HS8.2.12

# Satellite imaging to identify pathways for recharge of the confined aquifers in California's San Joaquin Valley

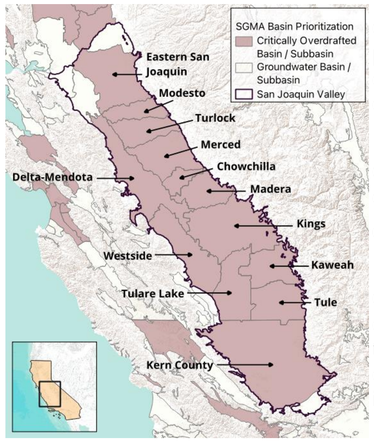
Stanford Doerr School of Sustainability | The Center for Groundwater Evaluation and Management
*Rosemary Knight*

Sylvia Zhang[1], Rosemary Knight[1]
[1]Department of Geophysics, Stanford University

*Contact:*
sylviazh@stanford.edu

EGU26-15172
Abstract:
This presentation participates in OSPP
Outstanding Student & PhD candidate Presentation contest

## 1. The problem with overdraft




California relies on pumped groundwater, especially during drought periods.

Groundwater overdraft:

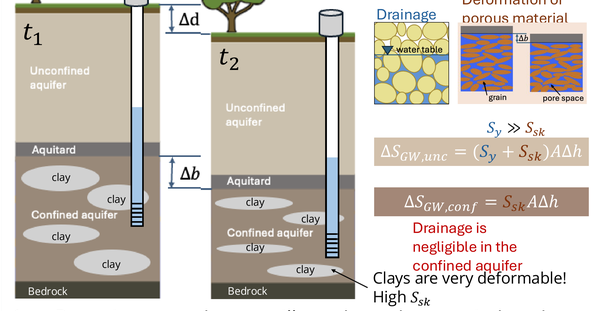
**extraction > recharge**

Overdraft from the confined aquifer leads to **land subsidence**, causing costly infrastructure damage.

## 2. Aquifer deformation theory

$$\Delta S_{GW} = S_y A\Delta h + S_{sk} A\Delta h + \cancel{S_w A\Delta h}$$

Drainage | Deformation of porous material | ~~Expansion of water is negligible~~




$S_y \gg S_{sk}$

$\Delta S_{GW,unc} = (S_y + S_{sk}) A\Delta h$

$\Delta S_{GW,conf} = S_{sk} A\Delta h$

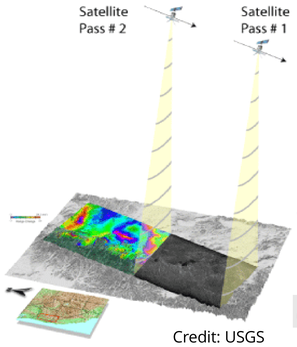
Drainage is negligible in the confined aquifer

Clays are very deformable! High $S_{sk}$

1. Pumping or recharge will produce changes in head.
2. For the same volume of groundwater added/removed, a confined aquifer experiences much larger head changes: $\Delta h_{conf} \gg \Delta h_{unc}$
3. Head changes cause volume changes of pore spaces between sediment grains. Confined aquifer deformation is proportional to $S_{sk}$. Aquifer deformation results in land surface displacement.

$$\Delta d \approx \Delta b = -\sum_i S_{sk,i} b_i \Delta h_i$$

## 3. Finding the InSAR recharge signature




Credit: USGS

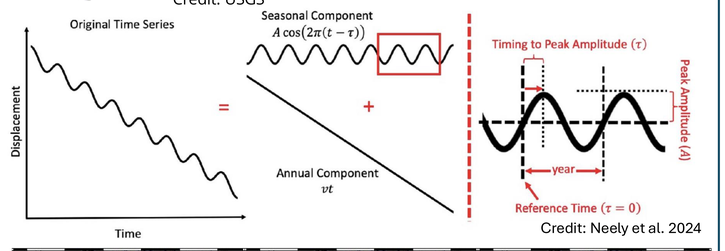
### Interferometric Synthetic Aperture Radar

We used the TRE Altamira vertical displacement dataset, which is derived from ESA's Sentinel-1 acquisitions.

