Radar Remote Sensing for Monitoring Water Infrastructure

Sacramento Delta / false color UAVSAR POLSAR image / 7 m resolution

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Remote Sensing for Monitoring Water Infrastructure

The Vision: Widespread, Rapid Identification for Targeted Response

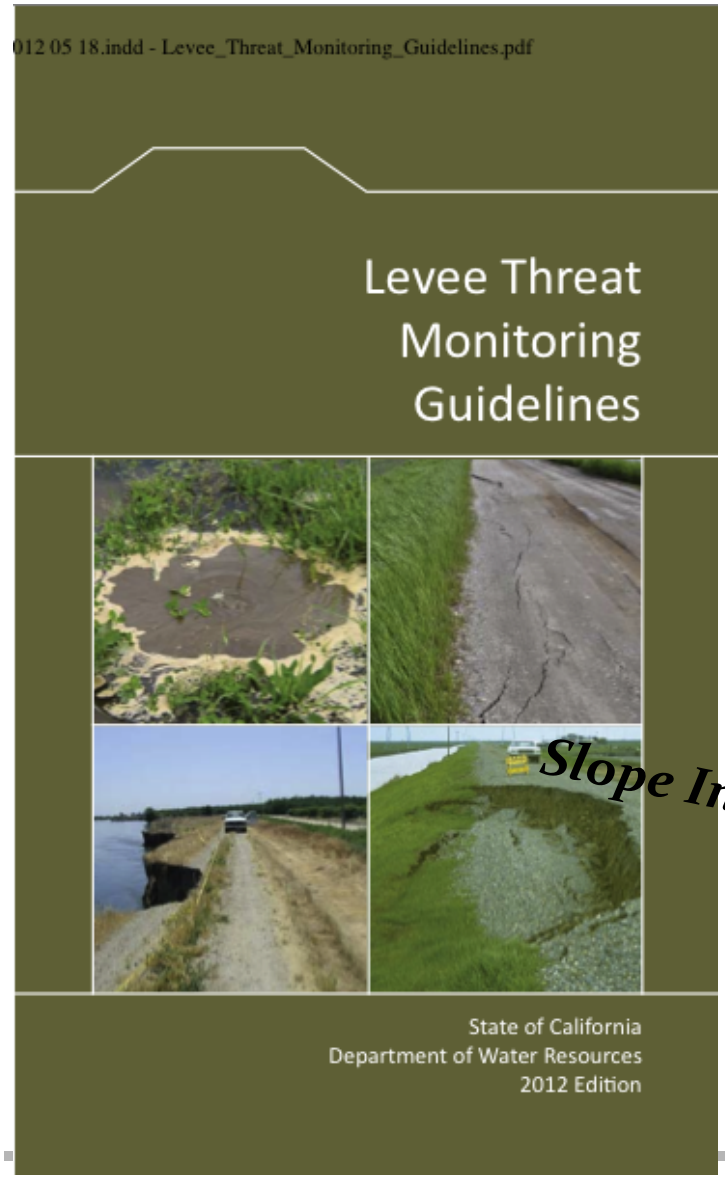
The USACE, other federal agencies, and numerous state and local entities currently monitor many thousands of miles of levees throughout the United States. This infrastructure serves both as flood protection barriers and water conveyance infrastructure.

Remote sensing can augment ground-based and visual surveys by:

- **providing *consistent monitoring* across all sites**
- **imaging areas that are *difficult to access* on the ground**
- **enabling *rapid assessment* of large areas to give a snapshot of conditions at many sites at the same time**
- ***detecting* areas that *change* by small amounts or in subtle ways**
- ***informing a targeted monitoring program* that can *identify potential problem spots* and/or provide continual monitoring of those sites to identify when/how they change**

