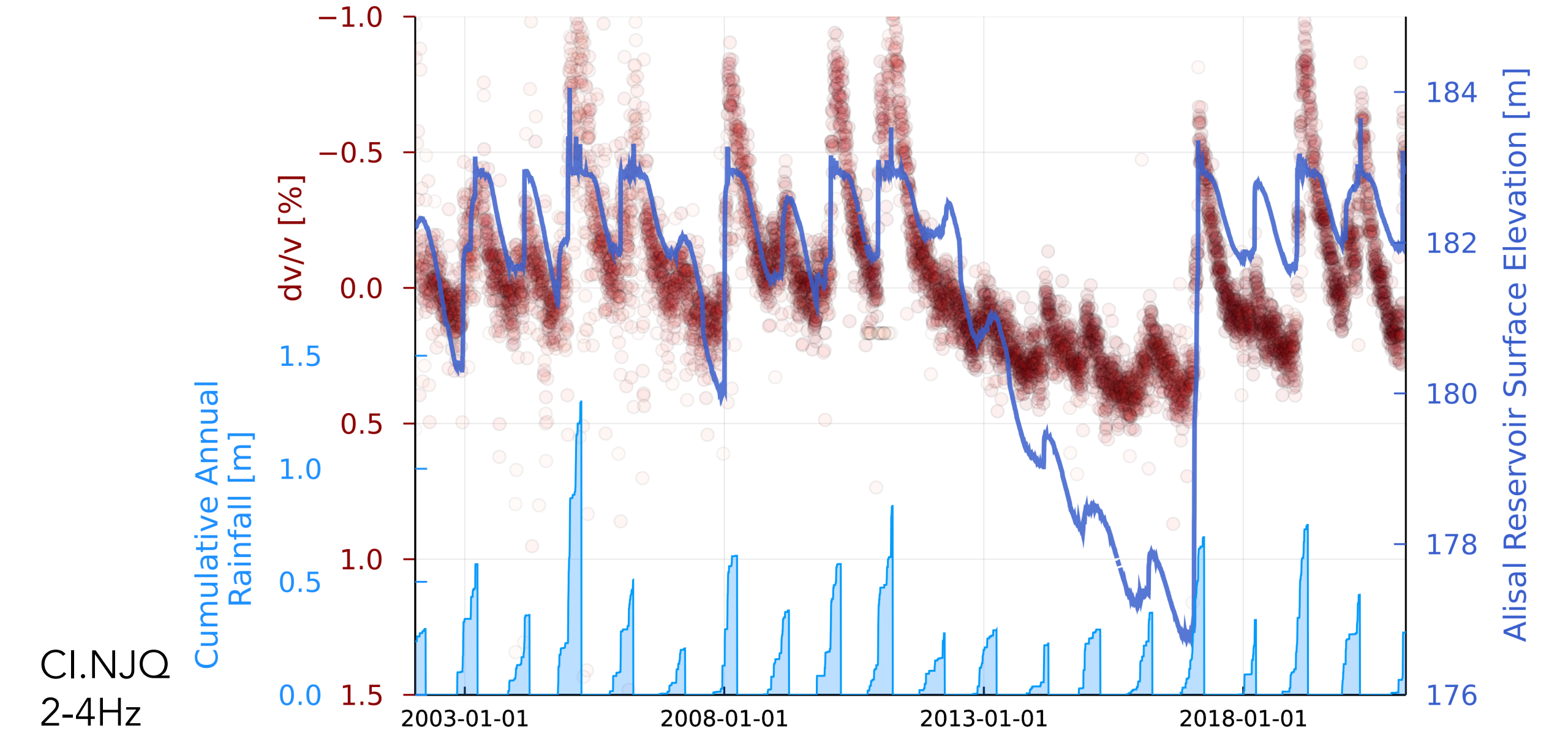
SeisNoise.jl

Clements and Denolle (2021?)