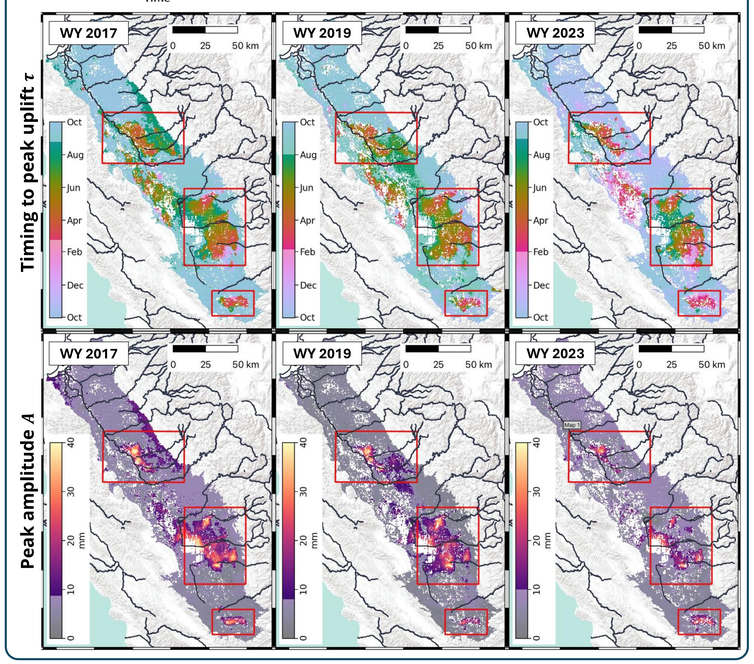
### Seasonal decomposition pf vertical displacement time series

$A$ = peak amplitude
$\tau$ = timing to peak uplift

$$d(t) = vt + A\cos\big(2\pi(t-\tau)\big) + d_0$$

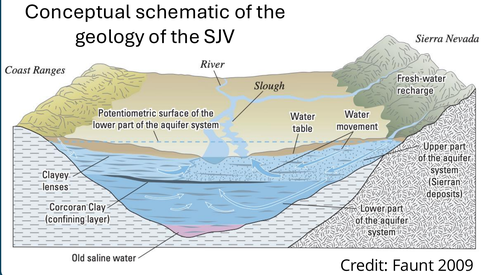



Credit: Neely et al. 2024

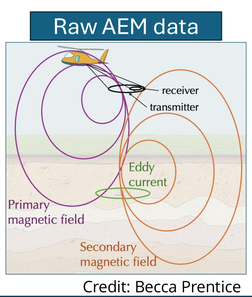



## 4. "Seeing" the subsurface with airborne-electromagnetic (AEM) data

Conceptual schematic of the geology of the SJV




Credit: Faunt 2009




Credit: Becca Prentice

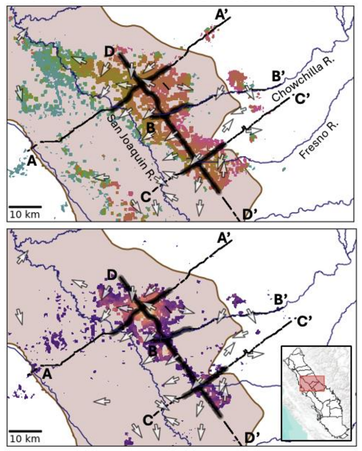
Inversion → Resistivity model

Drillers logs + Transform → Sediment-type model

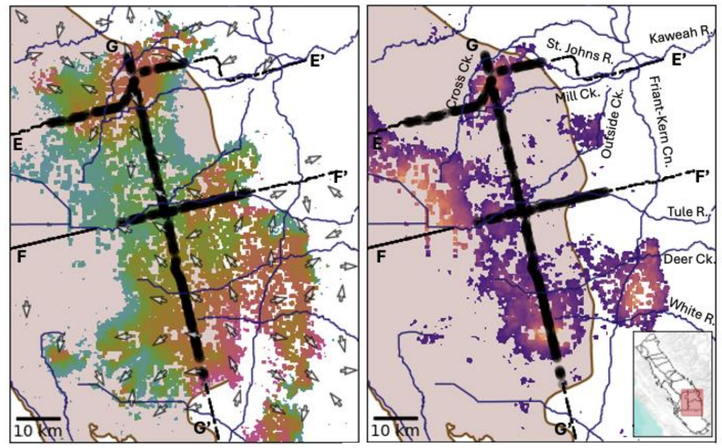
Fraction Coarse-Dominated
1.00 *Mostly sands, gravels*
0.75
0.50
0.25
0.00 *Mostly clays, silts*

