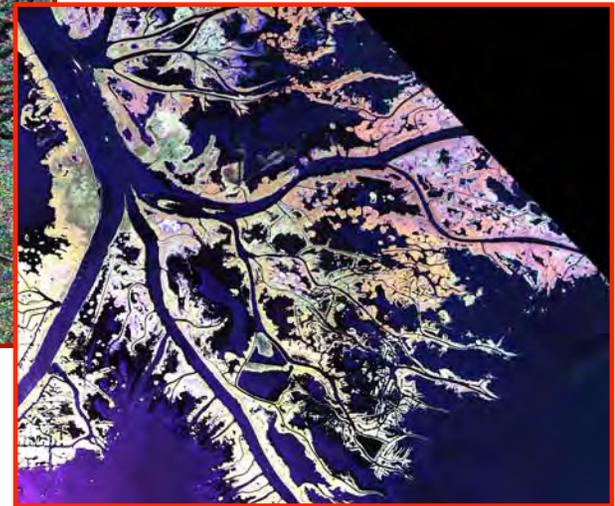
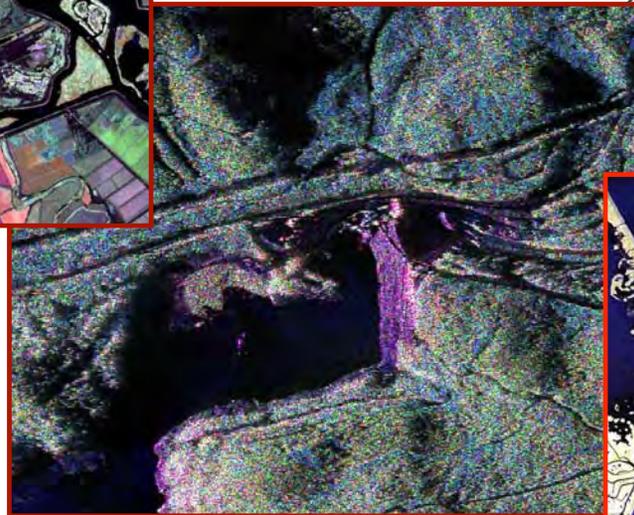


# *Synthetic Aperture Radar Monitoring Capabilities:*



*Levees ...,*

*Dams ...,*



**Cathleen E. Jones**

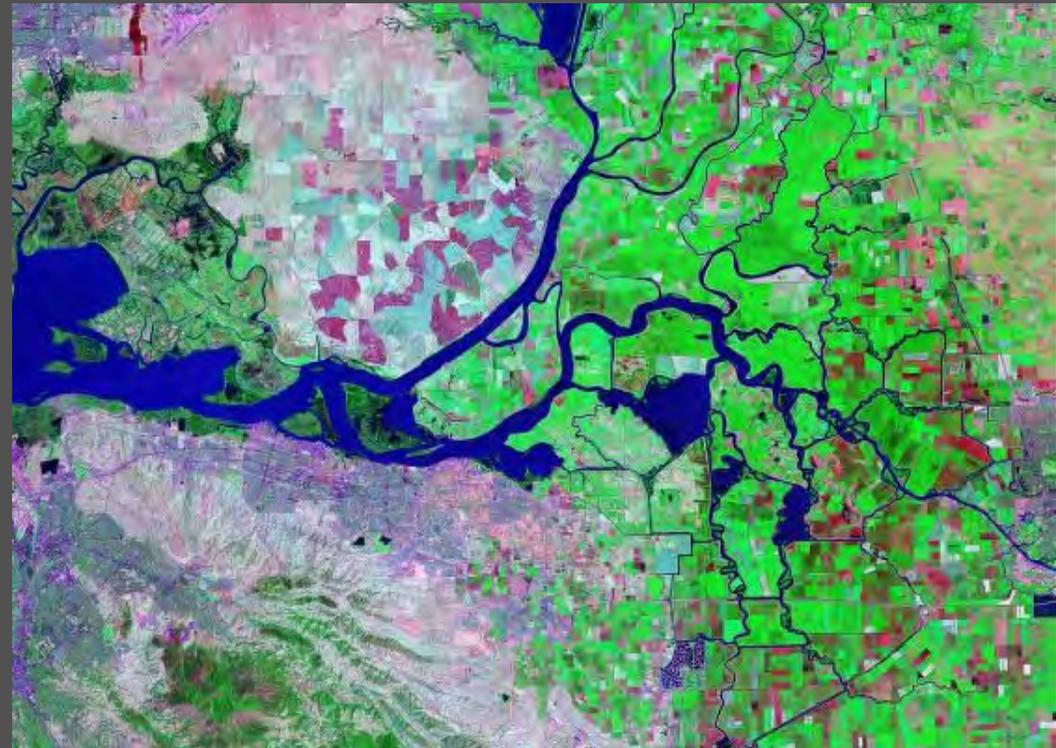
*Jet Propulsion Laboratory, California Institute of Technology*

*June 9, 2011*

*...and the Gulf Oil Spill*

# Radar Measurements of the Sacramento-San Joaquin Delta

Critical Infrastructure: The Levees



- Over 60 reclaimed islands surrounded by 1100 miles of levees
- Most islands lie below mean sea level.
- Collects run-off from approximately 2/3 of the state via the Sacramento and San Joaquin rivers.
- Supplies water to ~2/3 of the residents of California and to almost all of the agriculture of the Central Valley.

**THE DELTA IS THE MOST CRITICAL WATER RESOURCE IN CALIFORNIA.**

# Radar Measurements of the Sacramento-San Joaquin Delta

NASA Applied Science: The Project

**Project: Monitoring Levees and Subsidence in the Sacramento-San Joaquin Delta**

**Funding Agency: NASA**

**Decision Support Partner: Ca. Dept. of Water Resources**

**Duration: 2010-2012**

## **Objectives:**

**Provide an *independent and verifiable* source of information with the *spatial extent* needed to cover the 1100 miles of levees within the Delta, with sufficient *ground resolution* and *temporal frequency* to detect changes indicative of potential levee failure.**

## **Risk Assessment & Disaster Management (Levees)**

- Assess changes in levees on a monthly basis.
- Support emergency response to floods.

## **Water Resource Management (Subsidence/Levees)**

- ***Short Term:*** Support decisions on the allocation of funds for levee repairs.
- ***Long Term:*** Provide critical subsidence rate measurements to inform a viable long term water management plan.



# Radar Measurements of the Sacramento-San Joaquin Delta

Focus on Decision Support: The Partners



- Remote Sensing Radar Instrument
- Radar Processing Expertise



**Decision Support Partner for improved flood protection**

- Levee integrity
- Levee repair
- Flood emergency response



- Hydrology
- Earthquake & Fault Analysis



- Hydrology / Subsidence
- Long-term modeling of Delta

Jet Propulsion Laboratory (Dr. Cathleen Jones (P.I.), Dr. Scott Hensley)  
California Dept. of Water Resources, Delta-Suisun Marsh Office (Mr. Joel Dudas)  
USGS, Ca. Water Science Center & Southern California Earthquake Center (Dr. Gerald Bawden)  
HydroFocus, Inc., Davis, Ca. (Dr. Steven Deverel)

