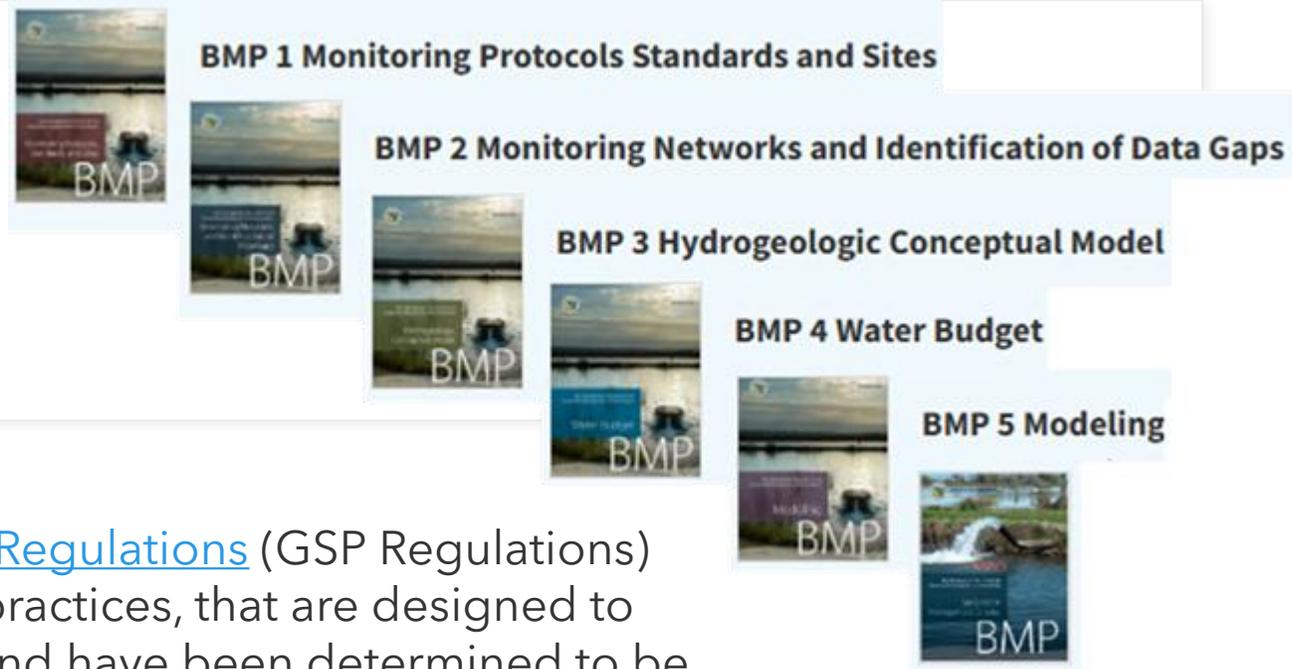


# Subsidence Best Management Practices

Ben Brezing - DWR, SGMO

# BMPs



The [Groundwater Sustainability Plan Emergency Regulations](#) (GSP Regulations) define BMPs as “the practice, or combination of practices, that are designed to achieve sustainable groundwater management and have been determined to be technologically and economically effective, practicable, and based on best available science.”

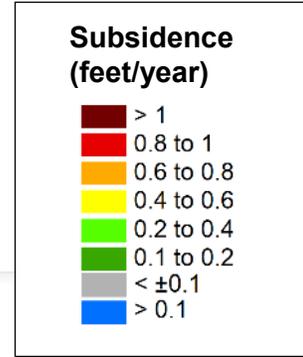
In brief, BMPs provide:

- Clarification
- Guidance
- Examples to help GSAs develop the essential elements of a GSP

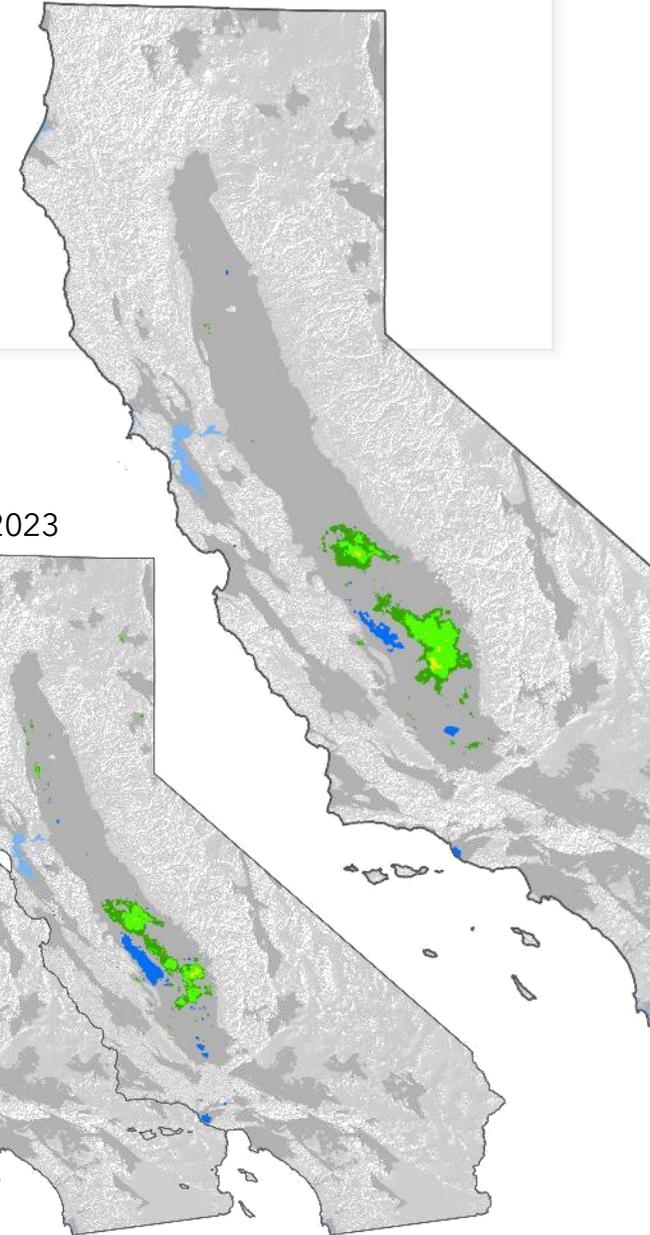
DWR has developed these BMPs based on technical information from other groundwater management efforts, existing standards, and other guidance or reference reports.

<https://water.ca.gov/Programs/Groundwater-Management/SGMA-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents>

# Recent Subsidence Data



WY 2024



WY 2016

WY 2017

WY 2018

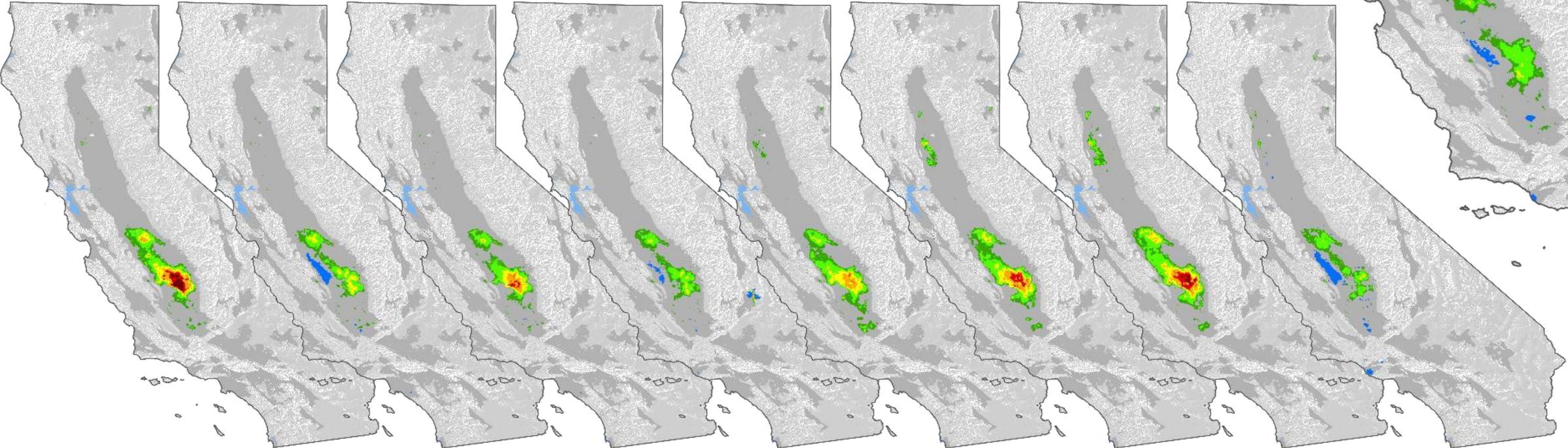
WY 2019

WY 2020

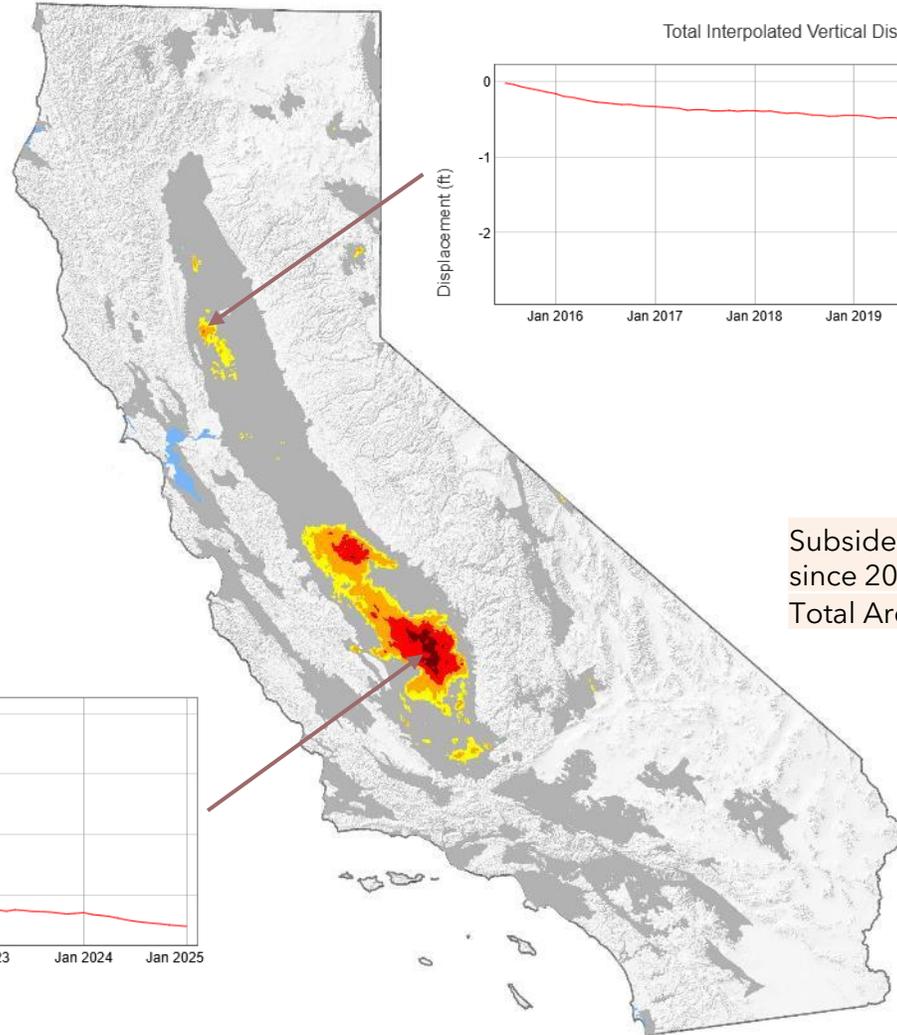
WY 2021

WY 2022

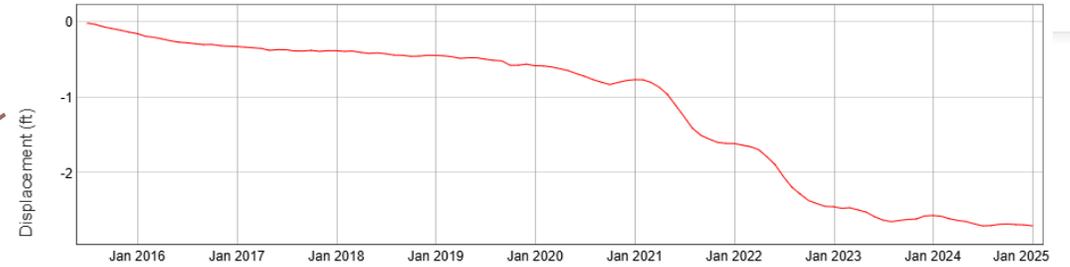
WY 2023



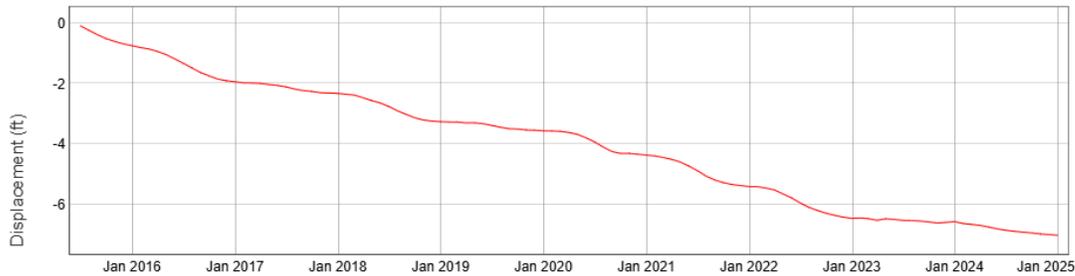
# Recent Subsidence Data



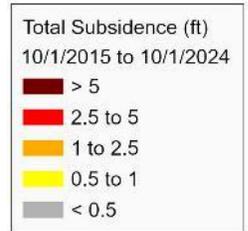
Total Interpolated Vertical Displacement (ft) for (39.01051, -122.07623)



