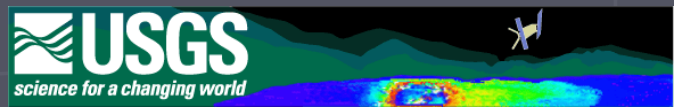
# Detection and Measurement of Land Surface Deformation, Pajaro Valley, CA, 2015-2018 Preliminary Results

Justin Brandt,

Marisa Earll, Wesley Henson, and Michelle Sneed

U.S. Geological Survey

October 20, 2021



# Detection and Measurement of Land Surface Deformation, Pajaro Valley, CA, 2015-2018

Project workplan:

Process and analyze land subsidence data for the period between 2015-18 for the PV Water service area, near Watsonville.

Analysis focuses on InSAR with calibration/validation using Continuous GPS data.

Historical context

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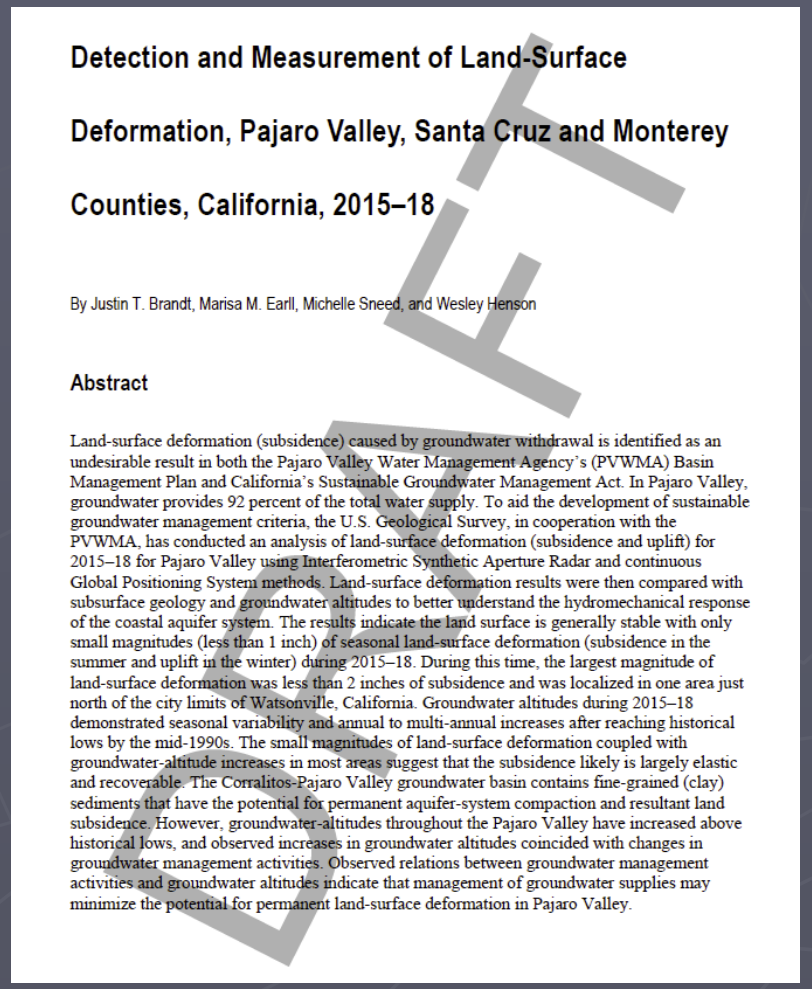
# USGS Publications

- Draft report in final stages of preparation
  - Expected release very soon (late October/Early November)
- USGS Data Release

Brandt, J.T., 2021, Interferometric Synthetic Aperture Radar and Groundwater Level Data, Pajaro Valley, Santa Cruz and Monterey Counties, California, 1970-2018, U.S. Geological Survey data release, https://doi.org/10.5066/P9FNARQO.