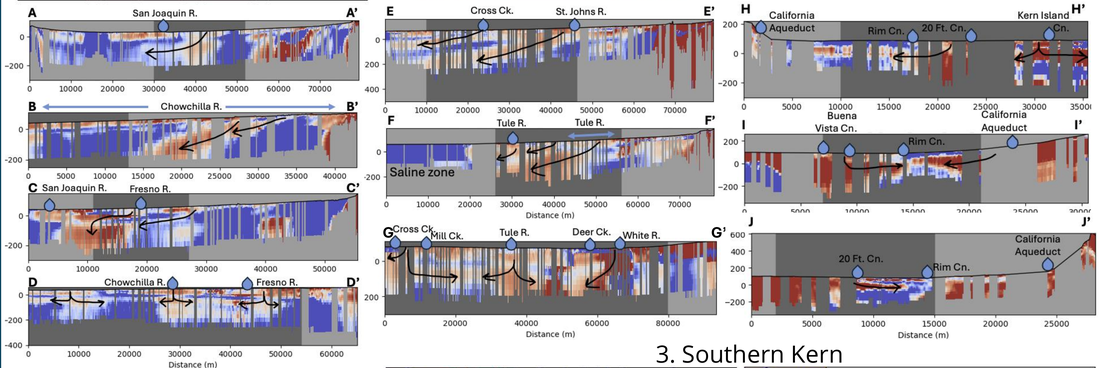
## 5. Pathways to the confined aquifers

1. Merced-Chowchilla-Merced

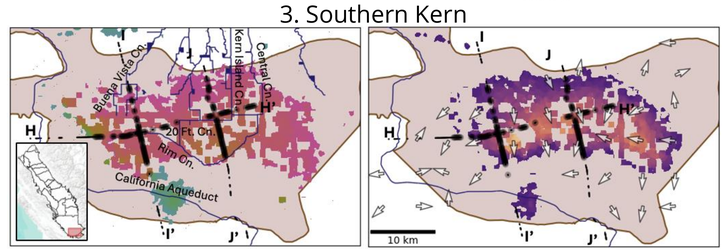


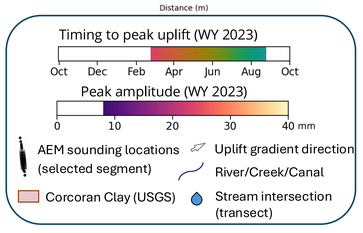

2. Kaweah-Tule



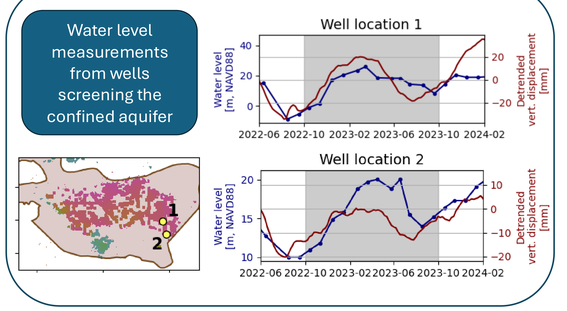




3. Southern Kern




Water level measurements from wells screening the confined aquifer




### Key takeaways

- Signals extracted from InSAR data show seasonal uplift patterns in consistent regions across wet water years 2017, 2019, and 2023.
- InSAR-observed displacement agrees with confined aquifer head level changes.
- There are pathways through coarse-dominated sediments leading to the confined aquifer, providing access for recharge of the deep aquifer.

## References

California Department of Water Resources, 2020, *Sustainable Groundwater Management Act 2019 Basin Prioritization Process and Results*
Faunt et al., 2009, *Groundwater Availability of the Central Valley Aquifer, California*, U.S. Geological Survey Professional Paper 1766
Neely et al., 2021, *Characterization of Groundwater Recharge and Flow in California's San Joaquin Valley from InSAR-Observed Surface Deformation*, Water Resources Research
Neely et al., 2024, *Exploring the InSAR Signature Associated with River-Sourced Recharge in California's San Joaquin Valley*, Environmental Research Letters
Prentice et al., *A New Approach to Transforming Airborne Electromagnetic Data into Models of Sediment Type*, (In review)

Sharing is encouraged