# Radar Measurements of the Sacramento-San Joaquin Delta

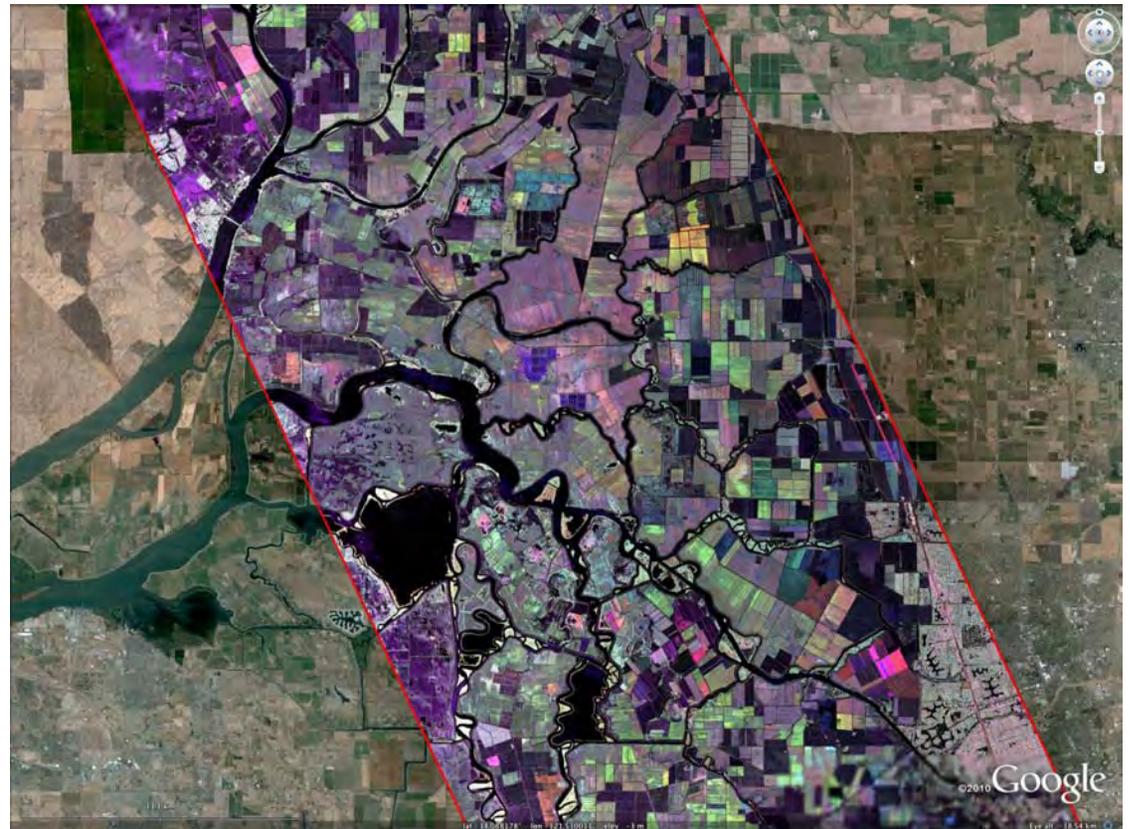
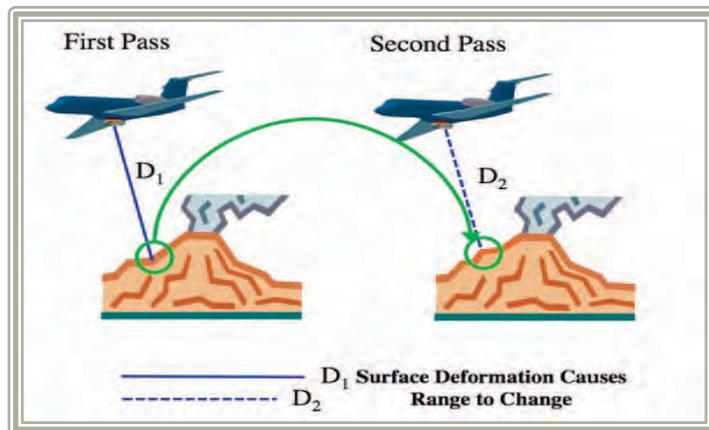
The Instrument: UAVSAR (Uninhabited Aerial Vehicle Synthetic Aperture Radar)



The UAVSAR L-band radar is housed in a pod flown on the NASA G-3 platform, shown here in flight over Edwards Air Force Base.

***UAVSAR flights image the Delta ~ monthly from 3 different directions to detect changes in the levees and measure subsidence rates.***

***19 flights completed since July 2009***



# Radar Measurements of the Sacramento-San Joaquin Delta

Damaged Levee Monitoring – The Initial Event and Long-term Effects

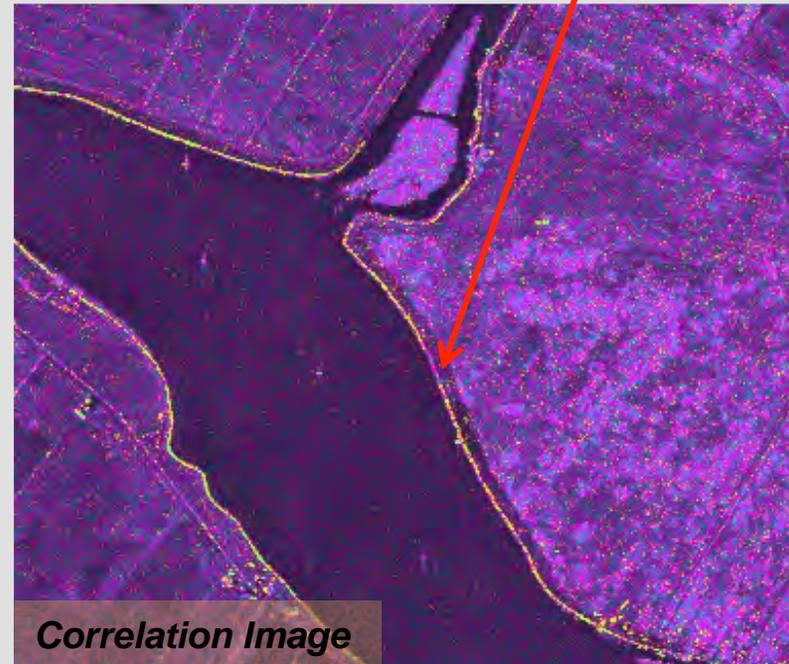
## Bradford Island



*Initial Effect:*



*A half-year after the event, the settling is spread out along more of the levee and smaller in magnitude.*



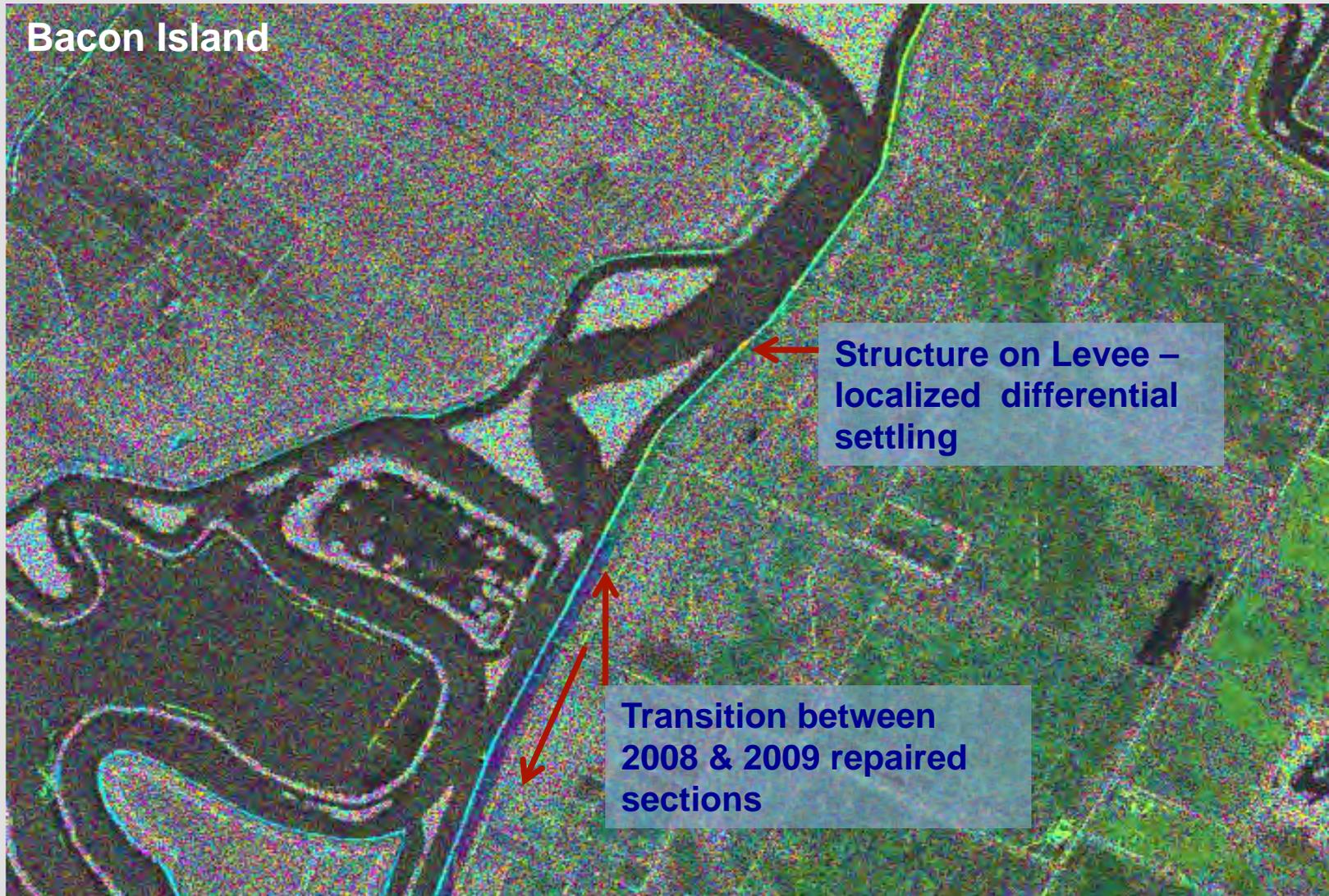
6 months temporal baseline 1/2010 - 7/2010