Detection and Measurement of Land-Surface Deformation, Pajaro Valley, Santa Cruz and Monterey Counties, California, 2015–18

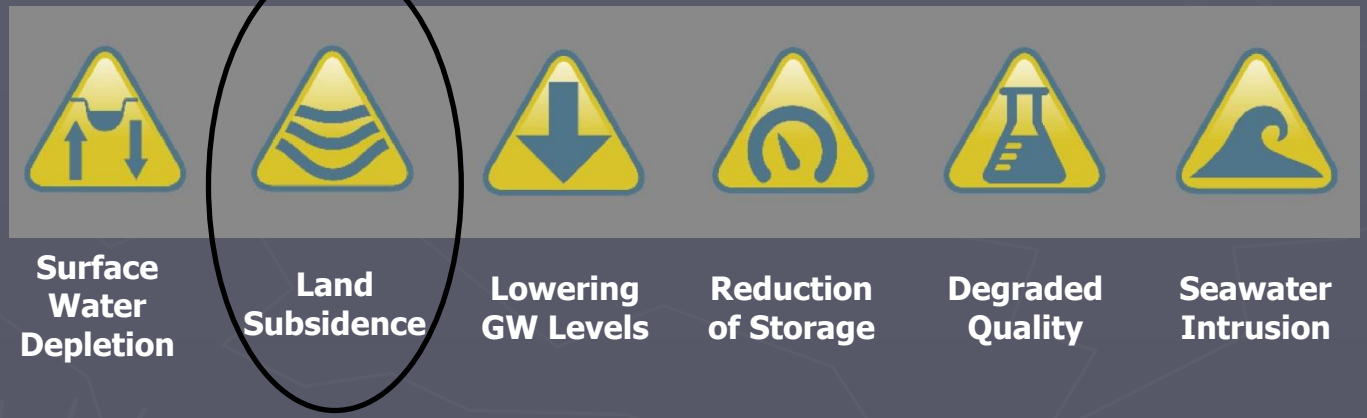
By Justin T. Brandt, Marisa M. Earll, Michelle Sneed, and Wesley Henson

Abstract

Land-surface deformation (subsidence) caused by groundwater withdrawal is identified as an undesirable result in both the Pajaro Valley Water Management Agency's (PVWMA) Basin Management Plan and California's Sustainable Groundwater Management Act. In Pajaro Valley, groundwater provides 92 percent of the total water supply. To aid the development of sustainable groundwater management criteria, the U.S. Geological Survey, in cooperation with the PVWMA, has conducted an analysis of land-surface deformation (subsidence and uplift) for 2015–18 for Pajaro Valley using Interferometric Synthetic Aperture Radar and continuous Global Positioning System methods. Land-surface deformation results were then compared with subsurface geology and groundwater altitudes to better understand the hydromechanical response of the coastal aquifer system. The results indicate the land surface is generally stable with only small magnitudes (less than 1 inch) of seasonal land-surface deformation (subsidence in the summer and uplift in the winter) during 2015–18. During this time, the largest magnitude of land-surface deformation was less than 2 inches of subsidence and was localized in one area just north of the city limits of Watsonville, California. Groundwater altitudes during 2015–18 demonstrated seasonal variability and annual to multi-annual increases after reaching historical lows by the mid-1990s. The small magnitudes of land-surface deformation coupled with groundwater-altitude increases in most areas suggest that the subsidence likely is largely elastic and recoverable. The Corralitos-Pajaro Valley groundwater basin contains fine-grained (clay) sediments that have the potential for permanent aquifer-system compaction and resultant land subsidence. However, groundwater-altitudes throughout the Pajaro Valley have increased above historical lows, and observed increases in groundwater altitudes coincided with changes in groundwater management activities. Observed relations between groundwater management activities and groundwater altitudes indicate that management of groundwater supplies may minimize the potential for permanent land-surface deformation in Pajaro Valley.

DRAFT

# SGMA and PV Water Basin Management Plan: Undesirable Results




"Significant and unreasonable land subsidence that substantially interferes with surface land uses"