Total Interpolated Vertical Displacement (ft) for (36.13088, -119.45010)

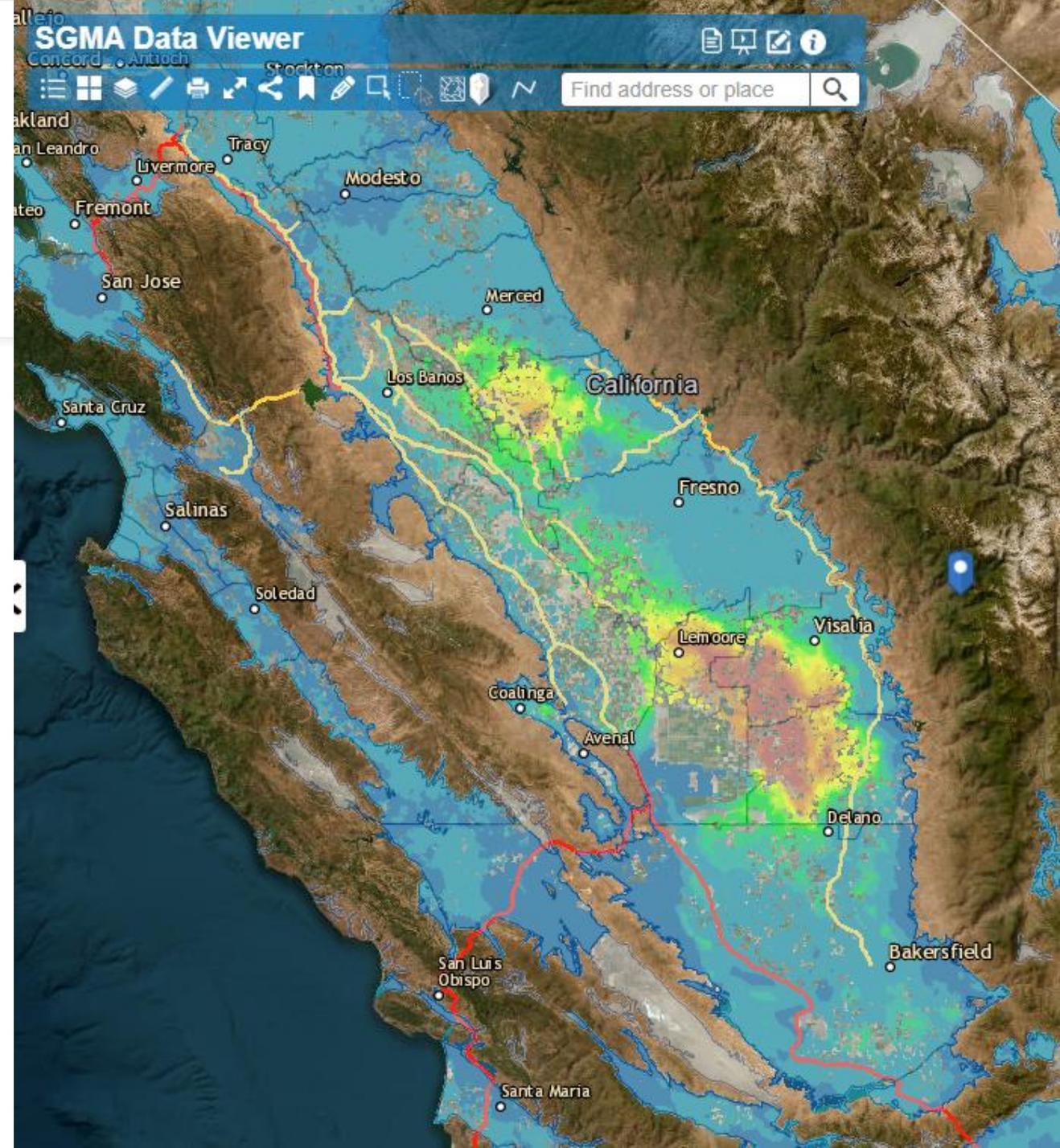


Subsidence (ft) since 2015	>0.5	>1	>2.5	>5
Total Area (sq mi)	4,959	3,256	1,384	258



# Subsidence Impacts to Conveyance, Flood Protection, etc.

- \$ Multi-Billion Impacts
- Inelastic Subsidence is Irreversible
- Immediate action is necessary

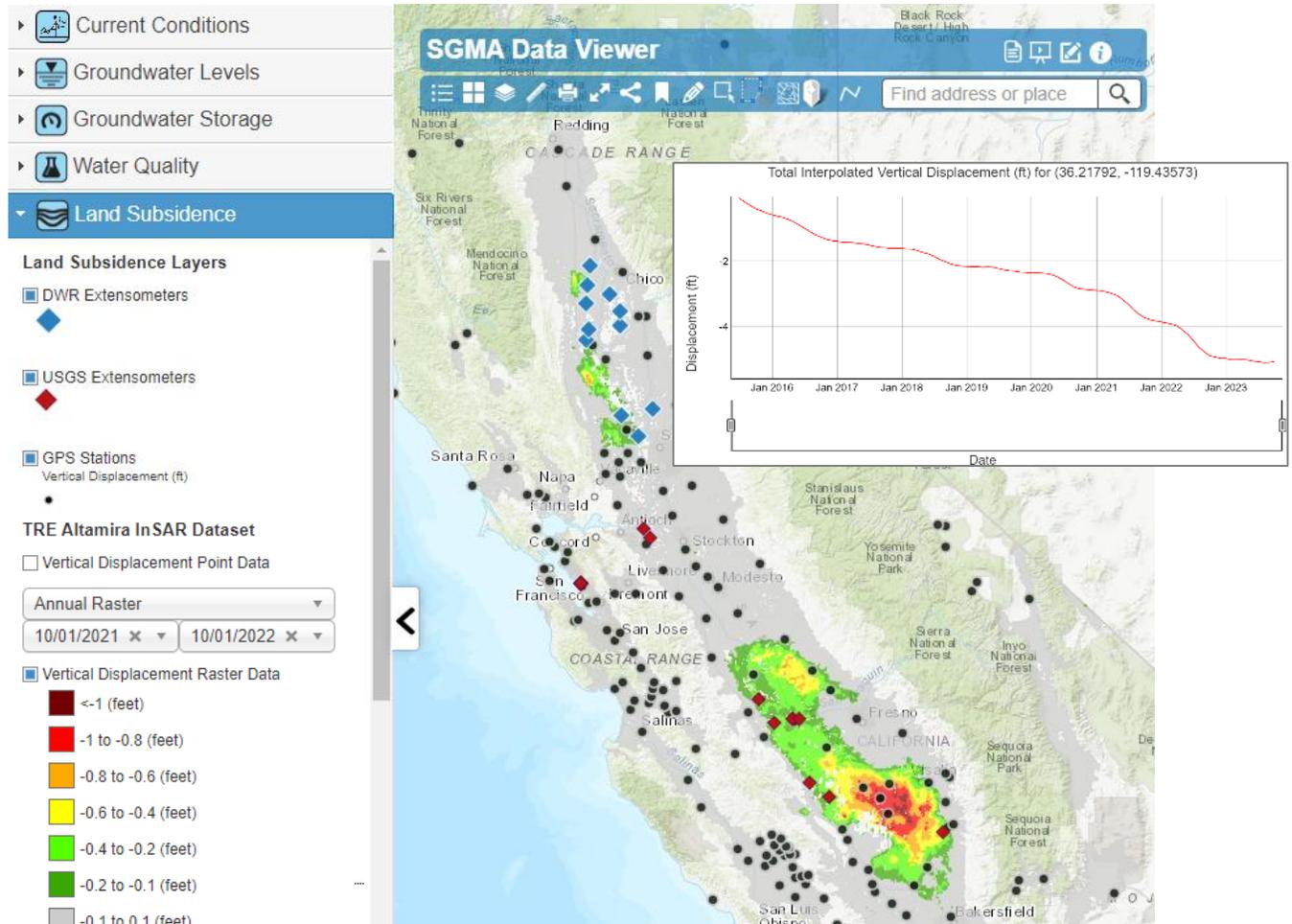


# Subsidence BMP

- Fundamentals
- Monitoring
- Critical Head Estimates
- Modeling
- Management
  - Public draft BMP release
  - 60-day public comment period
  - Public meetings

# Monitoring

- Interferometric Synthetic Aperture Radar (InSAR)
- Continuous GPS stations
- Spirit leveling
- Extensometers

