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

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.
UAVSAR GULF OIL SPILL CAMPAIGN
22-23 JUNE 2010 DEPLOYMENT

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

- 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
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.

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°
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 $\rho$ with surface tension $\sigma$:

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

gravity is the restoring force

surface tension and inertia are the restoring forces

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 H2O 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).
OIL CHARACTERIZATION FOR DIRECTED RESPONSE VARIATIONS IN THE AVERAGED INTENSITY

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.


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.
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.

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]
SCAT Latest Ground Observations

- No Oil Observed
- Very Light Oiling
- Light Oiling
- Moderate oiling
- Heavy oiling

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

Barataria Bay, Louisiana:

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

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


**UAVSAR MultiLooked Intensity Images**

17 June 2009

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

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)

Study area includes multiple UAVSAR flight lines from June 2010, June 2011, and July 2012 and one repeat line from June 2009.

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

Red: Double-Bounce Scatter
Green: Volumetric Scatter
Blue: Rough Surface Scatter
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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.