National Aeronautics and Space Administration

Gulf of Mexico Initiative

Final Report 2015

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FOREWORD

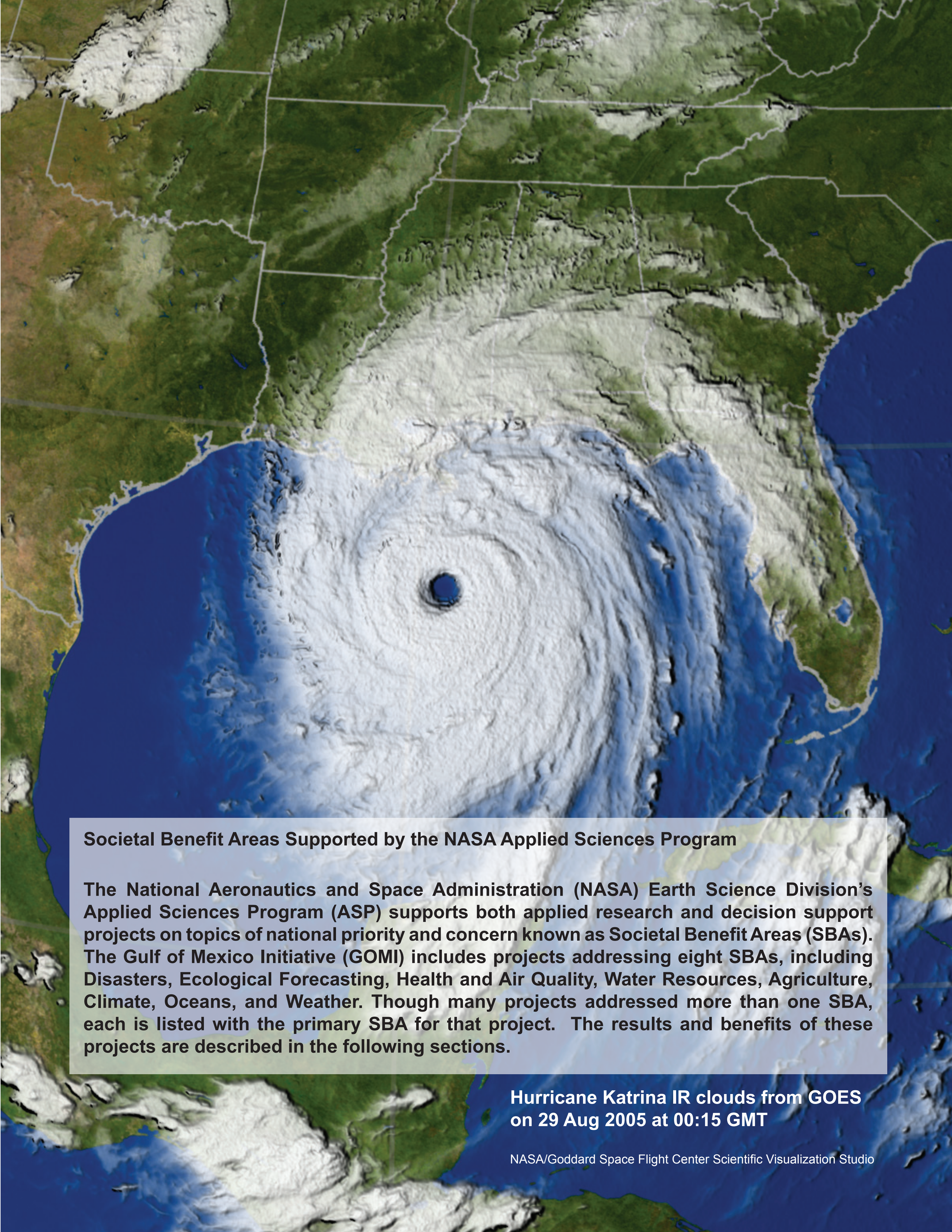
In 2005, large portions of the Gulf of Mexico were utterly devastated by Hurricanes Katrina and Rita. Many people were killed. The natural resources and habitats that provided livelihood, protection from storms, and recreational opportunities were washed away. Roads, bridges, water and sewer systems were destroyed. Life in the poorest region of the United States became much more difficult.

Two years later the region was still struggling. In 2007, the National Aeronautics and Space Administration (NASA) created the Gulf of Mexico Initiative (GOMI) to help the region recover and to prepare for the next disaster. The John C. Stennis Space Center, the Gulf of Mexico Alliance and the Mississippi-Alabama Sea Grant program held meetings in each of the Gulf Coast states to document the high-priority issues of the states, communities and businesses. In 2008, NASA issued a Request for Proposals (RFP) to address the important issues identified by the states that could be addressed with NASA assets. Thirty-five projects were funded that focused on topics such as water quality and management, ecological monitoring and forecasting, oceans, disaster management, and public health. In 2009, NASA issued another RFP to address topics of interest to the Applied Sciences Program that were also relevant to the Gulf Coast region. Thirteen projects were funded that primarily focused on topics such as climate and weather.

Over 200 people from across the country worked on these 48 projects. They created new algorithms, processes, models and tools that helped resource managers, policy makers, businesses and government agencies understand their environment, serve their constituents, plan for the future, and respond to crises. Members of these teams played critical roles in responding to other disasters such as the Deepwater Horizon oil spill and the Fukushima tsunami. The GOMI projects advanced the state-of-the-art in Earth science and resulted in successes such as the conservation and restoration of critical habitats, better estimates of the impact of droughts, safer flights over the Gulf of Mexico, and cost savings for state and local agencies – just to name a few.

The remainder of this report provides detailed information on the 48 projects that comprised NASA's Gulf of Mexico Initiative – the problems they addressed, the teams that worked on them, and the results of their efforts. The capabilities developed may also address other problems of interest to you. If so, please contact Stennis Space Center.

Duane Armstrong
Chief, Applied Science & Technology Projects
NASA, Stennis Space Center



Societal Benefit Areas Supported by the NASA Applied Sciences Program

The National Aeronautics and Space Administration (NASA) Earth Science Division's Applied Sciences Program (ASP) supports both applied research and decision support projects on topics of national priority and concern known as Societal Benefit Areas (SBAs). The Gulf of Mexico Initiative (GOMI) includes projects addressing eight SBAs, including Disasters, Ecological Forecasting, Health and Air Quality, Water Resources, Agriculture, Climate, Oceans, and Weather. Though many projects addressed more than one SBA, each is listed with the primary SBA for that project. The results and benefits of these projects are described in the following sections.

Hurricane Katrina IR clouds from GOES on 29 Aug 2005 at 00:15 GMT

NASA/Goddard Space Flight Center Scientific Visualization Studio

DISASTERS

The Disasters SBA promotes the use of Earth observations in detecting, forecasting, mitigating, and responding to natural and man-made disasters. Eleven GOMI projects developed and demonstrated new capabilities for disaster risk assessment, mitigation, response and damage assessment. These projects addressed topics as diverse as storm surge, fire risk, levee failures and evacuation planning. The tools and techniques created by these projects have been used to respond to other disasters such as the Deepwater Horizon oil spill and the Fukushima tsunami. This section summarizes the accomplishments of those teams.

Projects

An Analysis of Storm Surge Attenuation by Wetlands Using USGS, FEMA, and NASA Data

Coastal Fire Assessment in the Northern Gulf Coast

Subsidence and Land Loss in Southern Louisiana

Evaluation of Hurricane Evacuation Routes Resiliency to Storm Damage

Improved Levy Management via Remote Sensing

Improving Post-Hurricane Katrina Forest Management with MODIS Time Series Products

Gulf Coast Subsidence: Insight for Decision Makers from InSAR, Geodesy and Geophysical Modeling

Establishing a Prototype Decision Support Tool Using NASA and other Data for the Gulf of Mexico Alliance (GOMA)

Evaluation of Hurricane Evacuation Routes Resiliency to Storm Damage

Establishing the Application of High Resolution Satellite Imagery to Improve Coastal and Estuarine Models

Oil Slick Detection Using NASA Active and Passive Sensors

New Orleans after levy breaks from Hurricane Katrina. August 2005

PI: Pat Fitzpatrick, Geosystems Research Institute, Mississippi State University			
Partners: NASA Marshall Space Flight Center; Northern Gulf Institute; Universities Space Research Association			
Users: National Oceanographic and Atmospheric Administration; Federal Emergency Management Agency			
RFP: 2008 ROSES A.28			
ARL Start	**4**	**ARL End**	**4**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

The storm surge of Hurricane Katrina (2005) caused extensive catastrophic flooding and major levee breaches in New Orleans, Louisiana (see Figure 1). Some have postulated that the loss of the state's wetland "buffer" due to erosion enhanced the surge. Wave setup contributions to the surge are often augmented due to wetland loss. Wetlands attenuate wave energy, particularly the longer period energy that contributes the most to run-up and wave overtopping on levees.

