Coastal Marsh Monitoring for Persistent Saltwater Intrusion

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Background

- NASA Applied Sciences funded four investigation projects in support of the Gulf of Mexico Alliance (GOMA) Governor's Action Plan.
- Coastal Marsh Monitoring for Persistent Flooding and Saltwater Intrusion was one of the four investigation projects.

Background (cont'd)

- Coastal wetlands
  - are economically vital as fish and shellfish nurseries;
  - filter contaminated water flows; and
  - mitigate the impact of storm surge on life and property.
    - Scientists have estimated that every **3.8 to 4.3 miles of wetlands reduce storm surge by an average of one foot** (Louisiana Coastal Wetlands Conservation and Restoration Task Force 2006).

Background (cont'd)

- These wetlands are disappearing at the rate of more than **25 square miles a year**.
- Hurricanes Katrina and Rita destroyed an estimated 75,520 acres (**118 square miles**) of Louisiana coastal marshes either by shear or by flooding.[1]
- Saline floodwaters from storm surge persisted for weeks and months after the storms.

[1]Barras, John A. 2006. *Land Area Change in Coastal Louisiana After the 2005 Hurricanes—A Series of Three Maps.* U.S. Geological Survey Open-File Report 06-1274

GOMA Priority Issue

- Coastal Community Resilience (R-2) priority issue:

To increase the safety of Gulf communities by better understanding risks of localized sea level rise, storm surge, and subsidence.

Resilience Action Items

- Specific action items relating to this task are as follows:
  - R2-A2: Obtain information on projected relative sea level rise, subsidence, and storm vulnerability to help prioritize conservation projects, including restoration, enhancement, and acquisition.

Resilience Action Items

– R2-A3 (most relevant): Develop and apply ecosystem models to forecast the habitat structure and succession following hurricane disturbance and changes in ecological functions and services that impact vital socio-economic aspects of coastal systems.

Resilience Action Items

– R2-A4: Develop a management tool that enhances resiliency of Gulf Coast communities to storm surge and flooding through improved data, models, tools, and methodologies for at least one pilot study area in the Gulf region, including the Pensacola, Florida area.

Saltwater Flooding

- Saltwater flooding of coastal marshes is a primary cause of wetland deterioration and habitat loss.
- Factors contributing to saltwater flooding include:
  - Storm surge,
  - Rising sea level, and
  - Subsidence.

Objectives

- Our objective is to provide resource managers with remote sensing products that support ecosystem forecasting models requiring salinity and inundation data.
- Specifically, the proposed work supports the habitat-switching modules in the Coastal Louisiana Ecosystem Assessment and Restoration (CLEAR) model, which provides scientific evaluation for restoration management.[2]

[2] Twilley, R.R., ed. 2003. *Coastal Louisiana Ecosystem Assessment and Restoration (CLEAR) Model of Louisiana Coastal Area (LCA) Comprehensive Ecosystem Restoration Plan - Volume I: Tasks 1-8.* Final Report to Department of Natural Resources. Baton Rouge, LA.

CLEAR

- The CLEAR Model is a coastal-ecosystem forecasting system designed to link modeling, monitoring, and data management.[3,4]
- CLEAR is a collaborative effort between the Louisiana Board of Regents, Louisiana Department of Natural Resources, U.S. Geological Survey, and the U.S. Army Corps of Engineers.

[3]Twilley, R.R., ed. 2003. *Coastal Louisiana Ecosystem Assessment and Restoration (CLEAR) Model of Louisiana Coastal Area (LCA) Comprehensive Ecosystem Restoration Plan - Volume I: Tasks 1-8*. Final Report to Department of Natural Resources. Baton Rouge, LA.
[4]Twilley, R.R., B.R .Couvillion, I. Hossain, C. Kaiser, A.B. Owens, G.D. Steyer, and J.M. Visser. 2008. Coastal Louisiana Ecosystem Assessment and Restoration Program: The role of ecosystem forecasting in evaluating restoration planning in the Mississippi River Deltaic Plain. American Fisheries Society Symposium 64:29-46.

Habitat Switching Module

- The habitat-switching module
  - simulates shifts in vegetative community type given long-term shifts in salinity and inundation due to restoration projects.[5]
  - uses salinity and inundation output from a hydrodynamic model to predict changes in habitat type under different restoration alternatives.