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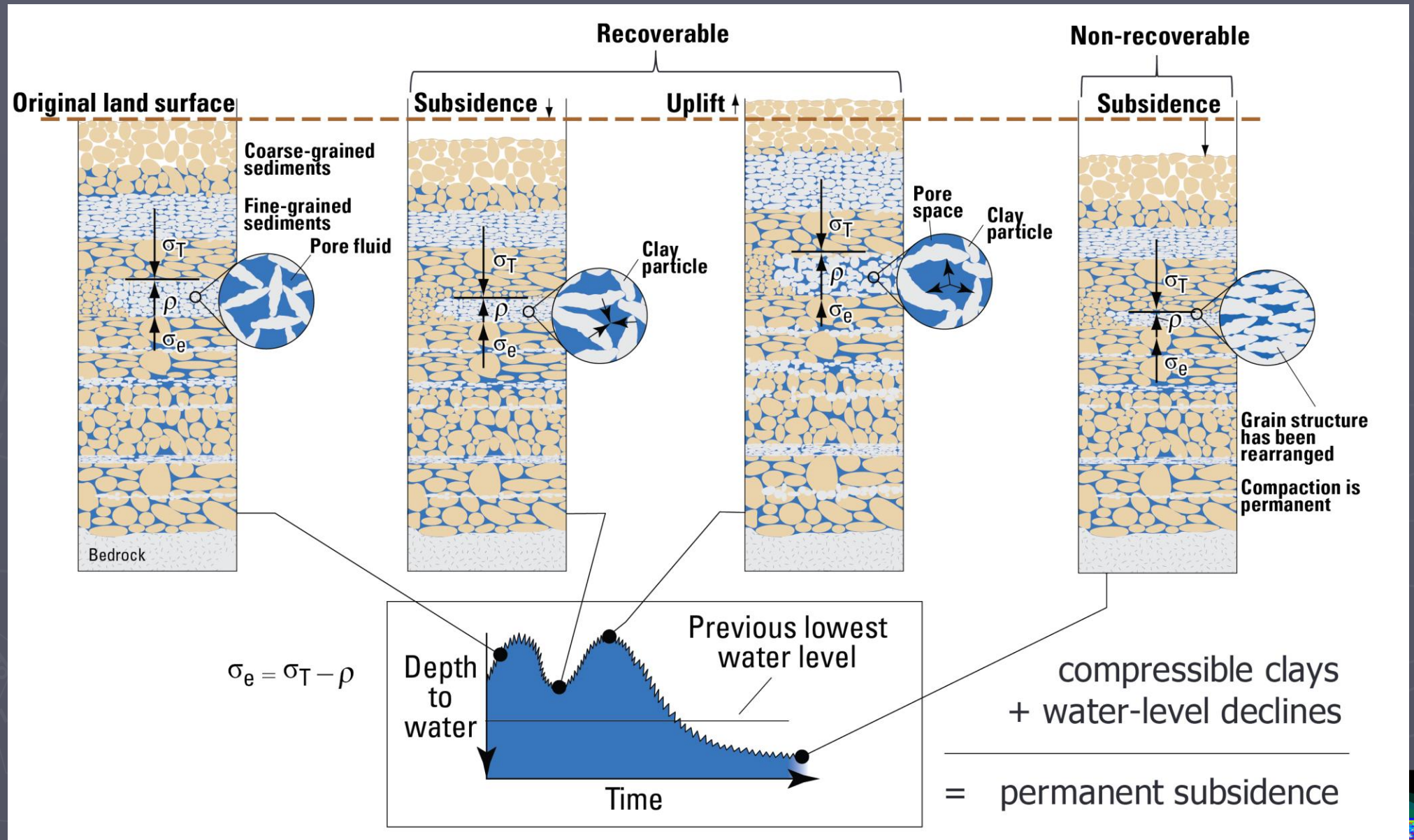
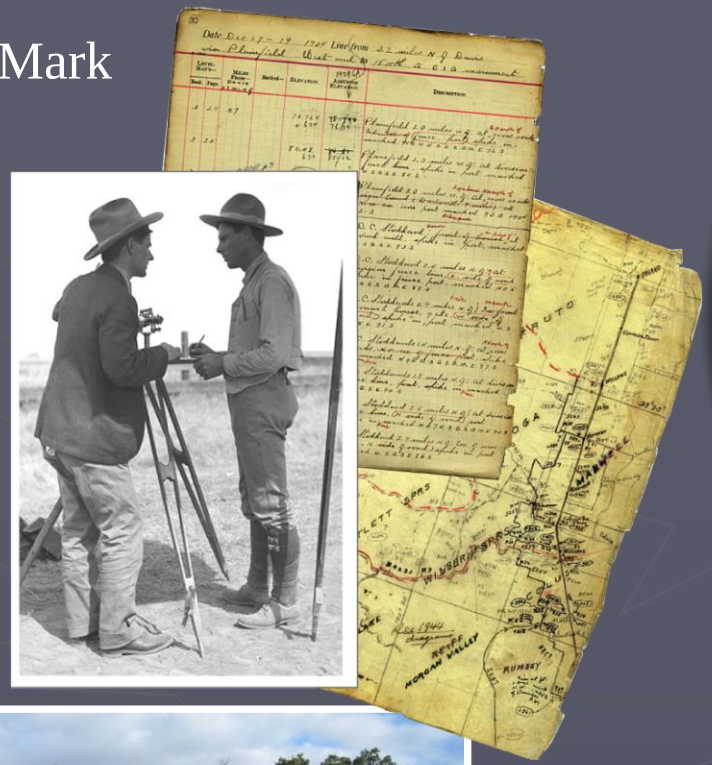
# Land Subsidence
## A deep process: Aquifer-System Compaction