Sacramento/San Joaquin Delta, CA

Levee Threats / Levee Status
Radar Remote Sensing Capabilities



Seepage

Cracks

Sand Boils & Sinkholes

Slope Instability

Subsidence

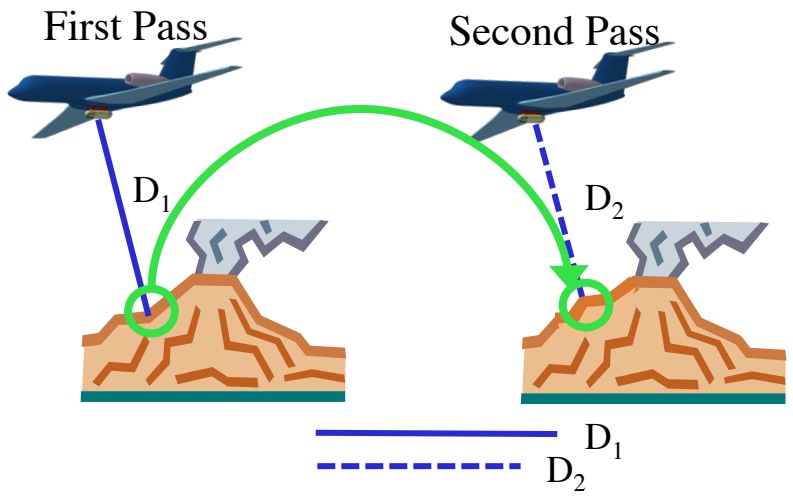
Photo credit: Tom Williams, Gerald Bawden, Cathleen Jones

Radar imaging ≠ photogrammetry or visual surveys

Microwave-band Radar can…

1) See through clouds, smoke, haze.
2) Image day or night, in any light conditions.
3) Rapid, relatively high resolution, across large areas
4) Detect standing water.
5) Determine surface type.
6) Identify surface change.
7) Detect very small scale (few millimeters) movement of the ground.

Differential Interferometry (INSAR)



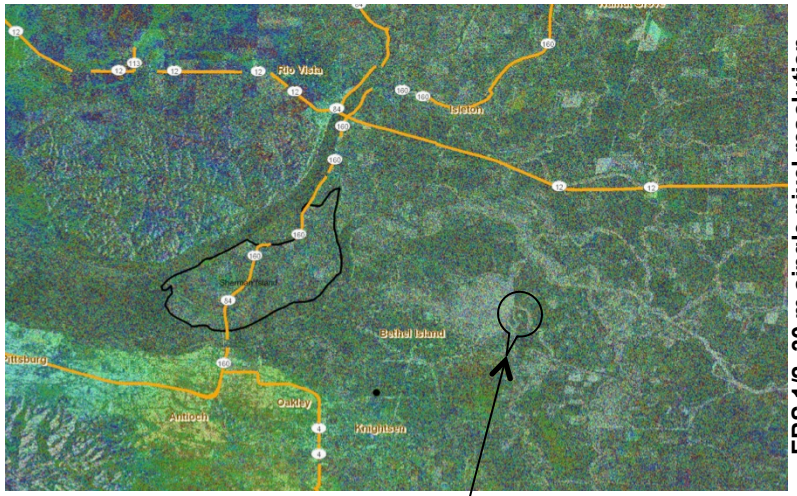
Very small shifts in the surface can be detected with radar.

Radar Assessment of Levee Status

Motivation: High Resolution Radar Can Resolve The Levees

April 2008, UAVSAR HH (red) –VV (blue) – HV (green) / 7 m resolution after averaging

Technology advancement in last decade:



ERS 1/2, 30 m single pixel resolution

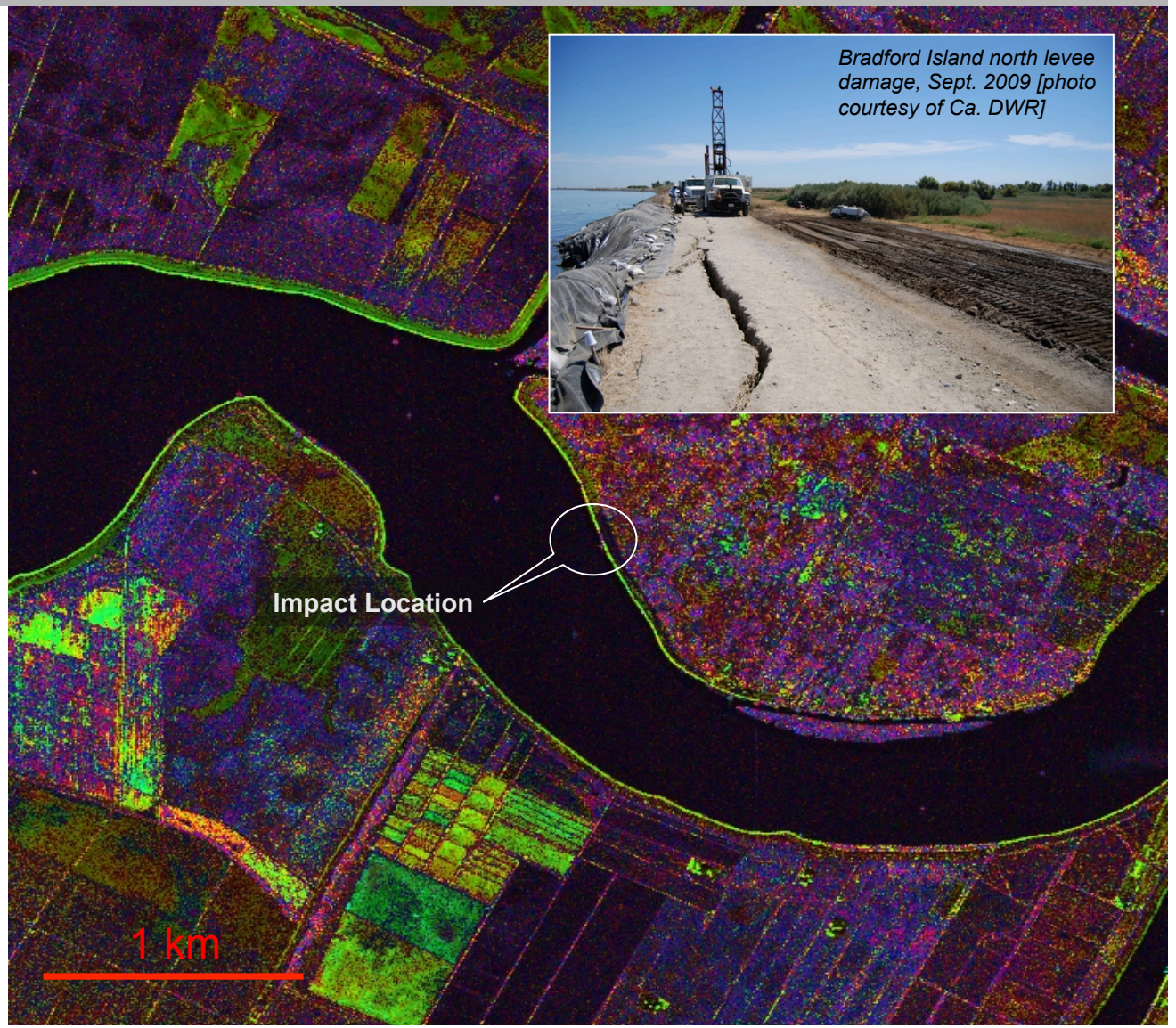
… compare feature resolution to that of UAVSAR

Levee Damage from Impact

Example: Sacramento Delta, Bradford Island, 2009

On August 28, 2009 a ship rammed the north levee on Bradford Island. This image was made from an interferogram between UAVSAR data collected on July 17 and Sept. 10, so evidence of the impact and repair are seen in the data.