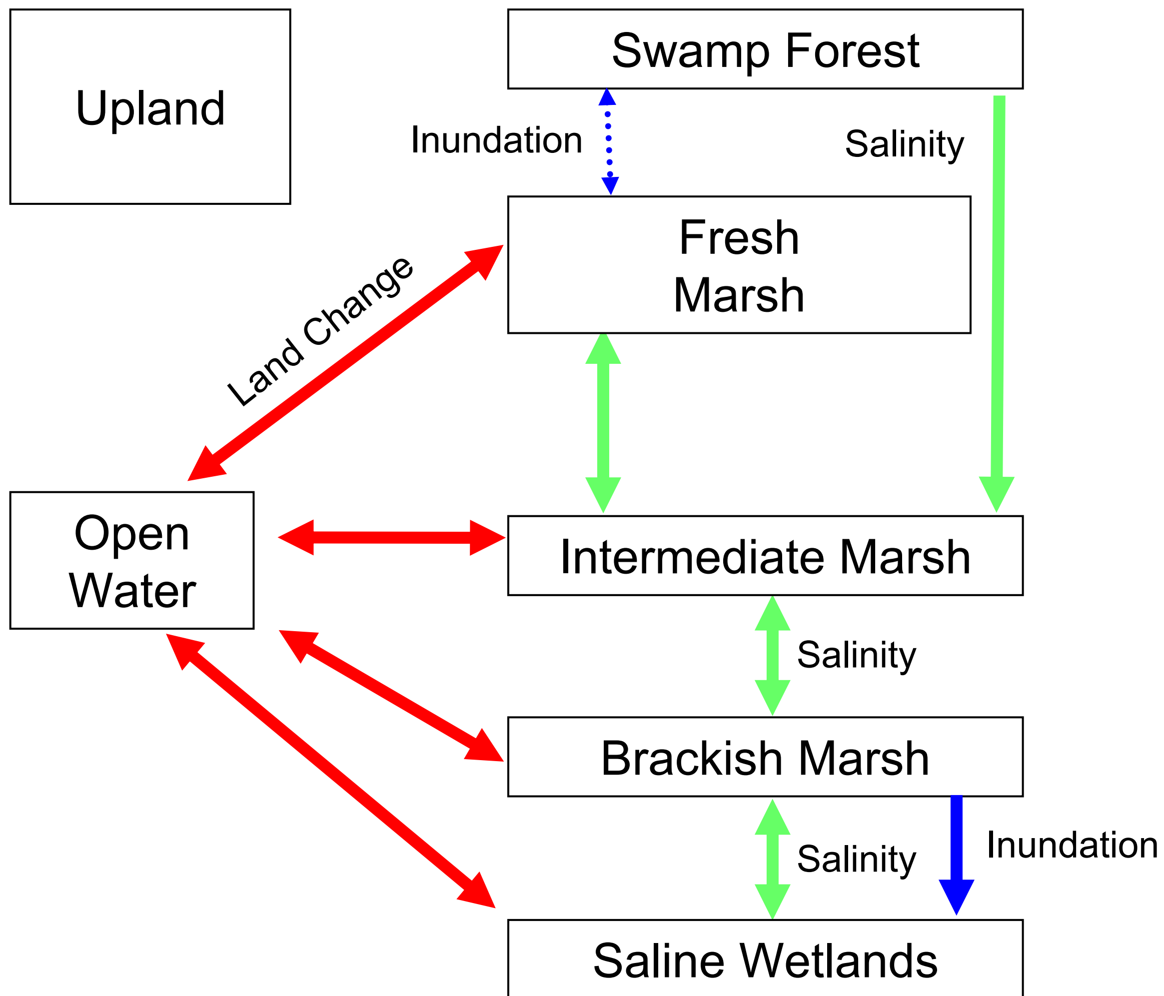
[5]Visser, J.M., C. Kaiser, and A.B. Owens. 2008. Forecasting 50 years of habitat switching in coastal Louisiana: No increased action & preliminary draft master plan, Vol. IV, Chapter 4. In: *Coastal Louisiana Ecosystem Assessment & Restoration (CLEAR) Program: A Tool to Support Coastal Restoration* (R.R. Twilley, ed.), Baton Rouge.