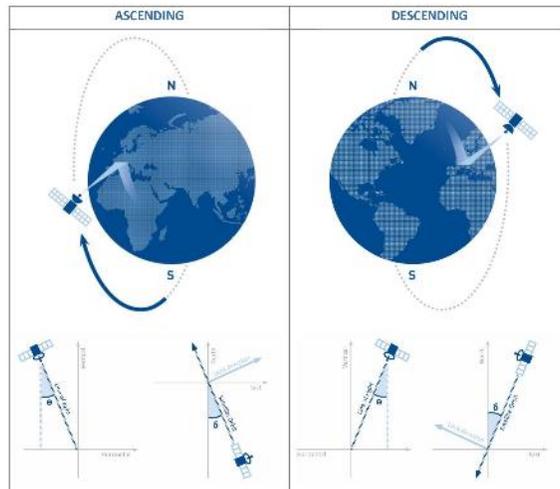
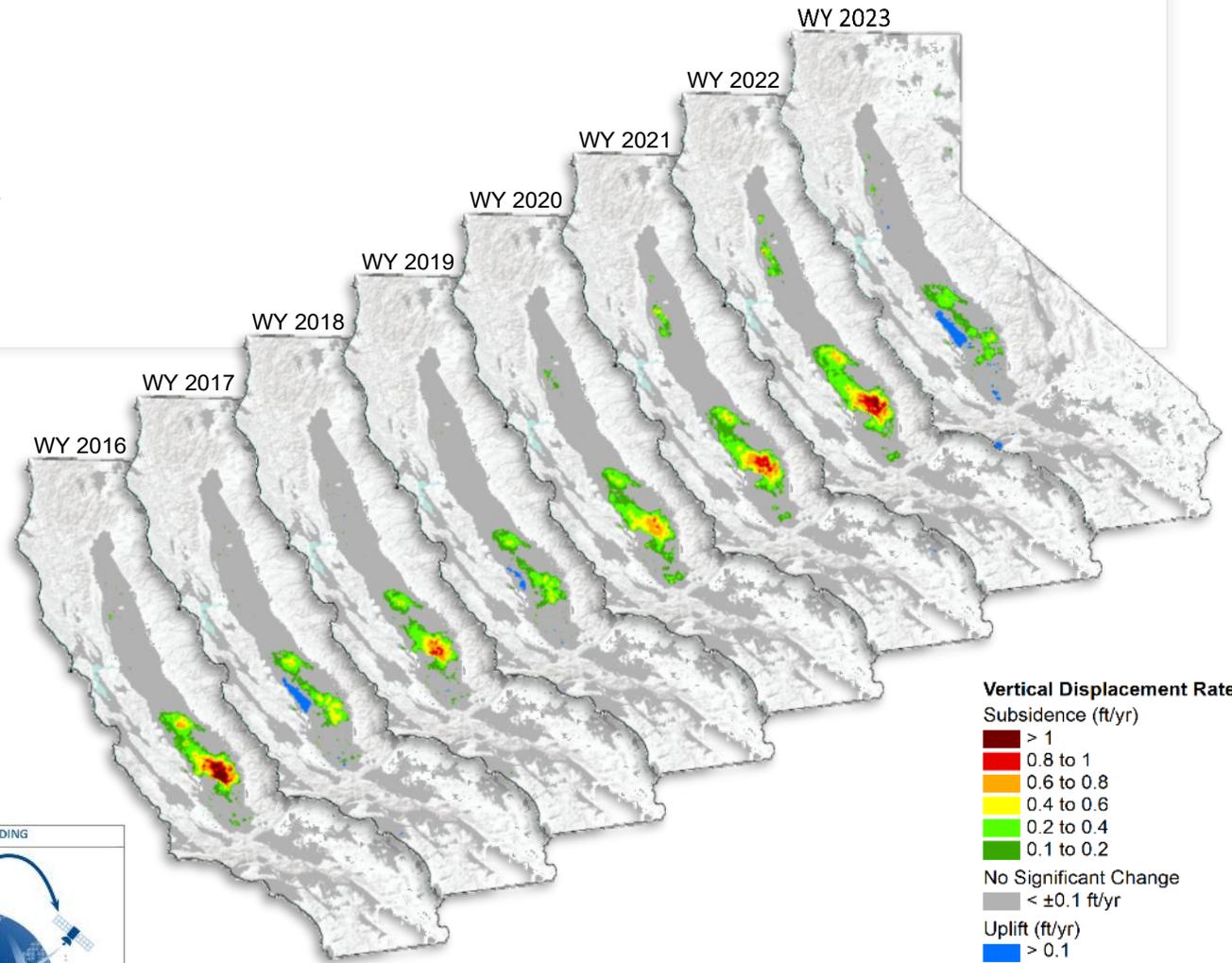


# InSAR Data – Sentinel-1A

Dataset and Reports Available on Open Data at  
<https://data.cnra.ca.gov/dataset/tre-altamira-insar-subsidence>

## TREA InSAR Subsidence Data

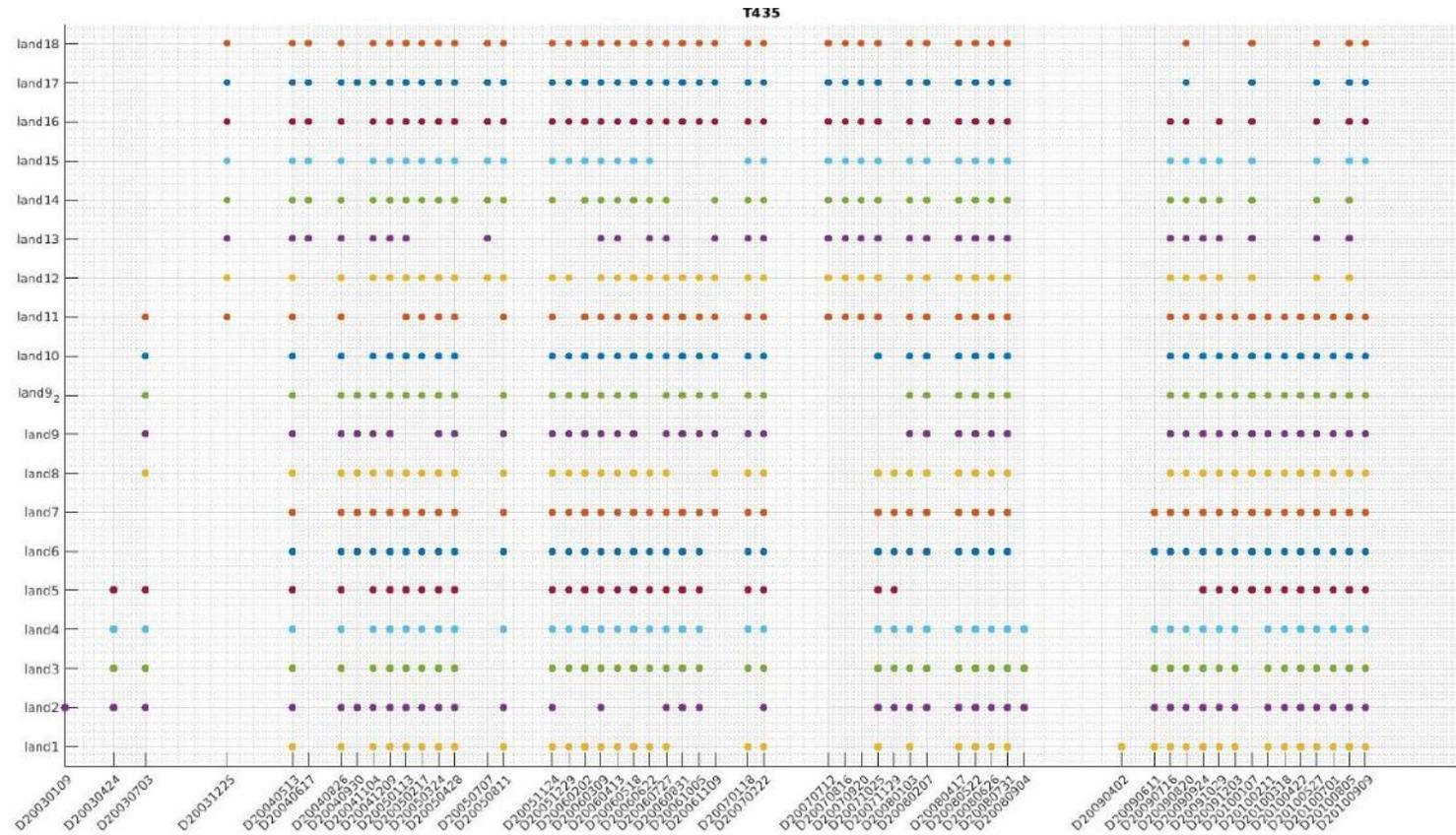
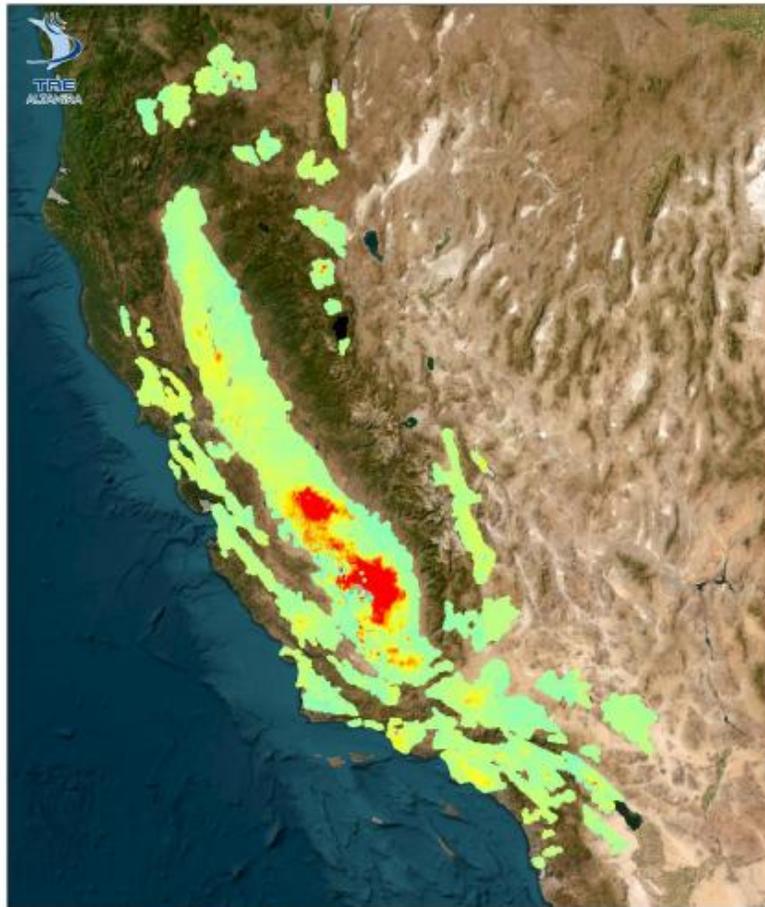
- Monthly timesteps
- Quarterly Updates
- Cumulative Displacement since June 2015
- Annual Displacement since January 2015
- 100x100 meter resolution
- GIS Raster Image services
- European Space Agency (ESA)  
Sentinel Satellite



TREA, 2023

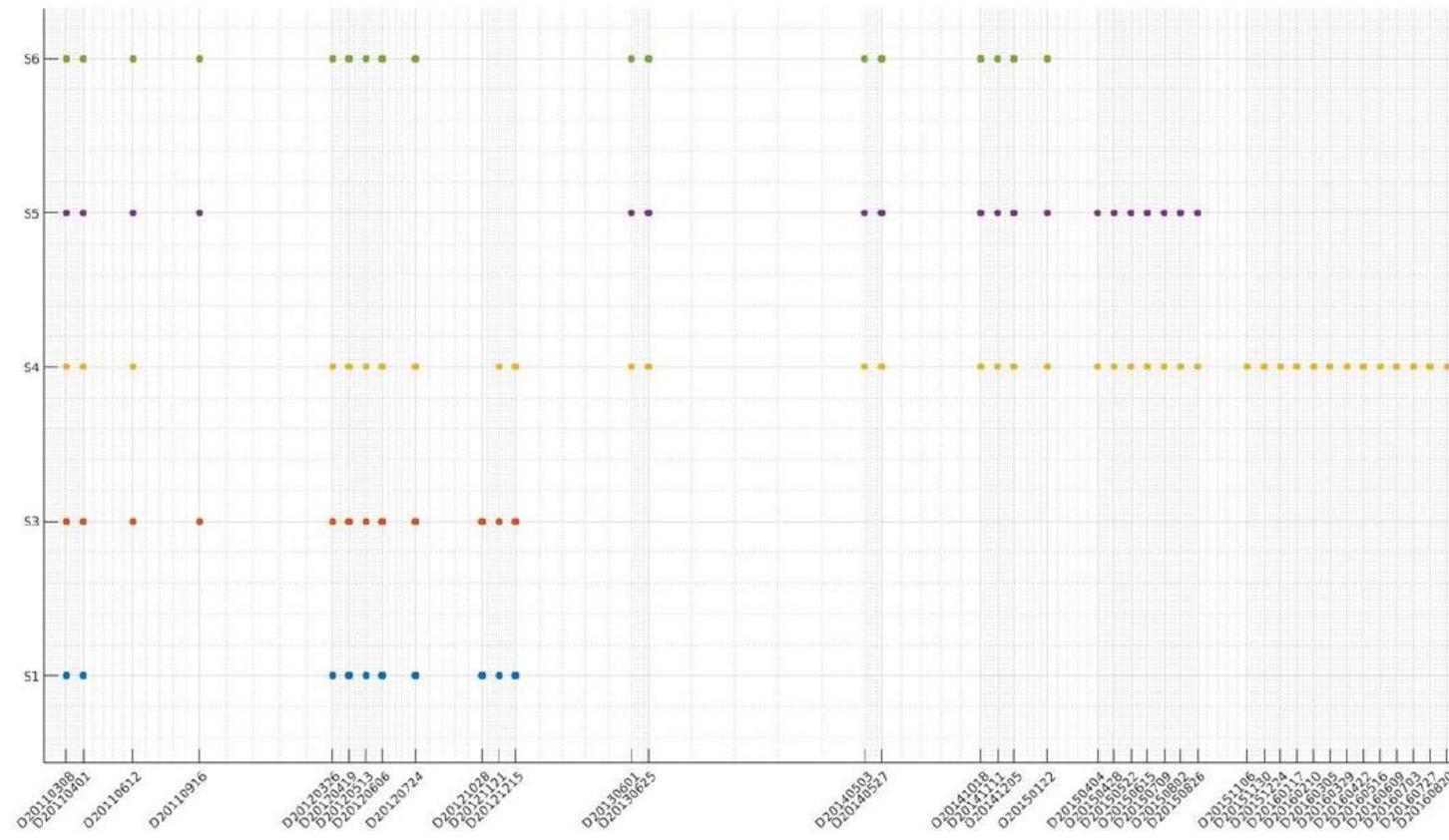
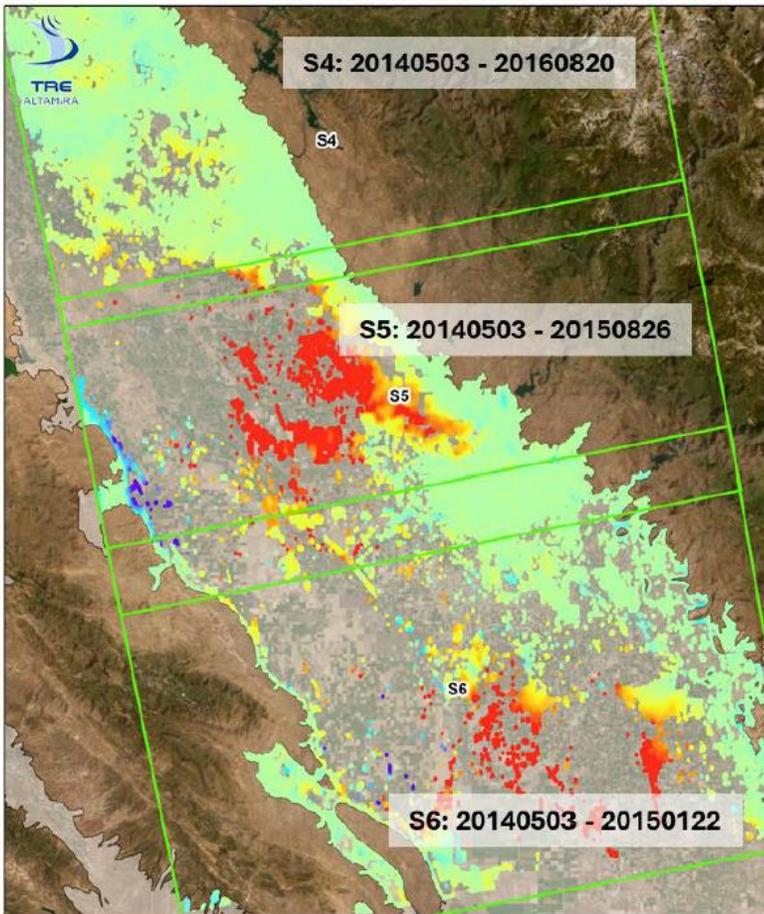
# InSAR Data – ENVISAT (2003-2010)