The surface temperature affects seismic velocities

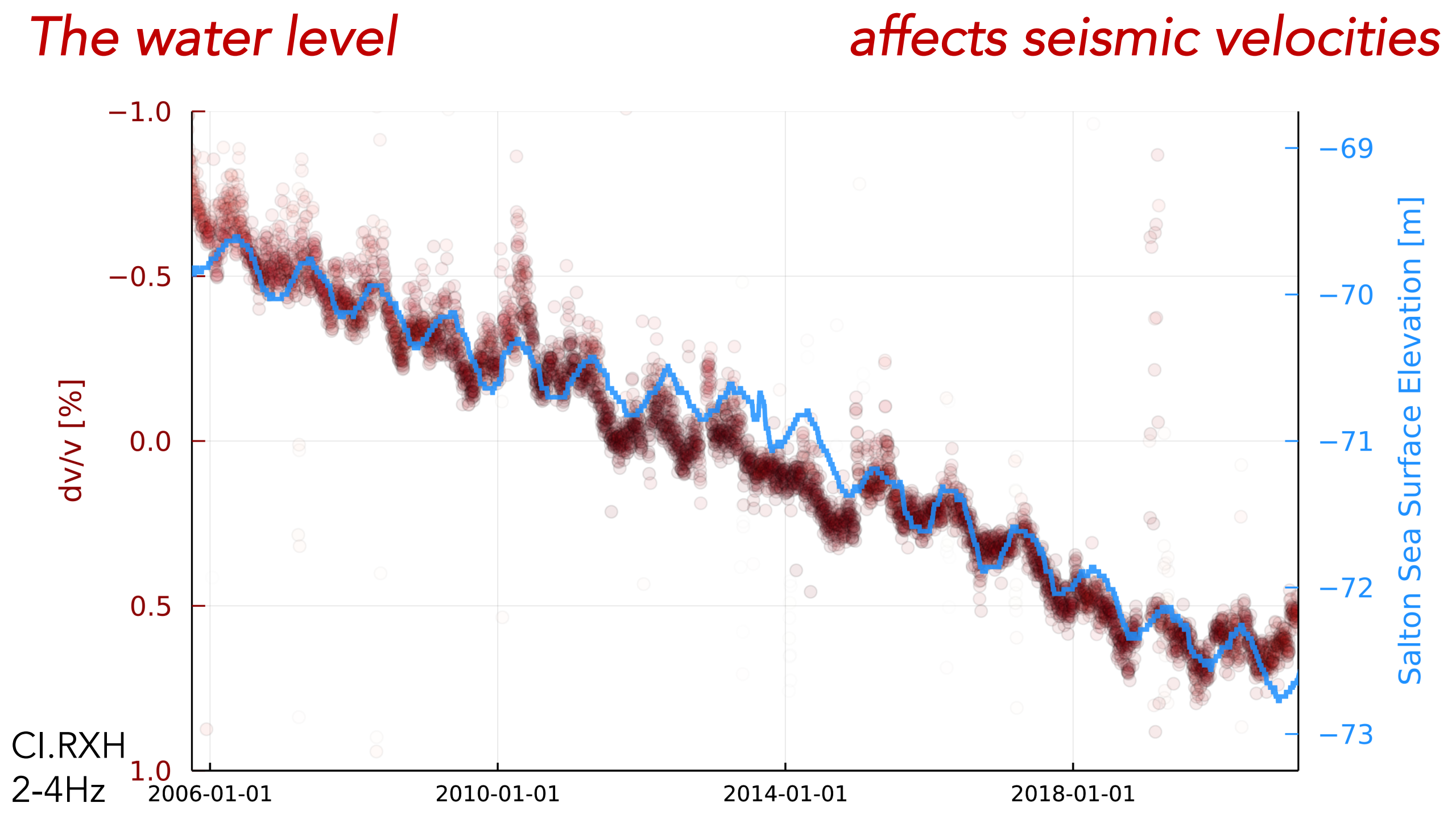


The water level