# Radar Measurements of the Sacramento-San Joaquin Delta

## Levee Change Detection

### Bacon Island

1 year temporal baseline 7/2009 - 7/2010



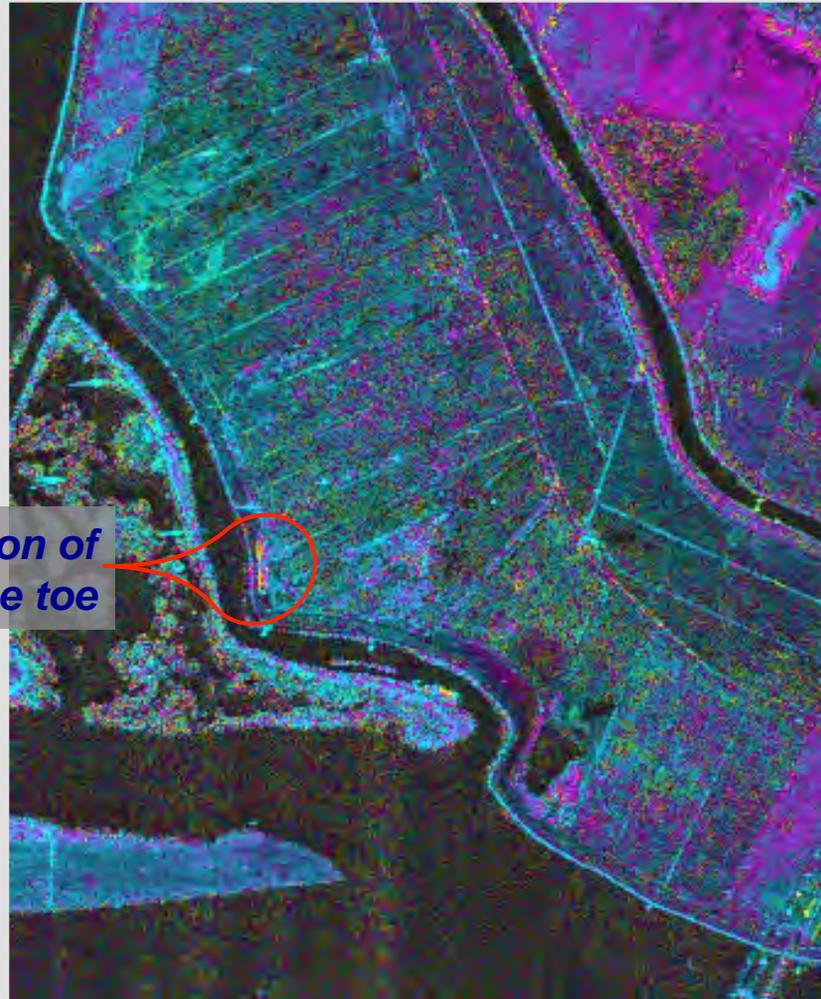
# Radar Measurements of the Sacramento-San Joaquin Delta

## New Levee Settling

### Sherman Island Set-back Levee:

*Deformation of  
levee toe*

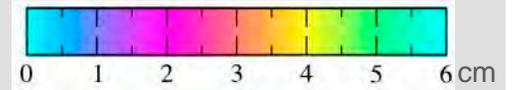
*Settling and compaction of  
new levees is normal. We  
use this tool to isolate areas  
with the most movement.*



37 day temporal baseline 3/3/2010 – 4/9/2010

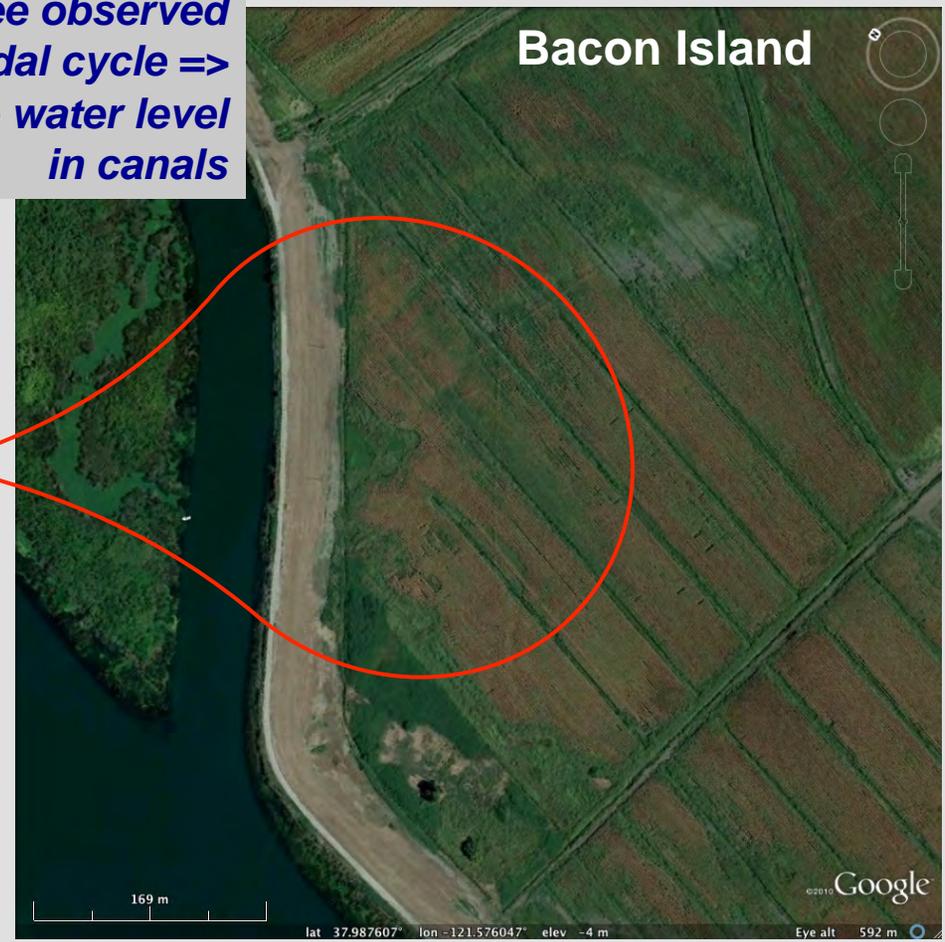
# Radar Measurements of the Sacramento-San Joaquin Delta

## Detecting Seepage Through Levees



*Change immediately behind levee observed during tidal cycle => related to water level in canals*