Dataset and Reports Available on Open Data at <https://data.cnra.ca.gov/dataset/tre-altamira-insar-subsidence>



# InSAR Data – Radarsat-2 (2011-2015)

Dataset and Reports Available on Open Data at <https://data.cnra.ca.gov/dataset/tre-altamira-insar-subsidence>



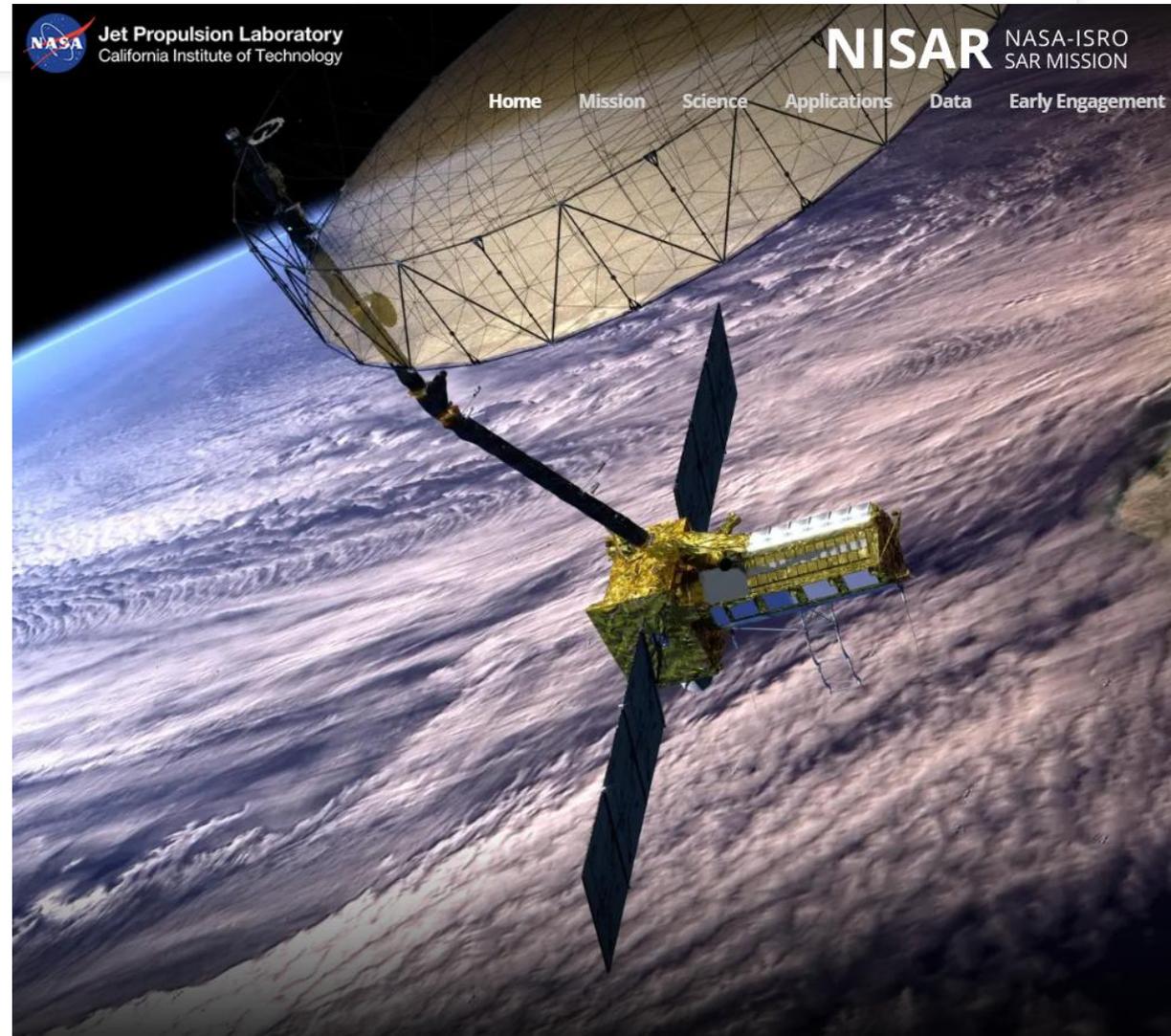
# InSAR Data – Upcoming



## APPLICATIONS

# Sentinel-1C captures first radar images

10/12/2024 11774 VIEWS 100 LIKES



# InSAR Data on SGMA Data Viewer

<https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#landsub>

- ▶ Current Conditions
- ▶ Groundwater Levels
- ▶ Groundwater Storage
- ▶ Water Quality
- ▼ Land Subsidence

## Land Subsidence Layers

- DWR Extensometers
- USGS Extensometers
- GPS Stations
- Estimated Vertical Displacement SJV DWR 1949 to 2005 (feet)

## TRE Altamira InSAR Dataset

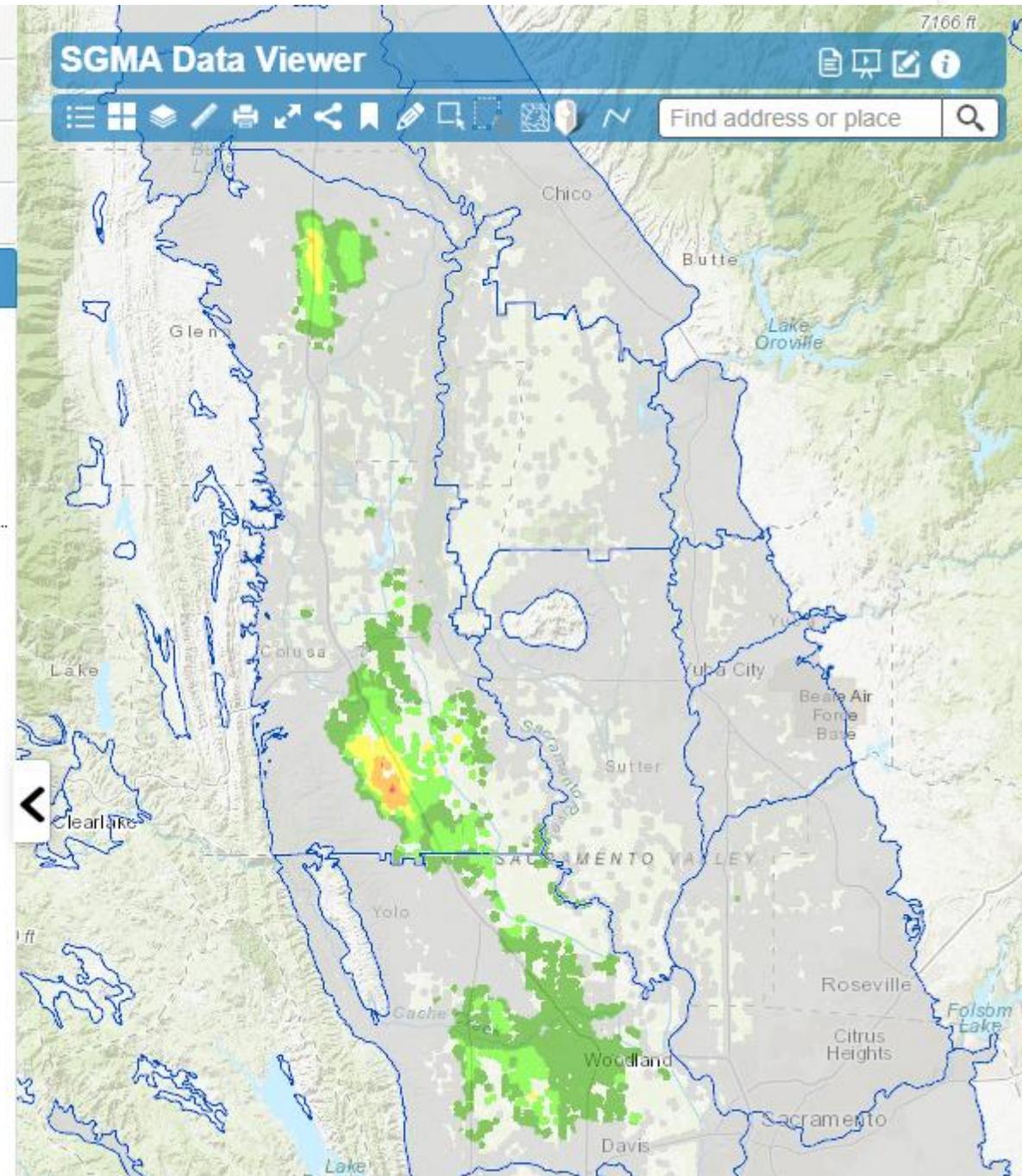
- Vertical Displacement Point Data

Annual Raster

10/01/2021 x 10/01/2022 x

- Vertical Displacement Raster Data

- <-1 (feet)
- 1 to -0.8 (feet)
- 0.8 to -0.6 (feet)
- 0.6 to -0.4 (feet)
- 0.4 to -0.2 (feet)
- 0.2 to -0.1 (feet)
- 0.1 to 0.1 (feet)
- >0.1 (feet)



# InSAR Data on SGMA Data Viewer

<https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#landsub>

- ▶  Current Conditions
- ▶  Groundwater Levels
- ▶  Groundwater Storage
- ▶  Water Quality
- ▼  Land Subsidence

## Land Subsidence Layers

- DWR Extensometers
- USGS Extensometers
- GPS Stations
- Estimated Vertical Displacement SJV DWR 1949 to 2005 (feet)