Figure 1 - Storm surge related flooding to New Orleans, Louisiana from Hurricane Katrina (Source: NOAA).

In response, this project was conducted, addressing the Gulf of Mexico Alliance (GOMA) priority issue of coastal habitat conservation and restoration, utilizing storm surge and wetlands data from the United States Geological Survey (USGS), the Federal Emergency Management Administration (FEMA), and the National Aeronautic and Space Administration (NASA). It also pertains to the priority issue of Coastal Community Resilience, which aims to "Increase the safety of Gulf communities by better understanding the risks of localized sea level wise, storm surge, and subsidence."

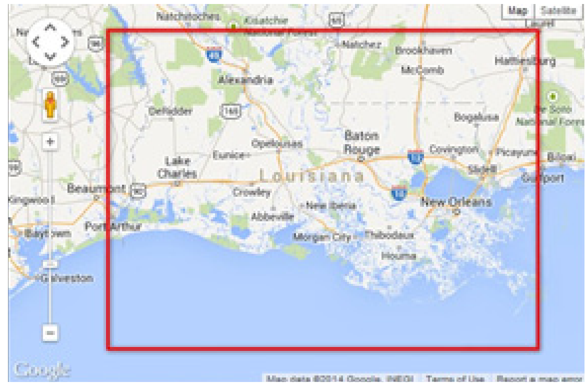


Figure 2 - Study area location. (Source: Google Maps).

Methods

A Hurricane Rita USGS monitoring network dataset (Figure 3), consisting of forty-seven sites with measurements every 30 days, was examined. This was accomplished by analyzing the loss of intensity of storm surge events in the Louisiana wetlands using storm surge datasets from the USGS, FEMA, and NASA. The project team examined radar data for heavy rain signal contamination, (i.e. light reflectivity). Project researchers obtained and examined topography data for this region, which combined Light Detection and Ranging (LiDAR) and USGS digital elevation model (DEM) data. The loss of surge intensity as a function of distance inland was analyzed, followed by correlations between vegetation type, density, and height for several classification schemes. Multivariate relationships were also examined using stepwise multiple regression and parallel coordinate graphical techniques.

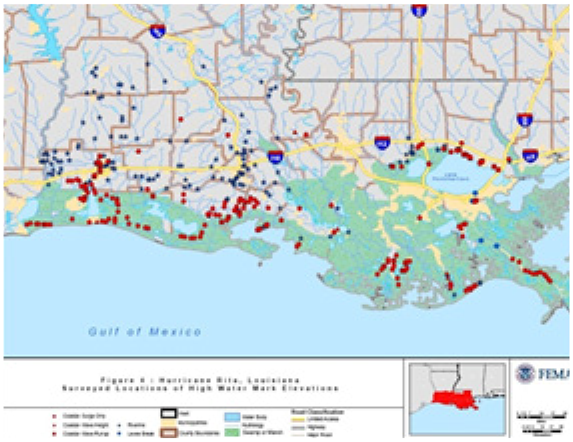


Figure 3 - Hurricane Rita high water mark data utilized during project (Source: FEMA).

An analysis was performed using Hurricane Georges data, using NASA's Advanced Microwave Precipitation Radiometer (AMPR) data as an input to storm surge estimation (Figure 4). The AMPR examination was used as an aid to compliment other Louisiana storm surge analysis. This involved examining radar data for heavy rain signal contamination, but most reflectivities were discovered at less than 25 decibel relative to Z (dBz). The AMPR 10.7 Gigahertz (GHz) channel was found to be relatively insensitive to light rainfall. Due to this insensitivity, this information could be used to help detect initial surges.

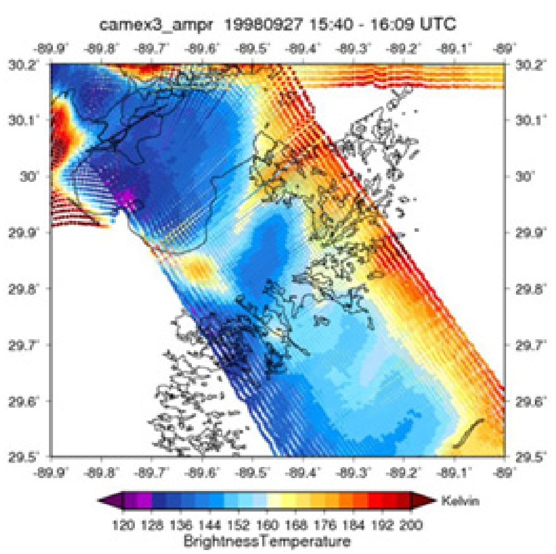


Figure 4 - AMPR brightness temperature data set from 9/27/1998 (1 day prior to Hurricane Georges landfall in Mississippi) that was examined as part of the project.

Results

One result of this research project was the eye-opening realization that the Louisiana coastline experiences three feet relative sea level rise per century. In regards to Hurricane Rita's landfall along the southwestern Louisiana and southeastern Texas coasts, analysis of the storm surge simulations suggested a two feet reduction in surge every three miles of wetlands (Figure 5), which is twice as much as other research suggests. However, near levee systems where water becomes trapped and reaches equilibrium, wetland erosion does not reduce the surge. Results from reviewing Rita data also indicated that the buffer impact decreases further inland than originally anticipated. The shortest period waves tend to be damped the most, and this effect increases as one goes inland. The results also indicated elevation was found to be 40% less influential than dissipative effects. This indicates a greater impact of subsidence than earlier believed.

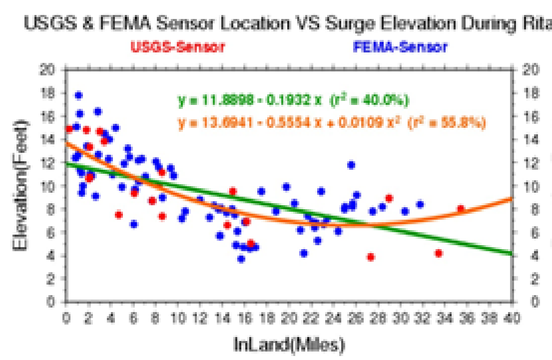


Figure 5 - Level of storm surge from USGS and FEMA data compared to distance to land.

This project's results showed the potential for detecting initial indications of storm surge as a hurricane approaches, utilizing data on ocean waves, sea surface temperature (SST), heavy rainfall, and the size of the land. This new capability for detecting storm surge intensity and location greatly increased the understanding the effects on storm surge and subsidence by the presence of wetlands and arms FEMA and NOAA with a new tool to manage their disaster mitigations, which include evacuation route planning as well as post-disaster recovery.

PI: William H. Cooke III, Geosystems Research Institute, Mississippi State University			
Partners: US Forest Service, Fire Sciences Laboratory; US Fish and Wildlife Service; Mississippi Forestry Commission			
Users: US Forest Service; federal, regional, state, and local fire managers			
RFP: 2008 ROSES A.28			
ARL Start	**3**	**ARL End**	**4**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

Most wildfires in the state of Mississippi over the past two decades occurred in the southern coastal region. The frequency of wildfires in this particular region threatens ecosystem stability and coastal resilience to natural or human-induced disasters. Post-hurricane re-settlement of people from coastal areas into adjacent, mostly ‘wildland’ areas increases the risk of wildfire due to an increase in the number of ‘built’ structures. In addition, an increased human presence in these areas may conflict with effective use of controlled burn to manage forests and reduce the amount of dried undergrowth.