Habitat Switching:
Habitat Change Forcing Functions

- Salinity*
- Inundation*
- Buoyancy of substrate / Soil type
- Grazing
- Fire
- Nutrient levels

From Dr. Jenneke Visser: CLEAR Desktop Modules, Presentation to DNR 2006

Habitat Switching Algorithm



From Dr. Jenneke Visser: CLEAR Desktop Model, Presentation to DNR 2006

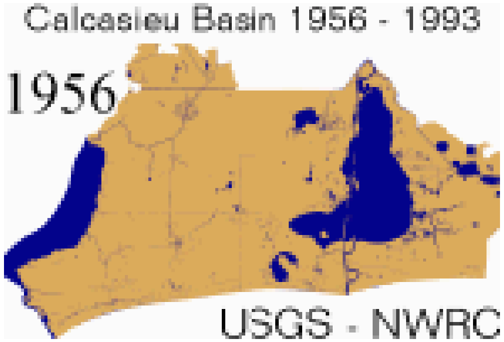
Switcher Thresholds

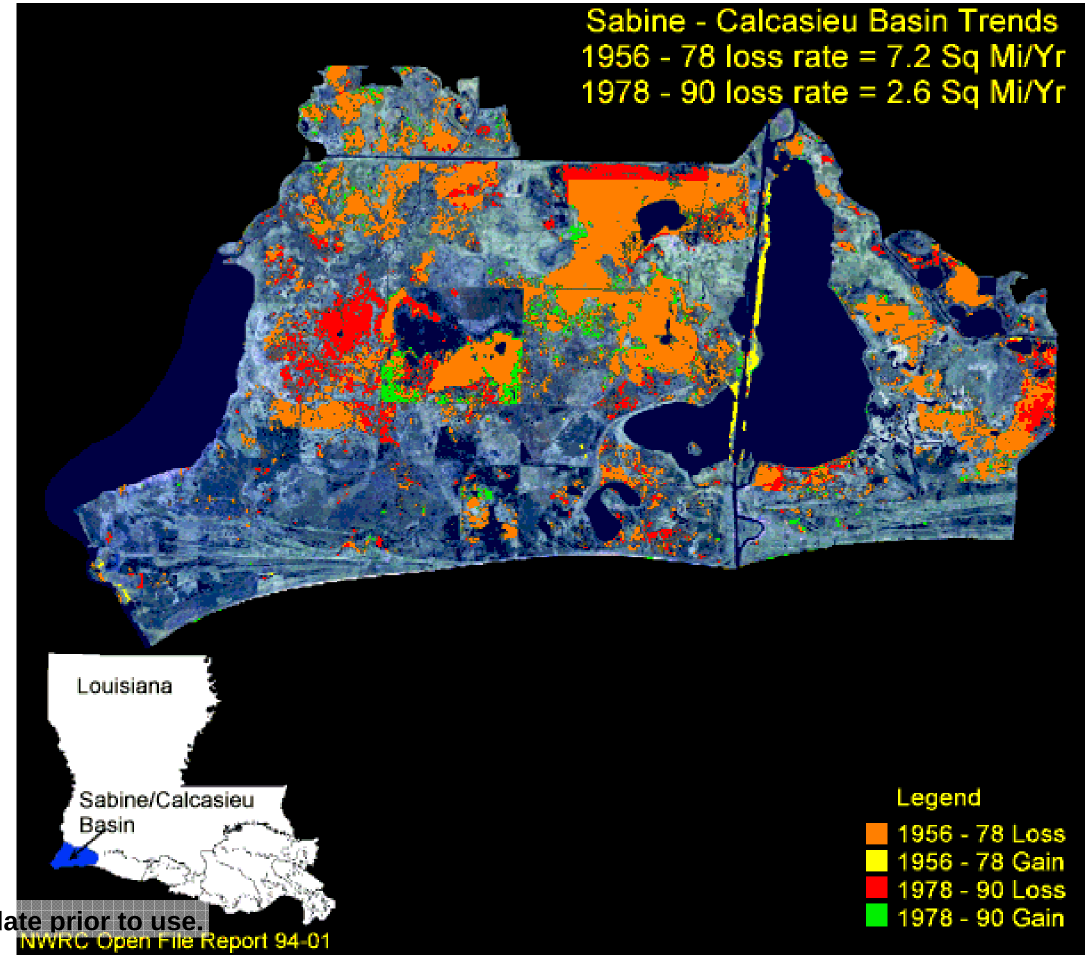
	Year 5 Habitat					
Year 0 Habitat	**Upland**	**Swamp forest**	**Fresh marsh**	**Intermediate marsh**	**Brackish marsh**	**Saline marsh**
Upland	Always					
Swamp forest		≤ 4 ppt and flooding < 100%	≤ 4 ppt and flooding = 100%	> 4 ppt		
Fresh marsh			≤ 2.5 ppt	> 2.5 ppt		
Intermediate marsh			≤ 1 ppt	1-6 ppt	>6 ppt	
Brackish marsh				≤ 6 ppt	6-15 ppt and flooding <64%	6-15 ppt and flooding >64% or >15 ppt
Saline marsh					<15 ppt and flooding <64%	>15 ppt or flooding >64%

Based on average annual salinities of each habitat. Note that little to no information exists where sites were monitored through a switch in habitat type.