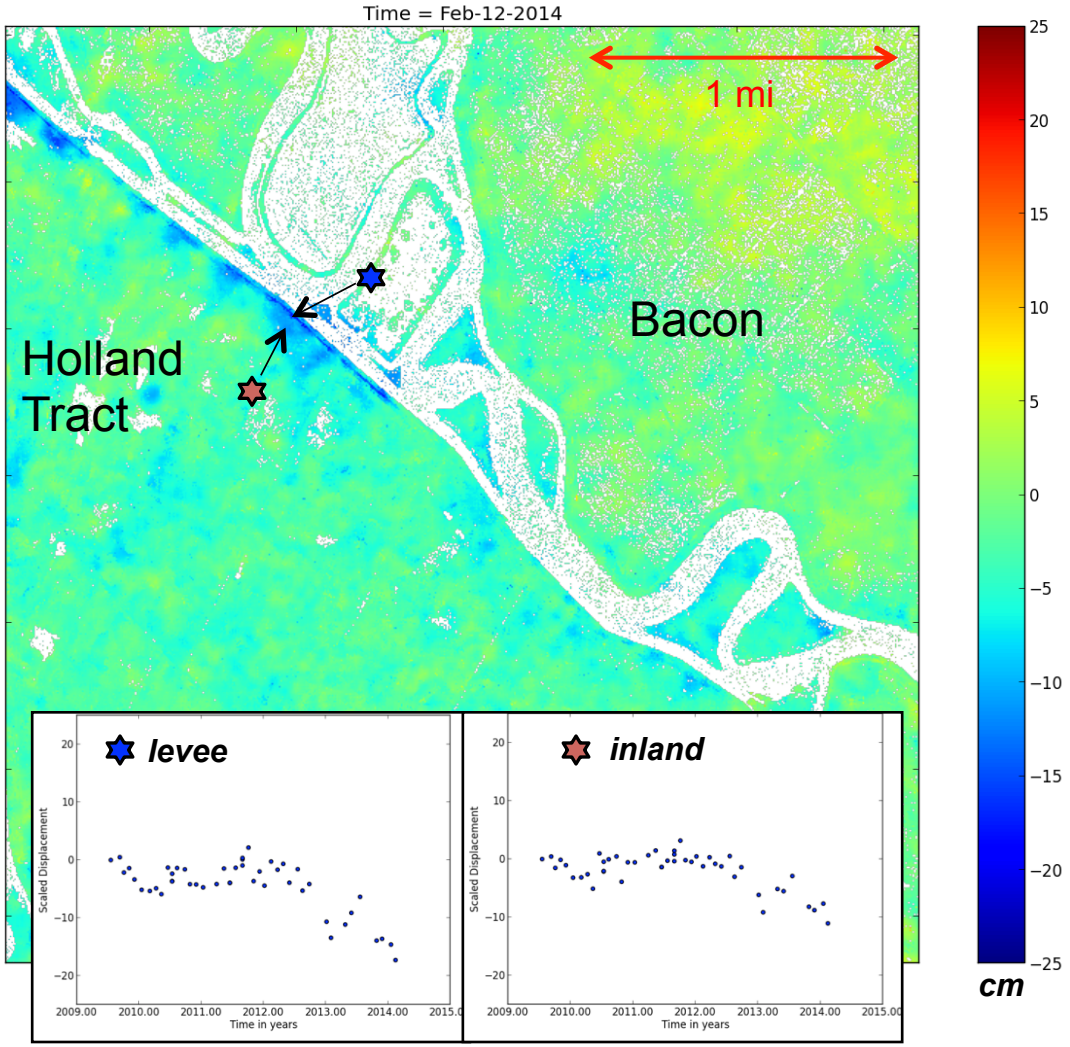
The plot shows a false color map overlaying the differential phase and correlation of the interferograms formed using the two data sets.