Figure 1 – Study area location. (Source: Google Maps)

In response to these increased risks, this project was conducted to enhance the Wildland Fire Assessment System, or “WFAS” (see Figure 2) developed by the United States Department of Agriculture (USDA) and the United States Forest Service (USFS), by integrating information from NASA satellites, numerical models and research results into a new tool, the Eastern Fire Potential Model (EFPM), which will emphasize the coastal environments of the Gulf of Mexico (Figure 1). These enhancements are relevant to Gulf of Mexico Alliance (GOMA) priority issues of water quality and coastal community resilience and the Disaster Societal Benefit Area of NASA’s Applied Sciences program.

Figure 2 - Example WFAS fire danger (i.e. potential) map that project aimed to improve, particularly for coastal areas in the southern U.S.

Methods

The project team worked to: 1) verify the effectiveness of EFPM to meet operational requirements; quantify improvements in the performance of EFPM; 2) characterize risks and uncertainties in the process; transition our research toward operations at the USFS Fire, Fuel, and Smoke Science Program; and 3) document improvements in decision making processes and socio-economic benefits. The USDA used a map from Bailey’s Eco-regions and Subregions of the United States map (at the province level), and a dataset of wildfire on federal wilderness areas from 1980 to 2010 to produce a severity of fire regime value for each province by four different measures: fire frequency, percent area burned, average fire size, and median fire size. Detection rates were examined in Cameron Parish, Louisiana and in Mississippi’s coastal counties where federally collected fire data existed. Buffers, based on the fire’s size, were created around the federal data set and then compared to the Moderate Resolution Imaging Spectroradiometer (MODIS) dataset for validation.

Figure 3 - Example of impacts posed by wildfire to coastal lands in the southern United States.

Relationships between normalized fire potential and the probability of at least one fire occurring during the following five consecutive days were evaluated across the state of Mississippi's coastal plain. There was consistency between observed and logistic model-fitted fire probabilities over the study area during both fire seasons.

MODIS and the Advanced Very High Resolution Radiometer (AVHRR) Normalized Difference Vegetation Index (NDVI) were effectively used as inputs in estimating fuels components to EFPM.

The project team computed and tested three indices to simulate changes in the spatio-temporal wildfire probability: 1) Accumulated difference between daily precipitation and potential evapo-transpiration; 2) Land Information System (LIS) simulated moisture content of the top 10 centimeters (cm) of soil; and 3) the Keetch-Byram Drought Index (KBDI).

Results

The fire potential indices based on the top 10 cm soil moisture and KBDI showed the largest impact on wildfire odds, increasing it by almost 2 times in response to each unit change of the corresponding fire potential index from January – mid-June period and by ~1.5 times from mid-September-December. These results suggest that soil moisture-based fire potential indices are good indicators of fire occurrence probability across this region. To predict local effects, such as the effects of traffic volume and roads, a new model was developed to enhance the 'gravity' model Use of this enhanced model, derived from Newton's law of gravity, resulted in predicting high population and vegetation interaction inside and around the cities reviewed, in the regions where cities are in close proximity, and are aligned along the major highways (Figure 4).

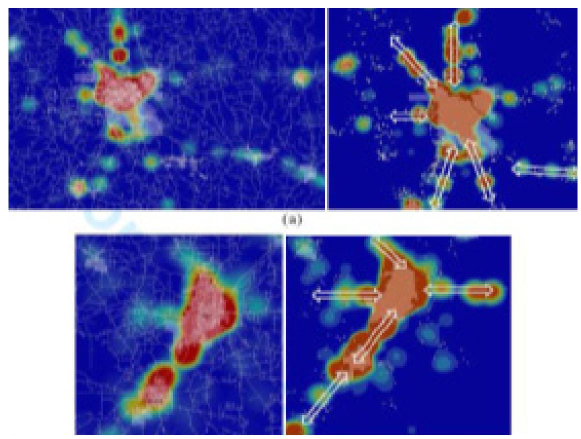


Figure 4 –Traffic volume and primary/secondary roads by road density for Hattiesburg (top) and Laurel (bottom), Mississippi.

Post-hurricane re-settlement of people from coastal areas exposed an increase in wildfire risk that had not been anticipated. Research methodologies used during this project, using existing assets and found to be compatible with planned tools for collecting data on vegetation, soil moisture, and precipitation, showed great promise for improving end-user fire management and planning activities.

PI: Tim Dixon, University of Miami			
Partners: Louisiana Department of Transportation and Development; Sejong University South Korea; University of Miami			
Users: US Army Corps of Engineers			
RFP: 2008 ROSES A.28			
ARL Start	**1**	**ARL End**	**3**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

Coastal Louisiana is an area plagued by both subsidence and frequent flooding, such as New Orleans, Louisiana after Hurricane Katrina (see Figure 1). In response, this project combined space geodetic measurements with high resolution, satellite and airborne imaging to produce flood prediction and subsidence detection products.

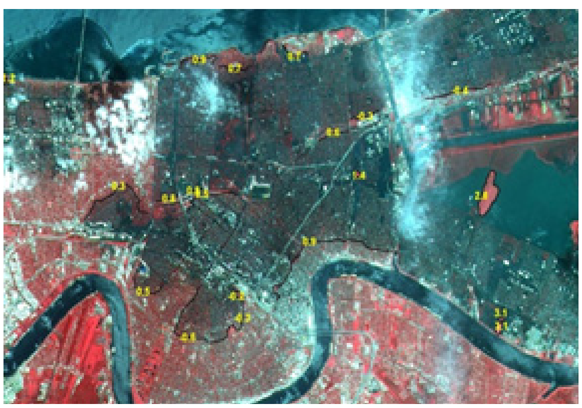


Figure 1 - Flooding in New Orleans, Louisiana recorded by Spot XS satellite image (point elevations in yellow text).

Pre-event and post-event satellite and airborne imaging have two goals. Prior to a flood event, the goal is to define areas already identified in the subsidence/elevation part of the study with key infrastructure at risk, e.g., bridges. This allows improved planning for flood damage repair, such as pre-positioning of resources. Imagery acquired immediately after a flood or storm surge allows rapid post-event damage assessment, thereby enabling resources to be focused in locations of maximum need.

The geodetic data, which was a combination of GPS (high temporal resolution) and Persistent Scatterers (PS) Interferometric synthetic aperture radar (InSAR) for high spatial resolution was used to define areas characterized by high subsidence rates. Elevation reductions as high as one inch per year have been documented in a few localities in the lower coastal Mississippi Delta, justifying the need for updated elevation and flood hazard maps. The subsidence project herein provides information on subsidence is apparent, allowing resources to be focused on areas most in need of more detailed field surveys and assessment.

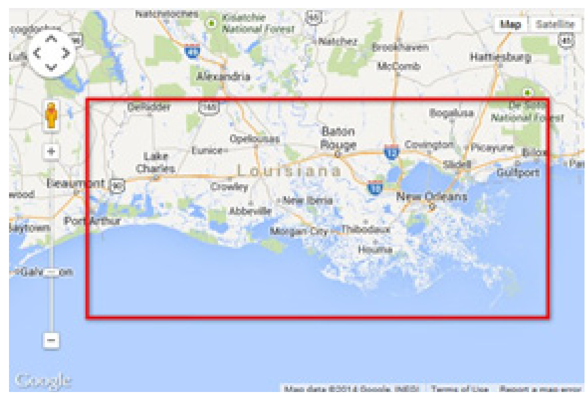


Figure 2 - Study area location. (Source: Google Maps).

Methods

The project was approached as follows:

First, a satellite-based technique was developed for measuring elevations and subsidence based on interferometry synthetic aperture radar (SAR or InSAR) extending PS techniques to non-urban areas and high precision GPS. In doing so, the project leveraged an earlier study that used space-based repeat pass InSAR data to map and estimate subsidence within New Orleans, Louisiana (Figure 3). Next, the project team used the InSAR time series data to generate appropriate background elevation and subsidence maps.

