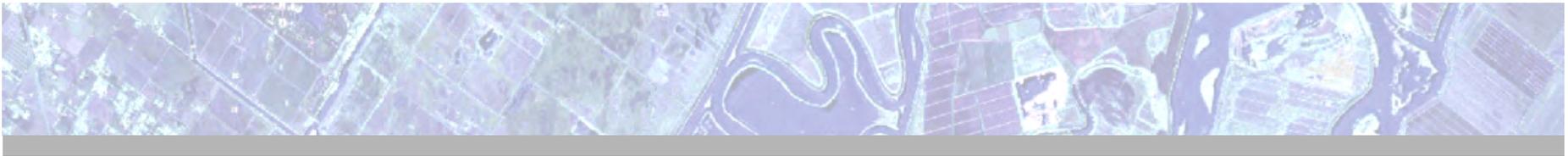


# *Radar Remote Sensing of Subsidence in the Central Valley and its Impact to the California Aqueduct*

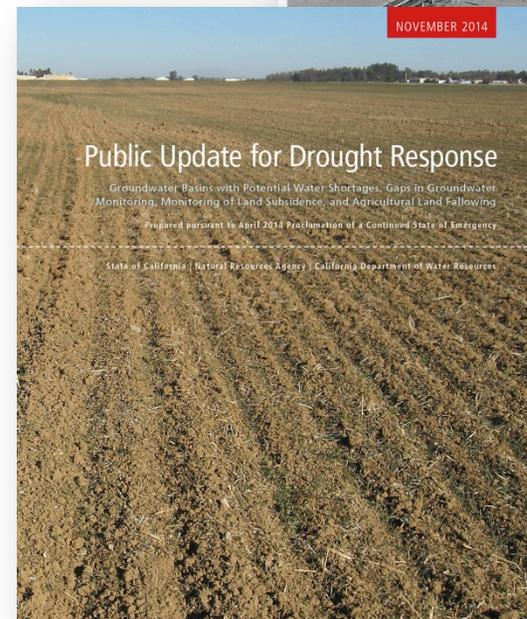
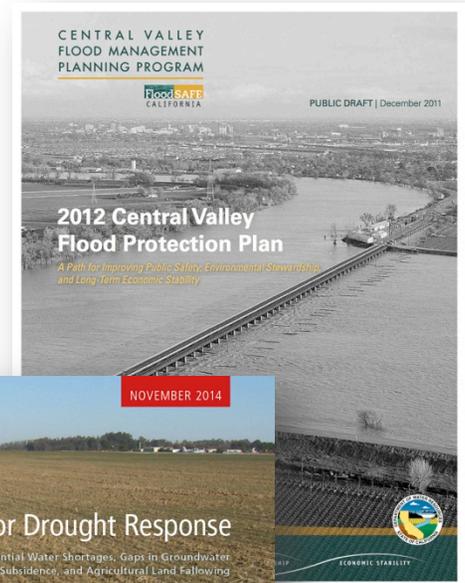


**Cathleen E. Jones, Tom Farr, Zhen Liu (Jet Propulsion Laboratory, California Institute of Technology)**  
*State of California Energy Commission, Staff Workshop*  
*10 November 2015*

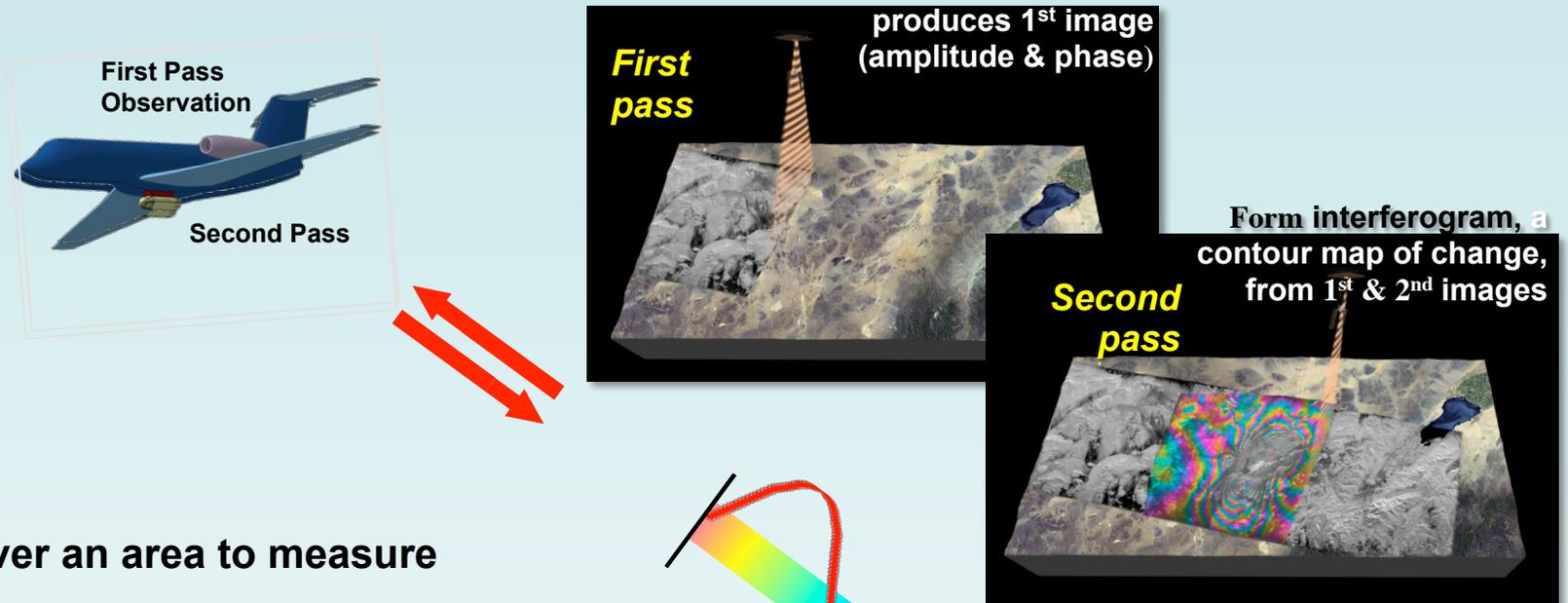


## Ca. DWR / NASA-JPL Study of Subsidence in the Central Valley

1. **The Technology – Radar Interferometry (InSAR)**
2. **Central Valley Subsidence – Satellite View**
  - **Contrast 2007-2011 with 2014-2015**
  - **Identify major large-scale subsiding areas**
3. **Central Valley Subsidence – Aircraft View**
  - **Identify small-scale subsidence features**
  - **Direct impact to California Aqueduct**