Radar Imaging of Localized Subsidence

Levee Settlement and Peat Soil Compaction

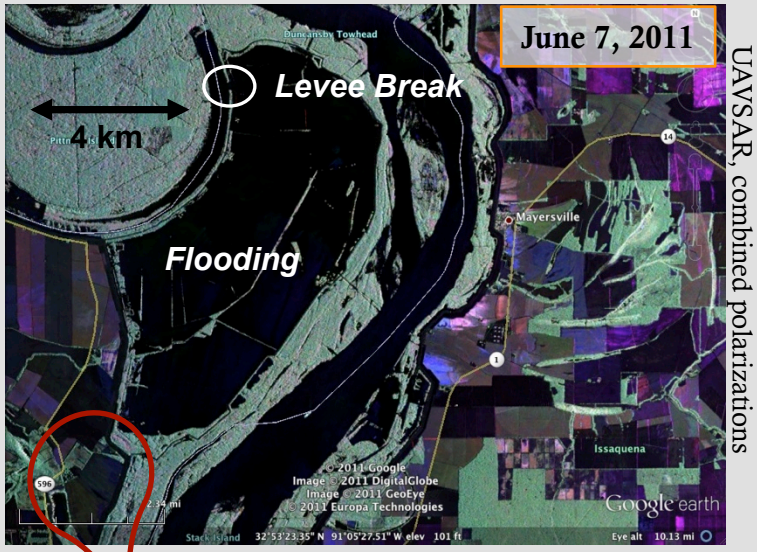
Total Movement, July 2009 – Feb. 2014



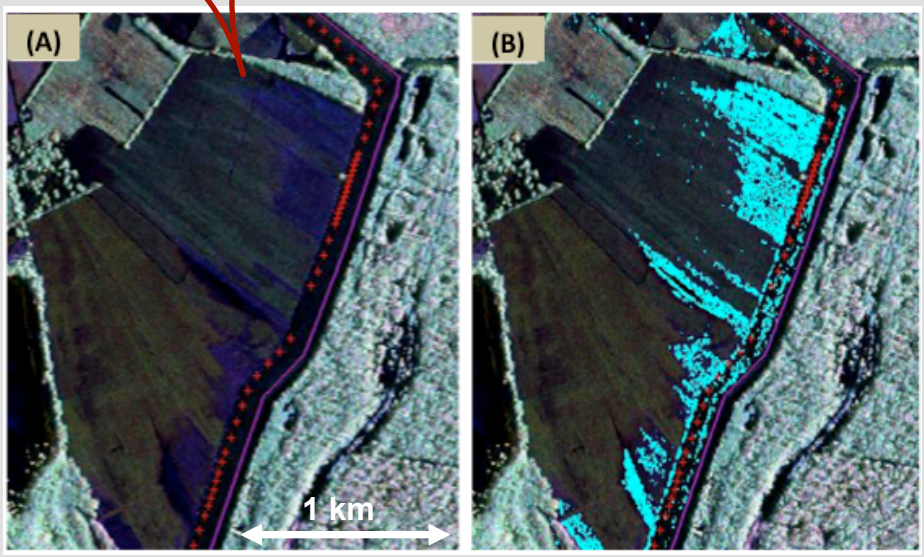
Radar Applied to Flooding and Major Seepage

Example: Mississippi River Flood, Spring 2011

NASA DEVELOP student project : JPL, Fall 2011 – Spring 2012



UAVSAR, combined polarizations

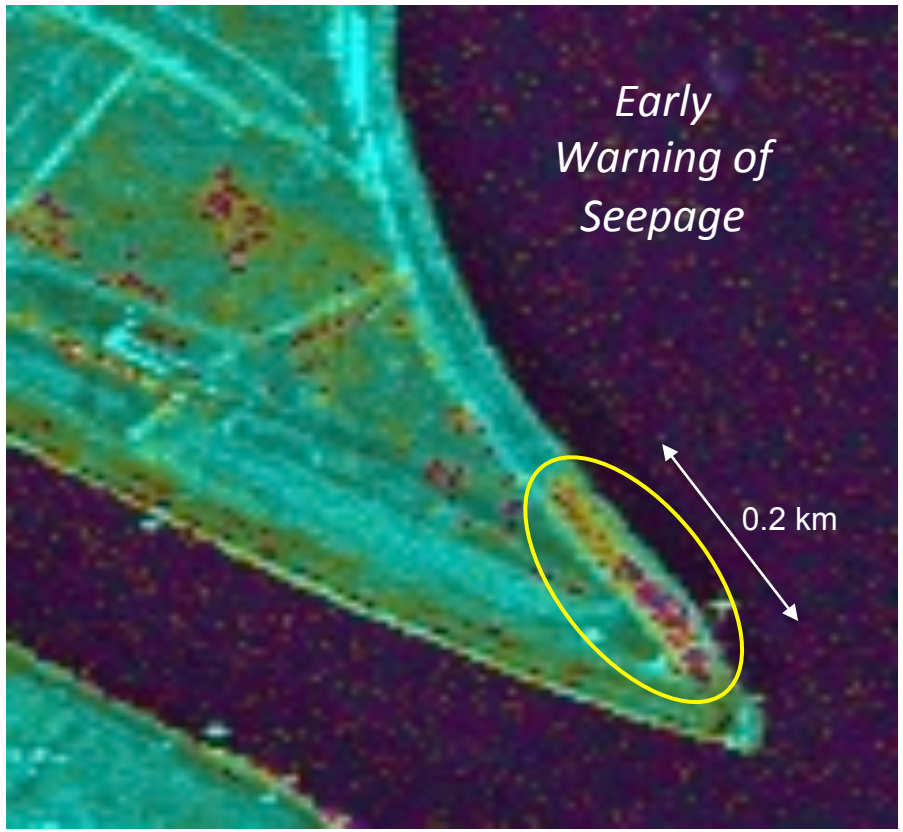


The radar data indicates not only large area flooding but also where there is seepage through relief wells along the levee in this area.