Existing low elevation and high subsidence "hot spots" were then identified which led to an assessment of an optimum technique for rapid detection of flooding. The latter was demonstrated using an area other than Louisiana that employed comparison of two dates of SAR backscatter data. Lastly, the project team compared the project produced elevation maps of sinking, flood prone areas to a Louisiana Department of Transportation and Development (DOTD) database for product validation.

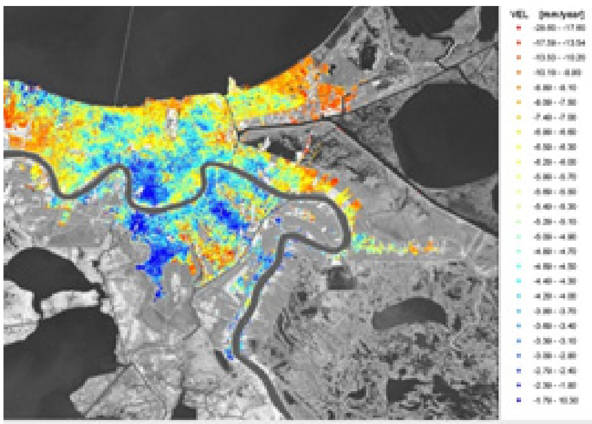


Figure 3 - First InSAR space-based map of subsidence rates for New Orleans area (Source: Dixon et al., 2006)

Project-produced height and elevation change products were computed and used to assess height stability of infrastructural features in New Orleans (Figure 5). It was assumed that this area was at or near sea level before the construction of the New Orleans area levees and marsh drainage, circa 1860, began a process of oxidation and compaction. Many of these subsiding areas evident in Figure 3 also flooded in lieu of Hurricane Katrina (Figure 4).

Results

As a result of this project, it was determined that that while some areas of the city of New Orleans currently lie more than three meters (m) below sea level, the buildings in New Orleans, due to building codes, are more stable and not subsiding nearly as much as the nearby land.

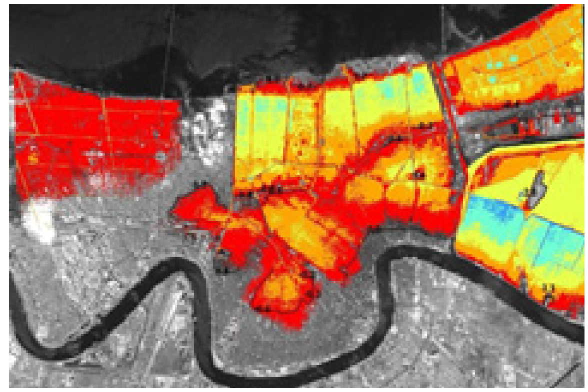


Figure 4 - Flooded areas in New Orleans, Louisiana that occurred in lieu of Hurricane Katrina.

The project further demonstrated the potential for using multi-date SAR data for improving the detection of flooded areas (Figure 6).

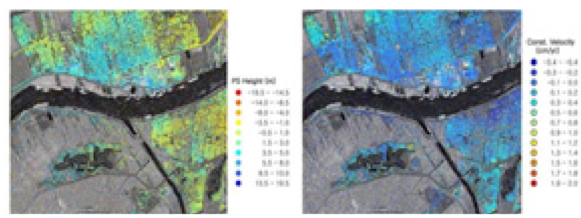


Figure 5 - PS-InSAR products indicating heights of persistent scatterer features in meters (left) versus persistent scatter elevation change in centimeters (right).

During the project, it became very clear that accurate flood prediction requires updated elevation and flood hazard mapping capabilities in order to maintain the safety and welfare of the state of Louisiana and especially those living in its coastal areas.

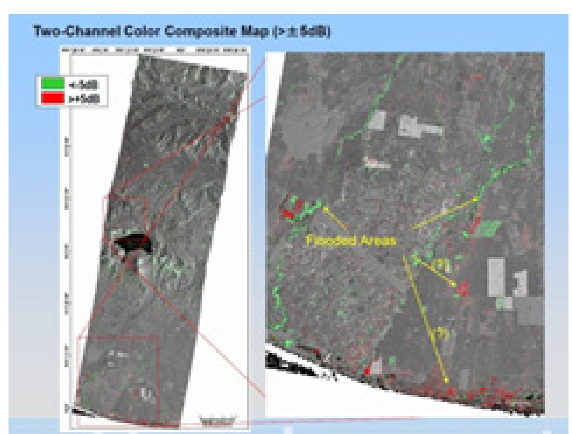


Figure 6 - Example flood map from 2 dates of SAR data.

PI: James Aanstoos, Mississippi State University			
Partners: US Army Corps of Engineers Research and Development Center; NASA Jet Propulsion Laboratory			
Users: Mississippi Levee Board			
RFP: 2008 ROSES A.28			
ARL Start	**2**	**ARL End**	**6**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

Man-made levees play an important role along the lower Mississippi River in keeping communities safe from catastrophic flooding disasters. Levee breaches occur (Figure 1) and often devastate affected communities. Thus, levees require monitoring and maintenance to be fully operational and safe. Improved knowledge of the viability status of these levees improves the allocation of resources to inspect, test, and repair them. Remote sensing assets of the National Aeronautics and Space Administration (NASA) provide a means to supplement in-situ levee inspection, monitoring, and assessment.

Figure 1 - Levee breach threatening adjacent highway.

In response, this project was conducted to provide remote sensing-based methods for improving that knowledge, giving levee managers new tools to prioritize their tasks. This project aimed to enhance decision making capabilities by using NASA's Unmanned Airborne Vehicle Synthetic Aperture Radar (UAVSAR) and ancillary data, to better understand the levee condition. The study area for the project regarded the lower Mississippi River in the state of Mississippi (Figure 2). In addition, this project aimed to provide remote sensing-based methods for improving that knowledge, giving levee managers new tools to prioritize their tasks.

Figure 2 - Study area location. (Source: Google Maps).

This project regarded a partnership between Mississippi State University (MSU) and the United States Army Corps of Engineers (USACE) Engineer Research and Development Center (ERDC). ERDC has developed a decision support framework for assessing levee condition. The primary objective of this project was to demonstrate the enhancement of that functionality using UAVSAR. Testing was done with study area levees critical to maintaining community resiliency.

Methods

The methodology used in this study consisted of collecting identified available remotely sensed data from key target sites (e.g., levees with known and/or potential issues) and analyzing such to find anomalies that might indicate features of interest, resulting in a levee condition classification. Using NASA's UAVSAR system for five flights between June 2009 and June 2011 provided exceptional remotely sensed data collection as well as data exploration and analysis of the levees. The UAVSAR backscatter data was used to classify levee anomalies

(Figure 3) and to show where flooding was evident (Figure 4). Also, temporally relevant Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), the French Satellite Pour l'Observation de la Terre (SPOT-XS), and National Agriculture Imagery Program (NAIP) imagery was acquired for use in the project.

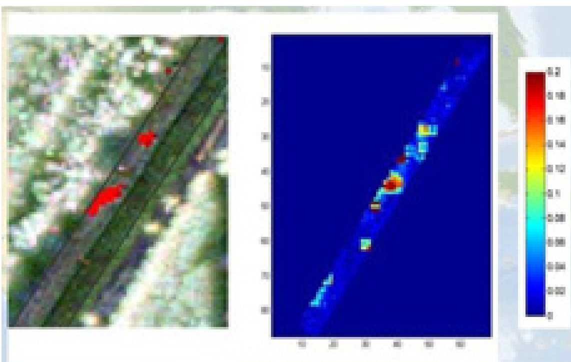


Figure 3 - Example UAVSAR-based levee anomaly classification product computed using RX anomaly classification technique.

A subset of these anomalous sites detected from the remote sensing data was then selected for formal in-situ inspections. The results of the latter surveys were used to develop and train algorithms to detect such conditions from remotely sensed data (e.g., from UAVSAR data). Finally, these algorithms were tested on other portions of the sample for verification.