## TRE Altamira InSAR Dataset

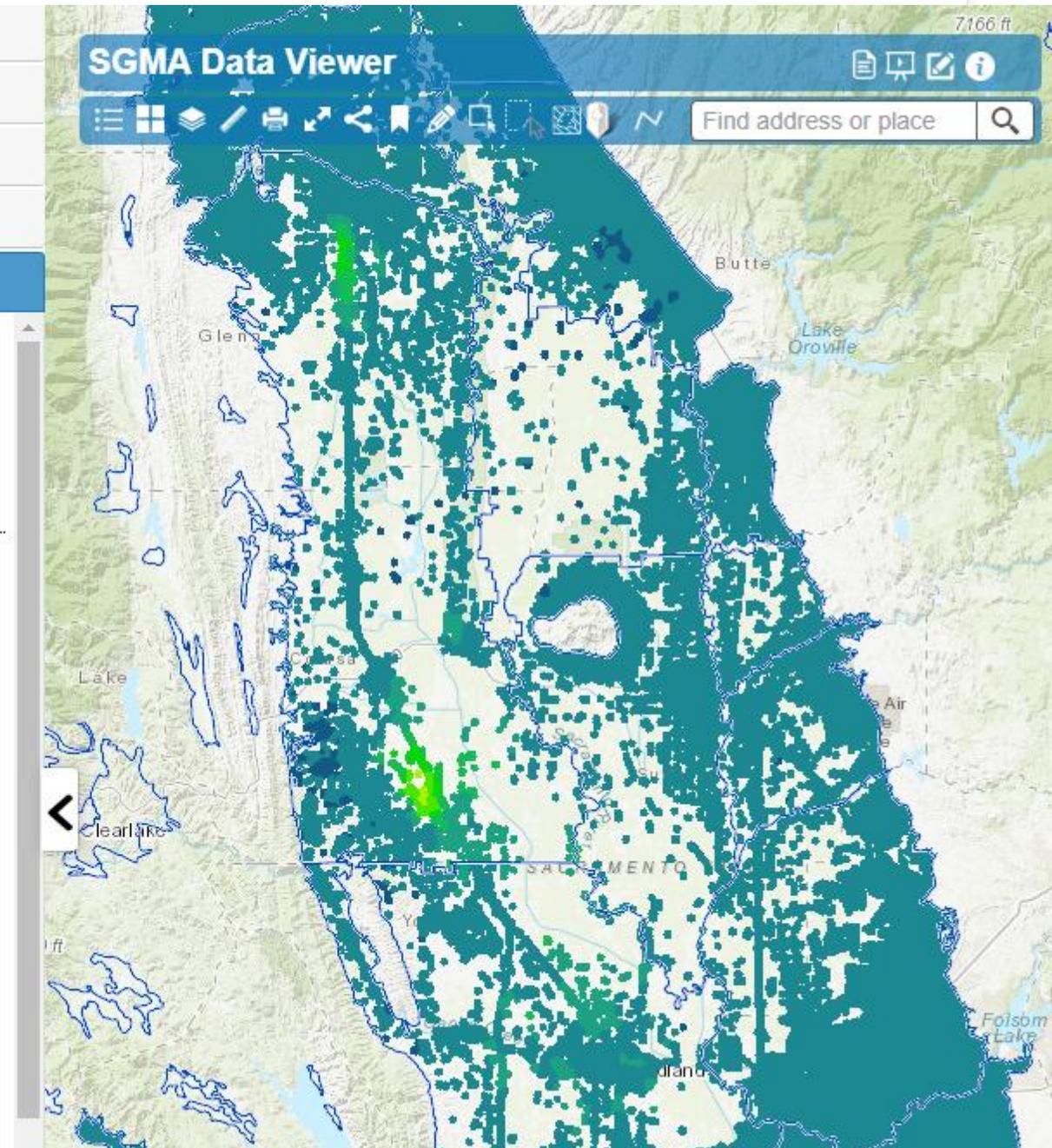
- Vertical Displacement Point Data

Total Raster

06/13/2015 x 07/01/2024 x

- Vertical Displacement Raster Data

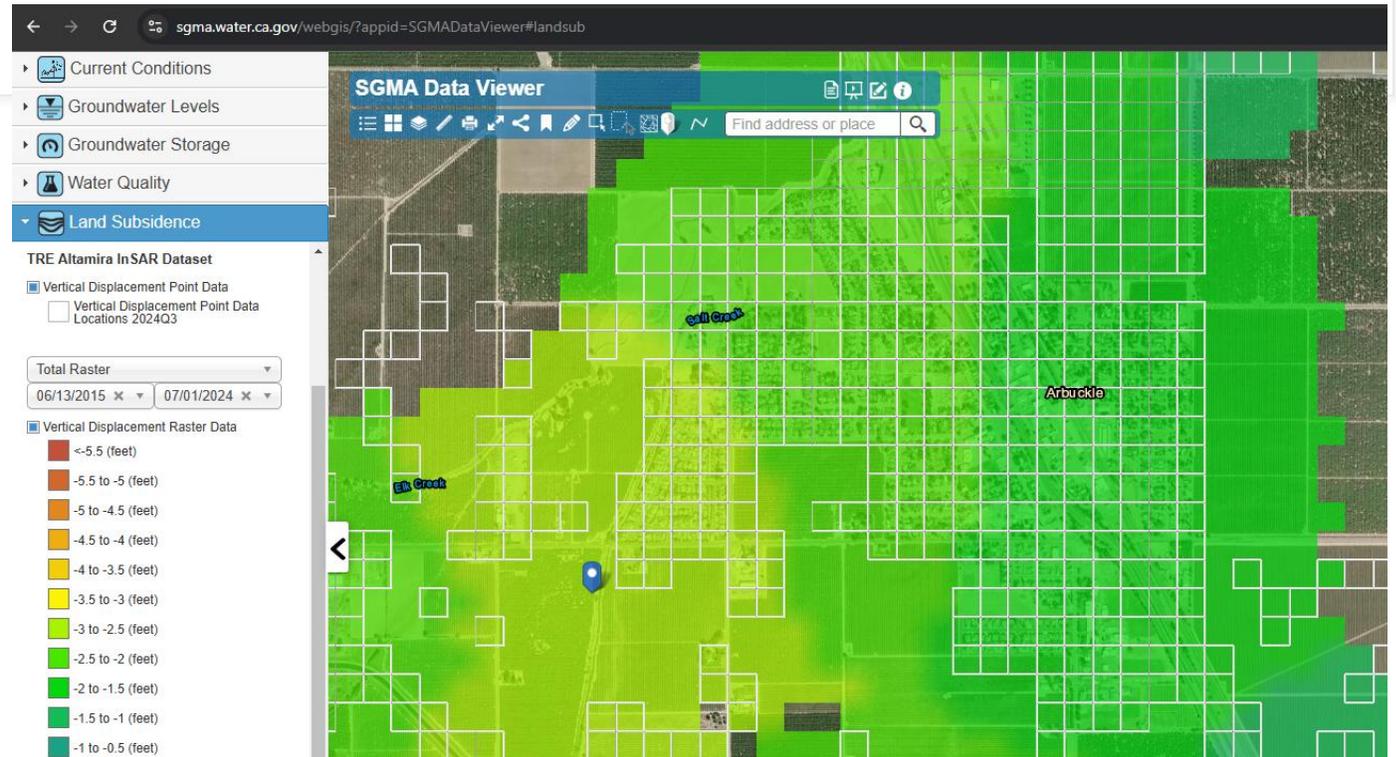
-  <-5.5 (feet)
-  -5.5 to -5 (feet)
-  -5 to -4.5 (feet)
-  -4.5 to -4 (feet)
-  -4 to -3.5 (feet)
-  -3.5 to -3 (feet)
-  -3 to -2.5 (feet)
-  -2.5 to -2 (feet)



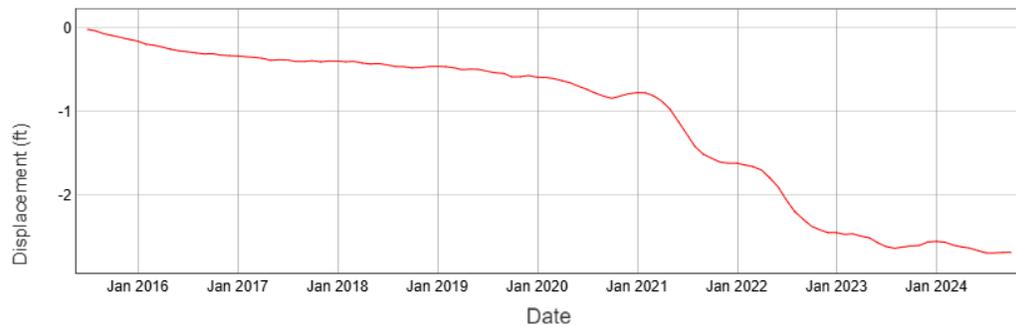
# InSAR Data on SGMA Data Viewer

<https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#landsub>

Select any location on the InSAR map layer to view and download vertical displacement timeseries data or use direct links .



Total Interpolated Vertical Displacement (ft) for (39.01123, -122.07565)



Raster Data Chart direct link:

<https://sgma.water.ca.gov/SGMAMapServices/report/displacement/raster?latitude=36.23328&longitude=-119.52009>

Raster Data Download direct link:

<https://sgma.water.ca.gov/SGMAMapServices/service/displacement/raster/download/csv?latitude=36.23328&longitude=-119.52009>

Example Links:

Point Data Chart direct link:

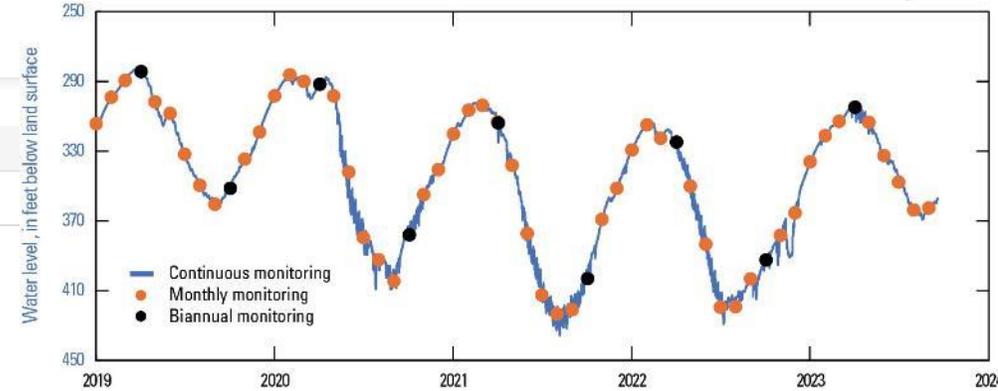
<https://sgma.water.ca.gov/SGMAMapServices/report/displacement/point?code=BTOTU4U>

Point Data Download direct link:

<https://sgma.water.ca.gov/SGMAMapServices/service/displacement/point/download/csv?code=BTOTU4U>

# InSAR Data on SGMA Data Viewer

Groundwater Level Monitoring with Consideration of Subsidence

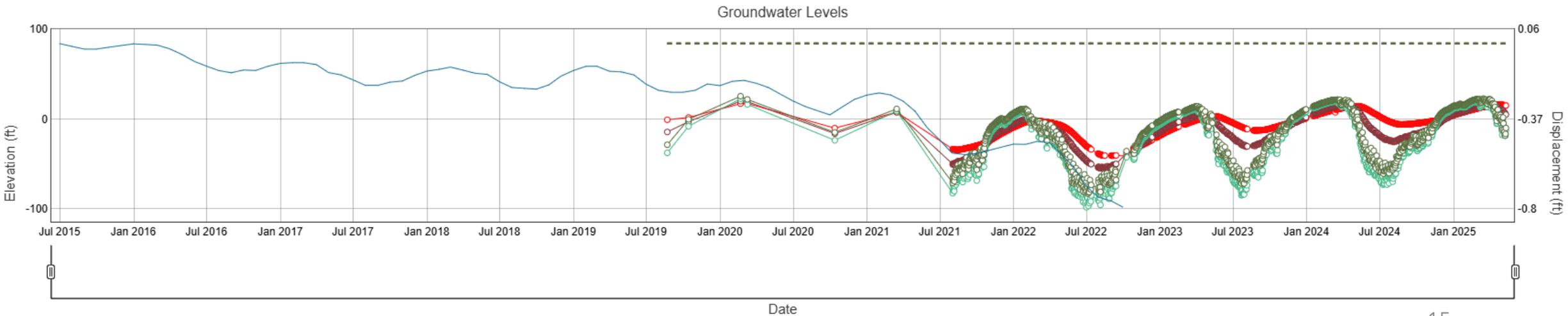


## Groundwater Elevation

Water Year Type  Land Subsidence

Date: (hover to see values)