# Measuring Subsidence

Bench Mark



Spirit Leveling

InSAR

GPS

Extensometer*

*measures part of land subsidence

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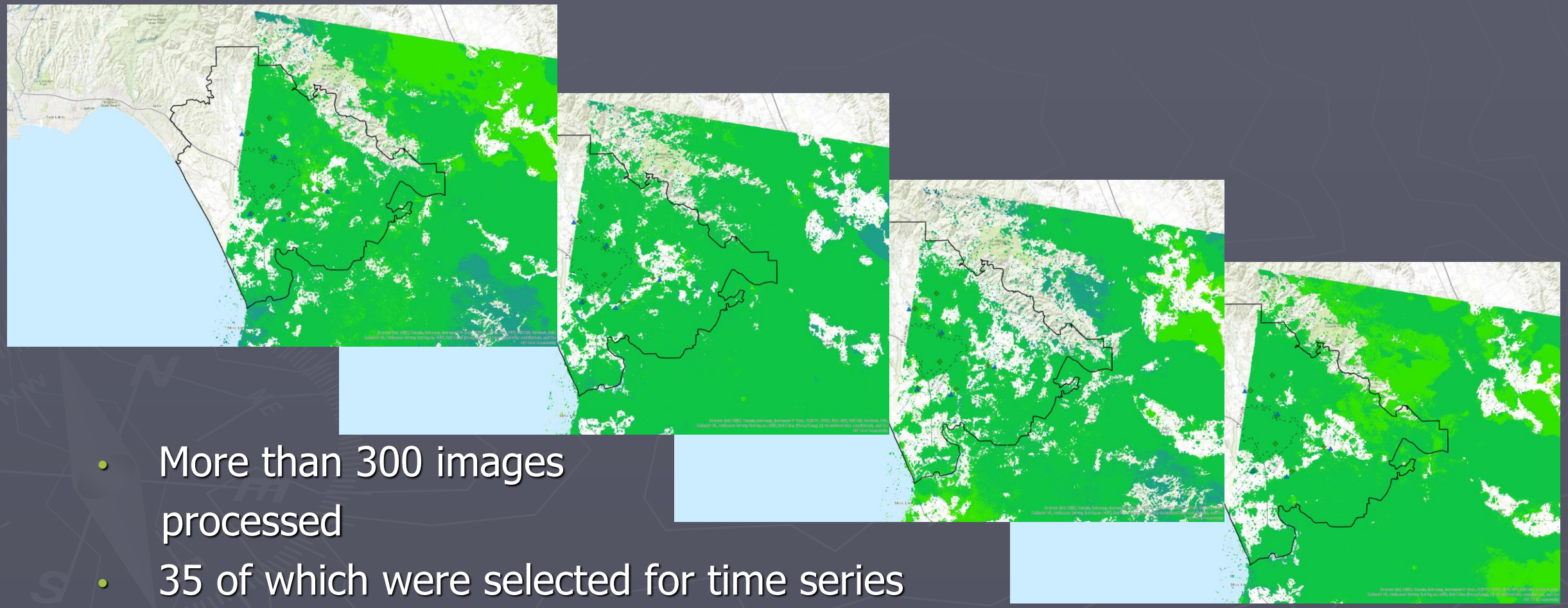
# InSAR images



- More than 300 images processed
- 35 of which were selected for time series analysis based on GPS analysis