We used the polarization-dependence of the radar return to enhance detection of leaking sections of levees and to automatically classify high-likelihood seepage areas.

Identification of Seep Locations

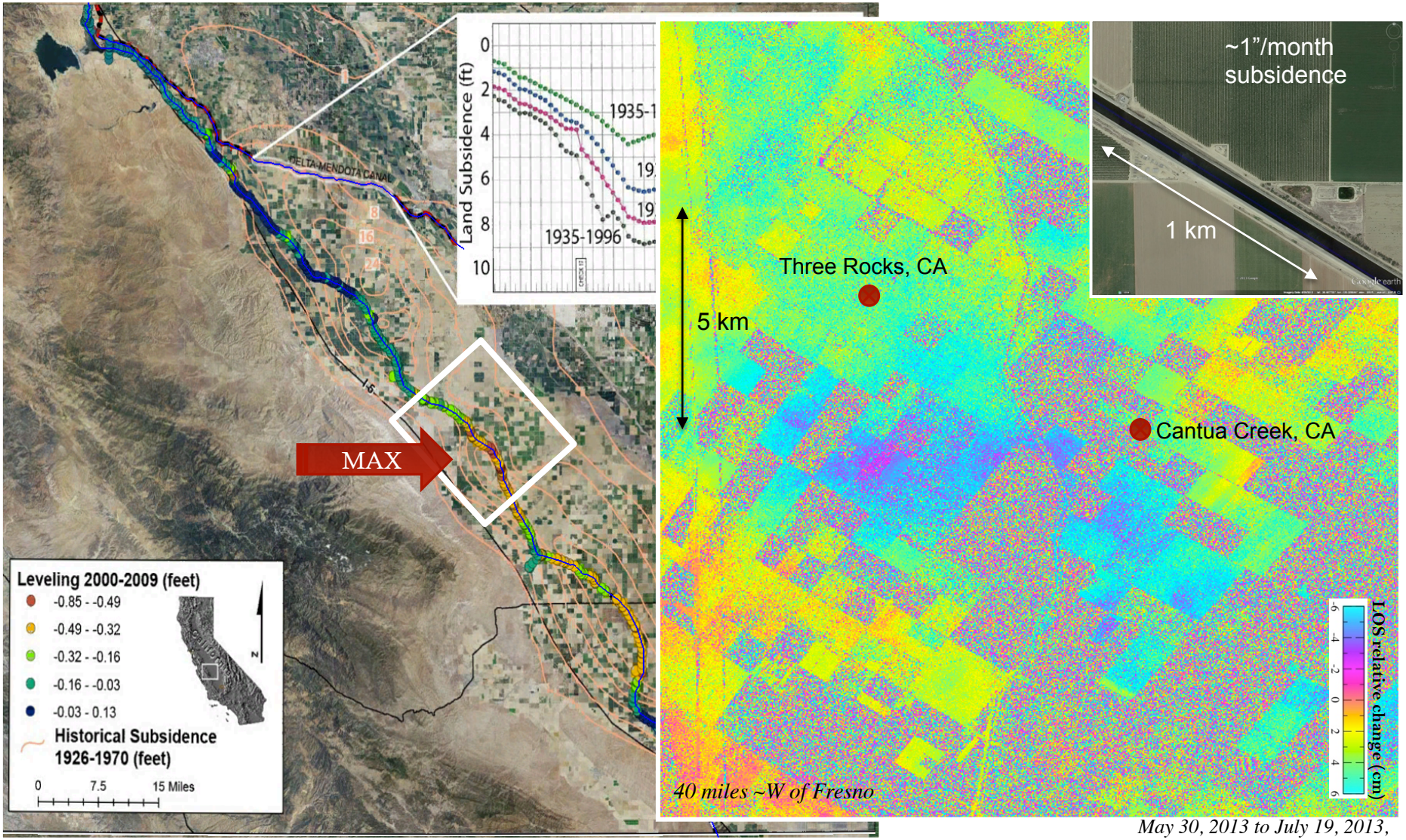
Radar Change Detection to Locate Small Seeps



Change detection across a high/low tidal cycle can be used to identify some mid-sized seeps in areas where the soil moisture varies with the water level in the adjacent canals.