- GSE
- GSE
- GSE
- GSE
- Vertical Ground Surface Displacement (InSAR)
- WSE 390540N1220607W002 : 1026.0 - 1036.0
- WSE 390540N1220607W004 : 865.0 - 936.0
- WSE 390540N1220607W006 : 583.0 - 603.0
- WSE 390540N1220607W008 : 290.0 - 300.0



# Other Subsidence Data on SGMA Data Viewer

<https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#landsub>

- ▶ Current Conditions
- ▶ Groundwater Levels
- ▶ Groundwater Storage
- ▶ Water Quality
- ▼ Land Subsidence

## Land Subsidence Layers

- DWR Extensometers
- USGS Extensometers
- GPS Stations
- Estimated Vertical Displacement SJV DWR 1949 to 2005 (feet)

## TRE Altamira InSAR Dataset

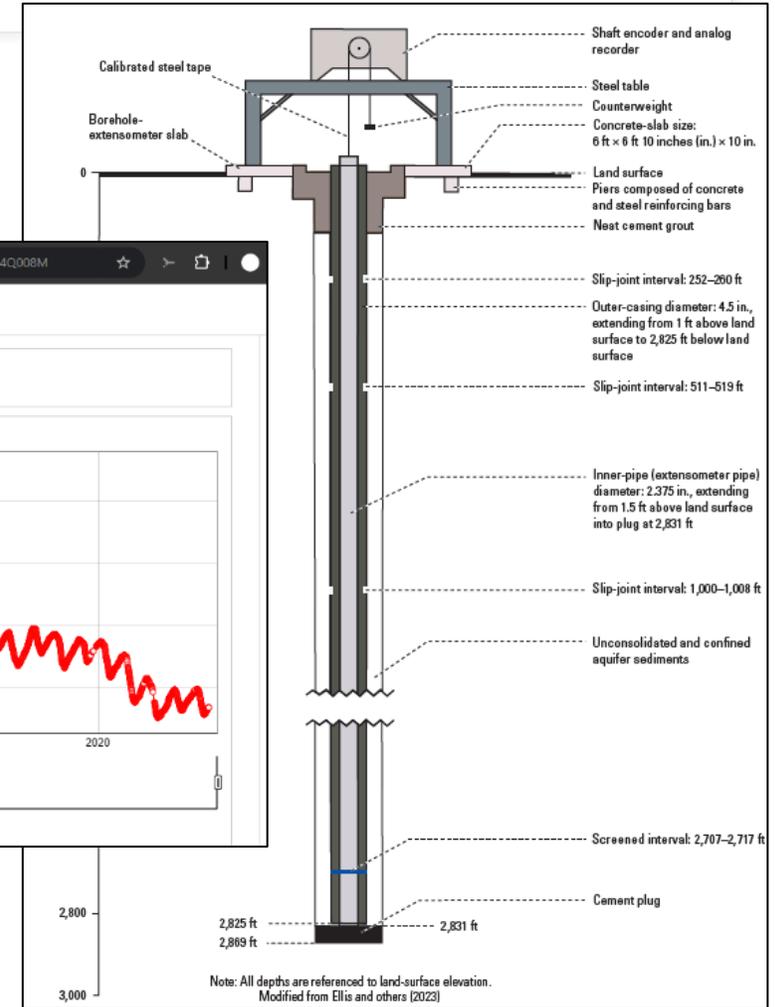
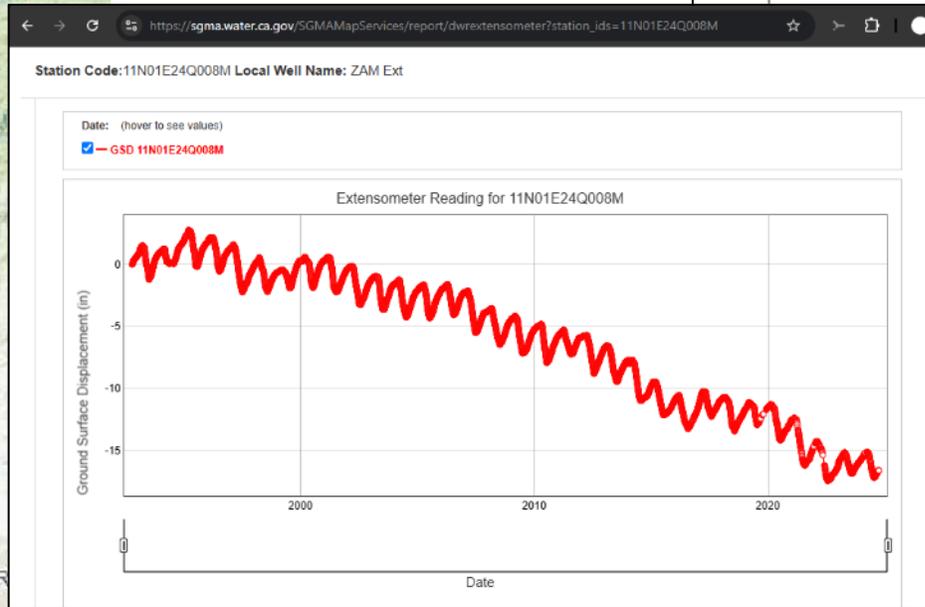
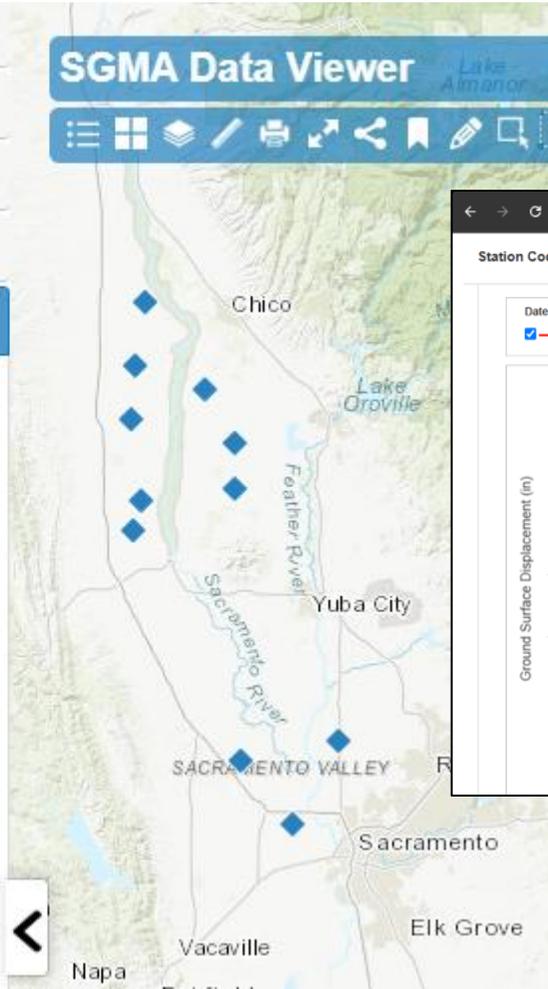
- Vertical Displacement Point Data

Annual Raster

07/01/2023

07/01/2024

- Vertical Displacement Raster Data



# Other Subsidence Data on SGMA Data Viewer

<https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#landsub>

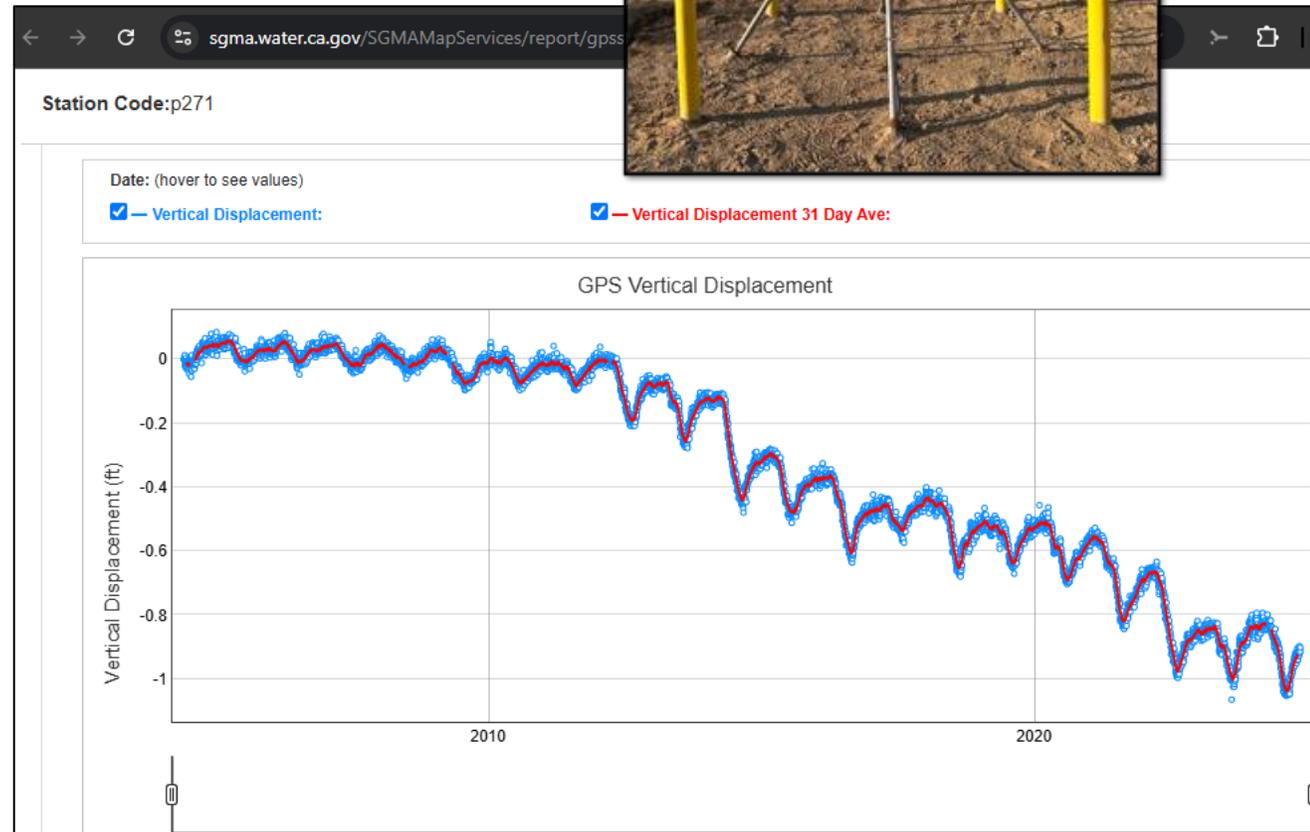
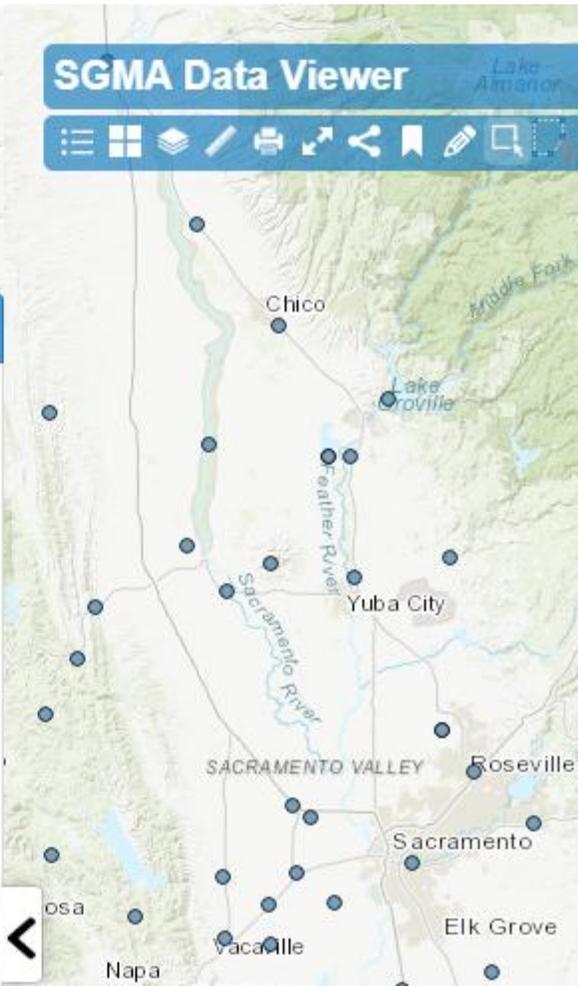
- ▶ Current Conditions
- ▶ Groundwater Levels
- ▶ Groundwater Storage
- ▶ Water Quality
- ▶ Land Subsidence