*Preliminary and subject to revision

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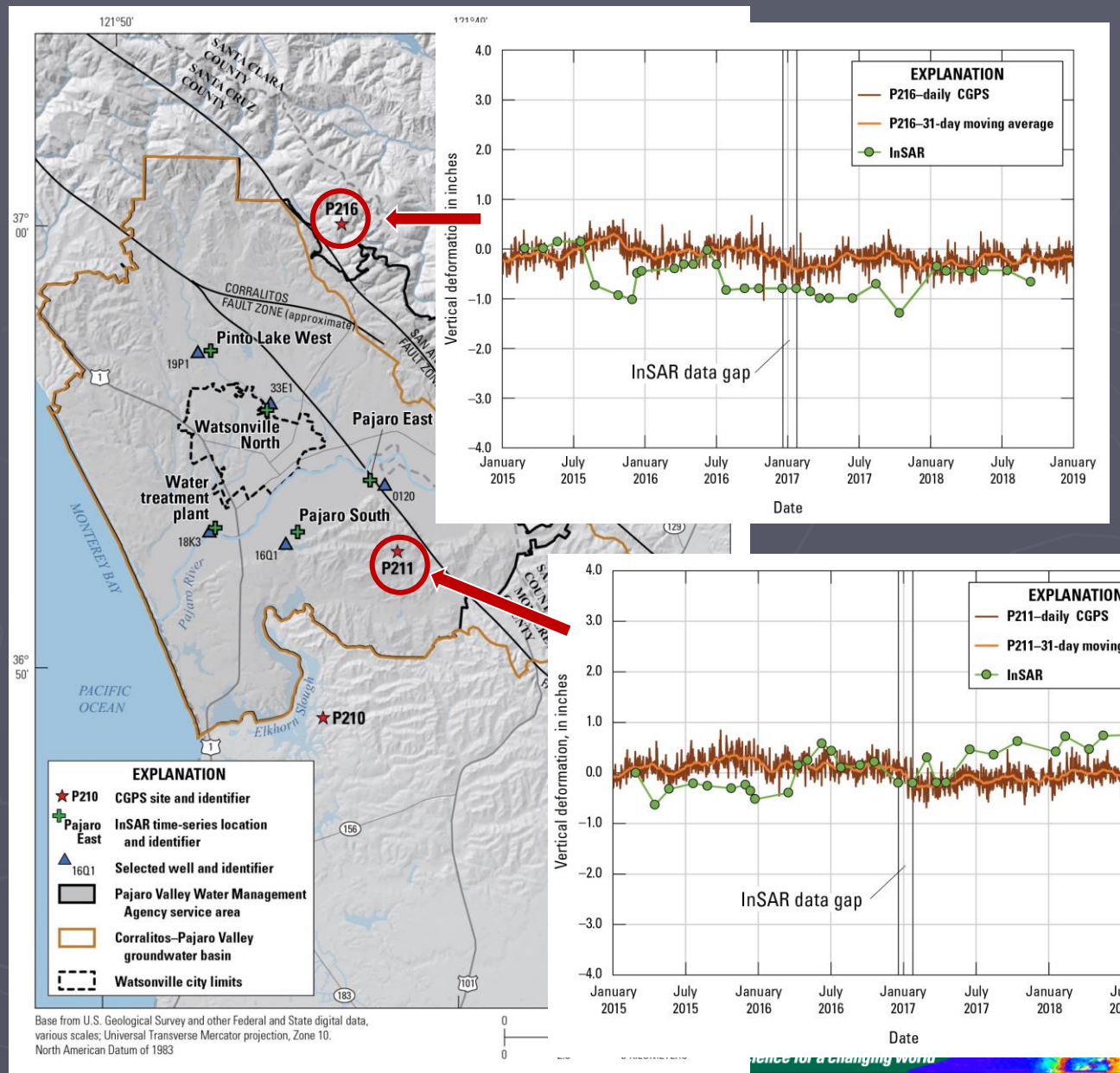
# Pajaro Basin, CA, 2015-2018