Results

As a result of this project, it became very evident that the resiliency of nearby communities was strongly tied to and dependent upon the design and quality of their levee systems. Some of the data products were also contributed to a DHS funded prototypical levee assessment tool that contains a geospatial data viewer (Figure 5).

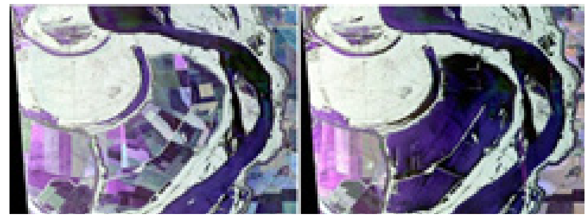


Figure 4 - UAVSAR imagery for April 28 (left) versus June 7, 2011 (right) in which agricultural flooding is clearly more evident on the June date.

This system helped increase awareness of sites on the levees with potential for breaches. Awareness of the importance of improving the efficiency of levee monitoring was another direct result of this project.

This project helped levee managers develop products and capabilities for increasing knowledge on the status of levee conditions, based on consideration remotely sensed data in conjunction with field surveys. This new method helps levee managers better allocate resources to inspect, test, and repair levee systems in most need. While UAVSAR imagery and technology showed potential for the application, the availability of such data is currently limited. Eventual development of such data streams is possible using space-based Synthetic Aperture Radar (SAR) with similar bands (in terms of frequency and polarizations) and spatial resolution.

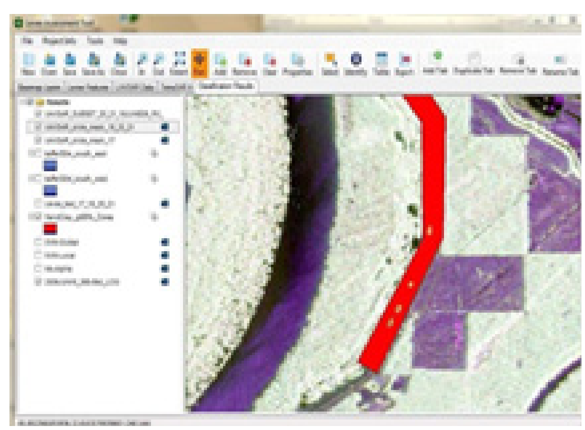


Figure 5 - Example of decision support system for levee assessment that employs UAVSAR data from project.

Improving Post-Hurricane Katrina Forest Management with MODIS Time Series Products

PI: David Lewis, Radiance Technologies			
Partners: Mississippi State University, NASA Stennis Space Center			
Users: Mississippi Institute for Forest Inventory			
RFP: 2008 ROSES A.28			
ARL Start	**2**	**ARL End**	**4**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

Hurricane Katrina hit the Mississippi Gulf Coast as a major category 3 hurricane on August 29, 2005, causing extensive damage to forests (Figure 1) across multiple coastal counties (Figure 2). Forest damage recovery efforts could have been aided by a regional forest monitoring system that locates and quantifies damage severity. Hurricane Katrina forest damage occurred due to wind, flooding, precipitation, and storm surge effects. Despite multiple studies, many information gaps remain for restoring and managing such storm-damaged coastal forest ecosystems. Initially after the storm, efforts to assess forest damage were greatly hindered by a lack of access to heavily damaged areas and limited field personnel.

Figure 1 - Coastal forest damage due to Hurricane Katrina, including plantation pine mortality (Source: Ricky Lawson, Forestry Images.org).

In response to these hindrances, this project was initiated to help improve the region's forest management in lieu of Hurricane Katrina's damage, employing Moderate Resolution Imaging Spectroradiometer (MODIS) data to view and assess the initial damage and subsequent recovery in terms of vegetation canopy greenness. For this project, the Mississippi Institute for Forest Inventory (MIFI) served as the main institutional partner. The project aimed to produce forest damage and recovery assessment products for helping MIFI to improve forest management decision-making.

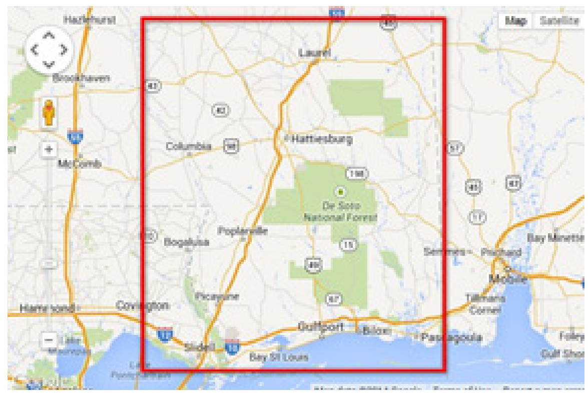


Figure 2 - Study area location. (Source: Google Maps).

The project pertained to multiple GOMA priorities: 1) Wetland and coastal conservation restoration; 2) Identification and characterization of Gulf of Mexico; and 3) Reductions in nutrient inputs to coastal ecosystems. The project regarded Disaster Management, Agriculture, and Ecological Forecasting Societal Benefit Areas of NASA's Applied Sciences program.

Methods

During this project, we employed daily and temporally composited MODIS time series data products to help improve Mississippi's state assessments of coastal forest damage and recovery from Hurricane Katrina. In particular, project employed 2000-present MODIS time series data products to quantify and assess forest damage and recovery extent and location across the Hurricane Katrina impact zone in Mississippi. In particular, MODIS Normalized Difference

Vegetation Index (NDVI) and Normalized Difference Moisture Index (NDMI) time series data were tried for aiding MIFI.

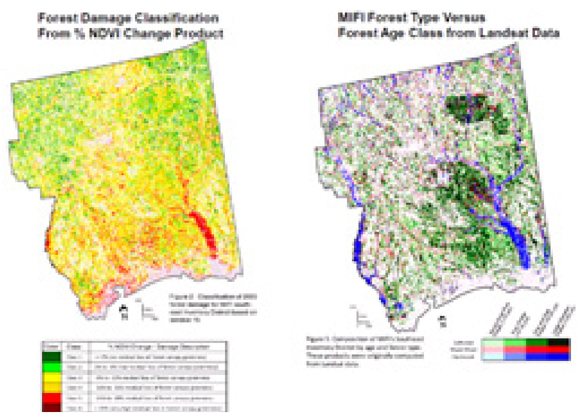


Figure 3 - MODIS NDVI-based forest damage detection product for initially after Hurricane Katrina compared to forest type and age class map from project.

MODIS 16-day NDVI-based vegetation damage detection products were used with ancillary data to assess the context of the hurricane-induced forest disturbance. Ancillary products included data on pre-hurricane forest type, age, and biomass conditions in addition to storm intensity, storm track, elevation, and site wetness. The MODIS damage and recovery products were also assessed by comparison to higher resolution Landsat and ASTER satellite data.

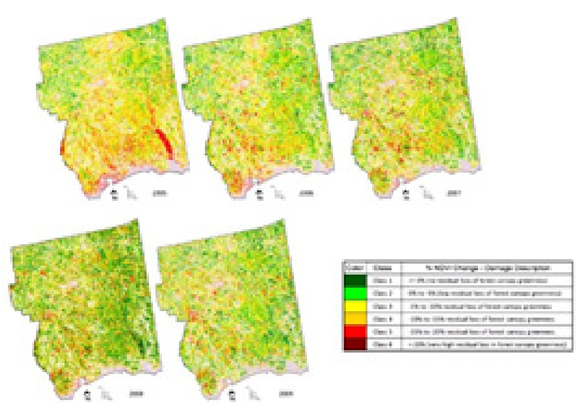


Figure 4 - MODIS NDVI-based forest damage and recovery products for 2005-2009.

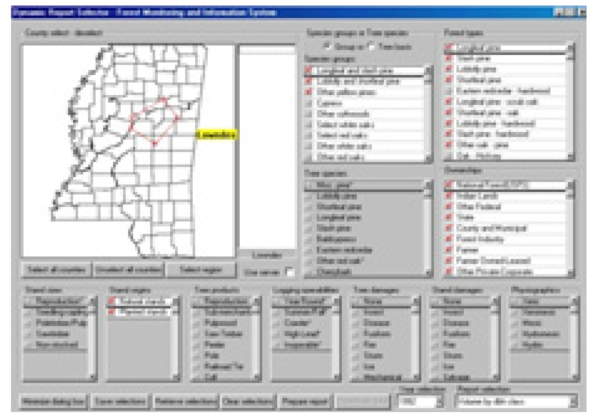


Figure 5 - GUI for MIFI's Forest Monitoring and Information System.