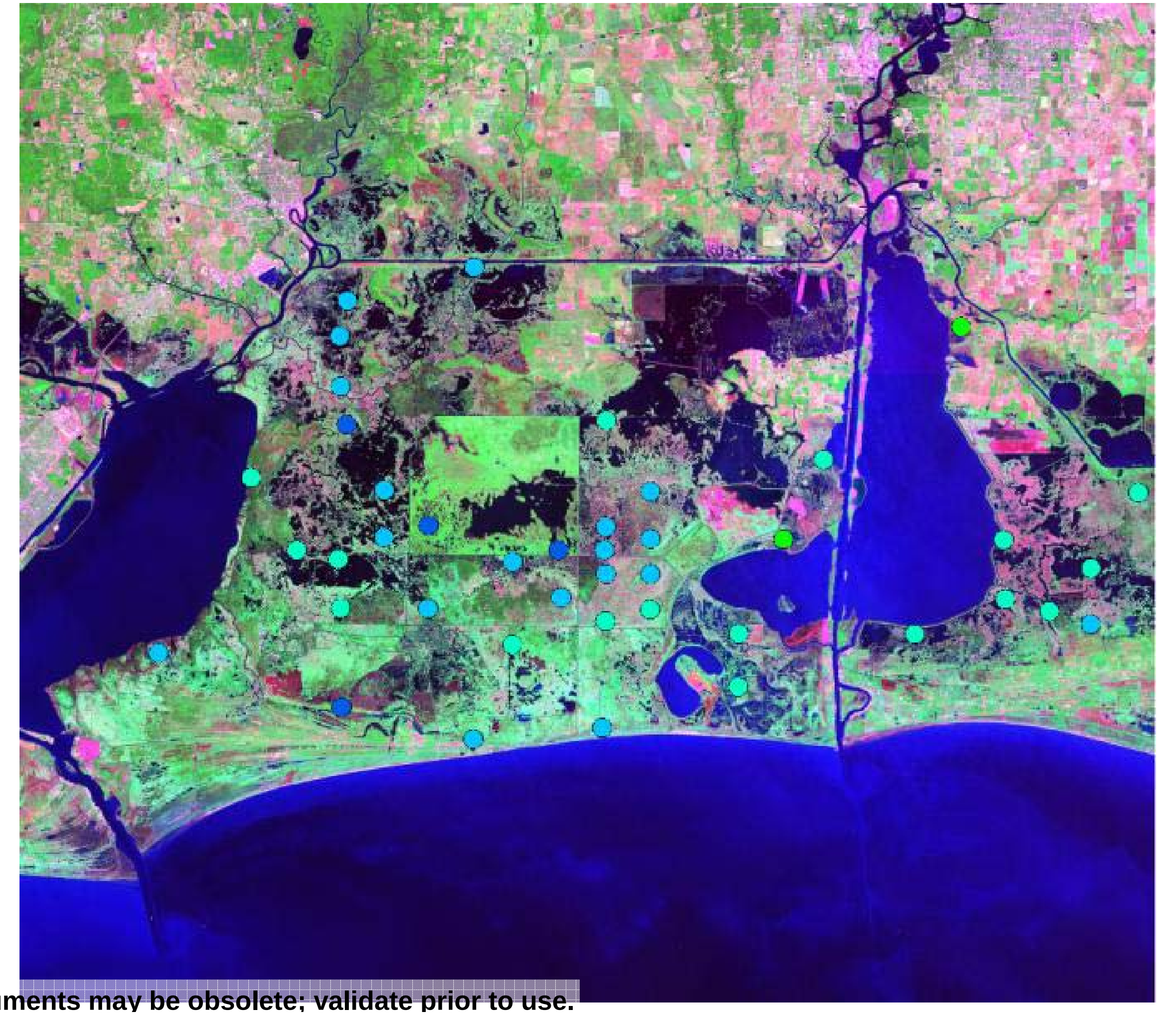
From Dr. Jenneke Visser: CLEAR Desktop Modules, Presentation to DNR 2006