affects seismic velocities



CI.NJQ
2-4Hz

The water level affects seismic velocities



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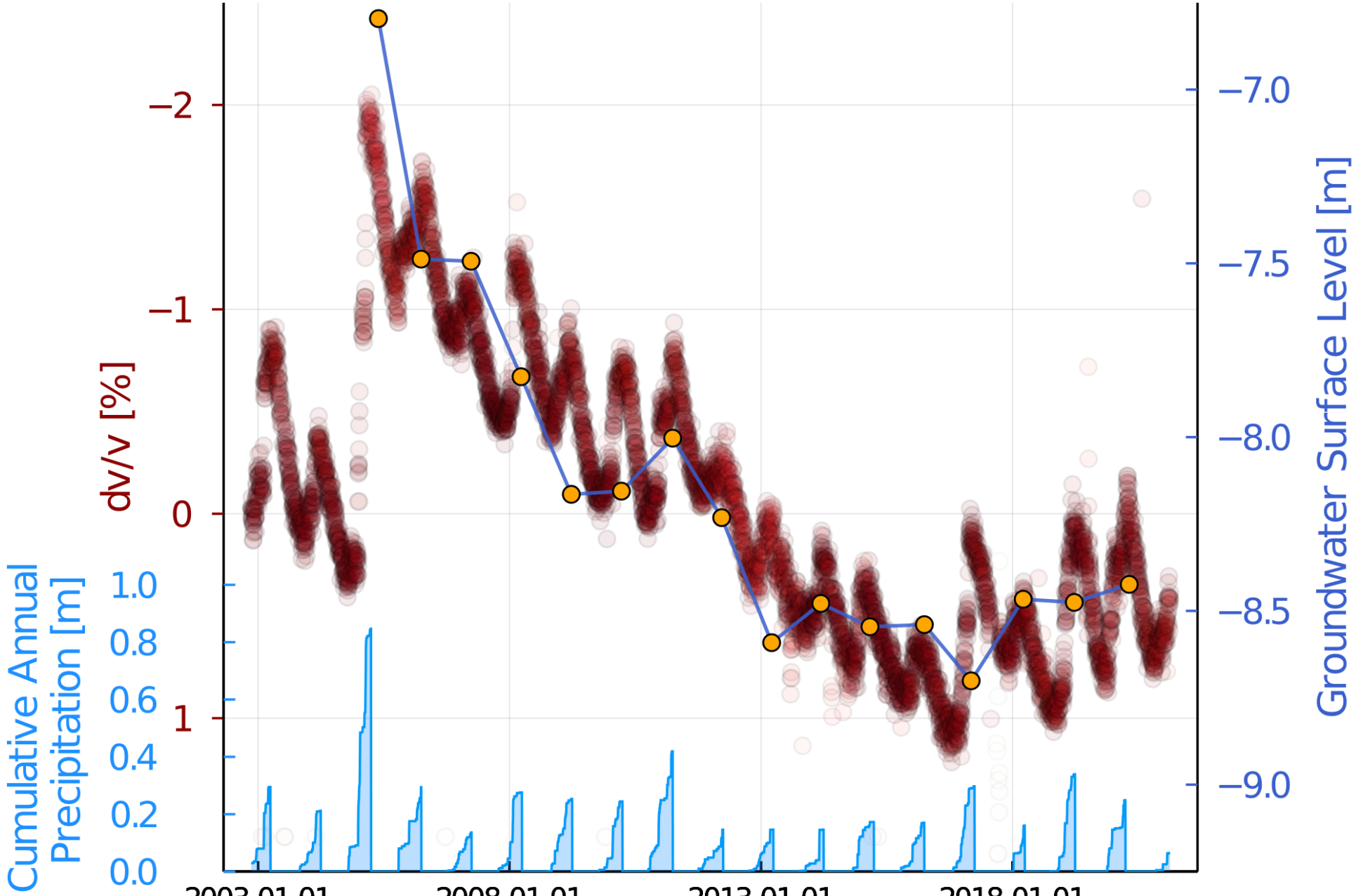
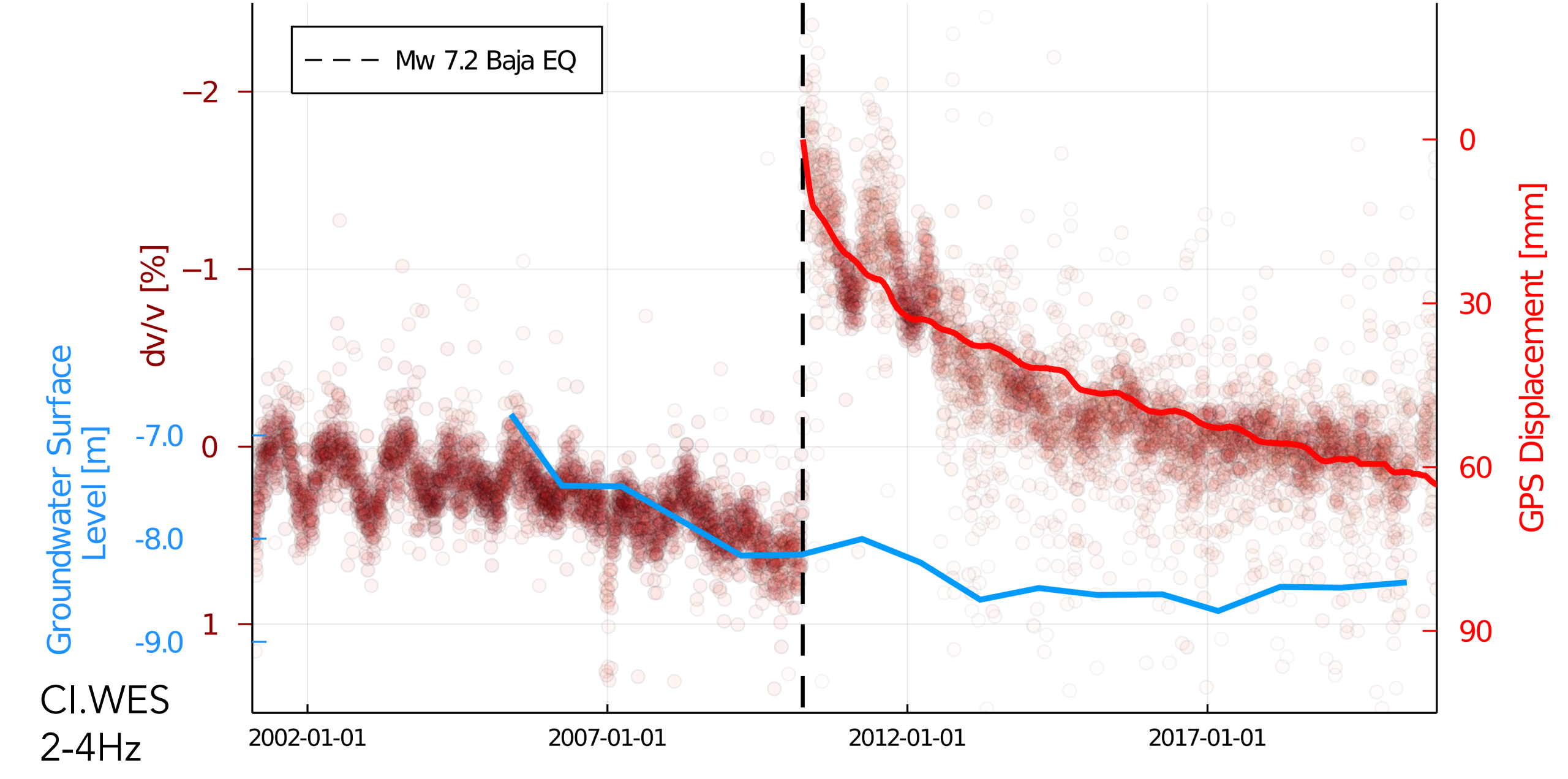