## Land Subsidence Layers

- DWR Extensometers
- USGS Extensometers
- GPS Stations
- Estimated Vertical Displacement SJV DWR 1949 to 2005 (feet)

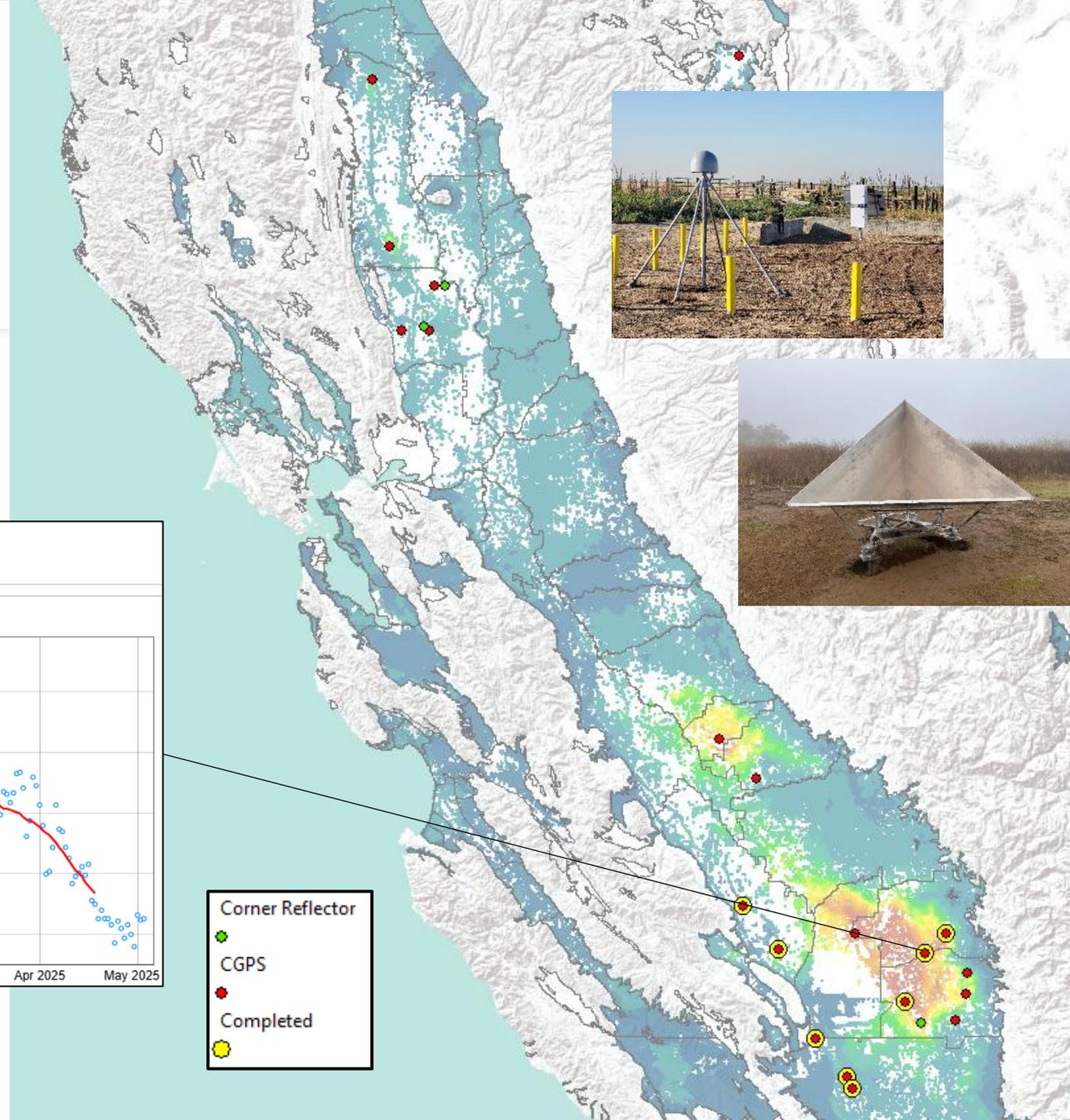
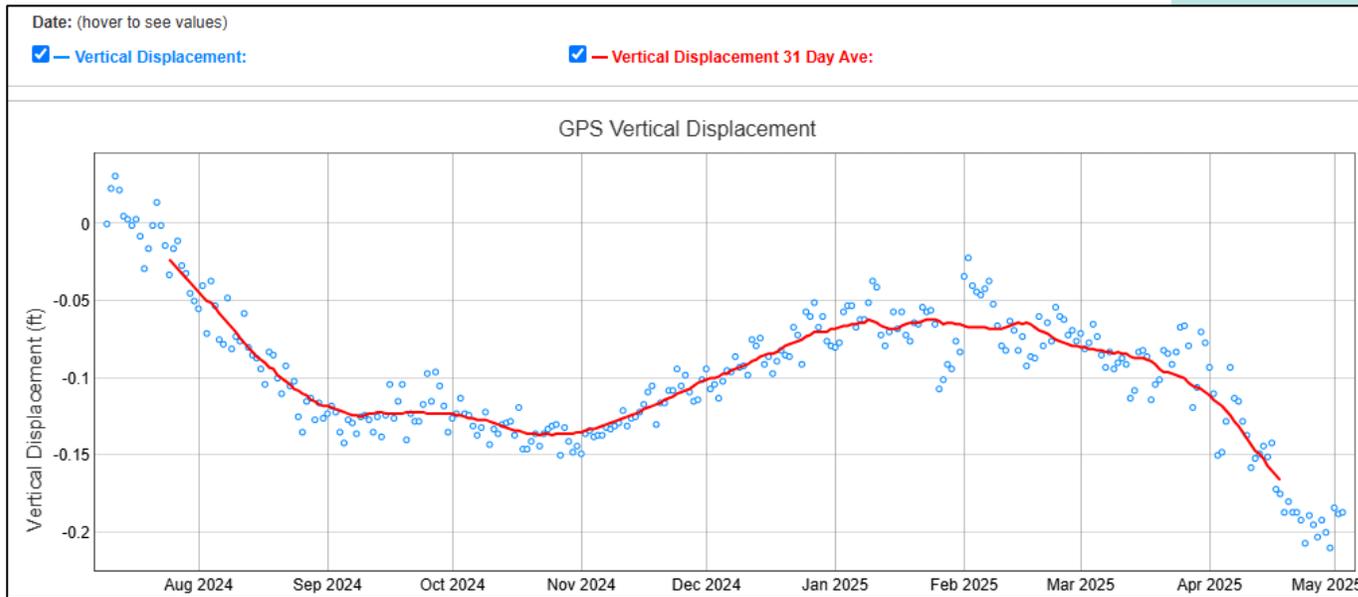
## TRE Altamira InSAR Dataset

- Vertical Displacement Point Data
- Annual Raster
- 07/01/2023 x
- 07/01/2024 x
- Vertical Displacement Raster Data



# California's Groundwater Monitoring and Technical Support Services (TSS)

- New CGPS Stations and InSAR Reflectors  
Contact: Tad Bedegrew (tad.bedegrew@water.ca.gov)

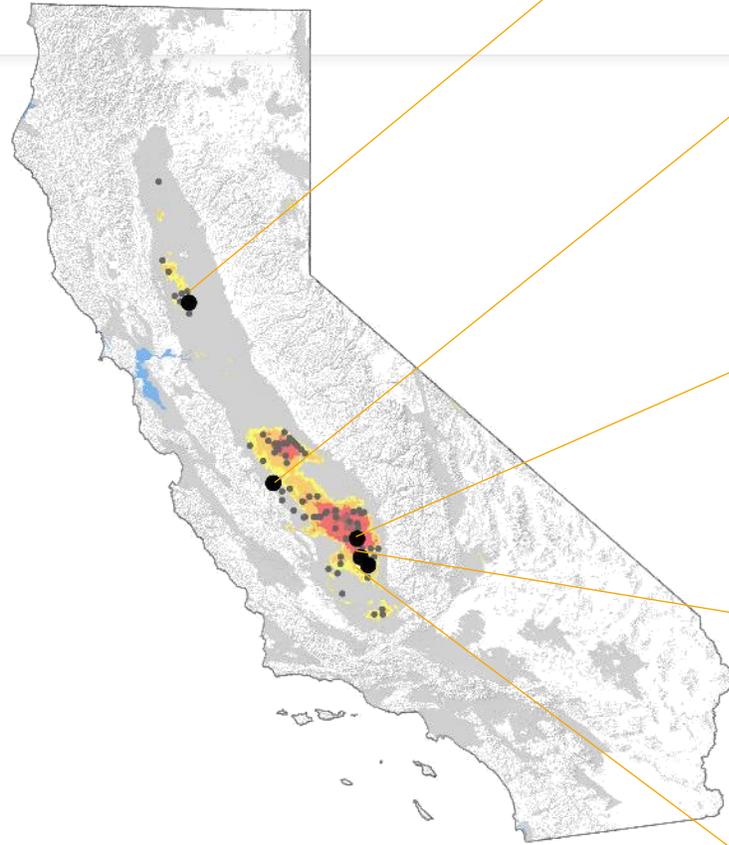
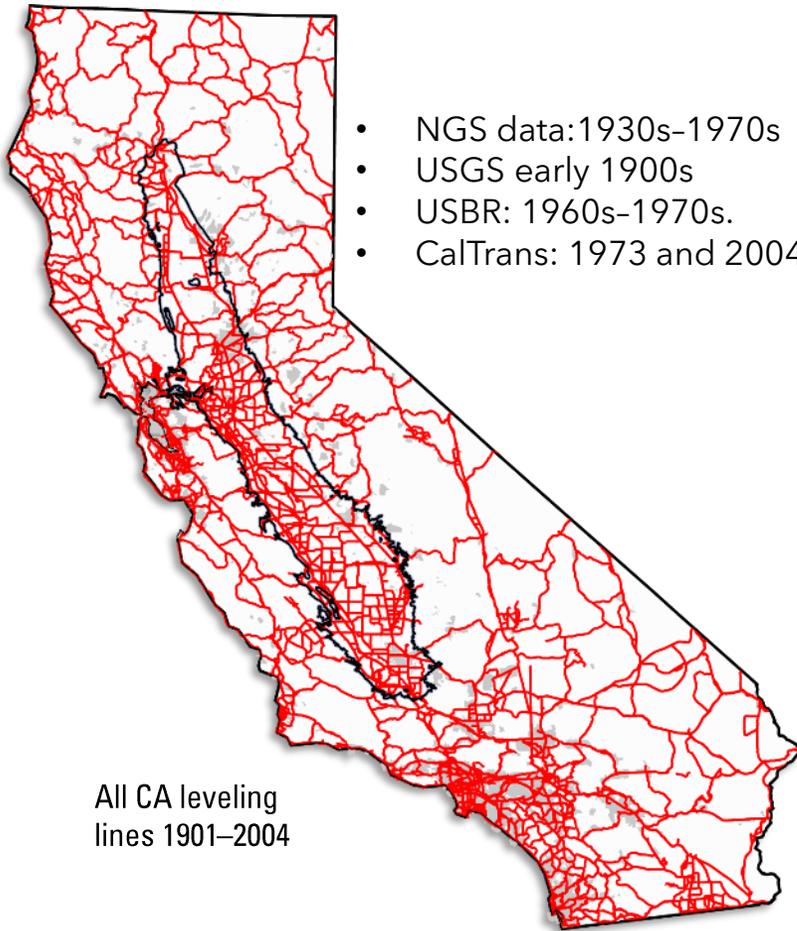