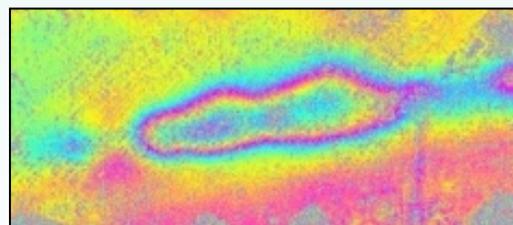
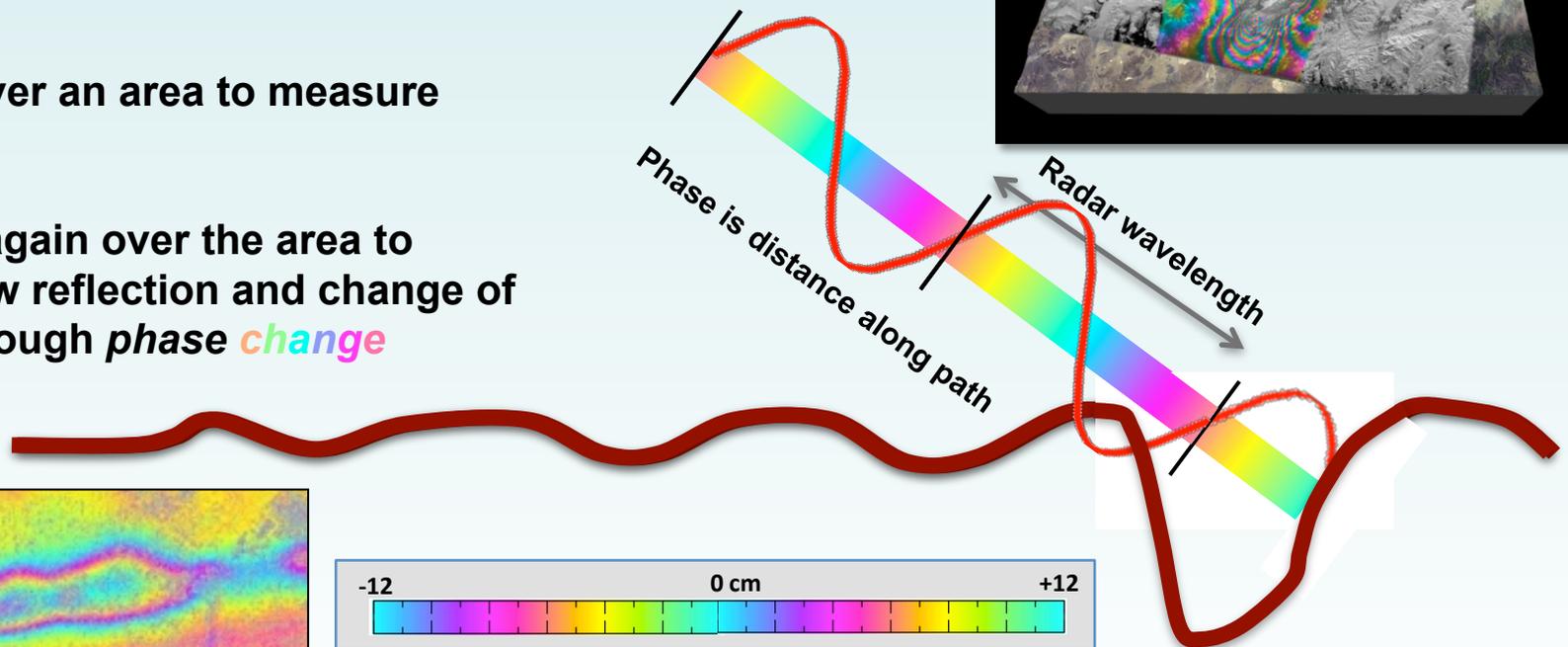


# Radar Interferometry for Measuring Surface Deformation



Radar flies over an area to measure reflection

Radar flies again over the area to measure new reflection and change of distance through *phase change*

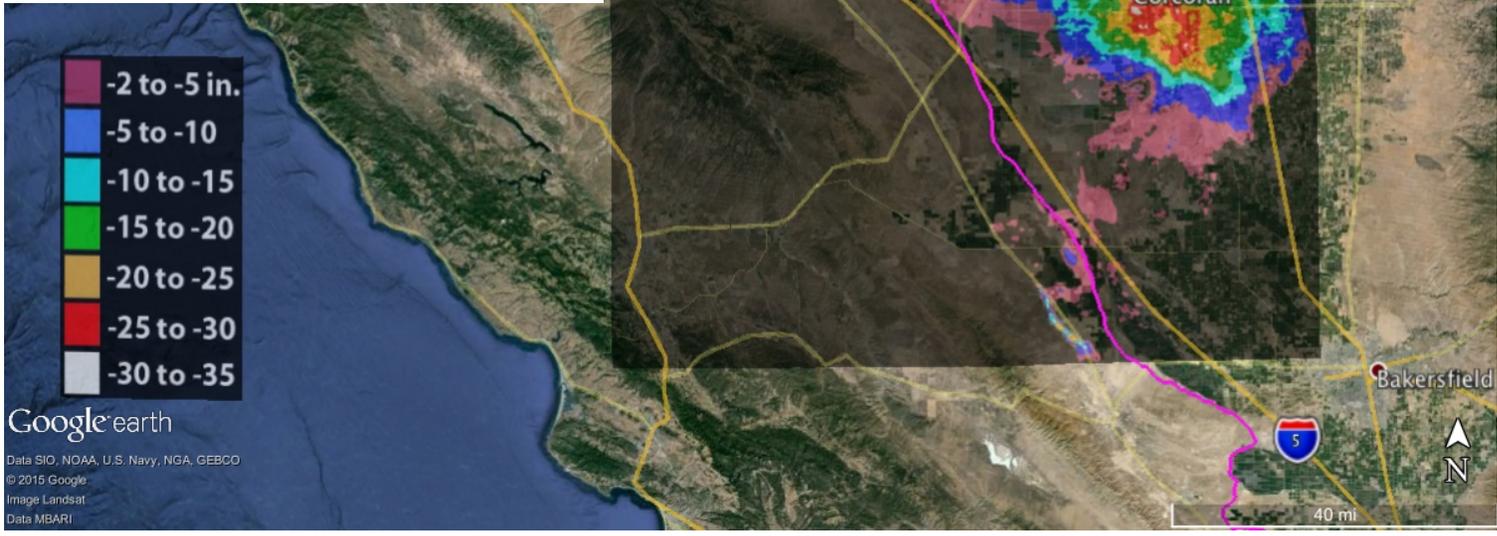
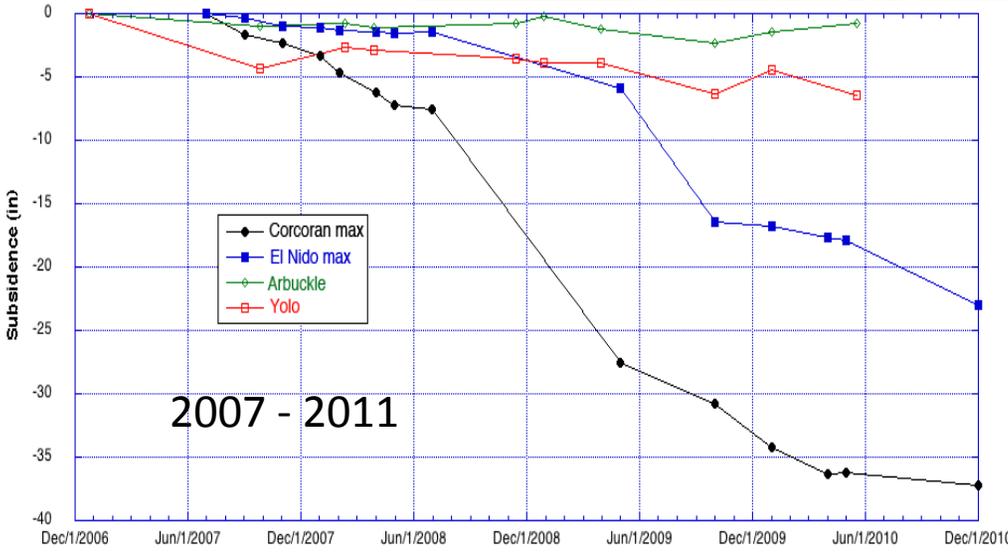