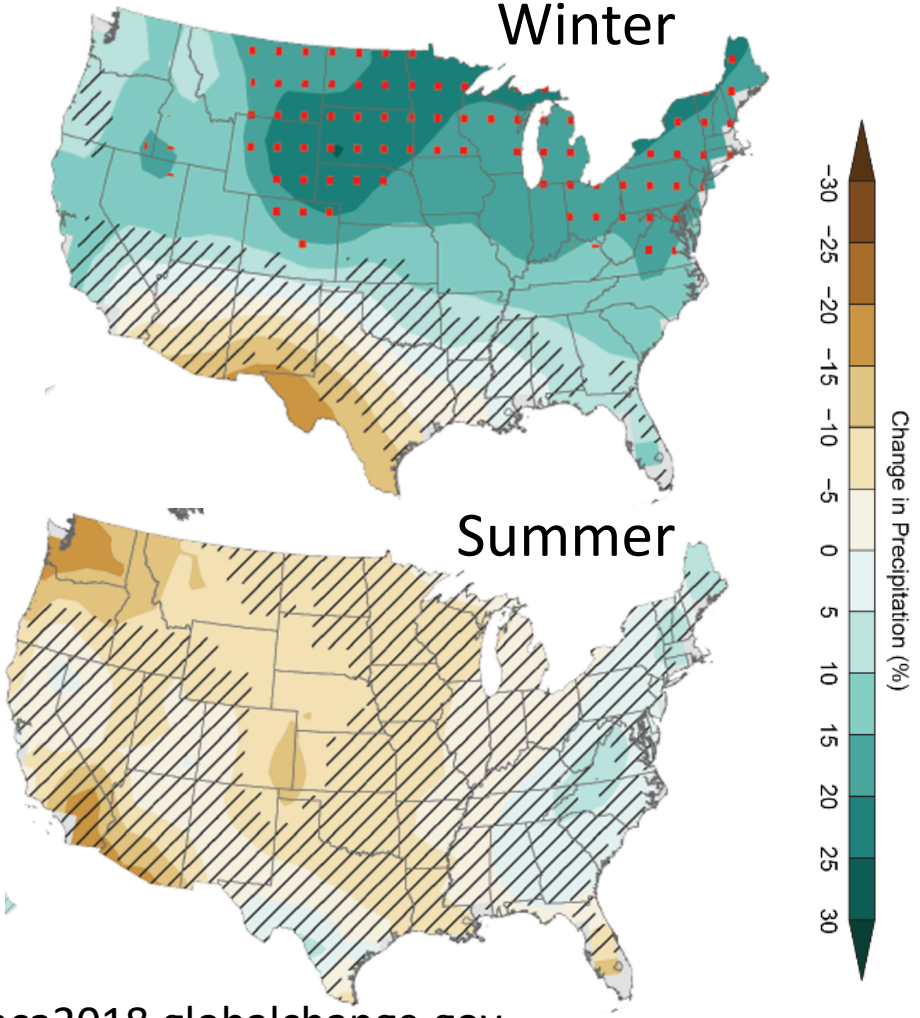
CI.LJR
2-4Hz

Tectonic and water factors affect seismic velocities

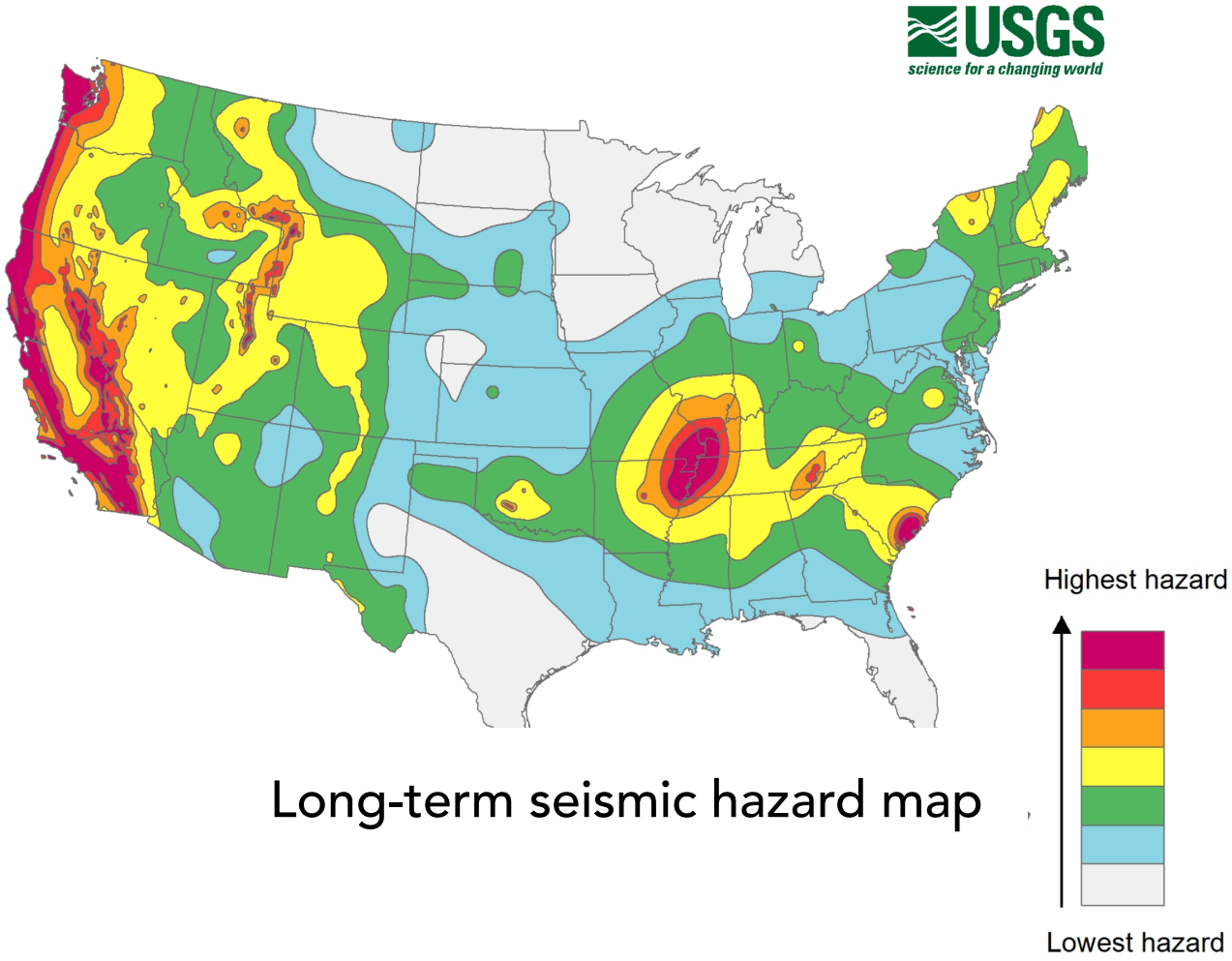


When the climate changes, the near surface changes, the seismic hazards changes …

Late 21st century change in precipitation



nca2018.globalchange.gov



Long-term seismic hazard map

SMVO: Structure Monitoring Virtual Observatory

The cloud-based SMVO will calculate and deliver point-based time series of seismic, geodetic, environmental, and hydrological properties updated daily.

Taka'aki Taira (UC Berkeley) – Nori Nakata (MIT) – Clara Chew (UCAR) – Estelle Chaussard (UO) – Marine Denolle (UW)