Sabine-Calcasieu Basin Study Area

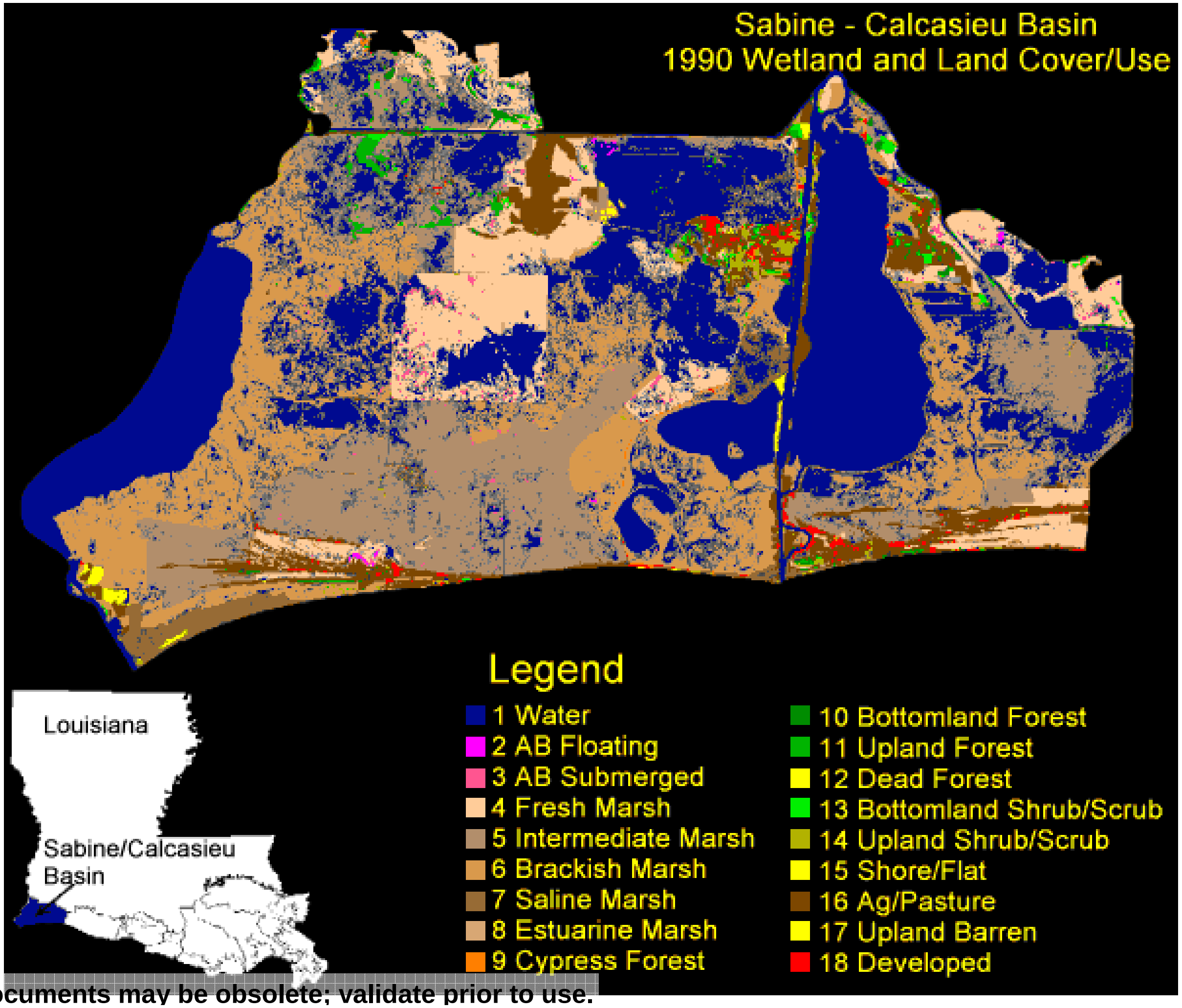




CRMS Monitoring Sites

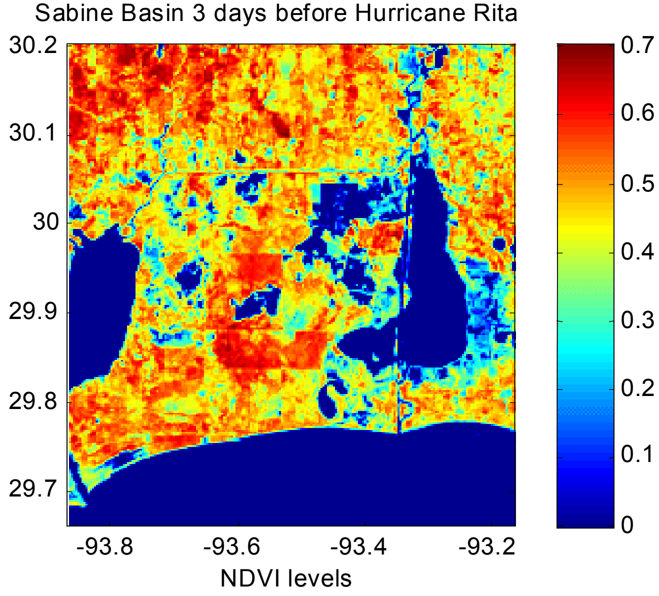


Wetland Habitats

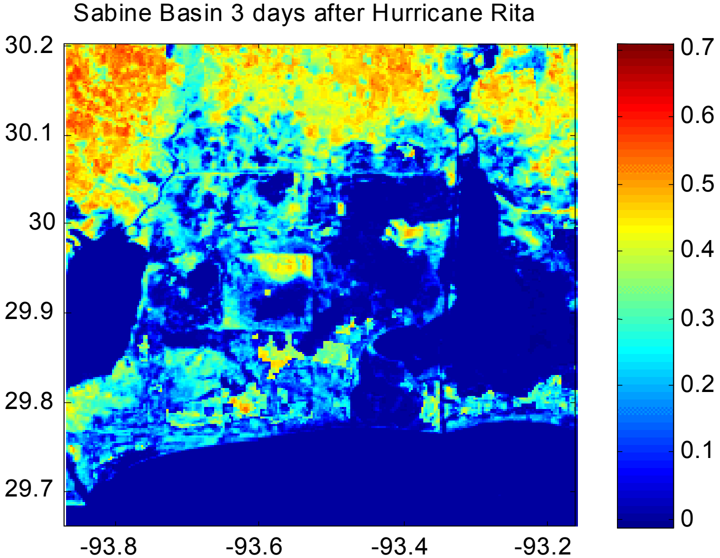


NDVI

3 days before Hurricane Rita



3 days after Hurricane Rita

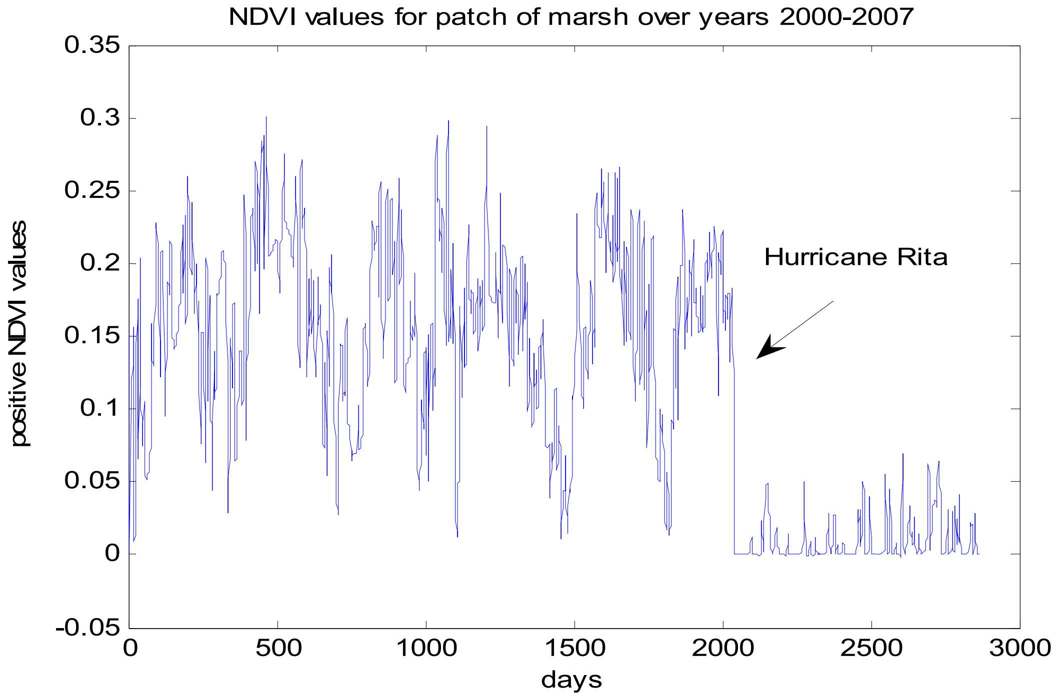


Normalized Difference Vegetation Index (NDVI) for Sabine Basin

Time Series Product Tool

- NASA SSC developed the Time Series Product Tool (TSPT) to derive daily NDVI values from the Moderate Resolution Imaging Spectroradiometer (MODIS) Aqua/Terra satellite data.
- NDVI time series were developed daily for years 2000-2007.