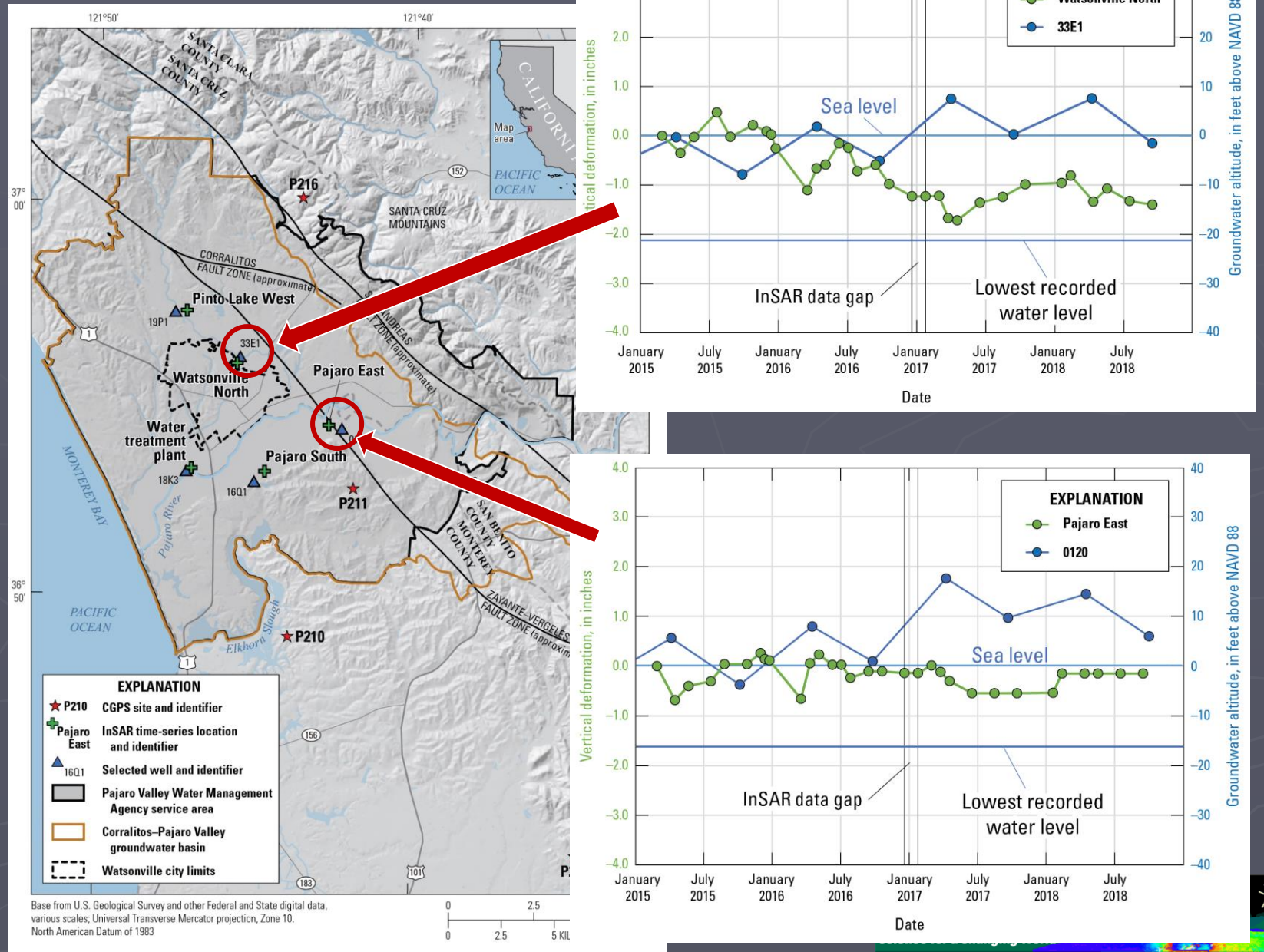
- In Pajaro, continuous GPS (CGPS) can't be used to assess subsidence in basin
  - Sites are in hills around basin
  - CGPS used as "ground truth"
- ~91% of InSAR and CGPS measurements (for same time and location) are within ~1/2"
  - RMSE of 0.3"
- Gives confidence in InSAR results




*Preliminary and subject to revision

# Pajaro Basin, CA, 2

- Water levels show seasonal variability
- Water levels generally increasing after reaching historic lows in mid-1990s
- Land surface generally stable
- Small magnitude (less than 2 inches) subsidence  localized to one area is likely recoverable