3 hour temporal baseline 7/12/2010 HH-polarization interferogram

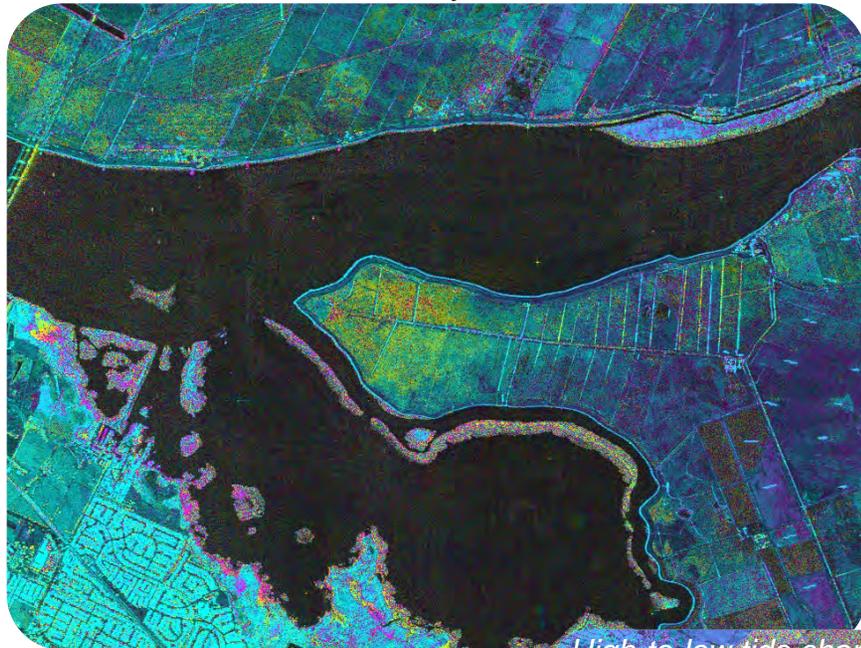


*An objective of our study is to determine whether the change is induced by seepage through the levee or from man-made structures.*

# Changes in the Sacramento Delta and Suisun Marsh

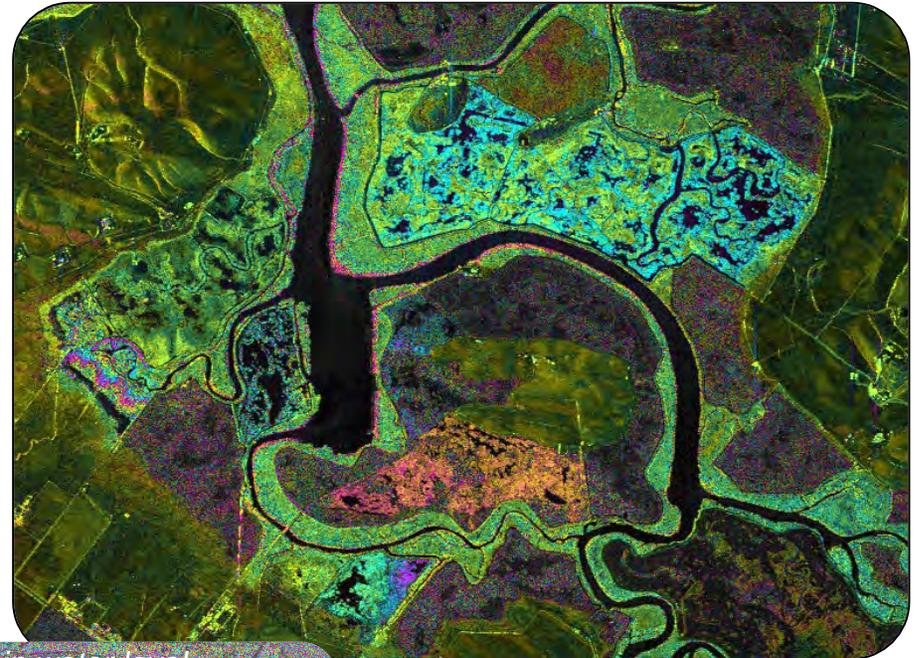
A few examples...

*Blind Point Peninsula, Jersey Island*

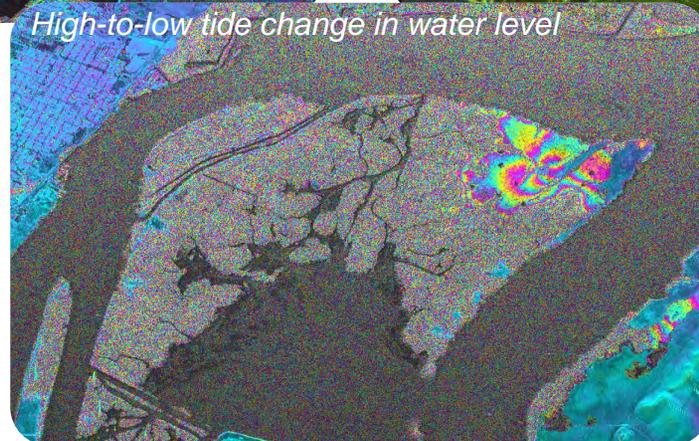


UAVAR pixel resolution = 7 m x 7 m

*Suisun Marsh: vegetation, soil moisture, and water levels*

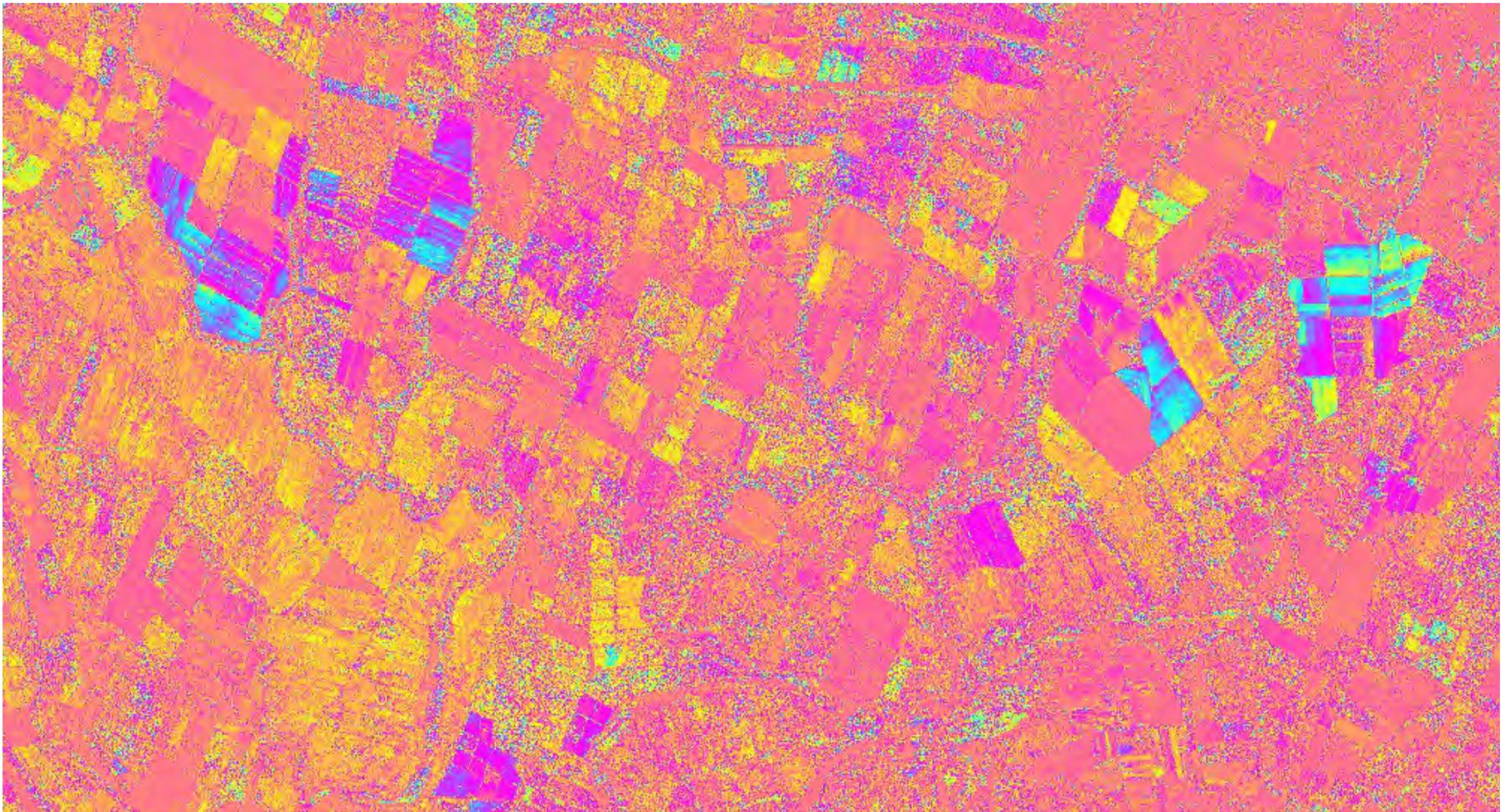


*High-to-low tide change in water level*



# Soil Moisture Change Detection

Changes in the radar return correlate with field boundaries, showing soil moisture changes.