- Corner Reflector
- CGPS
- Completed

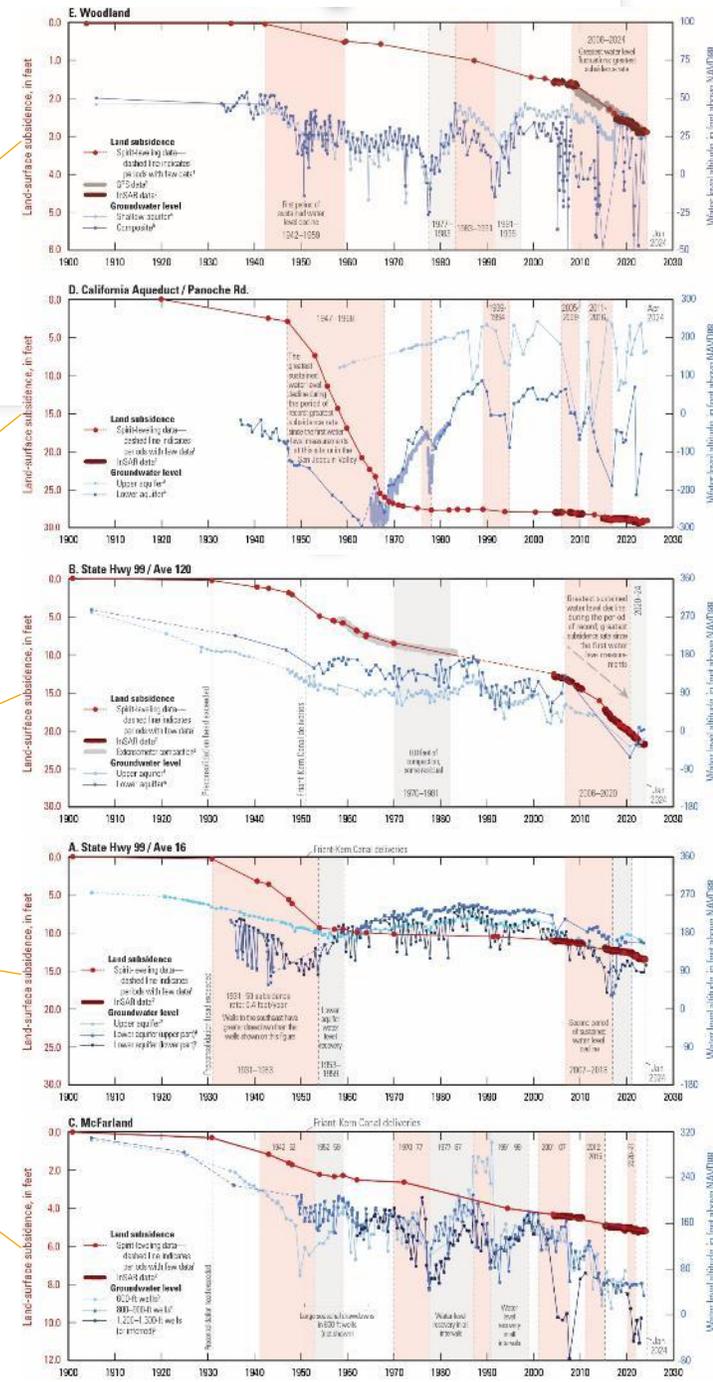
[https://sgma.water.ca.gov/SGMAMapServices/report/gpsstation?station\\_id=tula](https://sgma.water.ca.gov/SGMAMapServices/report/gpsstation?station_id=tula)

# Leveling and Long-Term Stress Data

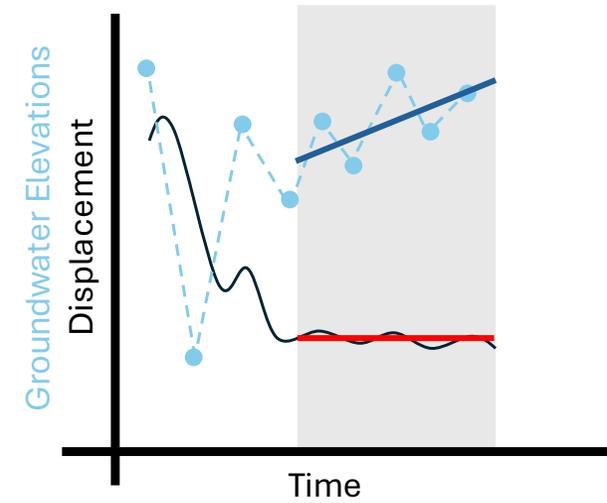
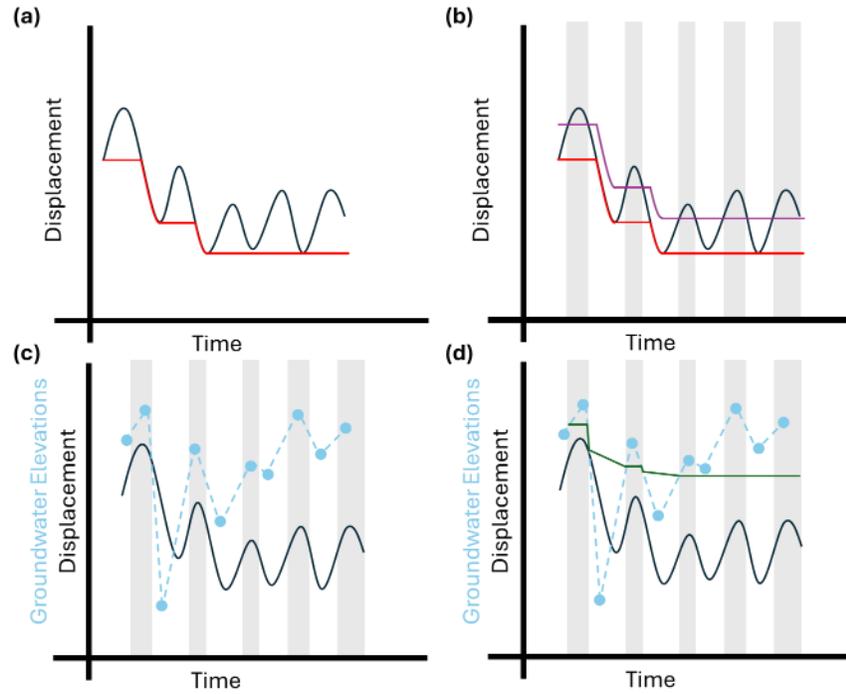
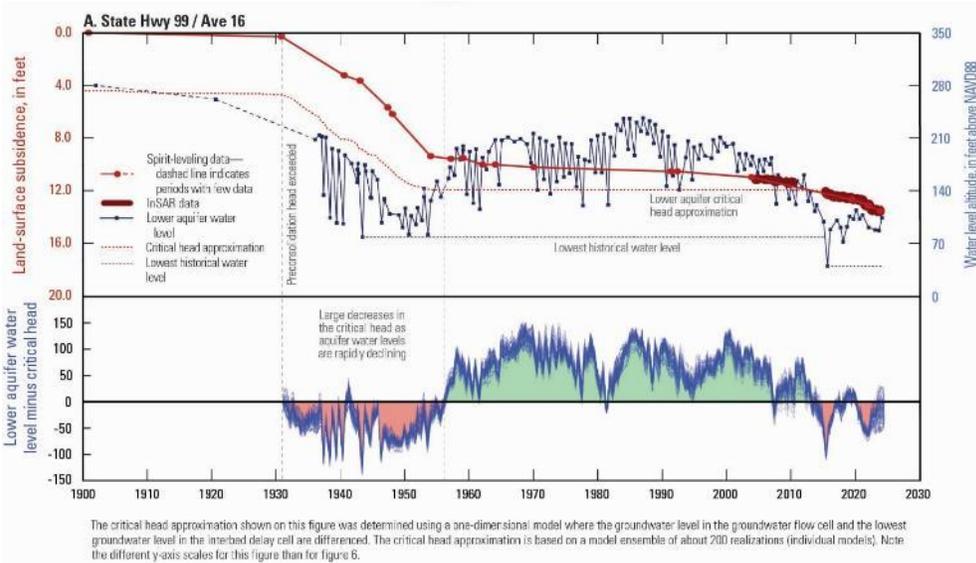
To be released on CNRA Open Data Portal and SGMA Data Viewer



- 5 sites discussed in BMP
- 50 sites included in upcoming CalGW/B118 Update 2025 appendix



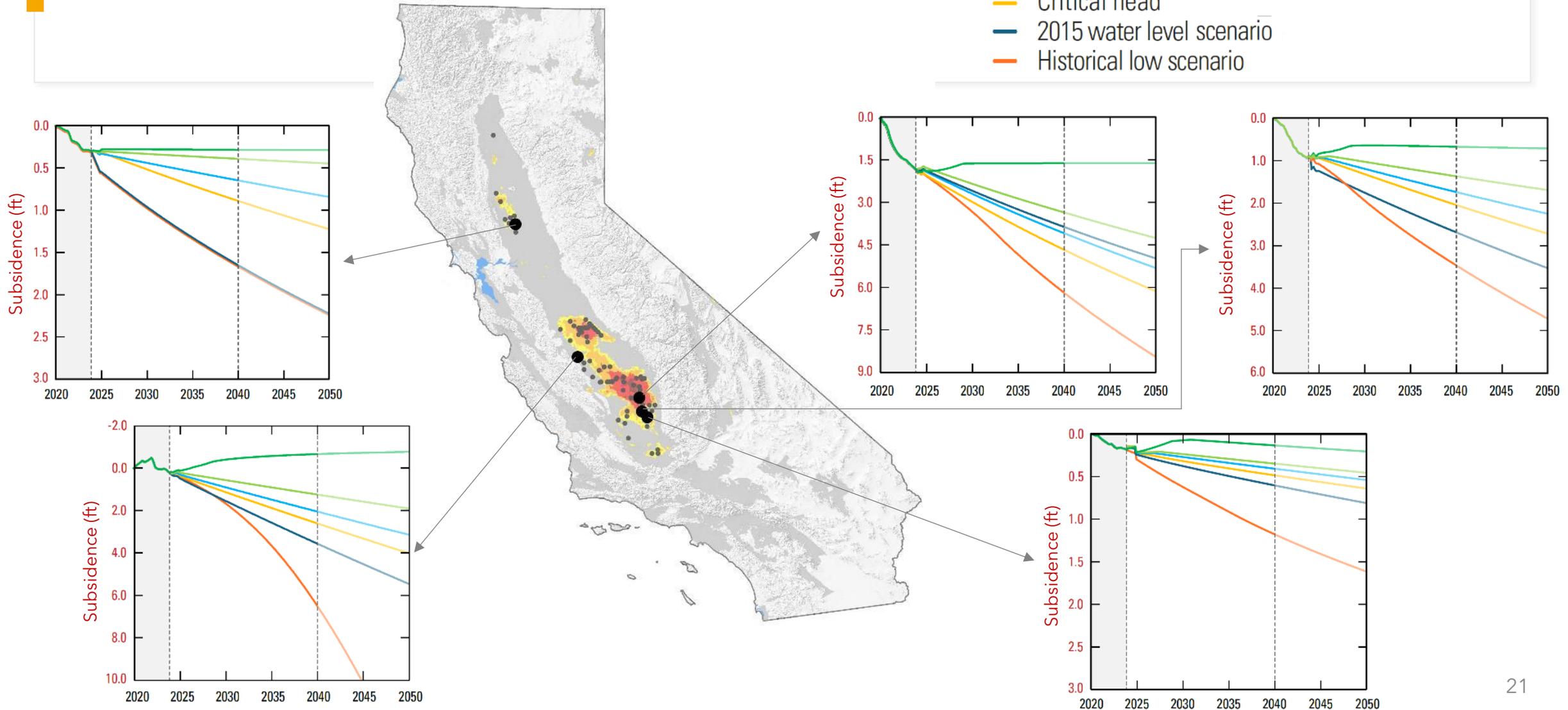
# Estimating Critical Head



# Modeling

## Subsidence Simulation Groundwater Level Scenario Examples

- Rebound scenario
- Critical head + 50 feet
- Critical head + 20 feet
- Critical head
- 2015 water level scenario
- Historical low scenario





# Thank you



Ben Brezing



[benjamin.brezing@water.ca.gov](mailto:benjamin.brezing@water.ca.gov)



<https://water.ca.gov/Programs/Groundwater-Management/SGMA-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents>