REMOTE SENSING FOR COMPREHENSIVE MONITORING OF GULF OIL SPILLS

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ABSTRACT
The 2010 Deep water Horizon Oil Spill due to the explosion of the BP oil rig on April 20, 2010 resulted in the largest accidental oil spill in U.S. history. The oil spill poses an unprecedented threat to the ecology of Gulf of Mexico (GOM) and its adjacent wetlands, causing extensive damage to marine and wildlife habitats. However, the long-term outlook is difficult to predict, because the full extent of the impact has yet to be quantified. Specifically, its potential specific impact on the coastal wetlands remains largely unknown. To assess the full extent of the impact of the oil spill on Louisiana's coastal wetlands, it is critical to (1) comprehensively retrace the trajectory of the oil slick over GOM until it reaches the shoreline, (2) identify and classify the extent of the oil within the contaminated coastal ecological systems/wetlands, and (3) quantify water level changes in the wetlands to help determine which part of a plant has been exposed to the oil floating on water surface, and (4) investigate whether the oil spill event may lead to permanent loss of marshes.

SUMMARY

To detect oil slicks in the ocean, active microwave sensor Synthetic Aperture Radar
(SAR) has been used for decades [Gade et al., 1998; Topouzelis, 2008], and SAR is still the most efficient satellite sensor for oil spill detection although it does not have capabilities for oil spill thickness estimation and oil type recognition. More recently, the Moderate-Resolution Imaging Spectroradiometer (MODIS) instrument, carried onboard the NASA satellites Terra and Aqua, has also been used to detect and monitor oil spills in the ocean water, based not on the optical properties of oil slicks but on the same backscattering principles of SAR [Hu et al., 2009]. To track oil beyond the coastline and assess the vegetation stress, timely and high-resolution imageries are needed to yield information about the properties and extent of oil in wetlands. It has been shown that NASA's Uninhabitated Aerial Vehicle SAR (UAVSAR) polarimetric SAR (PolSAR) images can accurately track the extent of oil within coastal wetlands [Ramsey et al., 2011]. Moreover, NASA's Airborne Visible Infrared Imaging Spectrometer (AVIRIS) sensor has also been successfully used to detect vegetation stress due to oil spills [Li et al., 2005]. In addition, a multitude of airborne remote sensing equipment including full-waveform Near IR topographic Light Detection And Ranging (LiDAR), and hyperspectral imager operated by the NSF-funded National Center for Airborne Laser Mapping (NCALM) at University of Houston can deliver other independent high-resolution datasets. Measuring water level variations in wetlands using in situ gauges with adequate spatial resolution is cost-prohibitive. More generally, limited numbers of gauging stations results in poorly constrained estimates of water storage behaviors in wetlands. Forest cover and habitat type complicates the ability to use any single remote sensing platform or instrument for accurate water level reconstructions. New methodologies and protocols are needed that use multimodal remote sensing observations to improve our ability to monitor continuous water levels. Advances in satellite geodetic and remote sensing technology enable us to monitor surface water changes with relatively high spatial (~tens of meters) and temporal (weekly) resolutions. It has been shown that satellite radar altimetry can observe water level changes in Louisiana wetlands after

retracking of radar waveforms [Lee et al., 2009]. Interferometric SAR (InSAR) also has a demonstrated capability to observe spatially relative water level changes in vegetated wetlands with high spatial resolution (~40 m) [Alsdorf et al., 2000; Lu & Kwoun, 2008; Kim et al., 2009; Wdowinski et al., 2008].

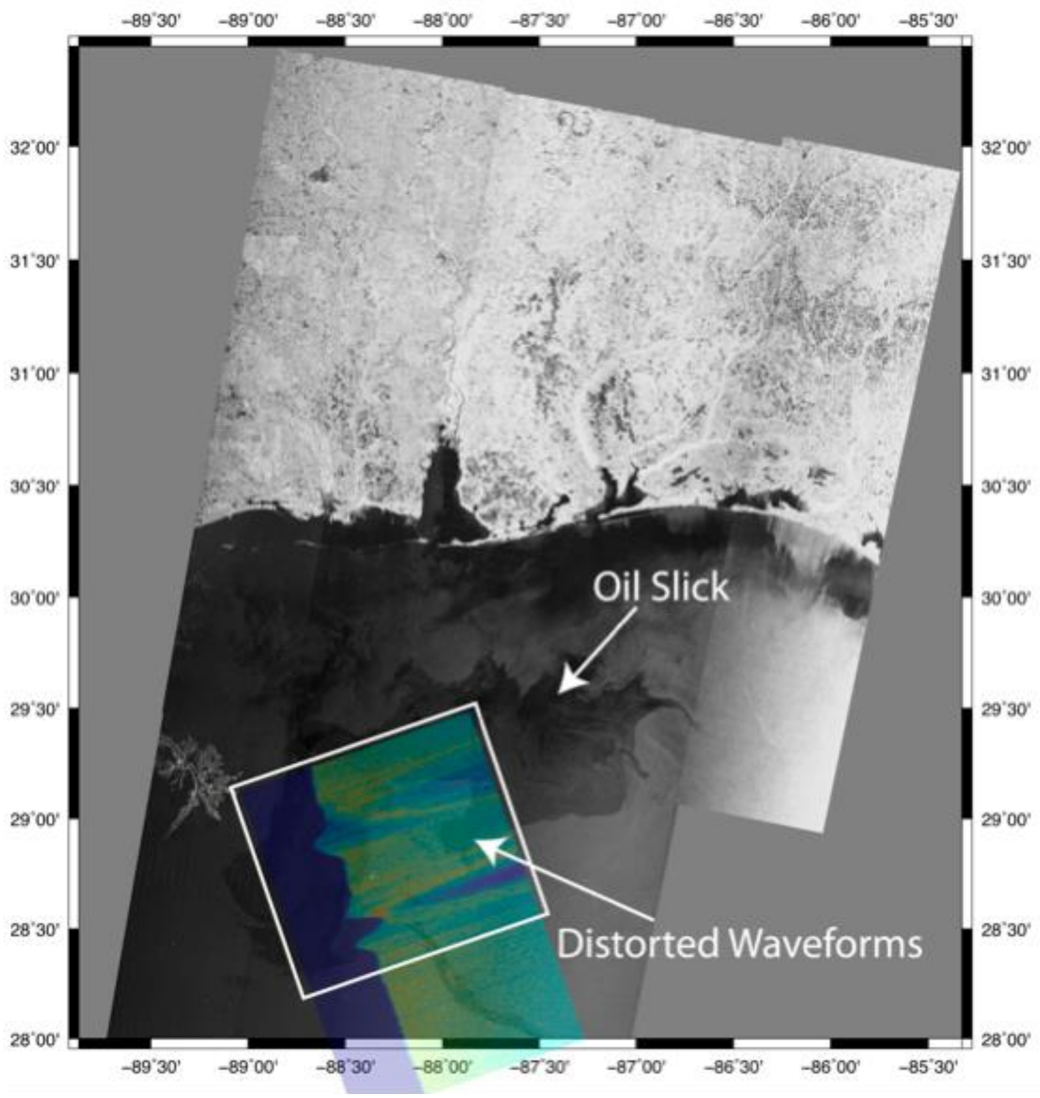

Figure 1. ALOS ScanSAR image (May 23, 2010) shows oil slicks with darker feature. Jason-2 satellite altimeter waveforms (May 24, 2010) also become distorted over the oil slick.

Our satellite-based monitoring system is to (1) classify the extent of oil spill and monitor/quantify its trajectory over the ocean surface using SAR, MODIS, and satellite radar altimeter waveform measurements and examine where oil has reached the Louisiana wetlands; (2) track oil extent and vegetation losses the coastal marshes of Louisiana using multiple ALOS PALSAR (46-day repeat) and Envisat ASAR (35-day repeat) imageries to provide spatially and temporally comprehensive maps of oil-affected wetland areas, which will be compared and augmented with the oil extent estimated from available existing airborne UAVSAR polarimetric measurements; (3) generate two-dimensional highresolution (~40 m) maps of absolute water level changes over the oilaffected wetlands by integrating InSAR and satellite radar altimeter measurements, and investigate which part of a plant is exposed to oil; (4) provide maps of potential permanent marsh losses due to the oil spill.

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