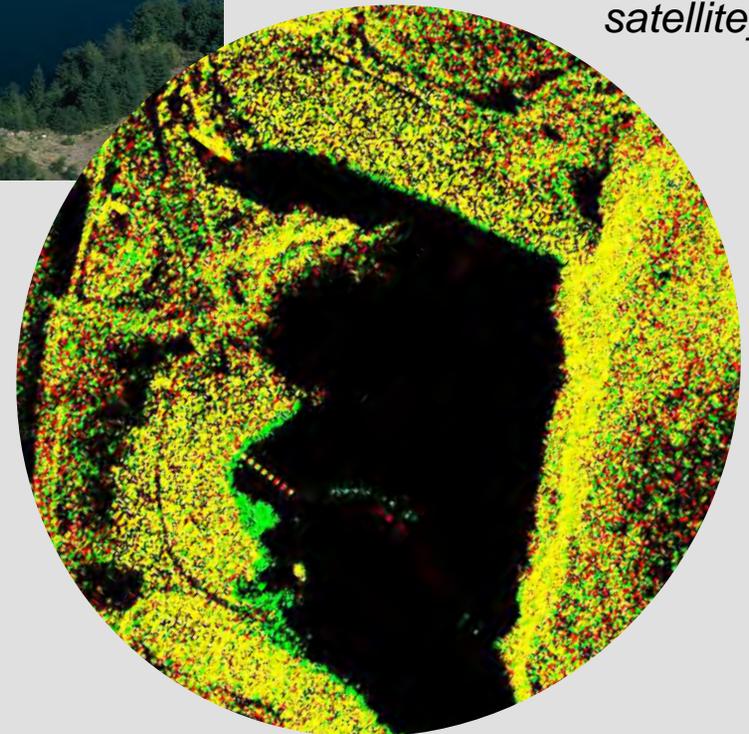
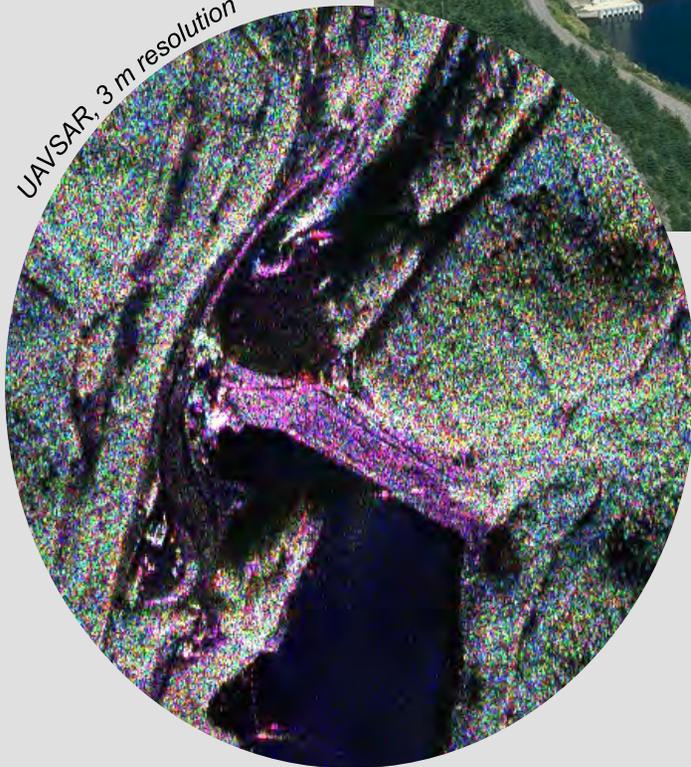
# Dam Safety Program / Flooding

## Monitoring Dam Embankments and Pools



*Green areas show reservoir pool lowering over 22 days in November 2010. [TerraSAR-X satellite]*

*UAVSAR, 3 m resolution*



# Dam Safety / Flooding

## Sediment Deposition and Erosion

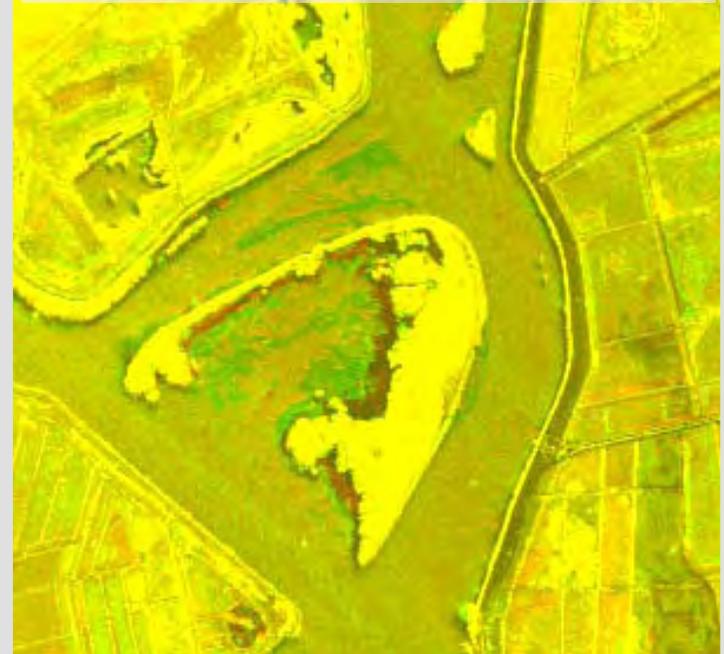


*July 2009*



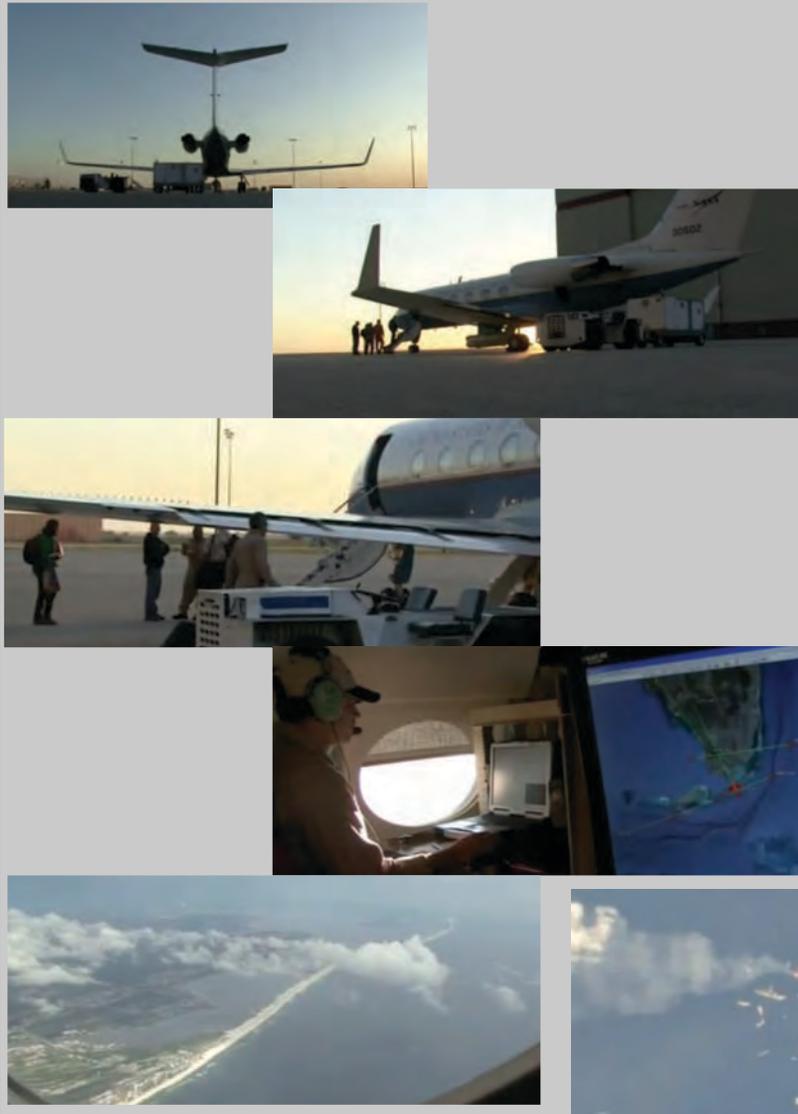
*July 2010*

*Green areas in the water channel  
show where erosion occurred  
between July 2009 and July 2010]*