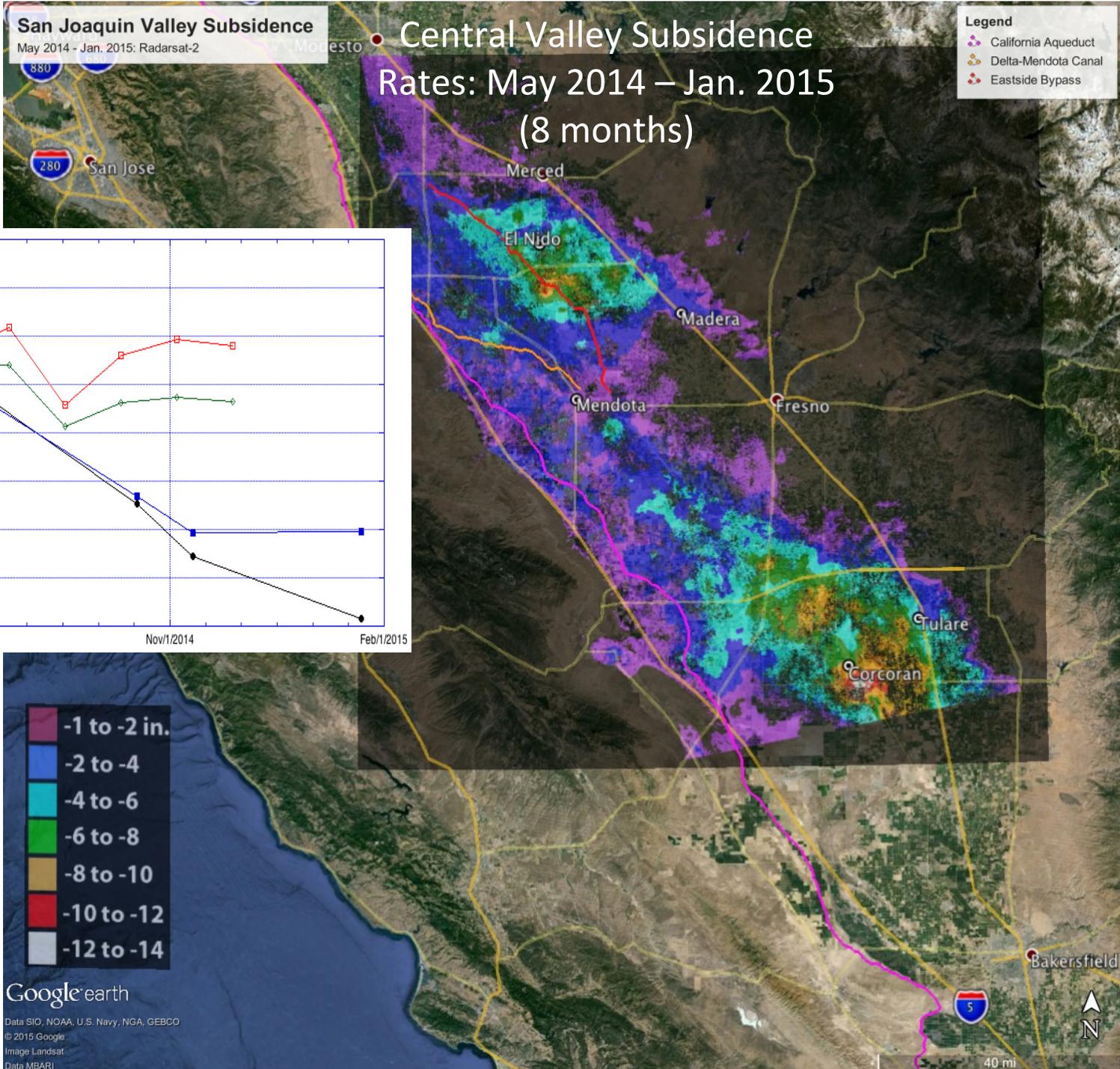
UAVSAR: 12 cm per color wrap



## ***Central Valley Subsidence: Measured from Space***







# Subsidence in the Central Valley of California: PALSAR, 2007-2011



Zhen Liu, Vince Realmuto, Tom Farr, JPL



# ***Central Valley Subsidence: Measured from Aircraft***



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File:Californiacentralvalley.jpg#/media/  
File:Californiacentralvalley.jpg](https://commons.wikimedia.org/wiki/File:Californiacentralvalley.jpg#/media/File:Californiacentralvalley.jpg)

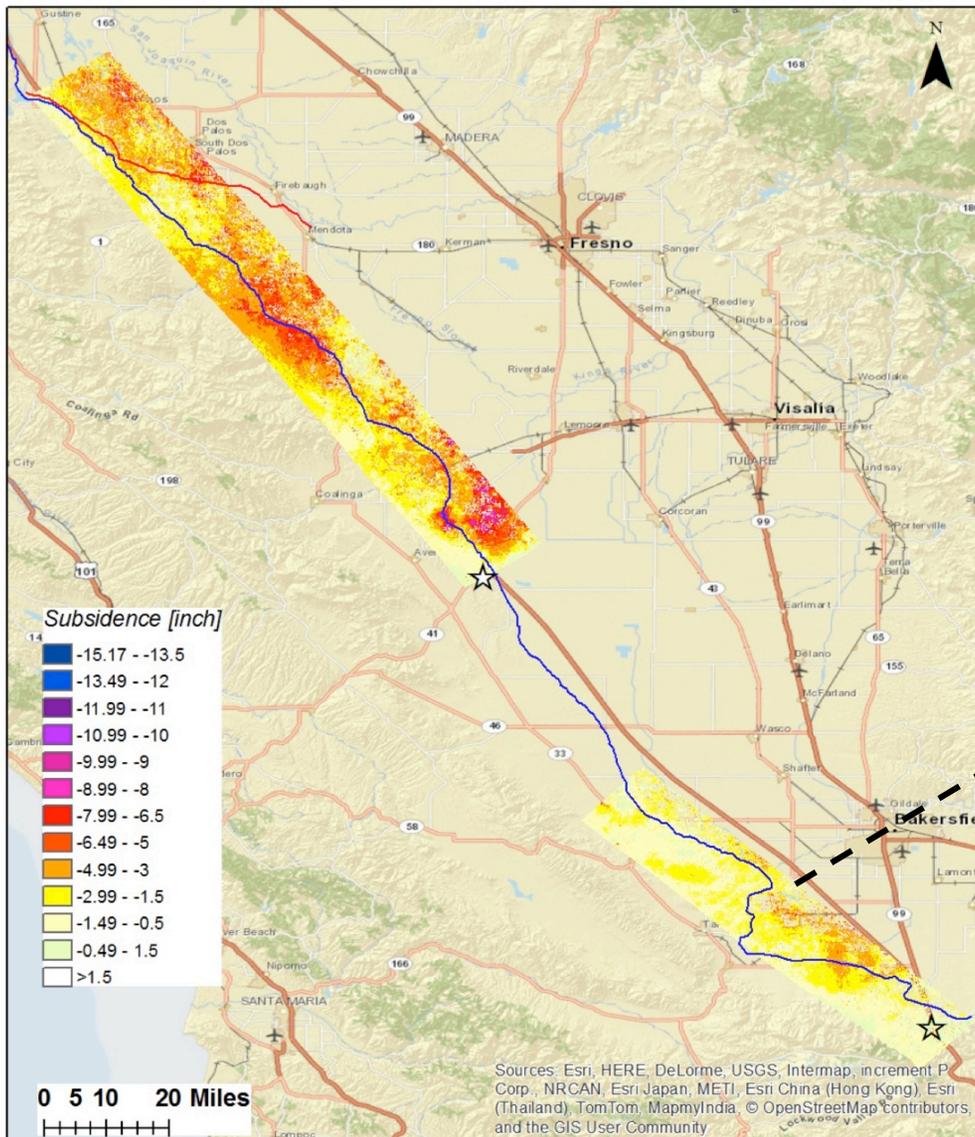
UAVSAR

NASA's Premier L-band Synthetic Aperture Radar

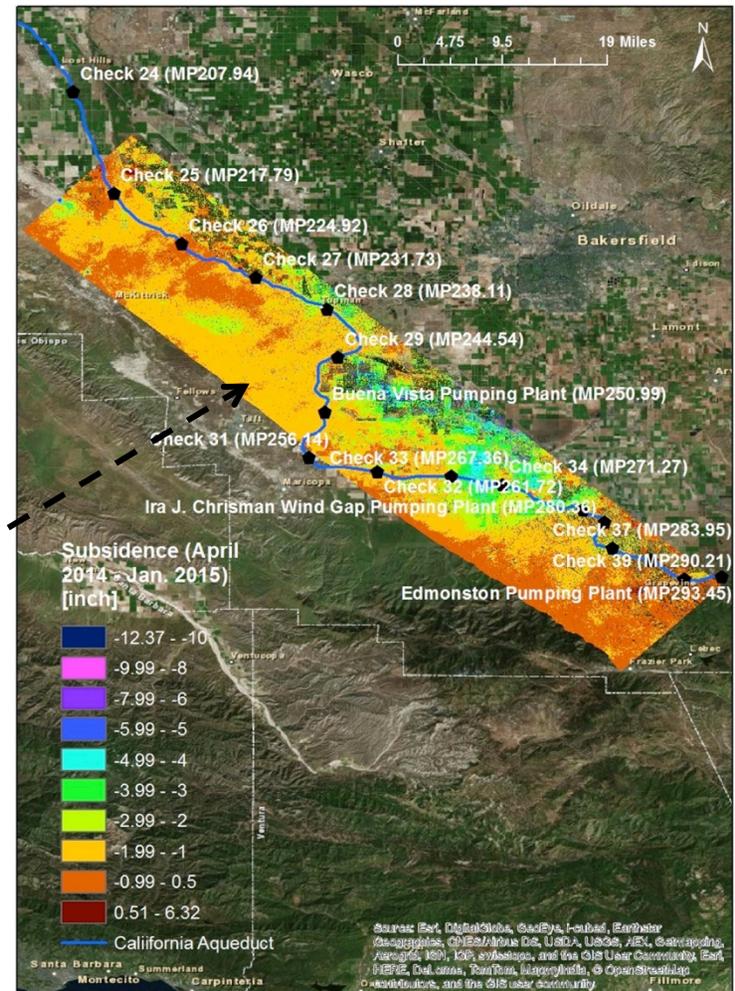
*NASA/JPL UAVSAR Airborne Radar*



# Subsidence Along the California Aqueduct

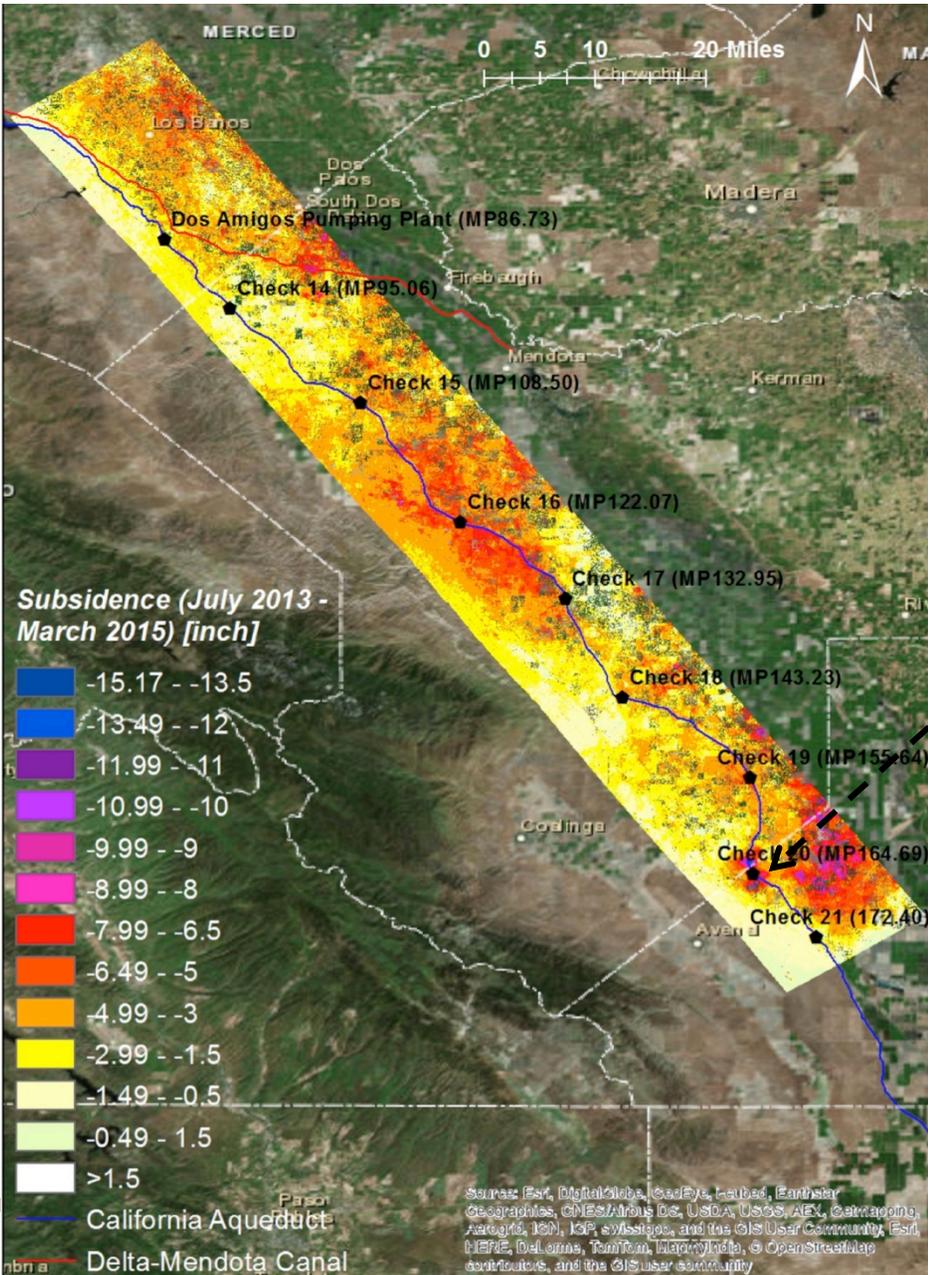


## Aqueduct west of Bakersfield:

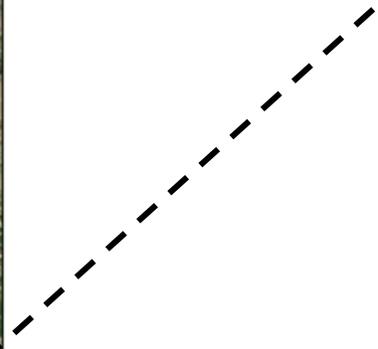


Progress Report: Subsidence in the Central Valley, California (Farr, Jones, Liu, 2015)

# Subsidence Along the California Aqueduct – Central Section

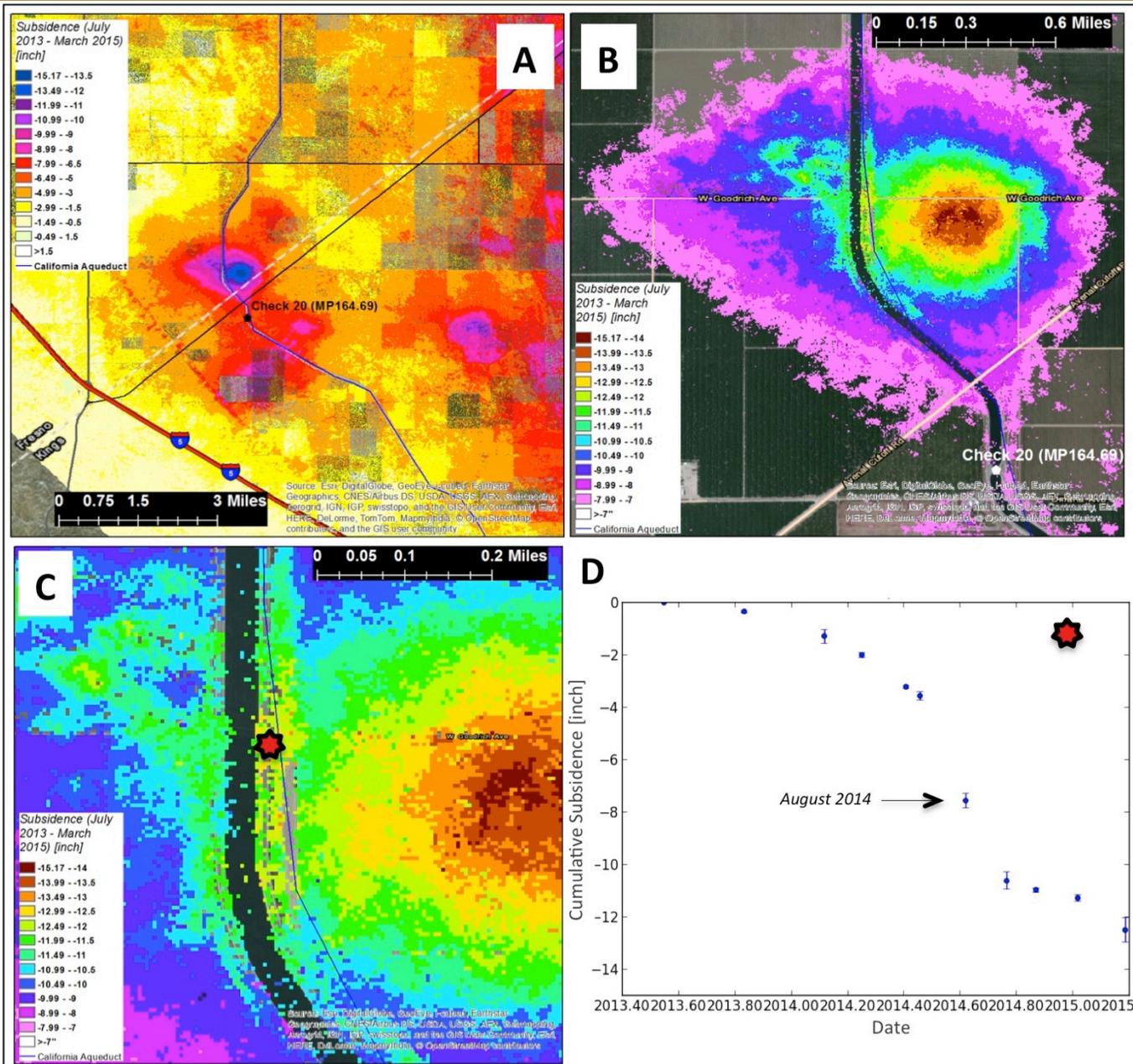


**New Subsidence Hot Spot**



Progress Report: Subsidence in the Central Valley, California (Farr, Jones, Liu, 2015)

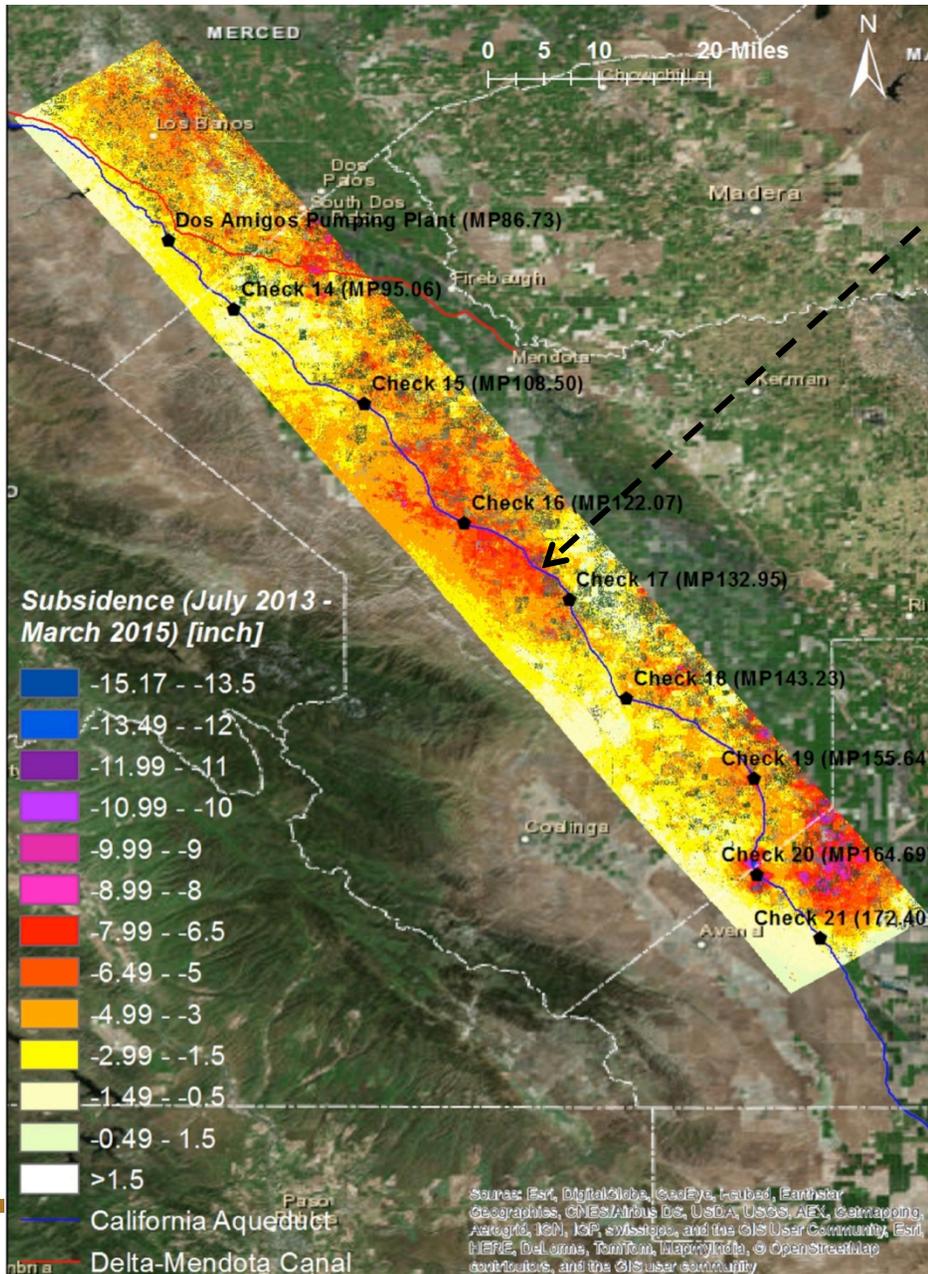
# Subsidence Along the California Aqueduct Worst Case Effect of Drought / Groundwater Pumping



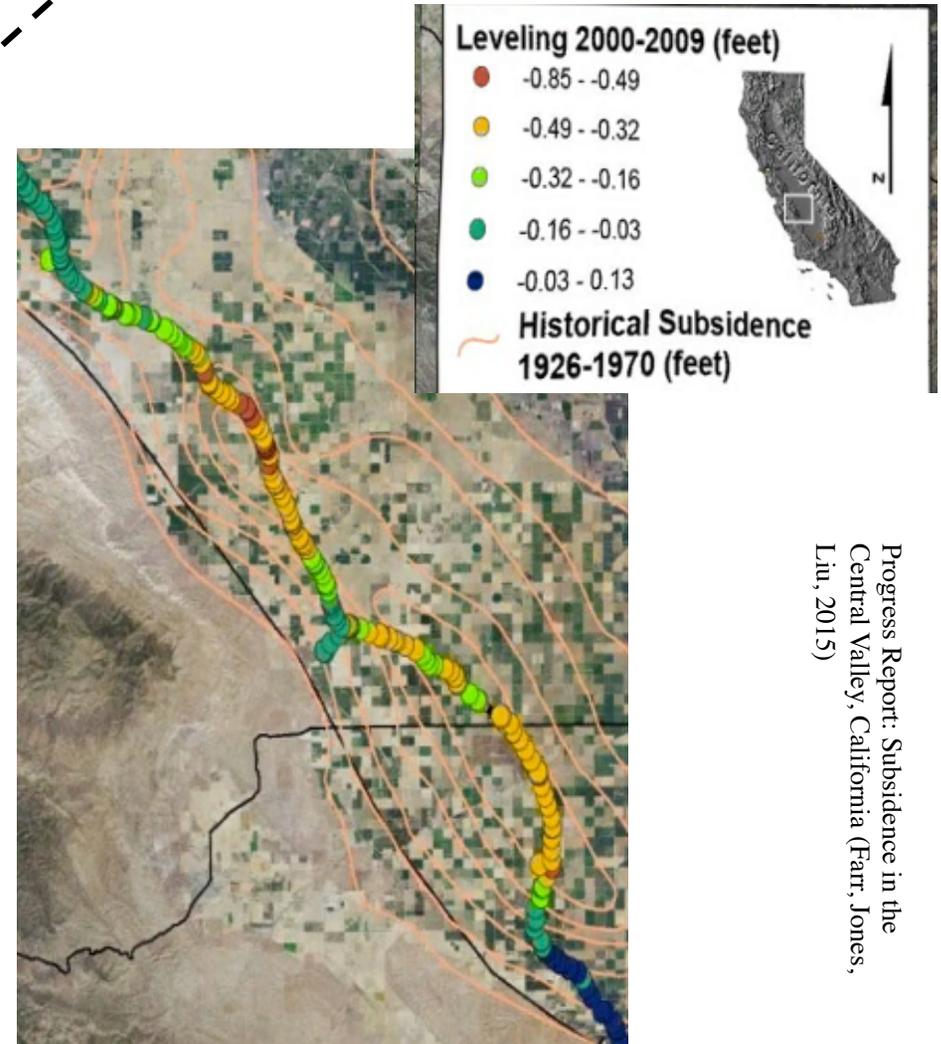
- A single well or cluster of wells can cause rapid subsidence of the aqueduct.
- Aqueduct subsided up to ~13" in < 2 years, and ~8" in 4 months
- 1.3 miles of the aqueduct subsided over 8"

Progress Report: Subsidence in the Central Valley, California (Farr, Jones, Liu, 2015)

# Subsidence Along the California Aqueduct – Central Section

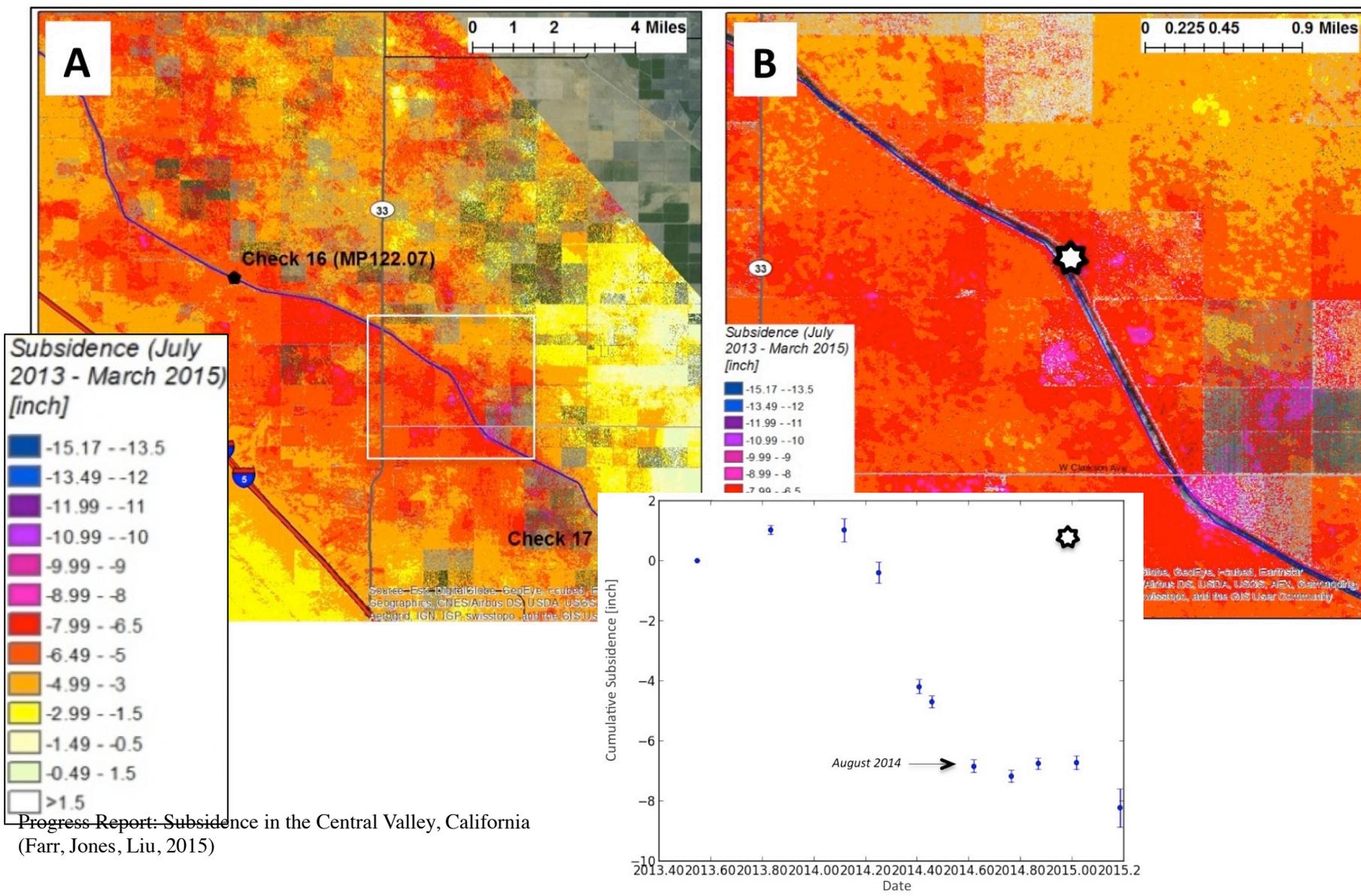


## Historical Subsidence Area



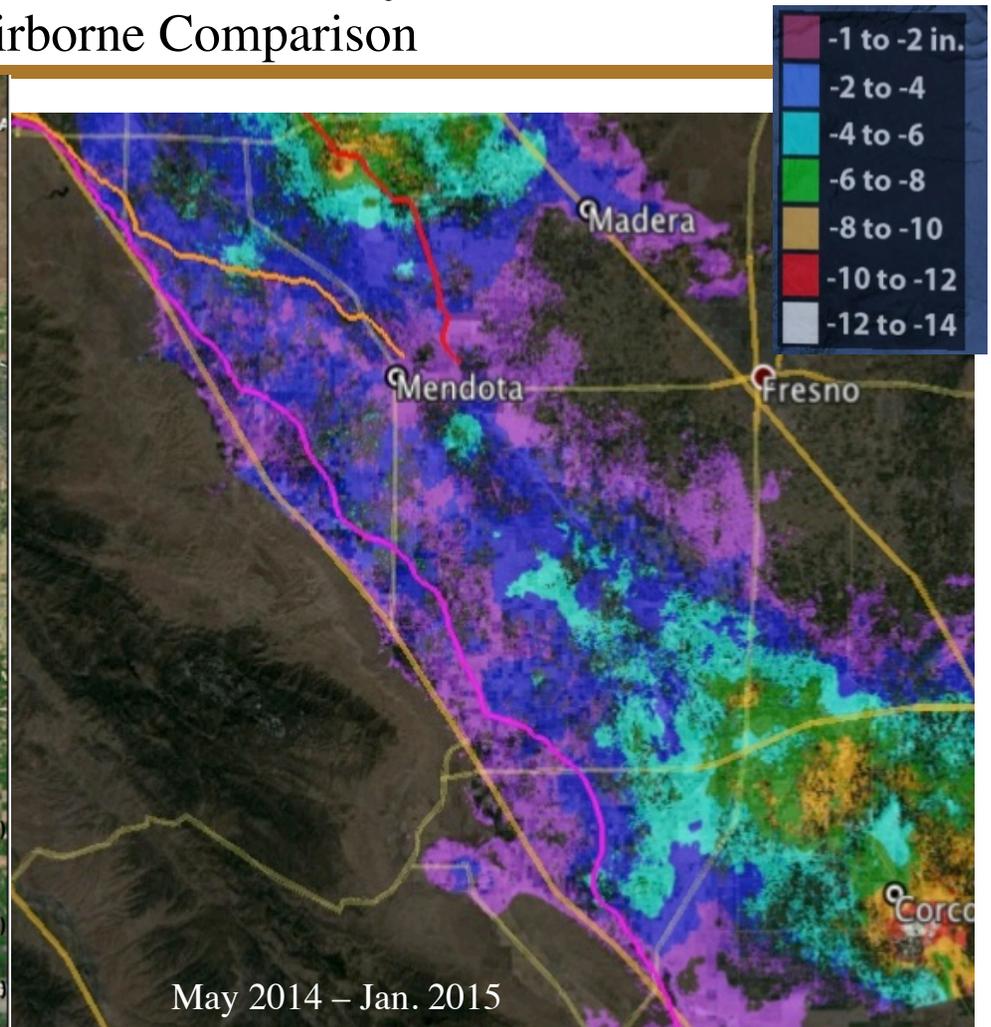
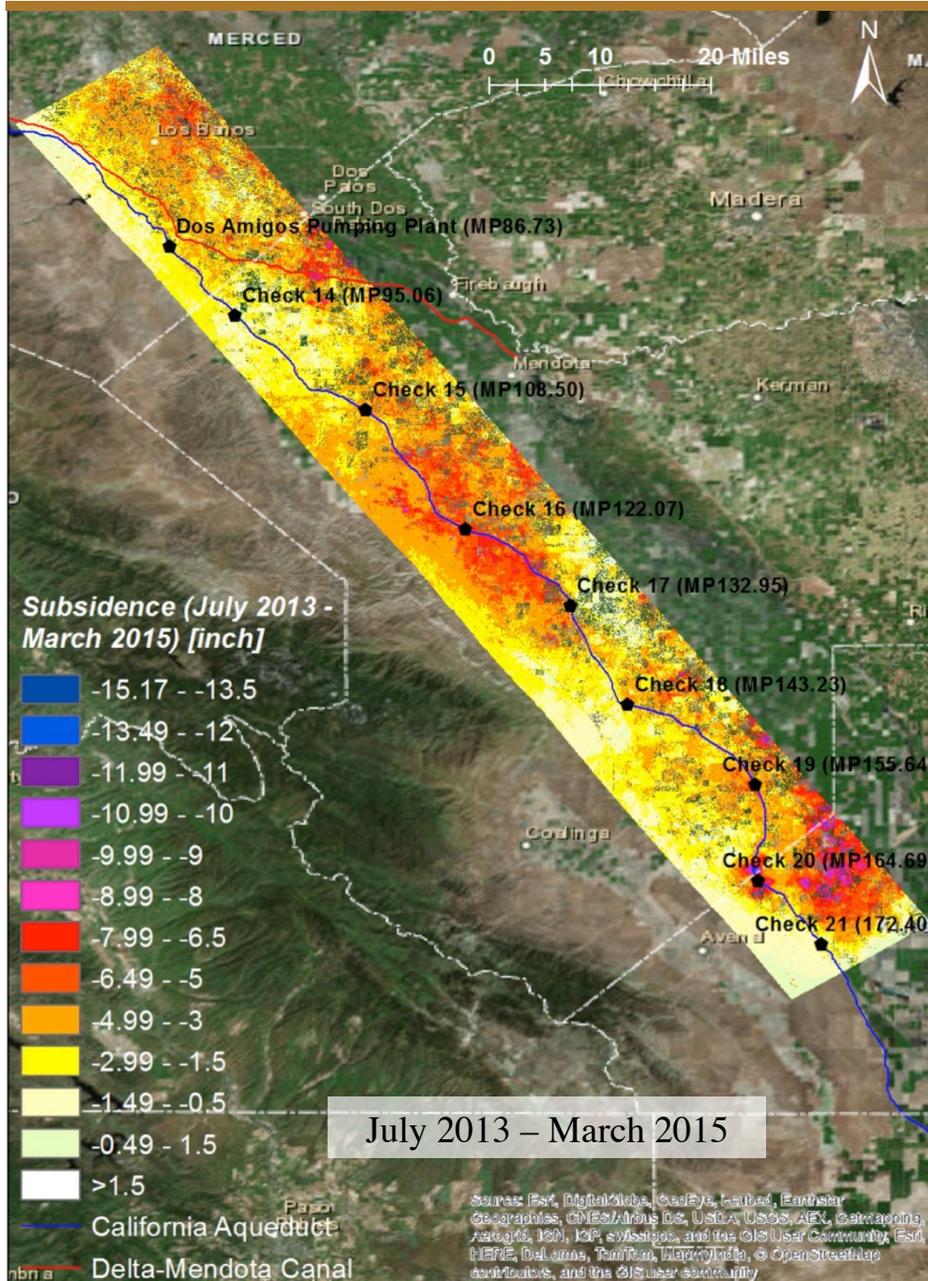
Progress Report: Subsidence in the Central Valley, California (Farr, Jones, Liu, 2015)

# Subsidence Along the California Aqueduct – Central Section



Progress Report: Subsidence in the Central Valley, California  
(Farr, Jones, Liu, 2015)

# Subsidence in Central Valley Spaceborne / Airborne Comparison



Progress Report:  
Subsidence in the  
Central Valley,  
California (Farr,  
Jones, Liu, 2015)

*Difference:*

1. *Different time periods*
2. *Spatial smoothing of spaceborne data*

# SUMMARY

## Remote Measurement of Subsidence from Space & High Altitude



- Groundwater is becoming a more important part of California's water resources
- Groundwater withdrawal can profoundly impact local areas
- Knowledge of the groundwater level is not uniformly available
- Interferometric Synthetic Aperture Radar (InSAR) gives:
  - Ground water state and dynamics
  - Impact to infrastructure