Figure 6 - Hurricane Katrina Forest Damage

Gulf Coast Subsidence: Insight for Decision Makers from InSAR, Geodesy, and Geophysical Modeling

PI: Ronald Blom, NASA Jet Propulsion Laboratory			
Partners: Physics-Harvey Mudd College; Louisiana State University; Cornell University			
Users: Federal Emergency Management Agency			
RFP: ROSES 2008 A.28			
ARL Start	**1**	**ARL End**	**2**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

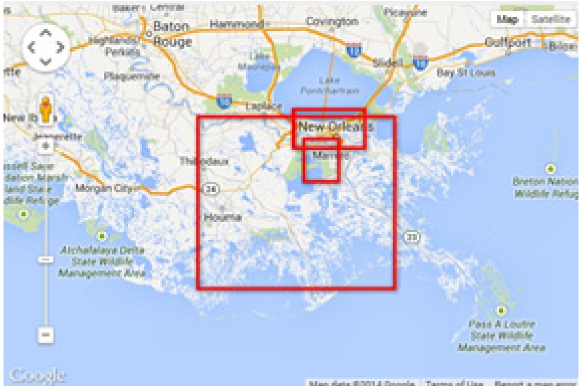


Figure 2 - Study area location. (Source: Google Maps).

Introduction

Recent hurricanes such as Hurricane Katrina demonstrated the vulnerability of the Gulf Coast to flooding impacts, particularly in the lower lying areas. Well-recognized components of this vulnerability are sea level rise and wetland loss (Figure 1).

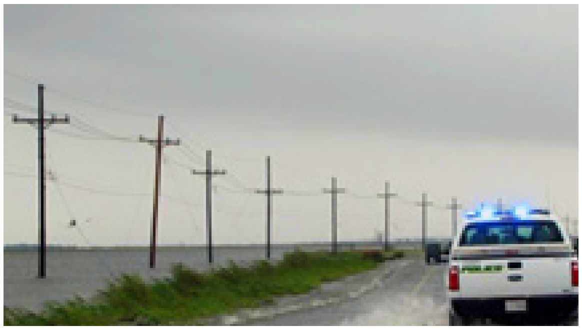


Figure 1 - Example of sinking landscape located near Port Fourchon, Louisiana acquired during Hurricane Isaac on August 30, 2012 (Source: NOAA). The telephone poles are now water covered even in non-hurricane conditions.

Wetland loss in the region occurs due to the interruption of the natural processes of sediment delivery and distribution. In addition, subsidence occurs due to many factors: (e.g., sediment compaction, sediment oxidation, fluid extraction, and sea level rise. Efforts to precisely measure current subsidence and obtain a geophysical understanding of crustal response, aids in monitoring and prediction of future subsidence. This project was initiated with the goal of using Air and space-based Interferometric Synthetic Aperture Radar (InSAR) data to help detect, monitor, and assess subsidence in southeastern coastal Louisiana (Figure 2).

Methods

The project resulted in a large volume of two-date UAVSAR L band data that was acquired over a large portion of southeastern coastal Louisiana and processed into InSAR data products, such as interferogram images. In doing so, each collection was made so that the two dates had opposite viewing geometry and flight directions (Figure 3). Once computed, the interferograms were colorized with a standard color lookup table that enables end-users to ascertain areas that are showing subtle indications (i.e. measurements) of uplifting or subsiding areas. This technology is capable of capturing slight changes in elevation due to subsidence, providing that the coherence is maintained between the two dates of InSAR data being compared. These data sets were used in project to help assess areas suspected to be vulnerable to subsidence, including areas adjacent to man-made levee structures. Once identified, such areas were communicated to end-users in the area who are monitoring subsidence and related sea-level rise using in-situ methods.

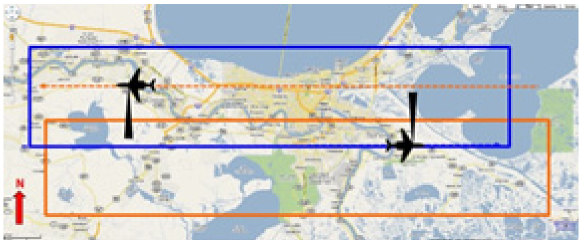


Figure 3 - Example dual date UAVSAR InSAR data acquisitions for June 16 versus September 3, 2009.

Results

The main results include: 1) The discovery that use of UAVSAR/InSAR techniques provided geographically comprehensive temporal snapshots of deformation in map form (Figure 4); 2) UAVSAR showed great promise with new and refined processing, especially for short repeat intervals with high coherence; 3) the computation of interferogram products must be tied to a geodetic datum; and 4) DESDynI-Earth Radar Mapper satellite is the right resource to provide this data.

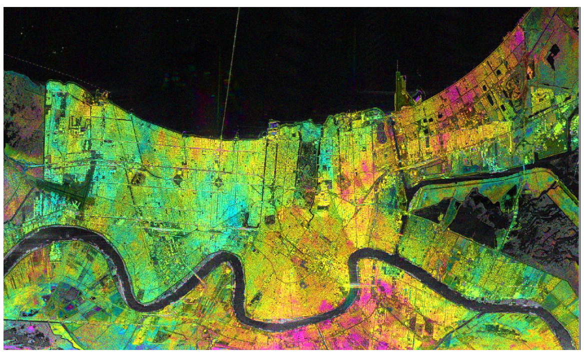


Figure 4 - Example 79 day UAVSAR repeat pass interferogram of New Orleans, Louisiana, showing zones of relative elevation change.

Given the dynamics of the Louisiana coastal environment, it is challenging to use InSAR data even if the data is of excellent quality, though L-band InSAR appears to maintain its coherence over a longer time span than that from C-band. Detected changes were also due to changes in water levels and soil moisture, as opposed to elevation.

Since the closure of this project, UAVSAR collected over coastal Louisiana continues to be utilized. Most recently, it was used to demonstrate how repeat pass interferograms detected the early phases of a large sinkhole that formed near Bayou Corne, Louisiana (Figures 5 and 6). Such products are often used to aid disaster management agencies like FEMA.

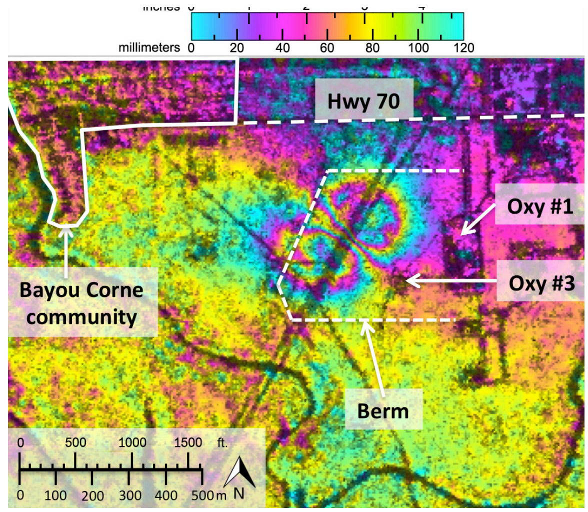


Figure 5 - Example of UAVSAR Interferogram for June 2012 versus 2011. This product demonstrates how InSAR data can be used to provide an early indication of the sinkhole near Bayou Corne, Louisiana (Source: JPL).

In conclusion, this project helped confirm that InSAR data helped detect, monitor, and assess subsidence across the southeastern coastal regions of Louisiana.

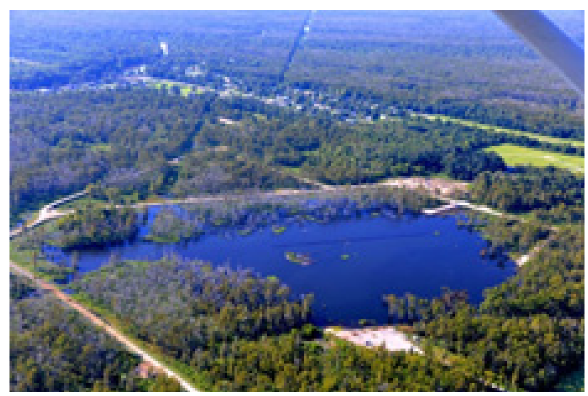


Figure 6 - Aerial view of sinkhole-induced pond near Bayou Corne, Louisiana acquired August 2012 (Source: JPL).

PI: Dave Jones, StormCenter Communications Inc.			
Partners: Texas Division of Emergency Management; NASA, Marshall Space Flight Center; University of Texas, Austin; DHS FEMA, Region IV; NOAA National Weather Service (Southern Region Headquarters), and the Atlantic Oceanographic and Meteorological Laboratory (Hurricane Research Division)			
Users: Texas Division of Emergency Management; FEMA Region VI; Gulf of Mexico Alliance; NOAA Integrated Ocean Observing System and National Weather Service (Southern Region Headquarters); South Florida Emergency Management			
RFP: 2008 ROSES A.28			
ARL Start	**4**	**ARL End**	**7**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

The goal of this project was to develop an enhanced prototype computer-based decision support system (DSS) tool to improve collaboration and decision making of states within the Gulf of Mexico Alliance (GOMA) (Figure 1 and 2). Addressing this goal fits with priorities established in the GOMA Action Plan. This project included a Federal, State, and Private sector partnership to design an improved decision making tool with the accuracy, detail, and timeliness required to offer guidance to emergency managers and to build a more informed community of Gulf Coast decision makers regarding storm impacts, sea level rise, and subsidence.

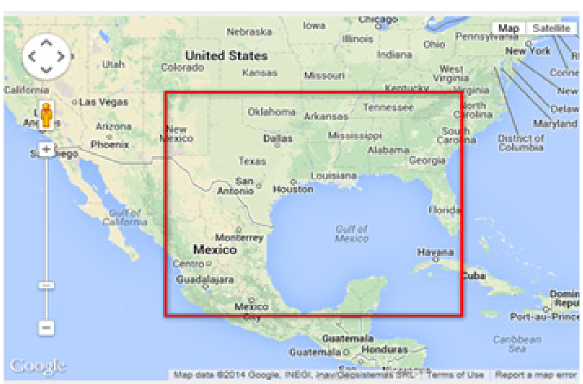


Figure 1 - Study area locations (Source: Google Maps).

Existing technology utilizing the Envirocast Vision Collaboration Module (EVCM) has been used to this point as seen in Figure 3.

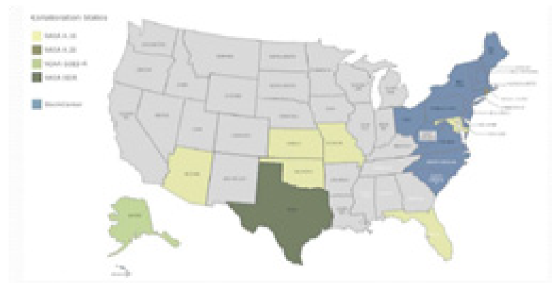


Figure 2 - StormCenter collaboration and data sharing partners in US with GOMI project initiated in Texas.

Methods

The project team worked to: 1) Enable real-time data sharing and collaboration between the Texas Department of Public Safety's Division of Emergency Management (TDEM), NWS and FEMA; 2) Improve the ability of state and federal agencies to increase situational awareness

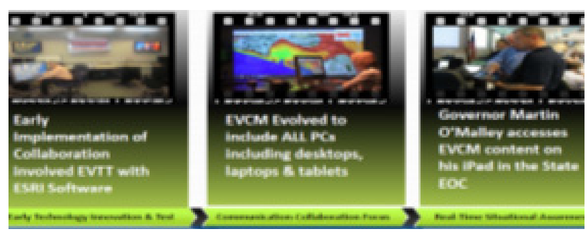


Figure 3 - EVCM Collaboration Technology Evolution

during developing hazard threats (such as volcanic activity and hurricane based events) and those in progress; 3) Improve coordination efforts relating to response and post hazard assessment and recovery; 4) Introduce a prototype tool to Gulf of Mexico Alliance (GOMA) partners to improve collaboration and coordination to address priorities of the GOMA Action Plan; 5) Increase use, awareness and sharing of NASA datasets to improve situational awareness, planning, response and recovery; and 6) Introduce a capability outside of GOMA for possible use and adoption.

The project team worked closely with several Federal partners that already established Envirocast® VisionTM TouchTables (EVTTs), to enhance the flow of critical storm-surge modeling. These partners had also been involved with new and innovative products being developed for improved decision-making capabilities utilizing NASA earth science research results and NOAA research / operational products.

To address project objectives, the project team enhanced a prototype tool that allows Gulf resource managers from GOMA states to integrate critical storm surge, localized sea level rise and subsidence information for at least one pilot area (e.g., Texas) on the Gulf Coast. NASA geospatial information and other datasets, as well as hurricane modeling data from the Hurricane Weather Research and Forecasting (HWRF) system of the NOAA were fed into the prototype and used with data-sharing demonstrations including volcanic ash models and "sea-ice" briefings.

Results

This project resulted in immediate benefits to all members of GOMA and helped meet a long-term goal of a partnership to support Gulf recovery and build resilience to future hurricanes. This project produced a greater sharing between GOMA members of geo-spatial and hurricane modeling information in real-time and collaboration, as well as a greater range of access (especially mobile access) that enabled better utilization of resources to enhance planning and help increase safety.

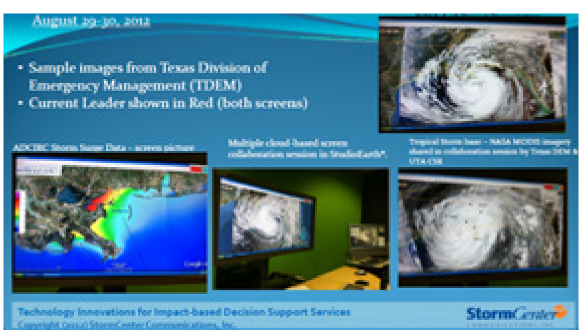


Figure 4 – Hurricane Isaac preparations; samples images from Texas Division of Emergency Management (TDEM)

An unexpected result of the EVCM effort occurred during preparations for Hurricane Isaac, Figure 4. The state of Texas was concerned that this storm would impact Texas after its Louisiana landfall. The system enabled the Texas Emergency Management Council to stand down and NOT mobilize due to Isaac's forecast and actual track. The collaboration made possible by this research led to cost savings for the state of Texas. This same level of cost savings is now available to all GOMA partners. The NWS invited StormCenter to present real-time decision making technology for use in decision making in South Florida.

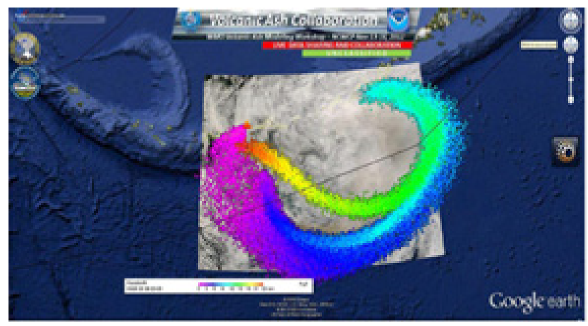


Figure 5 – Volcanic ash plume assessment product used as part of the project.

The live data sharing and collaboration resulting from this project was illustrated at the WMO Volcanic Ash Modeling Workshop, held in November 2012 (Figure 5) and used for communicating 2011 Japanese Tsunami/ Fukushima disaster impacts (Figure 6).

Figure 6 – Aerial view of Fukushima/ Tsunami disaster in Japan, an event covered with technology developed during the GOMI project (Source: Sandia National Lab).