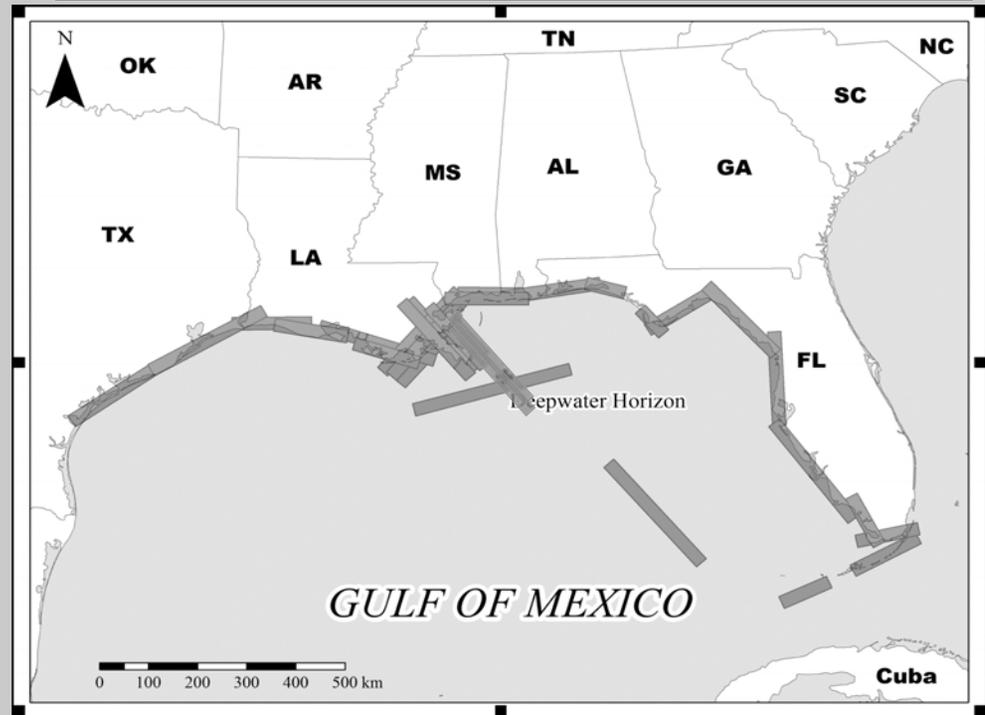


# UAVSAR GULF OIL SPILL CAMPAIGN

22-23 JUNE 2010 DEPLOYMENT

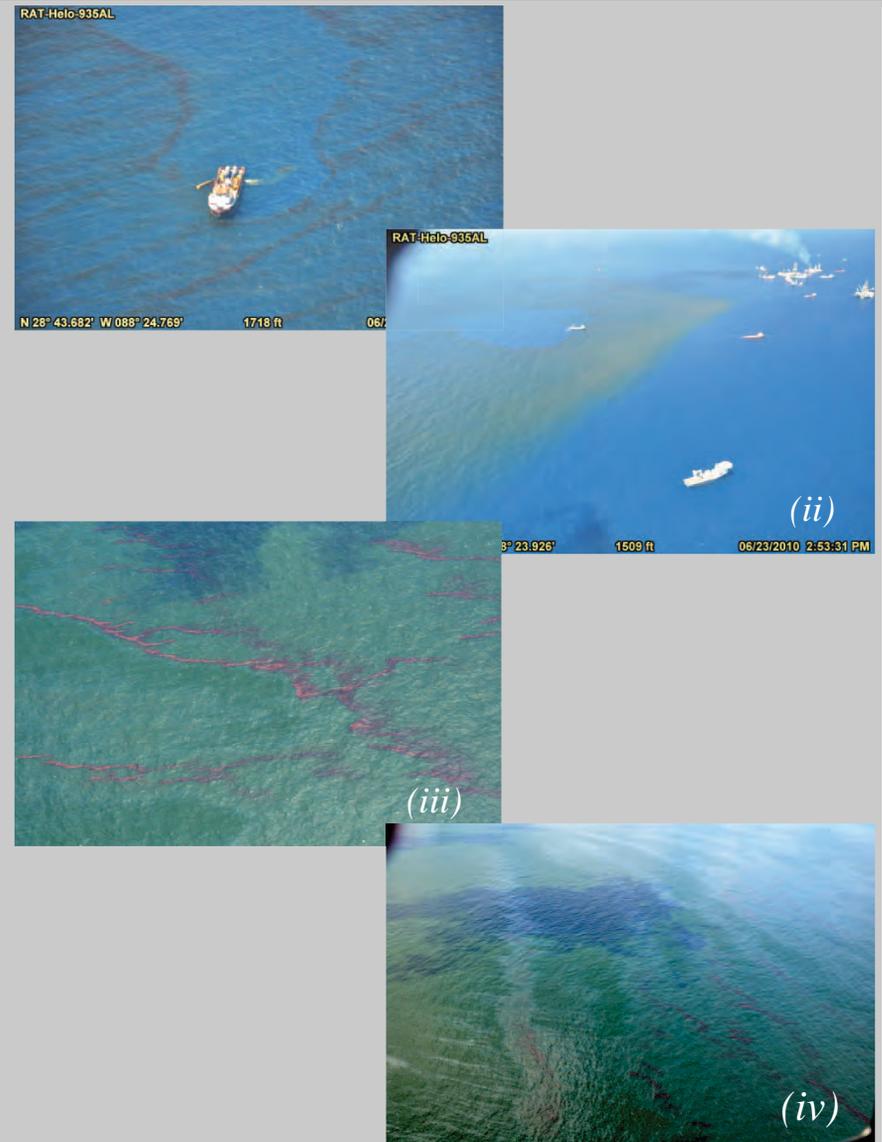
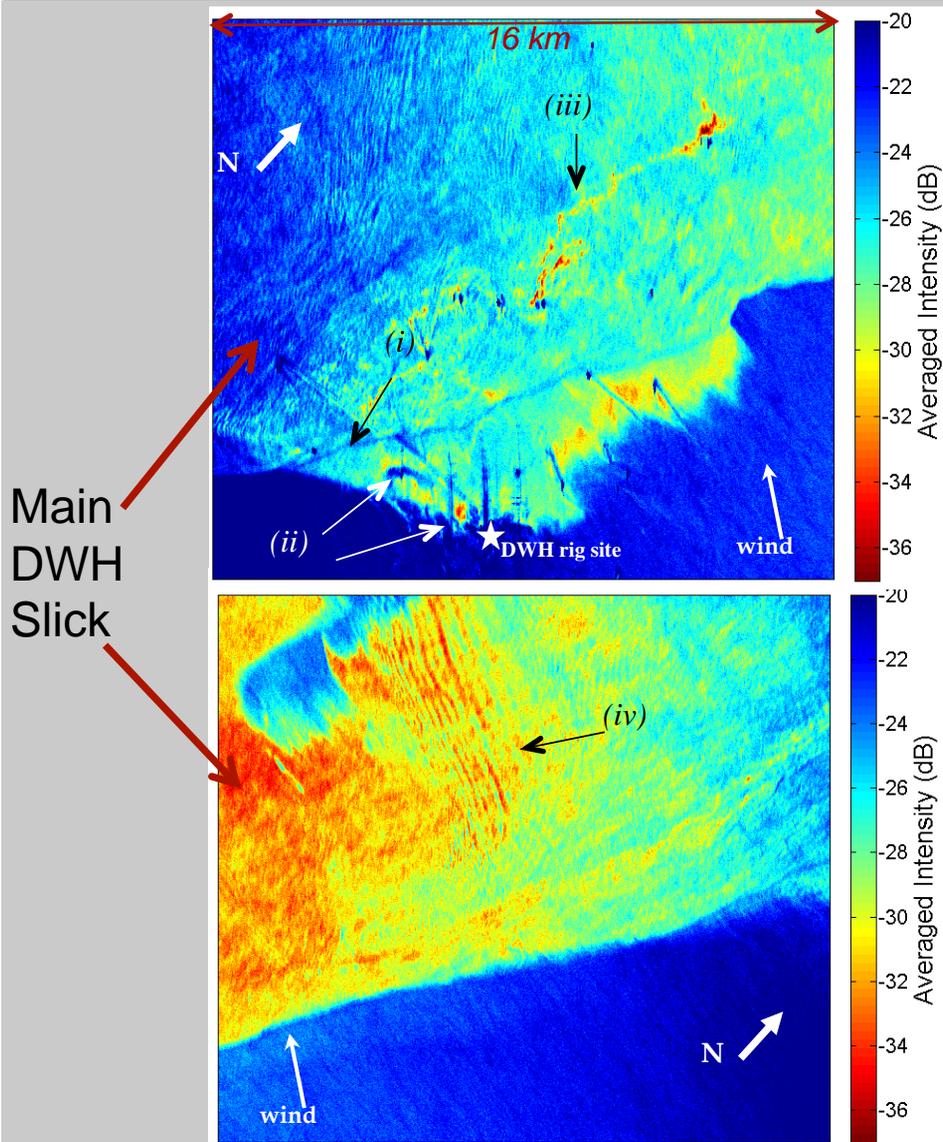