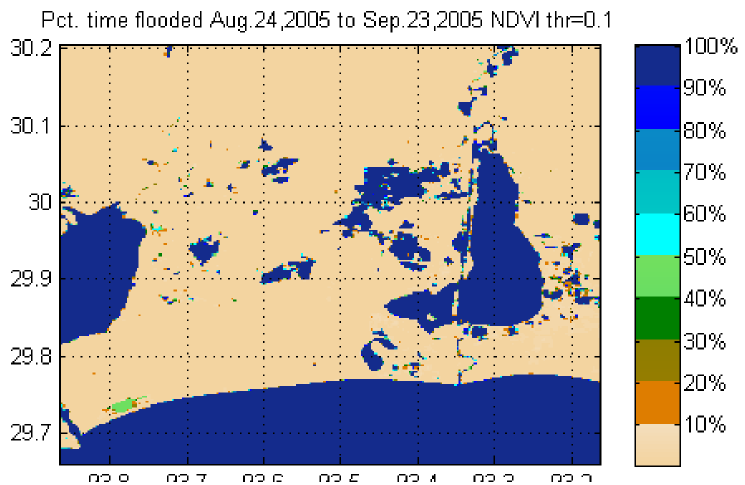
NDVI Time Series

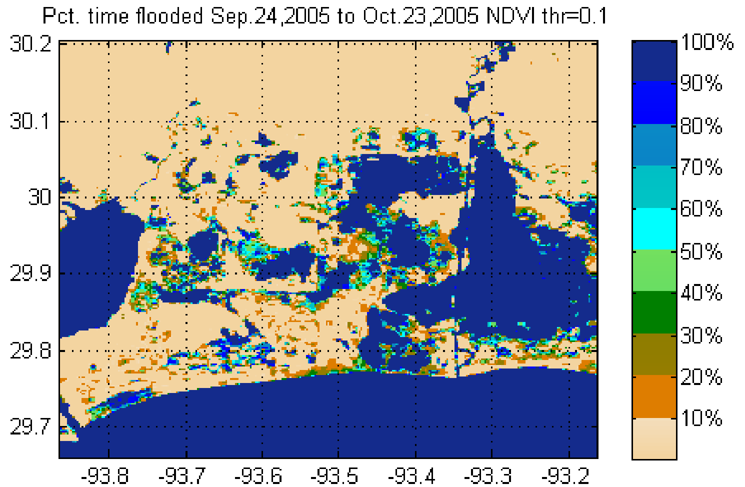


NDVI time series (2000-2007) for area of marsh between Lake Calcasieu and Mud Lake. Immediate results of flooding and lack of recovery are seen in NDVI values succeeding Hurricane Rita in 2005. (Note: negative values of NDVI are set to 0; days numbered from Feb. 24, 2000, to Dec. 31, 2007.)

Sabine Basin Flooding Before and After Hurricane Rita

- Percent flooding derived from MODIS NDVI time series with NASA TSPT
- Maps shows the amount of time (on percentage basis) that an area was flooded before and after Hurricane Rita (September 23, 2005)