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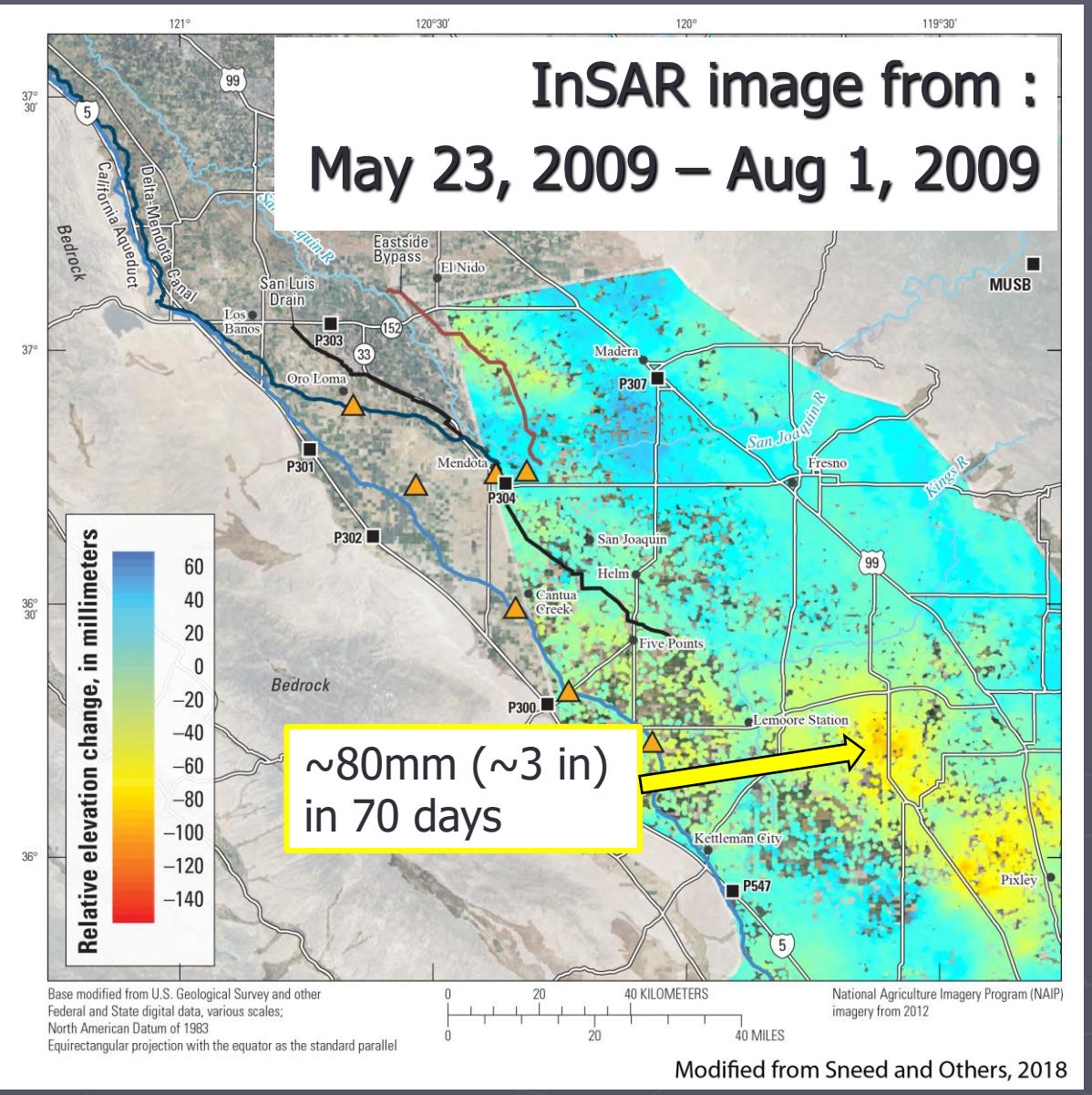
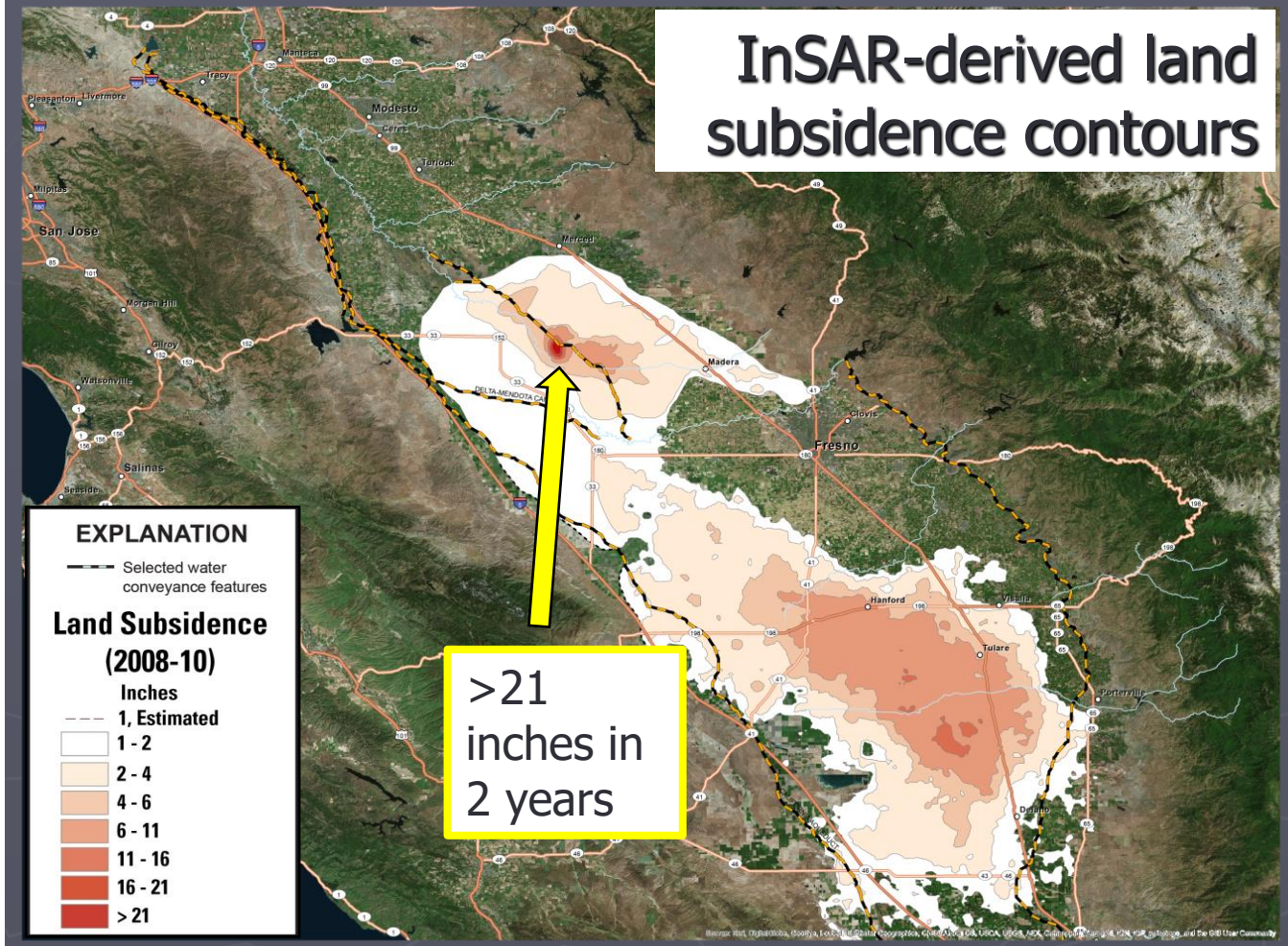
# San Joaquin Valley: Some Perspective