- 2 days, 20 flight hours
- ~5500 km of flight lines with 22 km swath width
- imaged an area of 120,000 km<sup>2</sup>



# UAVSAR GULF OIL SPILL CAMPAIGN

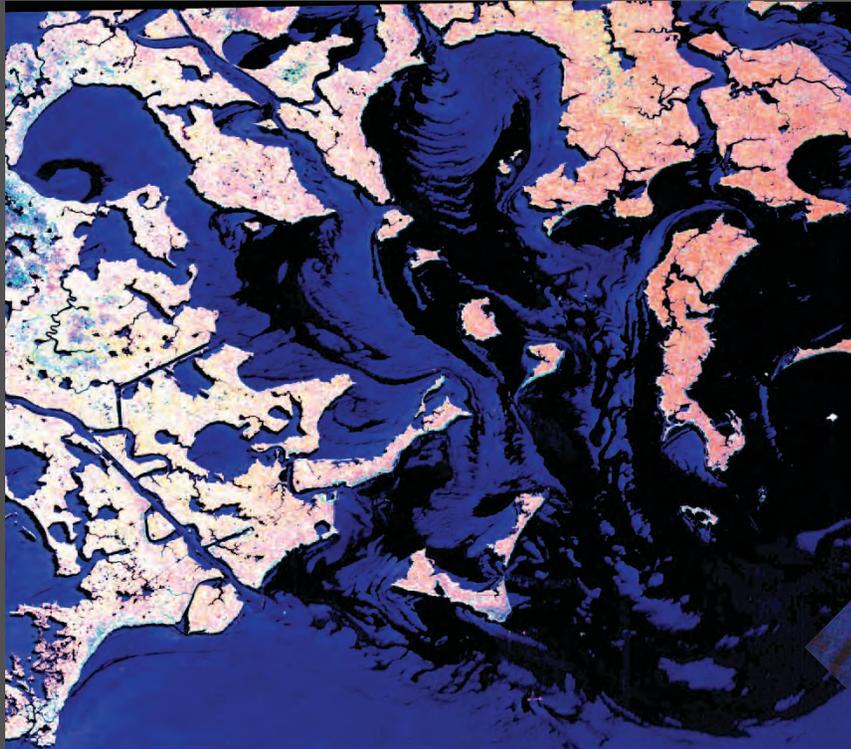
## OIL SLICK DETECTION AND CHARACTERIZATION



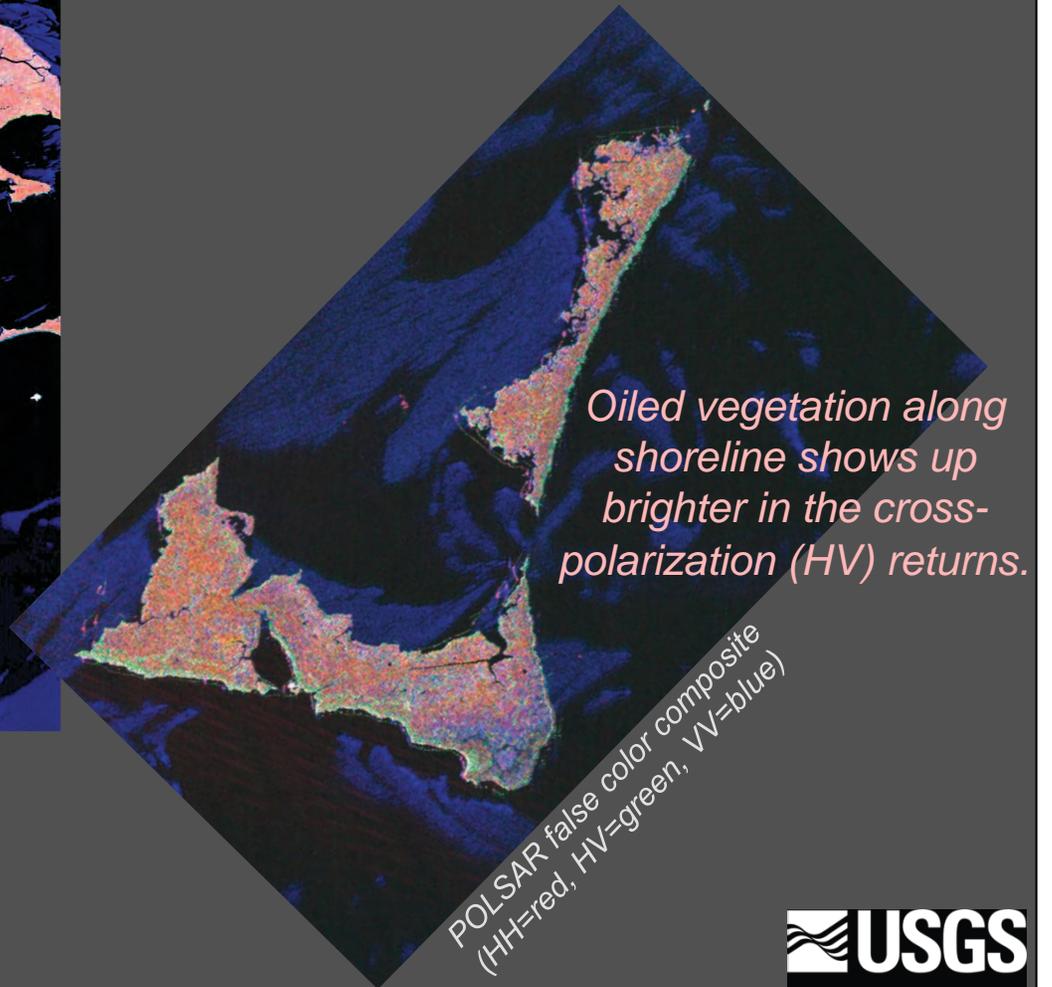
# UAVSAR GULF OIL SPILL CAMPAIGN

## MAPPING OIL EXTENT IN COASTAL WETLANDS

### *Barataria Bay, Louisiana:*



*Oil on water shows as dark areas in the radar image.*



*Oiled vegetation along shoreline shows up brighter in the cross-polarization (HV) returns.*