InSAR Applied to Other Critical Infrastructure

Example: California Aqueduct



May 30, 2013 to July 19, 2013,
UAVSAR InSAR change / 7 m resolution

Applications of Radar-based Movement Detection

Subsidence


Earthquakes


Water Mains

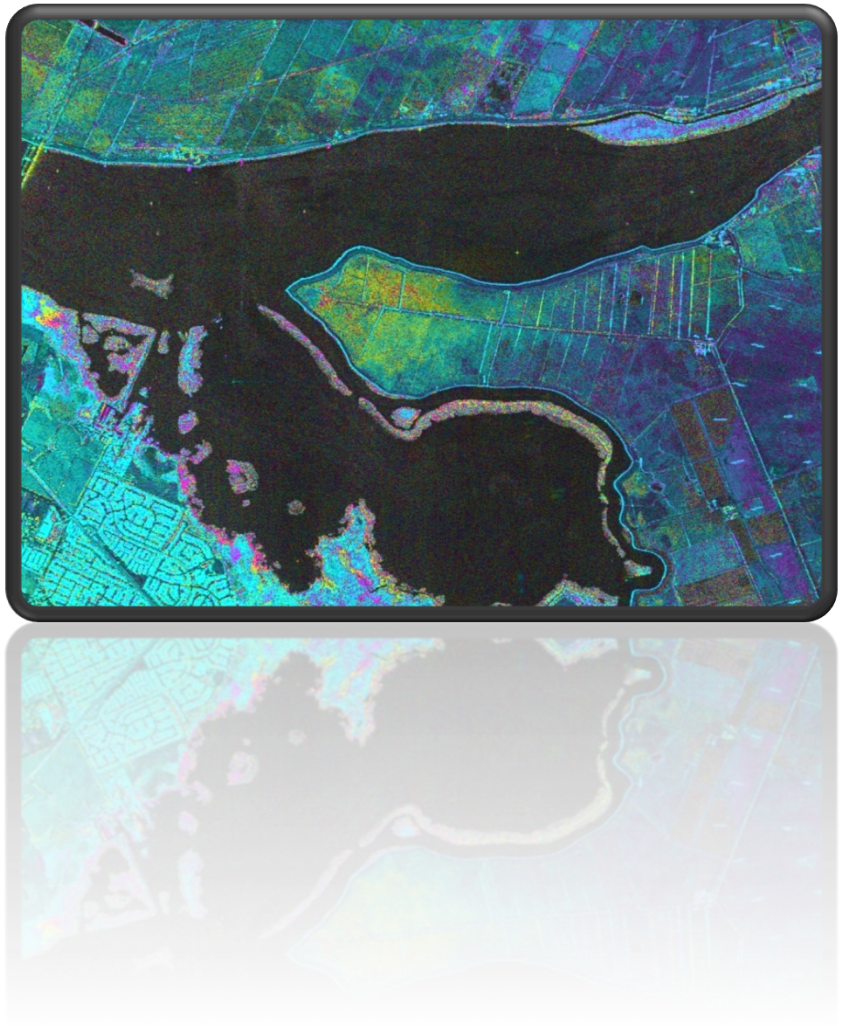

Levees


Sinkholes

Radar Remote Sensing of Infrastructure
Conclusions

Radar remote sensing:

- ***Rapid***
- ***Comprehensive***
- ***Consistent across large area***
- ***Advanced Warning***
- ***Emergency Response***



Economic, Efficient, Targeted Ground Resources

Collaborators on work shown: Mr. Joel Dudas (Ca. DWR); Dr. Gerald Bawden (USGS); Dr. Steven Deverel (HydroFocus, Inc.), Dr. Priyanka Sharma, Dr. Sang-Ho Yun, Dr. Scott Hensley, Austin Madson, Kevin O'Connell, Katrina Laygo, (JPL);