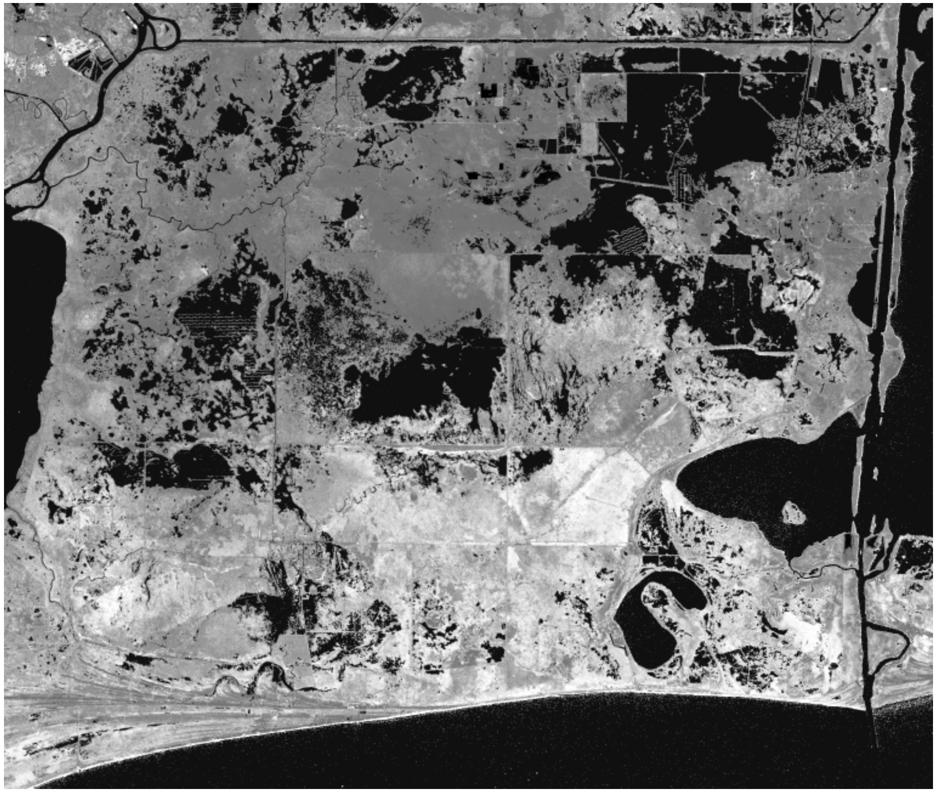
Top: Flooding during the month prior to Hurricane Rita.

Bottom: Flooding during the month following Hurricane Rita.

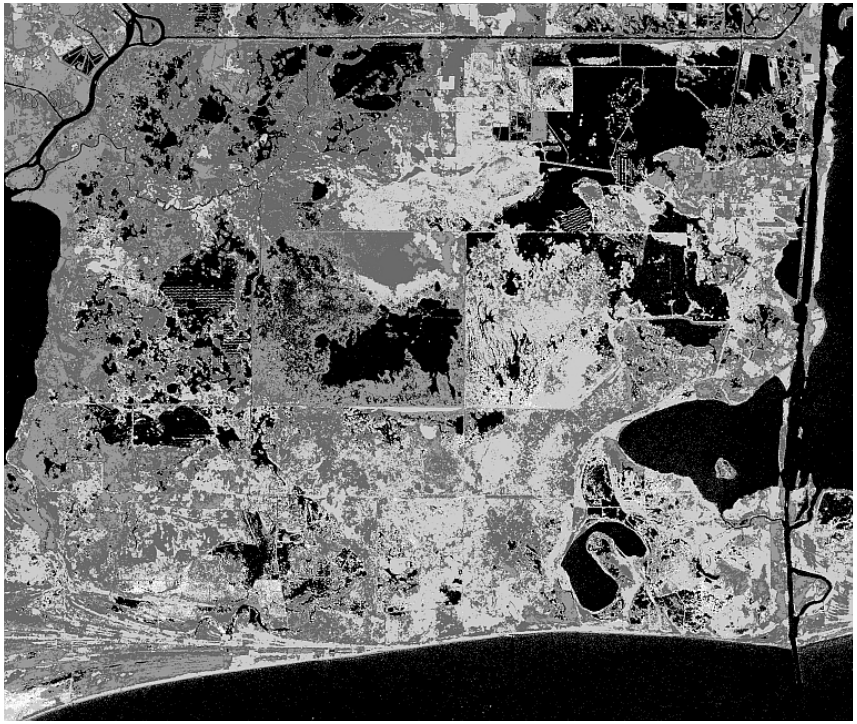
Soil Porewater Salinity Estimates from Landsat

Porewater salinity maps for Sabine Basin 2005; estimates made from Landsat 7 (10/31/2005) using Multiple Regression, result r2 =0.78

Salinities range from 0-30 ppt where brighter areas indicate higher salinity



Soil Porewater Salinity Estimates from Landsat



Porewater salinity maps for Sabine Basin 2005; estimates made from Landsat 7 (10/31/2005) using Neural net, rms=0.09

Salinities range from 0-18 ppt where brighter areas indicate higher salinity

Follow-on Work

- Validation with CRMS data.
- Fusion of salinity and inundation maps to produce maps of saltwater stress and inundation.
- Incorporation of results with Habitat Switching Thresholds to map habitats threatened by flooding and salinity stress.

Questions?