*POLSAR false color composite  
(HH=red, HV=green, VV=blue)*

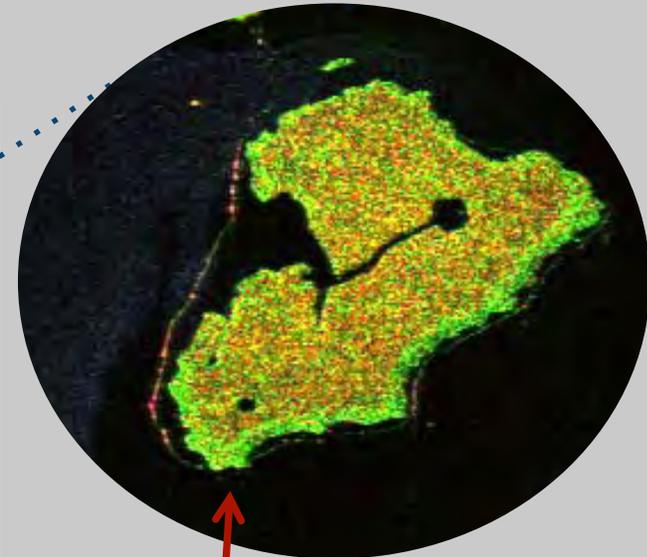
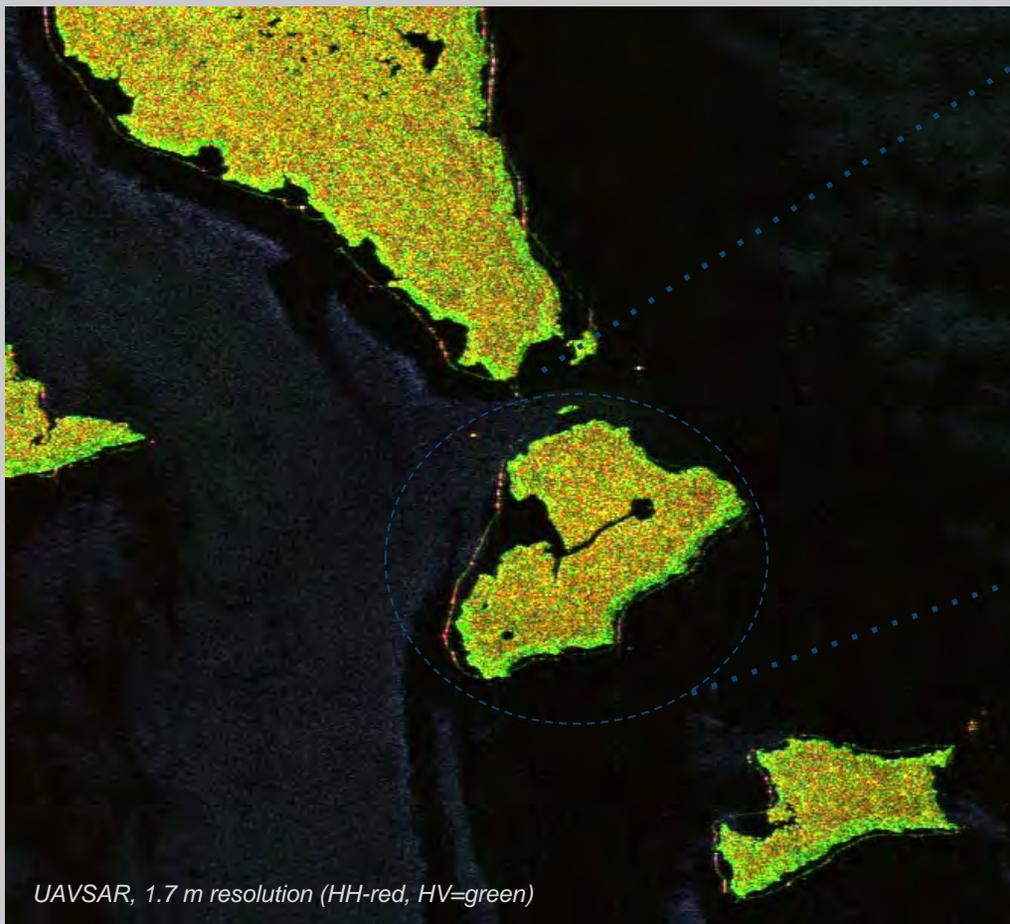


# UAVSAR GULF OIL SPILL CAMPAIGN

## RAPID RESPONSE APPLICATION: CONTAINMENT BOOMS

### High Resolution Radar for Response and Recovery: Monitoring Containment Booms in Barataria Bay

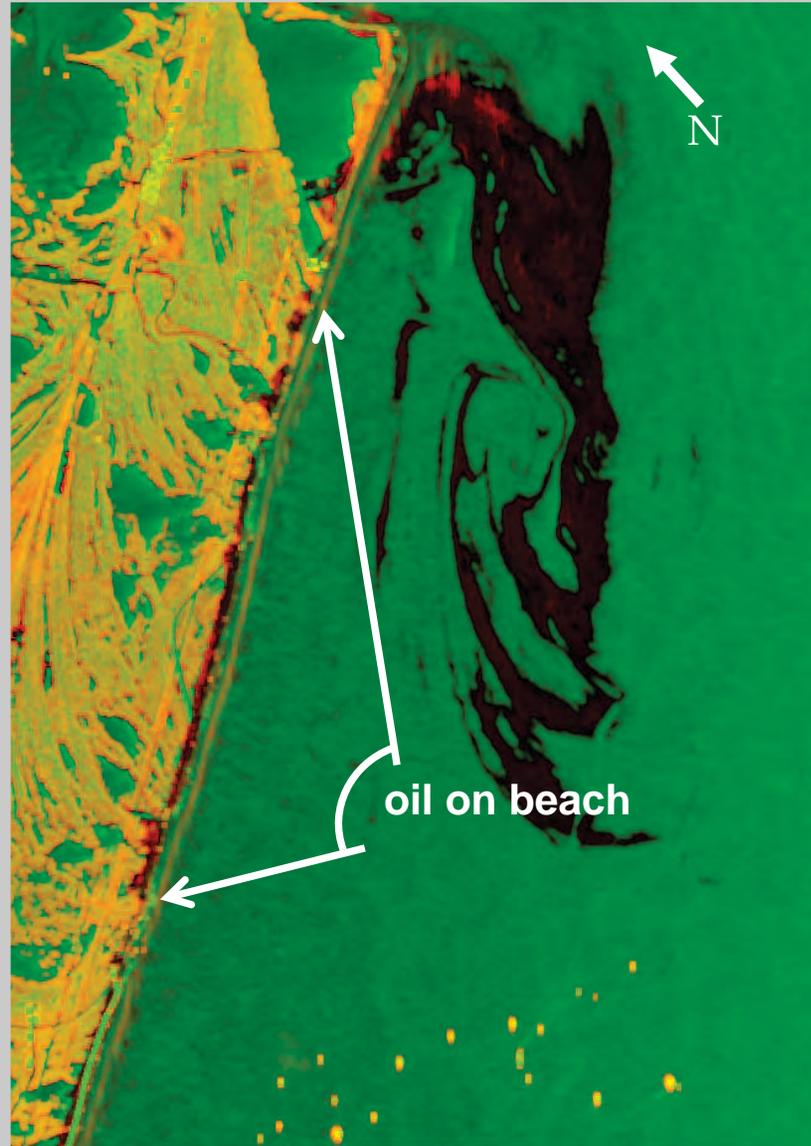
Cathleen Jones (*JPL/Caltech*), Bruce Davis (*DHS*)



# UAVSAR GULF OIL SPILL CAMPAIGN

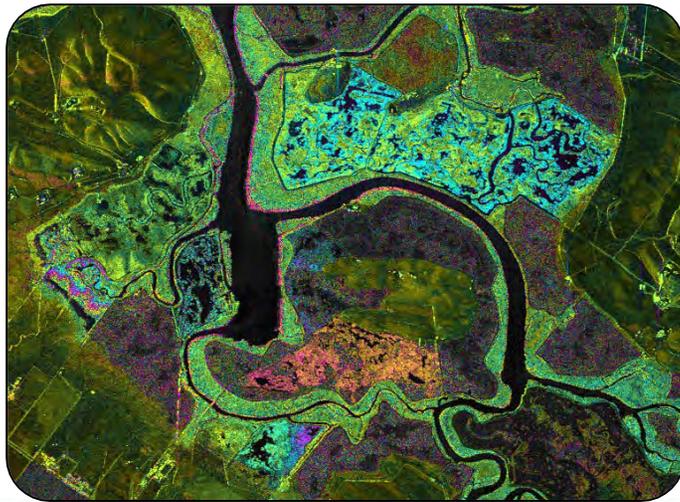
## RAPID RESPONSE APPLICATION: OIL ON BEACHES

Elmer's Island, Louisiana  
June 23, 2010



# SAR Capabilities for Water Resource and Hazards Monitoring

## Conclusions



**Radar remote sensing offers great potential for high resolution monitoring of ground surface changes and water extent over large areas at one time.**

**Our pilot projects working with Ca. DWR to monitor levees in the Sacramento-San Joaquin Delta, observing dams for DHS, and monitoring the effects of the Deepwater Horizon oil spill are developing the knowledge base needed to monitor small-scale critical infrastructure and waterways for flood management and disaster response.**