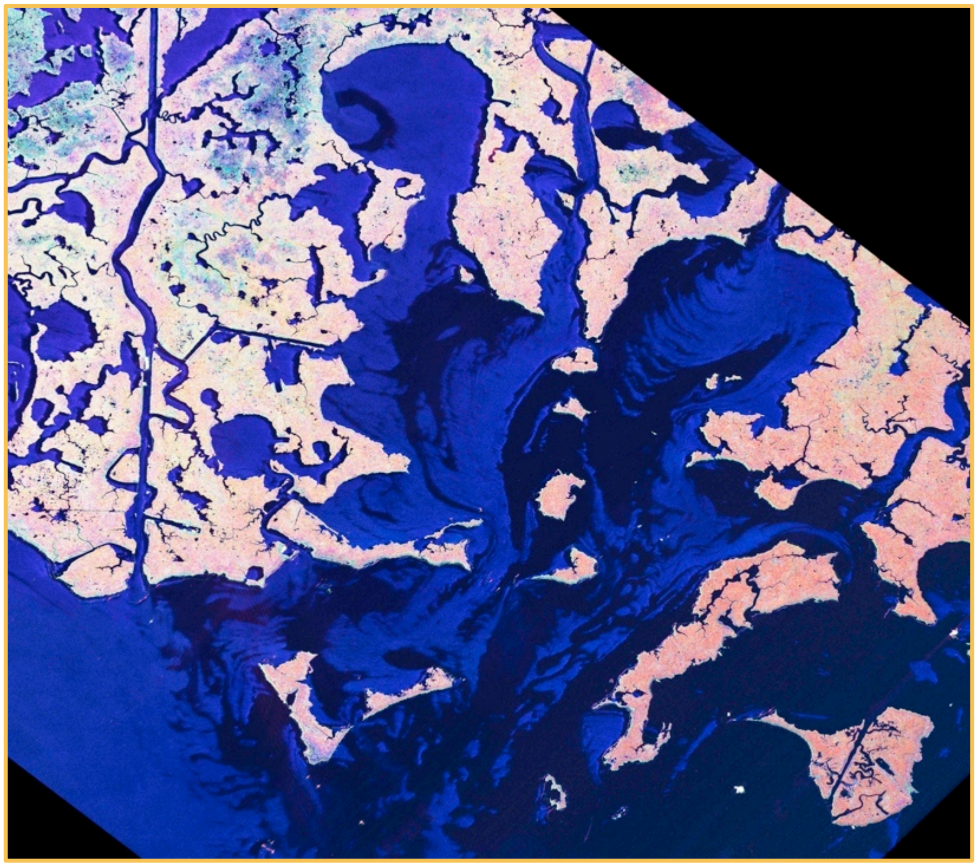
UAVSAR
Gulf Oil Spill Campaign
2010 - 2012



Barataria Bay, Louisiana – 23 June 2010 / UAVSAR HH-VV-HV / 7 m resolution

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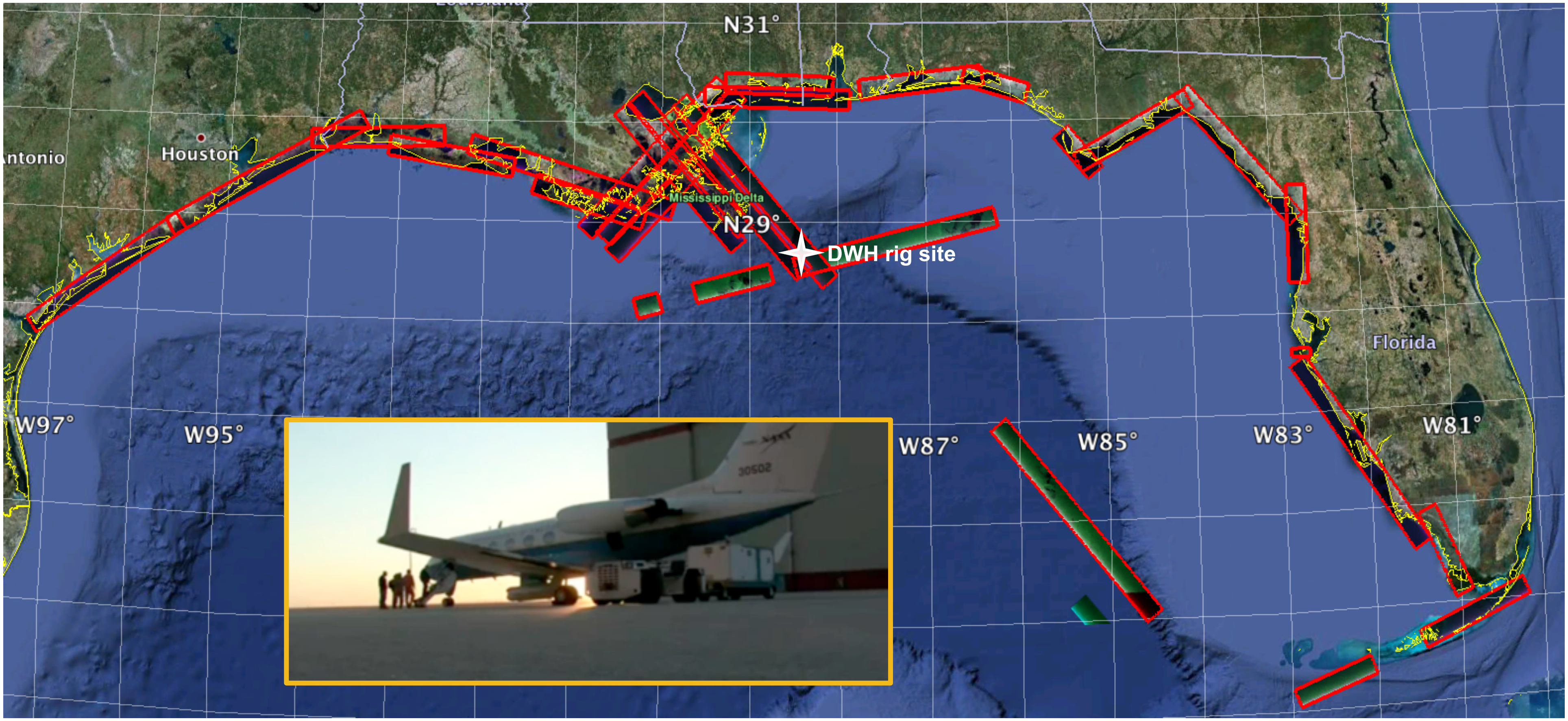
UAVSAR Workshop
Jet Propulsion Laboratory
March 26-27, 2013

Study Oil Spill Detection and the Impact of Oil Inundation in Wetland Ecosystems Using High Resolution Polarimetric L-band Radar

- Develop and validate algorithms for improved discrimination of oil slicks on water and collect data that will enable us to better determine oil properties with radar.
- Study the use of radar for determining the extent of oil penetration into sensitive coastal ecological zones, in particular, to map the spread of oil from the coastline into coastal wetlands.
- Use the radar data to determine the extent and nature of the damage to different coastal ecosystems and to track ecosystem recovery.
- Determine how SAR can better be used during oil spill response, either in open water, on the coast, or in inland waters.

- 2 days, 3 flights, 21 flight hours
- ~5500 km of flight lines
- Imaged an area of 120,000 km²

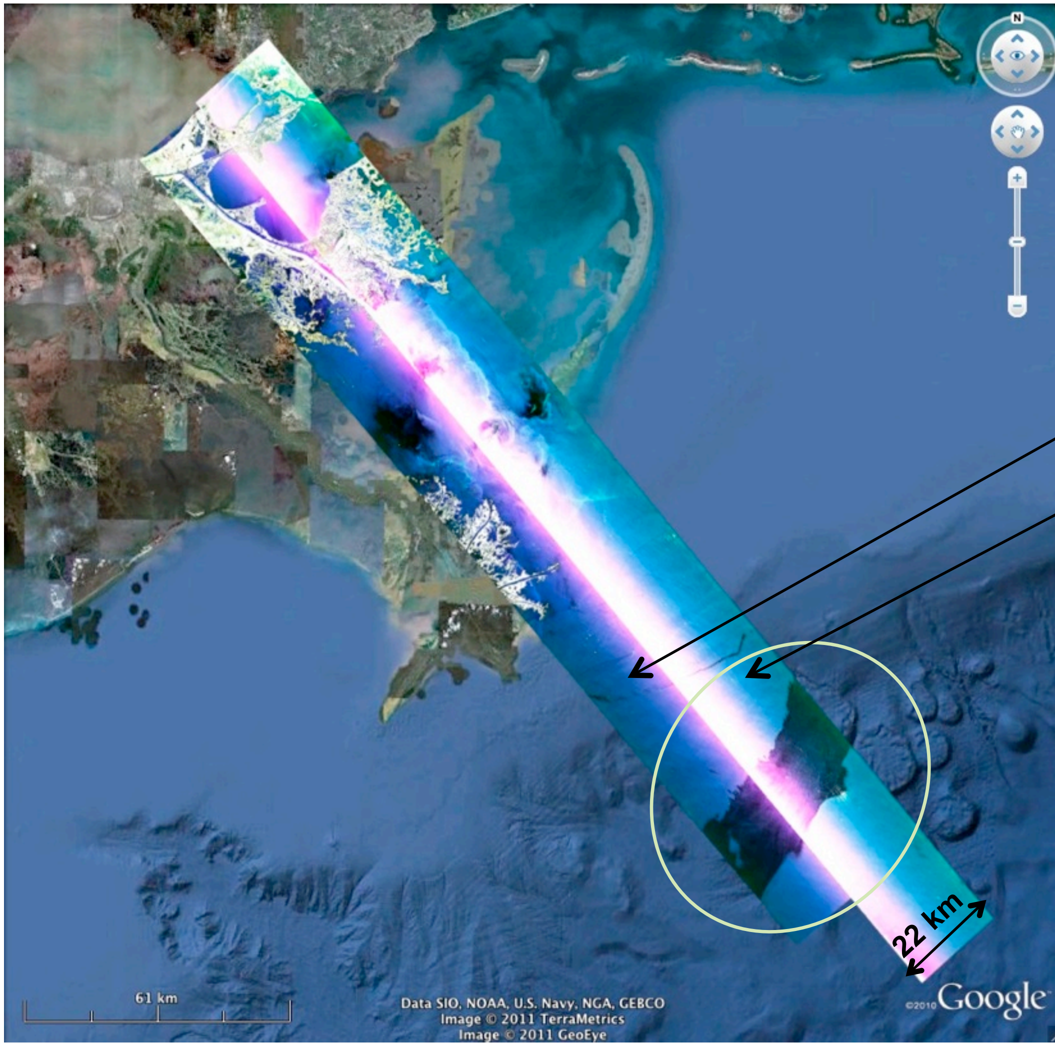


http://www.dfrc.nasa.gov/Gallery/Movie/Gulfstream/HTML/EM-0096-04.html

- UAVSAR revisits in June 2011 & July 2012
- Reacquired the Louisiana & Mississippi barrier island flight lines
- Matched season & tidal conditions in Barataria Bay for ecosystem impact studies

UAVSAR Flight Lines

The Main Slick of the Deepwater Horizon Spill



Two UAVSAR lines viewing the main slick from opposite directions were using in our analysis of the polarimetric response of the oil from the DWH spill.

gulfco_32010_10054_101_100623
collected 23-June-2010 21:08 UTC

gulfco_14010_10054_100_100623
collected 23-June-2010 20:42 UTC

Minchew, Brent, Cathleen E. Jones Benjamin Holt (2012), ***Polarimetric analysis of backscatter from the Deepwater Horizon oil spill using L-band radar***, TGRS, DOI: 10.1109/TGRS.2012.2185804.

Sea state: 1.0-1.3 m SWH
Wind: 2.5-5 m/s from 115°-126°

Effect of Surface Layer of Oil on Radar Backscatter from Water

Oil damps the small-scale capillary and gravity-capillary waves on the ocean surface mainly through a reduction in the surface tension at the gas-liquid interface.

Dispersion relationship for waves at the interface between air and a liquid of density ρ with surface tension σ:

$$\omega^2 = gk + (\sigma/\rho)k^3$$

gravity is the restoring force

surface tension and inertia are the restoring forces

$\rho_{oil}/\rho_{water} \approx 0.8 - 0.9$

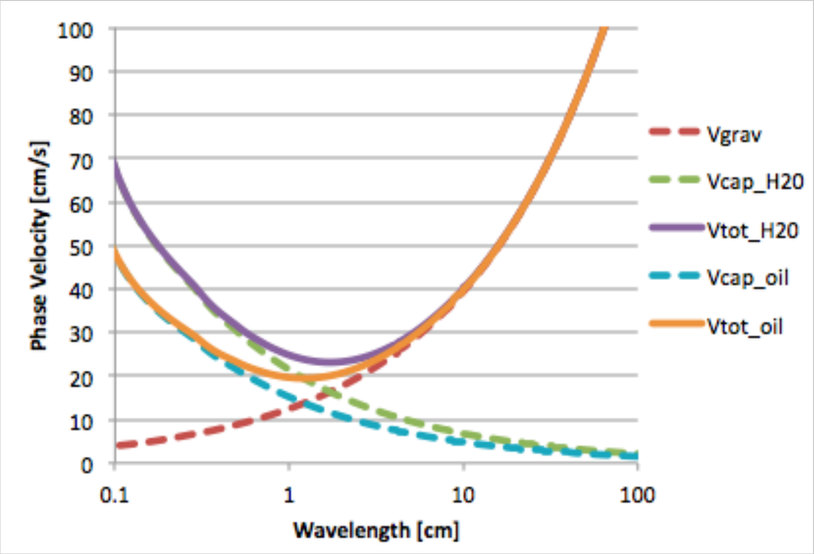
$\sigma_{oil}/\sigma_{water} \approx 0.25 - 0.5$

$$v_{phase} = \sqrt{\frac{g}{k} + \frac{\sigma}{\rho}k}$$

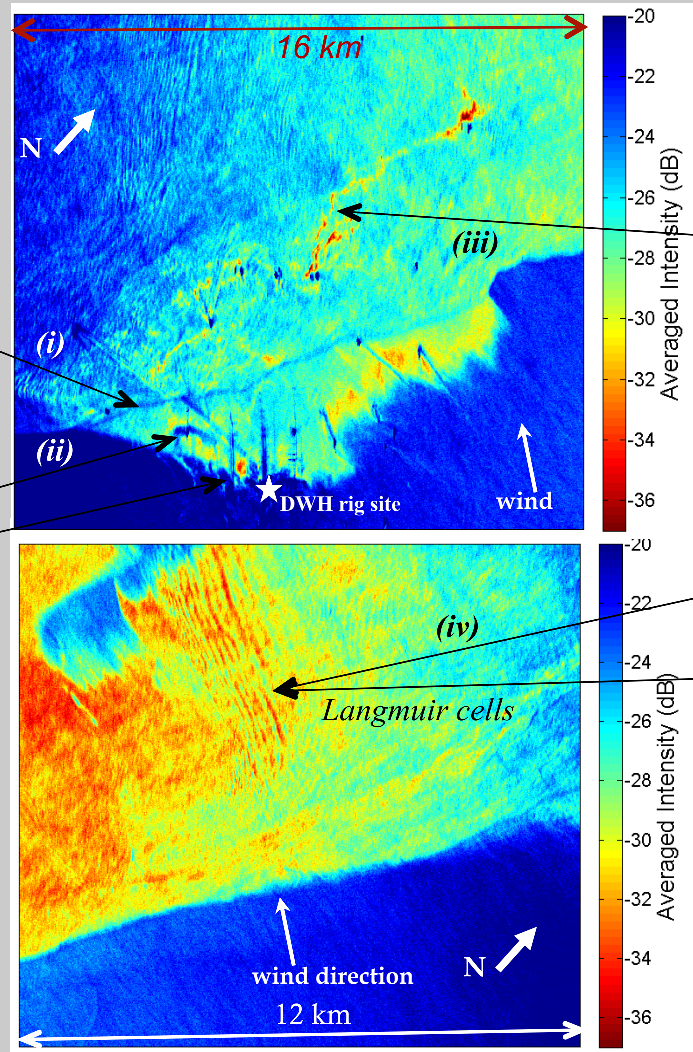
for a given velocity, k increases when the surface tension decreases

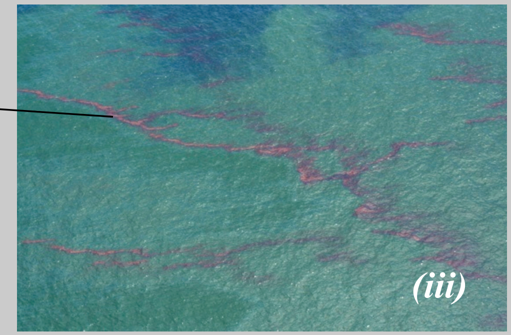
Ocean waves are excited by resonant forcing in a turbulent wind field. The wavelength of capillary waves resonantly excited in the presence of oil is smaller than for a clean water-air interface, hence the damping of the smaller wavelengths. This affects the roughness scale of the water surface. In a real slick, the surface characteristics will vary between pure H20 and pure oil, depending upon layer thickness, oil type, and areal coverage.

Also, in viscoelastic fluids gravity waves with short wavelength are damped by restoring forces arising from gradients in the surface tension (Marongoni effect).



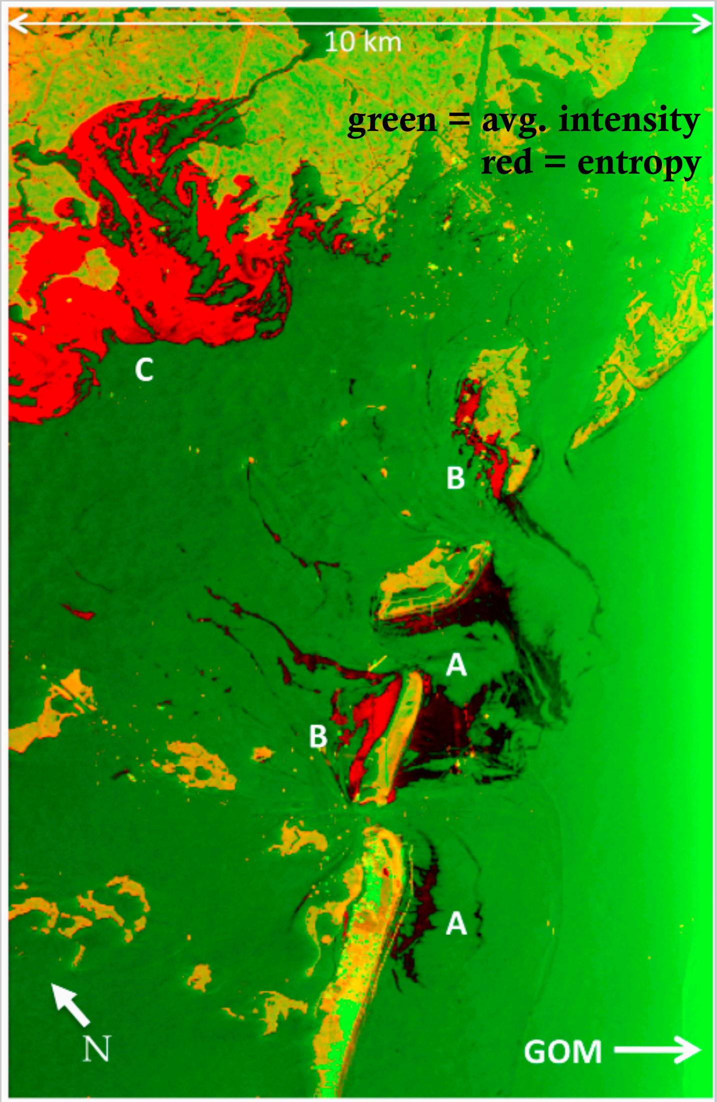
NOT ONLY IS THE OIL SLICK CLEARLY DIFFERENTIATED FROM THE SURROUNDING SEAWATER (DARK BLUE IN THE UAVSAR IMAGE), BUT THE LOW NOISE UAVSAR RADAR BACKSCATTER CAN DIFFERENTIATE SOME OIL CHARACTERISTICS WITHIN THE SLICK.





Jones, C.E. et al (2011). Studies of the Deepwater Horizon oil spill with the UAVSAR radar. Geophysical Monograph Series, 195, 33-50.

Photos taken over the slick on 23-June-2010 between 16:00 and 20:00 UTC (NOAA RAT-Helo and EPA/ASPECT)

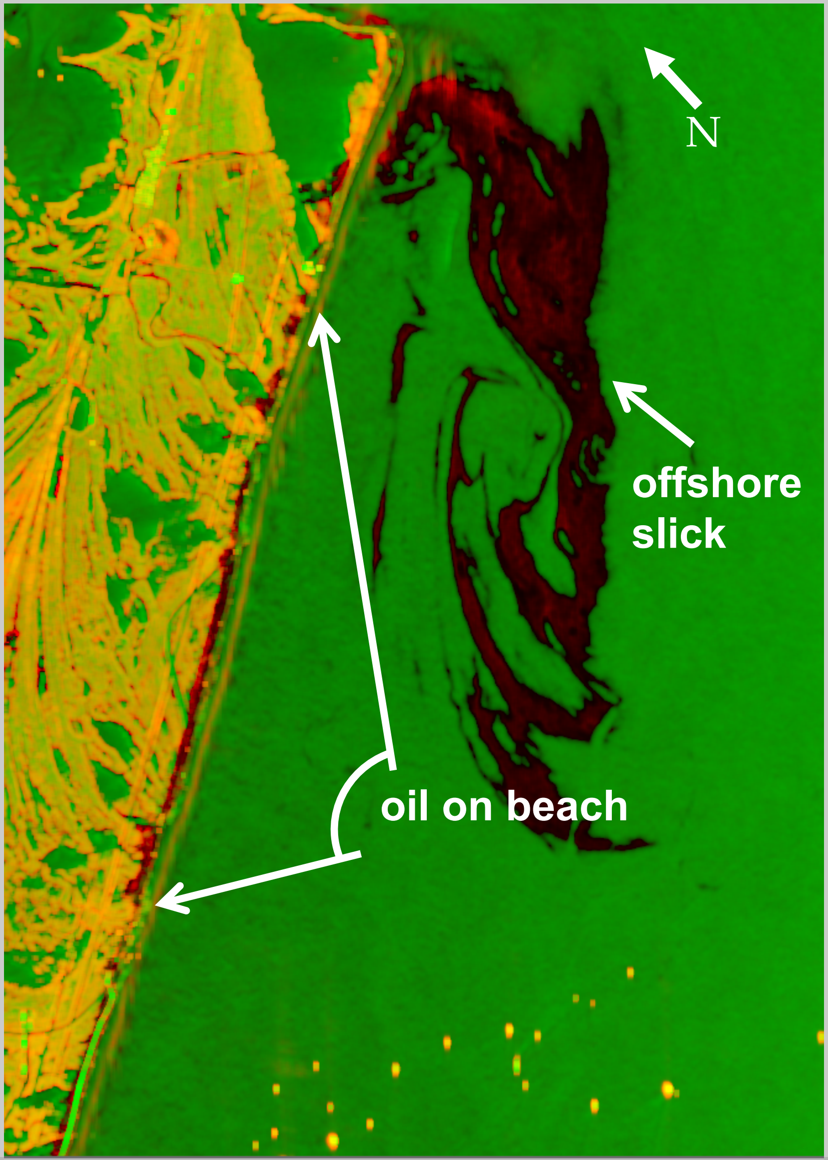


Large amounts of oil moved far into Barataria Bay in SE Louisiana on 16-17 June 2010, with oil remaining in the area until after the UAVSAR over- flight.

Weathered oil in the interior of Barataria Bay shows a significantly lower intensity and higher entropy than oil around the rig site or in the Gulf of Mexico approaching the Louisiana shoreline.

C. E. Jones, B. Holt, S. Hensley (JPL/Caltech), B. Minchew (Caltech), Studies of the Deepwater Horizon Oil Spill with the UAVSAR Radar, 2011, AGU Monograph Series.

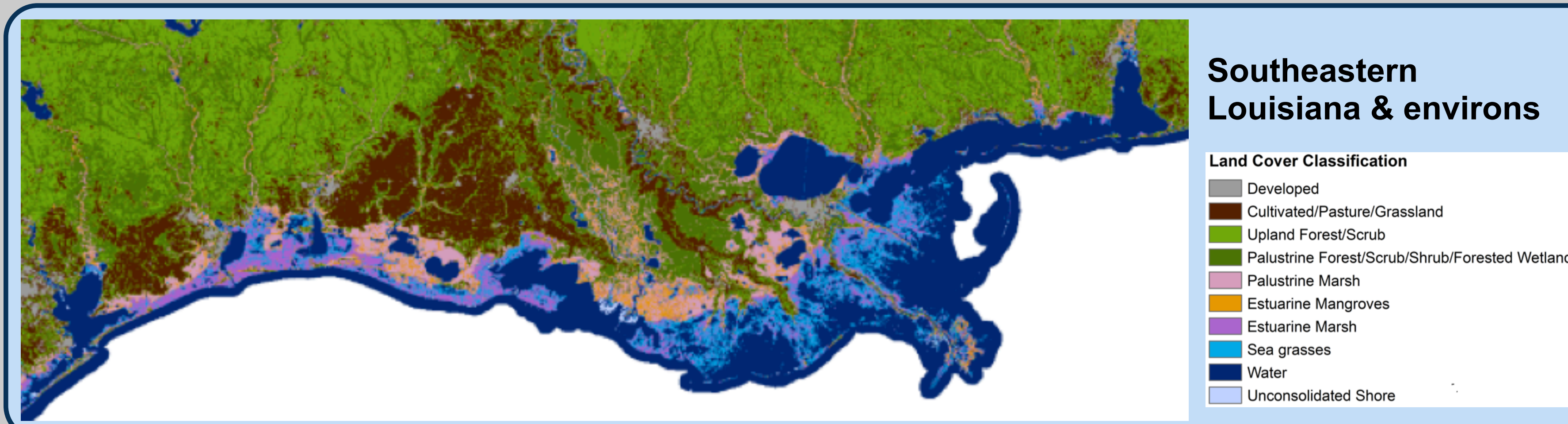
Elmer's Island, Louisiana
June 23, 2010



High resolution L-band radar can be used to identify newly oiled areas overnight to direct response crews the following day.

Jones, C.E. et al (2011). Studies of the Deepwater Horizon oil spill with the UAVSAR radar. Geophysical Monograph Series, 195, 33-50.

Impact of Deepwater Horizon Spill on the Gulf Ecosystems



Ecological zone impact begins when the oil hits the wetland interface.

If it is not known that oil is present, then ecological changes cannot be linked to the oil spill.

The primary indicator of the expected severity of impact to the marsh is the presence of oil in the marsh. In general, the thicker, more contiguous and extensive the oil, the higher the severity. At less extensive exposures, marsh sensitivity to oil is species-dependent.

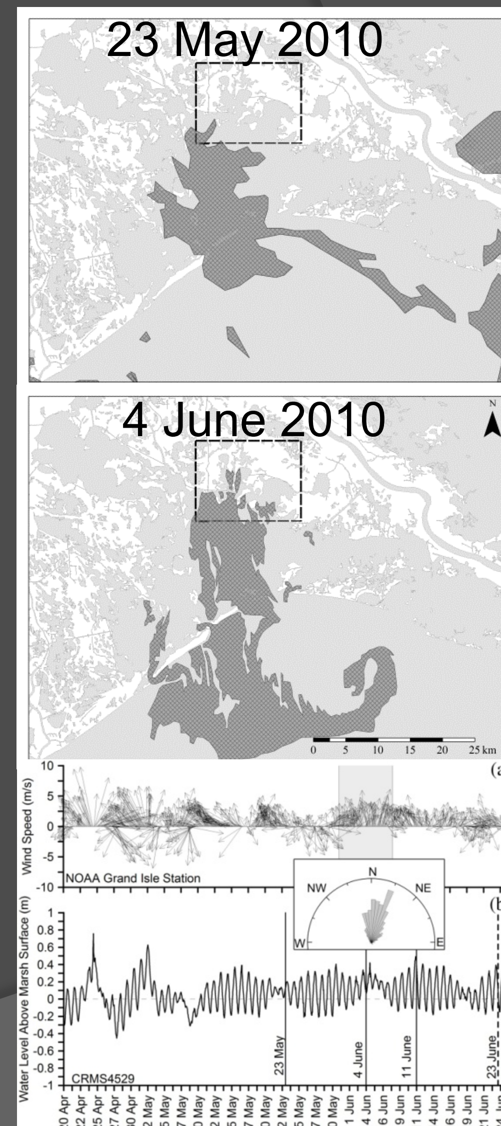
1. Dense canopy structures can limit the use of optical and shorter-wavelength radars for determining the extent of oil at ground level. *[Use longer wavelength (24 cm) L-band radar, multi-polarization]*

2. Open water channels in the marsh can be very small and the water is still, so tracking oil intrusion on the surface of the water requires higher resolution and lower noise than that of most satellite radar instruments. *[Need high resolution, high SNR]*

3. Differentiating oil-on-water from oil-on-sediment or vegetation using radar backscatter had never been demonstrated due to instrument limitations. *[Need high SNR, multi-polarization]*

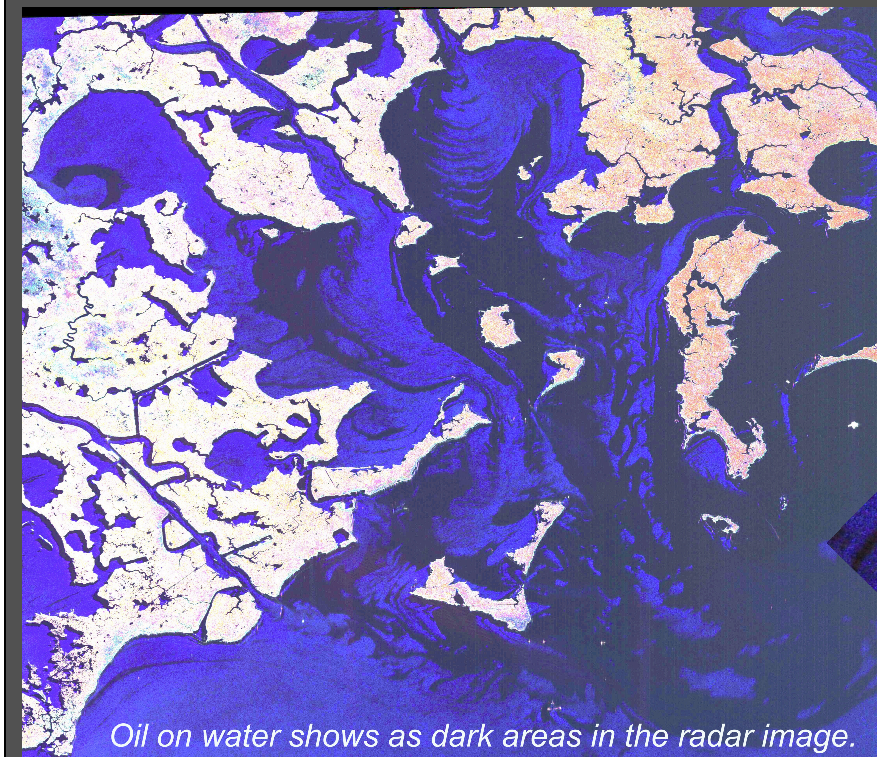
Environmental Response Management Application (ERMA) Shoreline SCAT Oiling Ground Observations

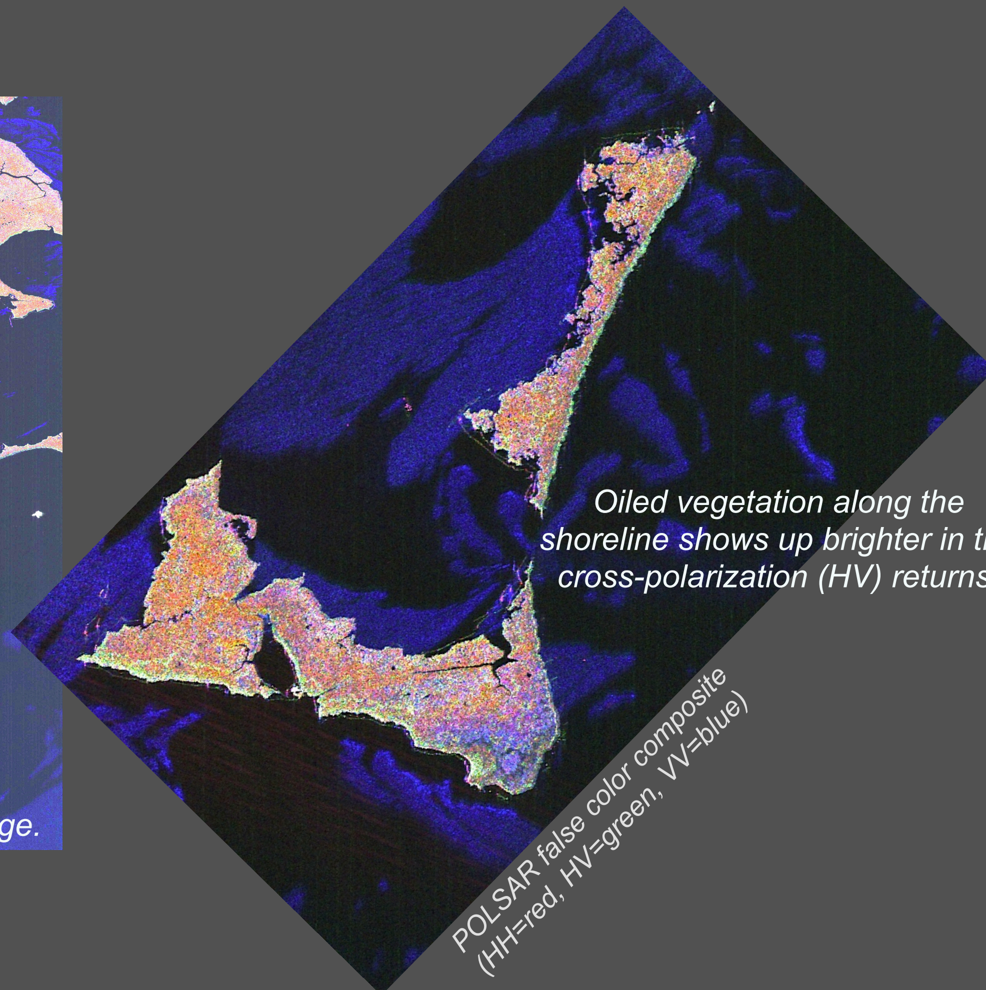
ERMA website: http://gomex.erma.noaa.gov



Ramsey III, E., A. Rangoonwala, Y. Suzuoki, and C. E. Jones, 2011. Oil Detection in a Coastal Marsh with Polarimetric SAR. *Remote Sensing*, 3, 2630-2662.

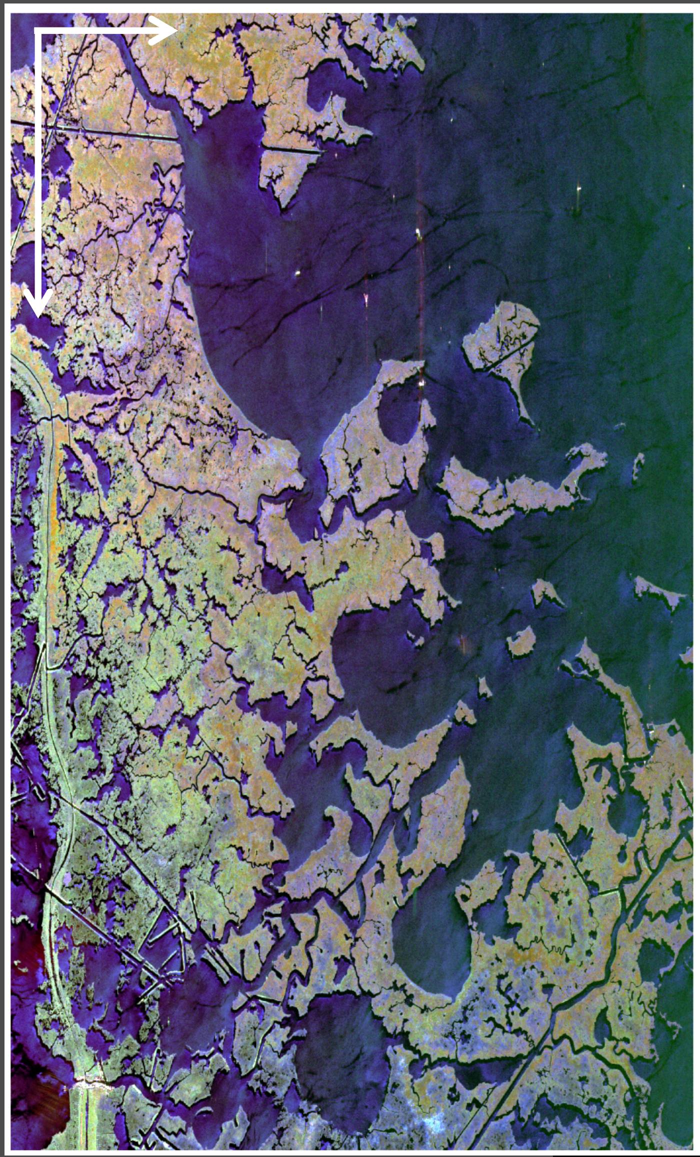
Barataria Bay, Louisiana:



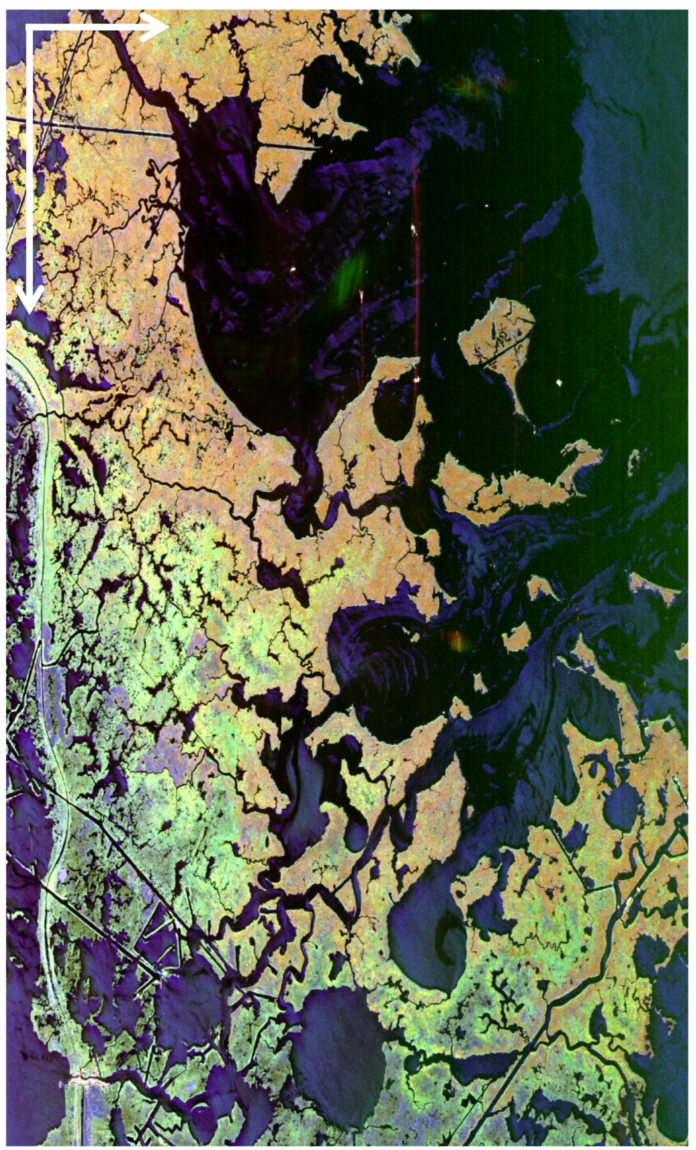


1. Ramsey, E., A. Rangoonwala, Y. Suzuoki, and C. E. Jones (2011). Oil detection in a coastal marsh with polarimetric synthetic aperture radar (SAR). Remote Sensing, 3, 2630-2662.
2. Jones, C.E., B. Minchew, B. Holt, and S. Hensley (2011). Studies of the Deepwater Horizon oil spill with the UAVSAR radar. In *Monitoring and Modeling the Deepwater Horizon Oil Spill: A Record-Breaking Enterprise*, Geophysical Monograph Series, 195, 33-50.

UAVSAR MultiLooked Intensity Images



17 June 2009



23 June 2010

Red: HH Backscatter
Green: HV Backscatter
Blue: VV Backscatter

Ramsey III, E., A. Rangoonwala, Y. Suzuoki, and C. E. Jones, 2011. Oil Detection in a Coastal Marsh with Polarimetric SAR. *Remote Sensing*, 3, 2630-2662.

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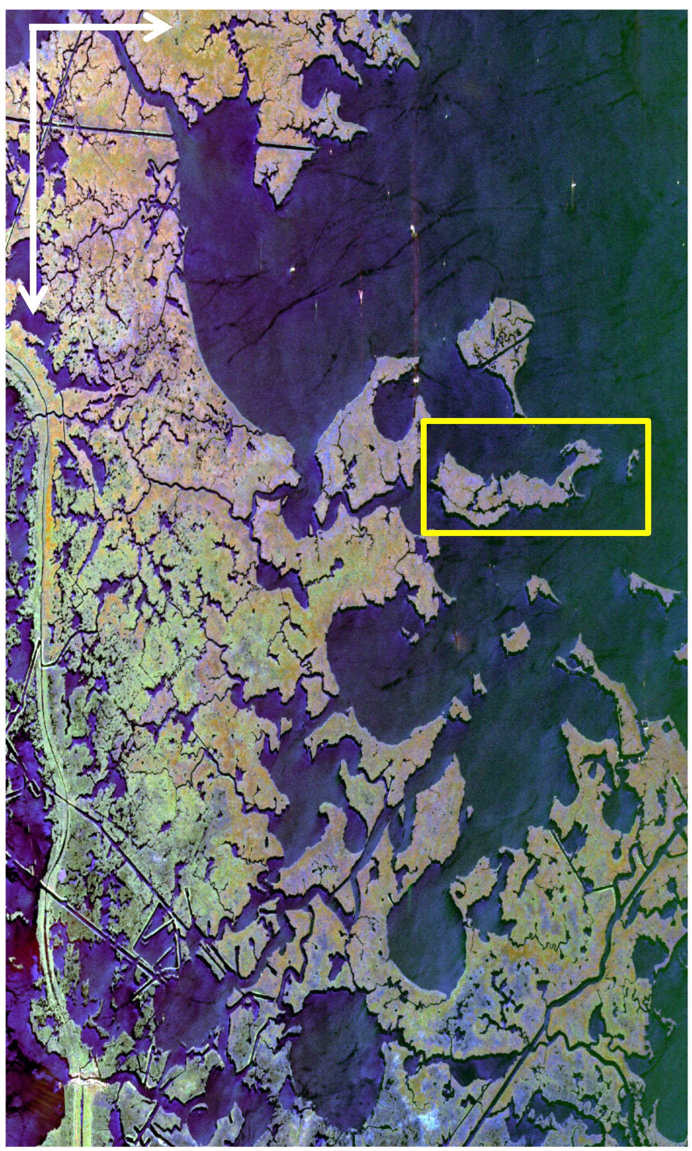

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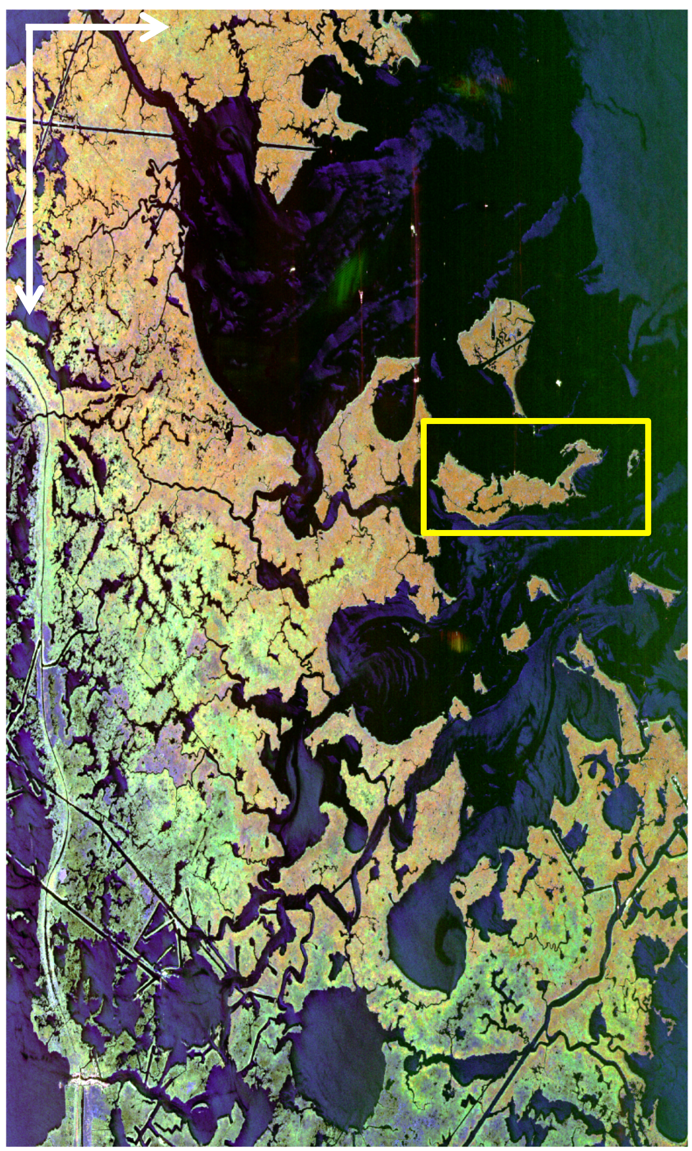

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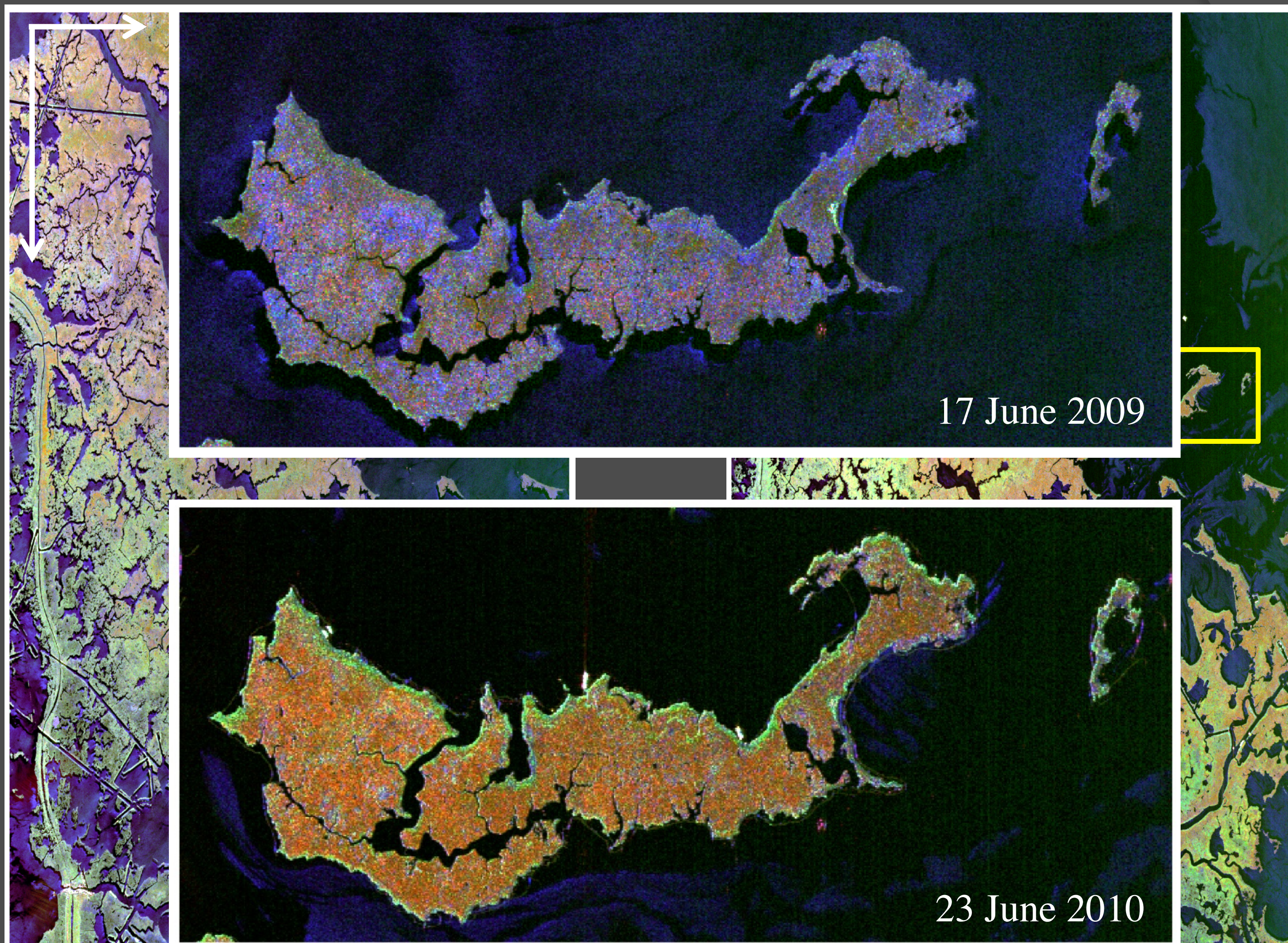

17 June 2009 | 23 June 2010

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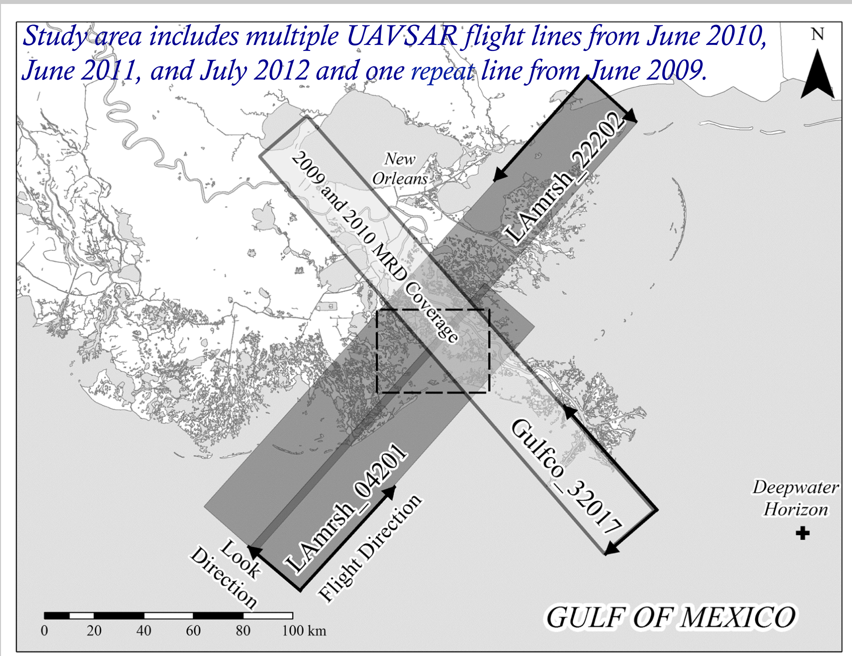
Oil Impact to Louisiana Wetlands (NASA ROSES Terrestrial Ecology study)

Elijah Ramsey (P.I.), Amina Rangoonwala, Terri Bannister, Zhaohui Chi ***(USGS, National Wetlands Research Center)*****,**
Cathleen Jones and Ben Holt ***(JPL)***



Goals of Study:

1. **Use L-band POLSAR to detect oil on waterways and marsh vegetation, including sub-canopy oiling of vegetation stalks and soil.**
2. **Track ecosystem impact and recovery.**

Classification Methods Studied:

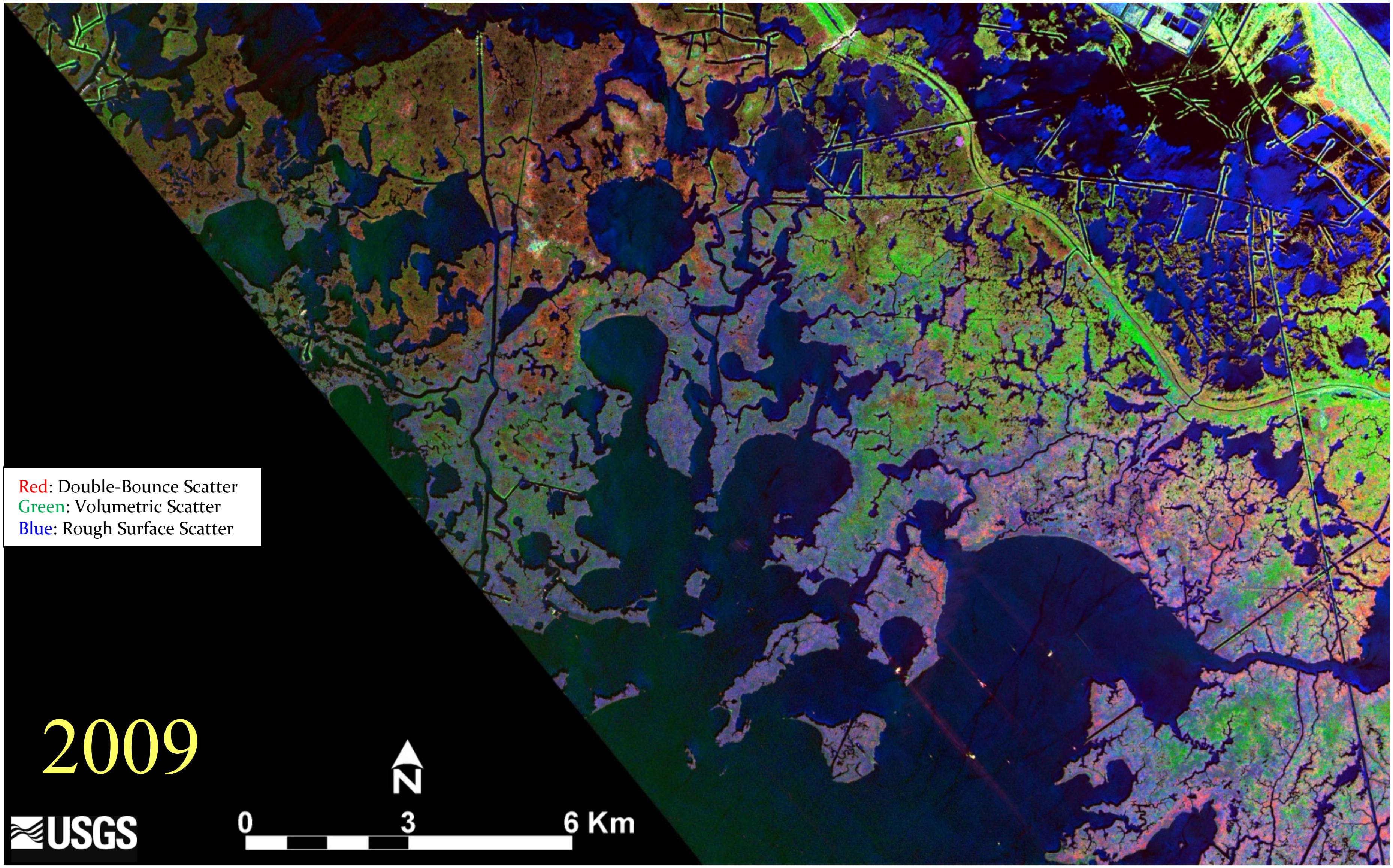
- ***Entropy/Anisotropy/Alpha Polarimetric Decomposition (Cloude-Pottier [CP])***
- ***Freeman-Durden Decomposition [FD]***
- ***Unsupervised Wishart Classification***

Photos taken 6/23/2010, courtesy of Bruce Davis (DHS)

MAP PROJECTED AND MULTIPLE DATES

FREEMAN-DURDEN DECOMPOSITIONS 2009 TO 2010

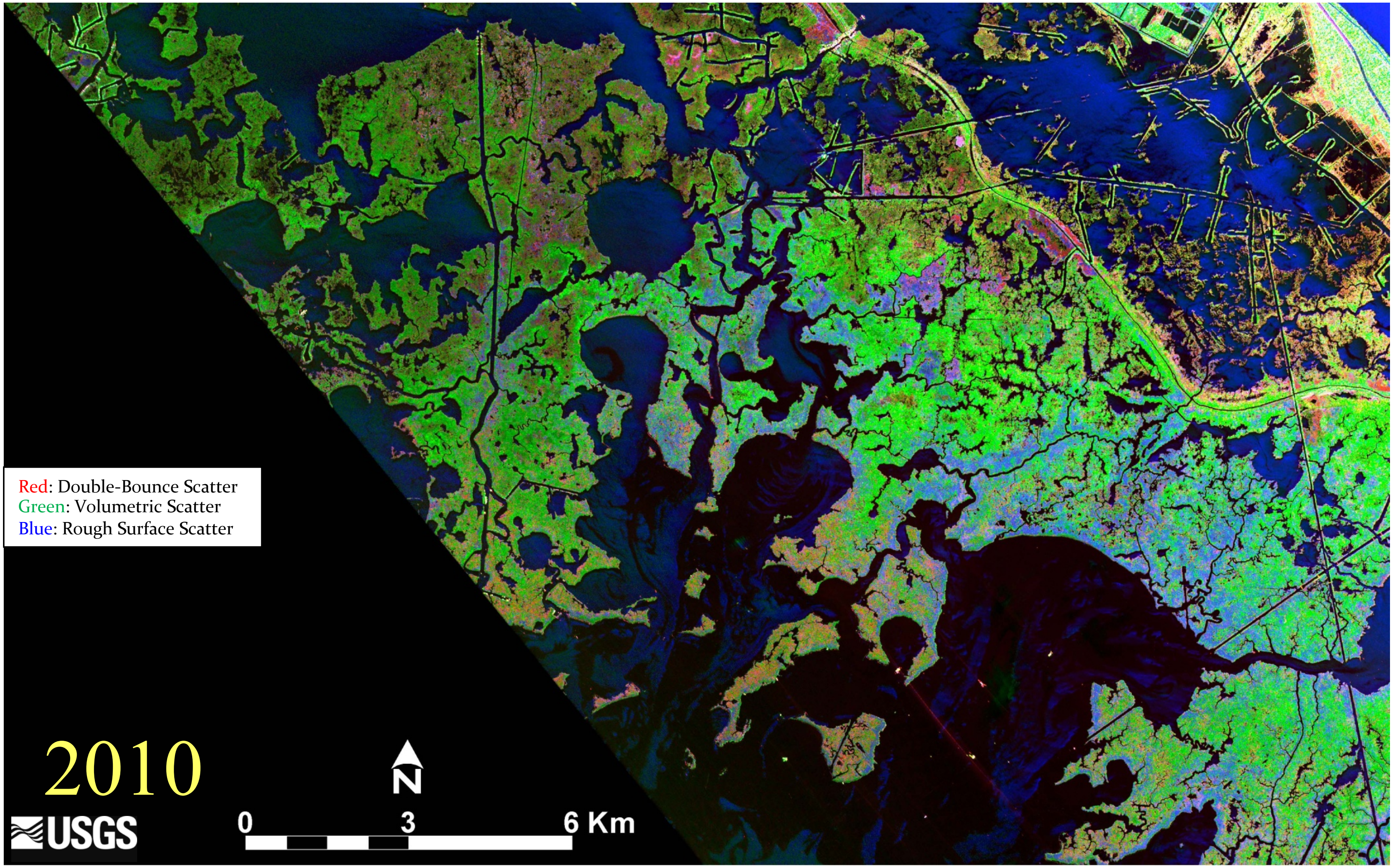
A. RANGOONWALA, T. BANNISTER, Z. CHI, E. RAMSEY



Map Projected and Multiple Dates

Freeman-Durden Decompositions 2009 to 2010

A. Rangoonwala, T. Bannister, Z. Chi, E. Ramsey



UAVSAR Gulf Oil Spill Campaign, 2010-2012:

- The combination of full polarization + low noise + high spatial resolution makes UAVSAR a unique instrument for oil spill monitoring.
- The low noise + full polarization reveals that L-band SAR can be used to characterize oil within a major slick, identifying areas with more oil (higher volumetric fraction).
- The high resolution + full polarization enables tracking of oil within coastal wetlands (land & water) and monitoring the oil on beaches and the integrity of containment booms.