Modified from Sneed and Others, 2018

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Results Recap:

- Prior to Study period: PV Water's Basin Management Plan and SGMA
  - PV Water had implemented a series of programs aimed to offset groundwater pumping demand to decrease seawater intrusion
- Water levels during study period
  - Seasonal variations with annual to multi-annual increases
  - Increasing above historic lows set during mid-1990s (drought)
  - Some water levels still below sea level
- Subsidence during study period
  - Basin is generally stable within error tolerances
  - One localized area with less than 2 inches subsidence is likely recoverable

*Preliminary and subject to revision

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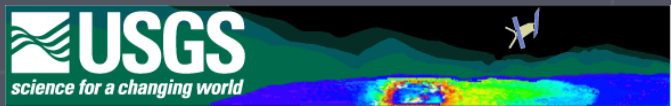
# Detection and Measurement of Land Surface Deformation, Pajaro Valley, CA, 2015-2018

Conclusions:

- InSAR and Continuous GPS methods are the most efficient way to monitor subsidence and uplift over large areas
  - Allows researchers and water managers to discover small problems before they become large problems
- Permanent Compaction – clay + water level declines
  - Pajaro has thick clays, but water levels are above historic lows and are increasing
- Conservation efforts meant to address sea water intrusion also have positive implications for subsidence
- USGS report nearly complete

*Preliminary and subject to revision



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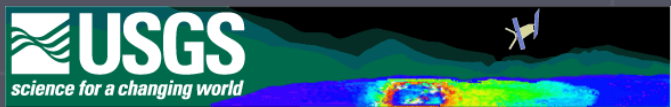
Questions?