IMPACT OF HURRICANE ISAAC ON RECOVERY OF SALTMARSHES AFFECTED BY THE BP OIL SPILL

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INTRODUCTION

- Oil spills are a major threat to sensitive coastal ecosystems
- They cause vegetation stress leading to loss of plant cover and eventually, retreat of the coastal shoreline.
- In the Gulf of Mexico, home to extensive oil extraction & refining, there are other factors in addition to oil stress:
  - Hurricanes and tropical storms
  - Sea level rise due to climate change
  - Subsidence due to decline in sediment supply from the rivers
- Barataria Bay in the Mississippi Delta
  - April to July 2010, largest coastal oil spill in US history
  - August 2012, hurricane Isaac passed over the same region
- Hyperspectral remote sensing is capable of:
  - Mapping the oil spill extent & determining its impact
  - Monitoring recovery, or lack thereof, after the double impact of the spill and the hurricane

Question:

Did hurricane Isaac have an effect on the recovering saltmarshes, two years after Deep Water Horizon oil Spill?

METHODOLOGY

AVIRIS was flown over Barataria Bay on three dates.
Region analyzed was 100 Km^2

- September, 2010 – 3.5 x 3.5 m pixels
- August, 2011 – 7.8 x 7.8 m pixels
- October, 2012 – 3.3 x 3.3 m pixels

Image preprocessing & classification

- Atmospheric calibration using ACORN mode 1.5
- 2010 images georegistered using NAIP imagery & 2011, 2012 images coregistered to the 2010 images to sub-pixel accuracy
- Land-cover classification (water, soil, dry & green vegetation) using supervised decision trees
- Detection of oiled pixels (oiled soil and dry vegetation) using oil absorption bands at 1730 and 2300 nm

Data analysis

- Compared green vegetation and water along oiled and oil-free shorelines to determine if hurricane impact was more severe in previously oil-impacted regions
- Compared marsh areas with varying oil penetration to determine if the impact severity is an important predictor of recovery

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AVIRIS imagery was collected by NASA under the Terrestrial Ecology Program

RESULTS

OIL MAPPING & CLASSIFICATION

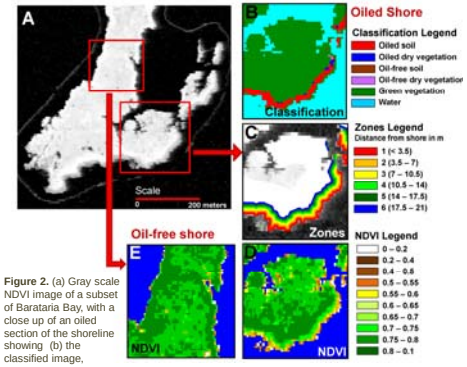

Figure 1. Location of Barataria Bay in the Mississippi Delta in the Gulf of Mexico, AVIRIS images of Barataria Bay depicted in color infrared bands with oiled shoreline shown in yellow.

Figure 2. (a) Gray scale NDVI image of a subset of Barataria Bay, with a close up of an oiled section of the shoreline showing (b) the classified image, (c) the zones as we move away from the shoreline, and (d) the NDVI image showing the low-NDVI band of pixels right next to the oiled shoreline. For comparison, (e) shows the NDVI profile for an oil-free section of the shoreline.

Classification of AVIRIS imagery:

- Successful, with 98% overall accuracy (Kappa = 0.97)
- Vegetation had recovered 1 year after oil spill

(Khanna et al. 2013 PlosONE)

OIL PENETRATION VS. RECOVERY

Figure 5. Snapshots of the location of four oiled sites along narrow island reaches with low, medium and high oil penetration into the marsh. Numbers represent oil penetration distance in meters to shore.

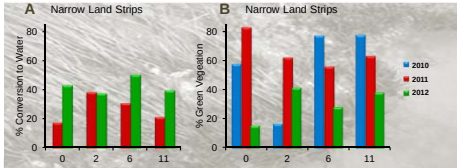

Figure 6. Percentage of area in the above four sites that A) was lost to open water and B) was green vegetation in 2011 and 2012 within 60m of the 2010 shoreline.

SALT MARSH EDGE RECESSION WITHIN ISLANDS

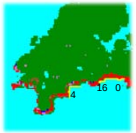

Figure 7. Snapshot of the location of three oiled sites along a single Island bank with low, medium and high oil penetration into the marsh.

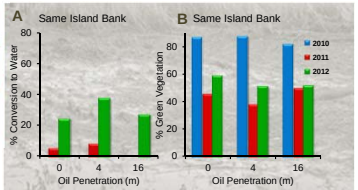

Figure 8. Percentage of area in the three sites to the left that A) was lost to open water and B) was green vegetation in 2011 and 2012 within 60m of the 2010 shoreline.

Saltmarsh edge recession:

- Significant both across and within the same island
- Larger rates of conversion to water in 2012 than in the previous years

OIL SPILL & HURRICANE IMPACTS

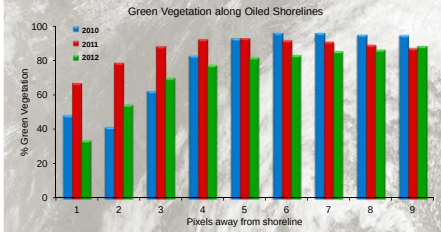

Table 1. Percent water pixels in the first 4 pixels (14 m) inland from the oiled vs. oil-free shores and in the first 2 pixels (7 m) inland from the two shores. More land was lost along oiled shores compared to oil-free shores.

	Oiled shoreline	Oil-free shoreline
First 4 pixels along shore	24.9	18.0
First 2 pixels along shore	34.7	27.1

Figure 3. The percent green vegetation in each zone increases as we move inland from the shoreline in all three years. While 2011 data shows recovery of the marsh after the oil spill, the 2012 data shows the die-back of marsh vegetation after the hurricane with higher impact closer to the shoreline.

Change detection analysis of all three image dates shows that:

- Green vegetation cover recovered in 2011 radiating inland from the shore with the pixels next to the shore recovering the least and pixels further inland, recovering completely
- The 2012 hurricane suppressed recovery causing greater loss of land along oiled shorelines than along oil-free shorelines (Chi-square p-value < 0.0001)

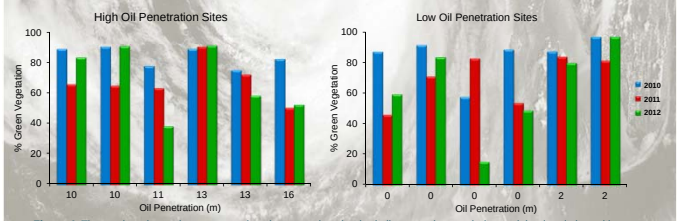

Figure 4. The two bar charts show a comparison between sites that had oil penetrating much deeper inland and sites with barely any oil penetration. There is no pattern or significant difference between these two groups of sites indicating that severity of impact did not influence recovery.

CONCLUSIONS

- Oil impact was apparent in the first four pixels (14 m) adjacent to the shore in September 2010.
- Recovery in August 2011 was robust but incomplete in the first three pixels (23.4 m) along the shore.
- Hurricane Isaac truncated recovery, and in many cases rolled it back, by October 2012. Loss of wetland to open water was significantly higher along oiled shorelines compared to oil-free shorelines, indicating that oil stress makes it more difficult for wetlands to withstand natural disasters like hurricanes.
- Location was greater determinant of impact/recovery than oil penetration into the marsh. Narrow island shores were especially vulnerable to land loss.

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