PI: Troy Frisbie, NASA Stennis Space Center			
Partners: Applied Geospatial Technology; University of Southern Mississippi Gulf Coast Research Laboratory; Computer Sciences Corporation; A2R Research			
Users: NASA Emergency Operations Centers at John C. Stennis Space Center and Michoud Assembly Facility			
RFP: 2008 ROSES A.28			
ARL Start	**2**	**ARL End**	**4**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

This project was conducted to identify and quantify risks associated with hurricane evacuation route conditions within 100 km of NASA's John C. Stennis Space Center (SSC), including the Michoud Assembly Facility (MAF) (see Figure 1). Multiple centers of the National Aeronautic and Space Administration (NASA) are located in areas vulnerable to hurricanes. Neighborhoods near these centers must evacuate when hurricanes are of significant magnitude and threat level. Evacuation routes are generally problematic, causing delays in evacuation and sometimes endangering those trying to leave. The area near SSC and the MAF are particularly vulnerable to hurricanes, having more recently been subjected to the catastrophic impacts of Hurricane Katrina.

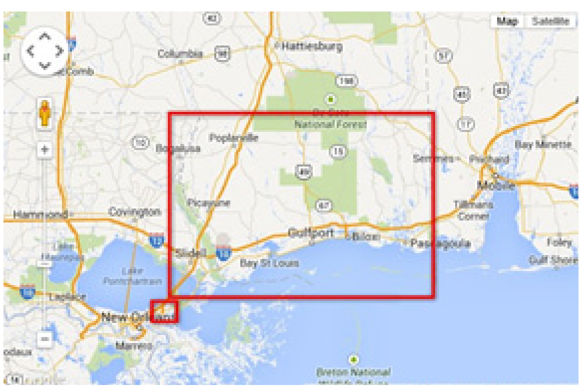


Figure 1 - Study area location. (Source: Google Maps).

Access to post-hurricane areas is often severely hampered as evidenced by Hurricanes Katrina and Ike. Water, trees, and debris on roadways can prevent post-storm ingress and egress for emergency response, utility repair, and search and rescue teams - diminishing a coastal community's resilience to hurricanes.

The MAF expressed a great interest in a follow-up to the NASA Incident Command System (ICS) Planning Dashboard project, formerly NASA Emergency & Planning Support or E-MAPS. This existing E-MAP decision support system addresses information such as flood inundation predictions, 3-D flood drainage, wind risk predictions, fire detection mapping, baseline site imaging, and prototype post storm analysis (see Figure 2). Other capabilities include site survey reports, ground crew rosters, and site damage viewable by NASA Headquarters.

Figure 2 - Entry GUI to NASA Emergency & Planning Support tool (E-MAPs), now called the ICS Planning Dashboard. The arrow points to a remote sensing flood prediction product that was assessed during the project.

Methods

This project is a follow-on to the earlier "E-MAP" effort and uses the Coastal Online Analysis and Synthesis Tool (COAST) as a Geo-browser. We utilized the most up-to-date flood modeling from the United States Army Corps of Engineers. In doing so, wind risk products generated from Coastal Change Analysis Program Regional Land Cover (C-CAP) and from Light Detection and Ranging (LIDAR) data were used to compute storm surge inundation risk maps. In addition, risks from sea, lake, and overland surges from hurricanes (SLOSH) were assessed using and modeled. Together, these were used to better assess and address cumulative risk as it applies to hurricane evacuations.

The COAST was used with assorted remote sensing and other geospatial data products to visually show the evacuation routes with NOAA Coastal LIDAR and National Geospatial-Intelligence Agency (NGA) Hurricane Katrina damage level data for a reference.

Results

Completion of this project improved a community's potential resiliency to hurricanes by analyzing weak links in evacuation routes. Identifying points along the routes that are at risk of flooding, being cluttered with debris, or tree fall enables community planners to focus pre-storm resources and action. These areas now have an effective tool set to develop contingency plans, store supplies in areas that cannot be evacuated, or even modify evacuation routes to reduce their risk. In addition, results from this project are now readily available to a wide range of users.

Project efforts resulted in a better model to identify primary and secondary evacuation routes, as well as storm surge risk mapping for the study area around the MAF. The NASA Emergency Operations Center (EOC) at SSC and MAF now have full access to the product functions through the ICS Planning Dashboard (Figure 2) and COAST (Figures 3 and 4), while integrating results into a client viewer that is accessible to others.

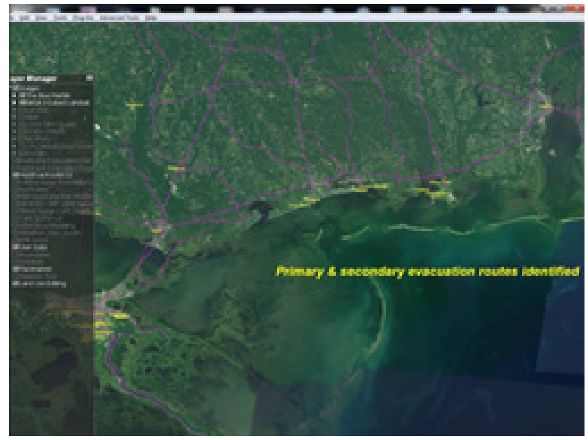


Figure 3 - Display of NASA COAST data viewer with hurricane evacuation routes over study area overlain onto Landsat image mosaic.

These products provide a great enhancement to the capabilities of utility repair crews and emergency response personnel (e.g., police and fire departments) that require immediate post-storm access to damaged areas. This product also improves information flow to the NASA EOC teams, such as military personnel at affected bases, and personnel that cannot evacuate (e.g., ride out crews at selected NASA facilities).

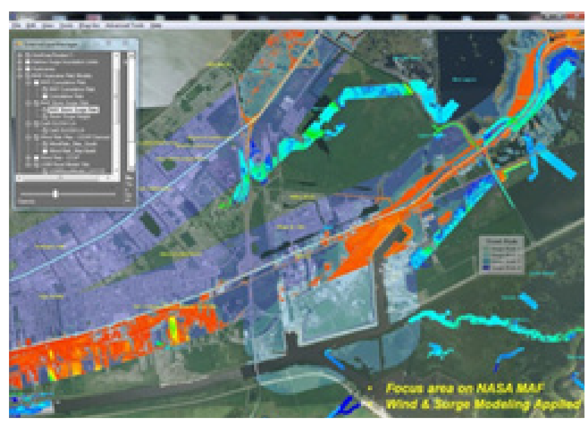


Figure 4 - Display of NASA MAF area from NASA COAST data viewer, showing relative flood risk mapping product in relation to evacauation route and other geospatial contextual data layers.

Establishing Application of High Resolution Satellite Imagery to Improve Coastal and Estuarine Models

PI: Scott Hagen, University of Central Florida			
Partners: USDA Forest Service; USFS Fire Sciences Laboratory; US Department of the Interior, Fish and Wildlife Services; Mississippi Forestry Commission			
Users: NOAA National Weather Service (Lower Mississippi River Forecast Center and Office for Hydrological Development); NOAA National Oceanographic Service (Coastal Survey Development Laboratory)			
RFP: 2008 ROSES A.28			
ARL Start	**1**	**ARL End**	**6**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

Coastal and estuarine models are depended on for providing hind-cast, now-cast, and forecast information on coastal water and land conditions. The spatial resolution of input data can affect output modeling performance. The overall goal of the project was to demonstrate the efficacy of employing high resolution satellite imagery to improve coastal inundation models that are presently employed by the National Oceanographic and Atmospheric Administration, or NOAA (NWS and NOS), the United State Army Corps of Engineers (USACE), and the Federal Emergency Management Administration (FEMA), and those state-of-the-art coastal and estuarine models under development and soon to be applied operationally. End users for the project included the Mississippi River Forecast Center in particular and the coastal modeling community in general.

The project aimed to extend Earth science research results to decision-making activities of Disaster Management and Water Resources Societal Benefit Areas. The work is a relevant Gulf of Mexico Alliance (GOMA) priority issue of Coastal Community Resilience.

Methods

The project used high-resolution satellite imagery to assess and characterize

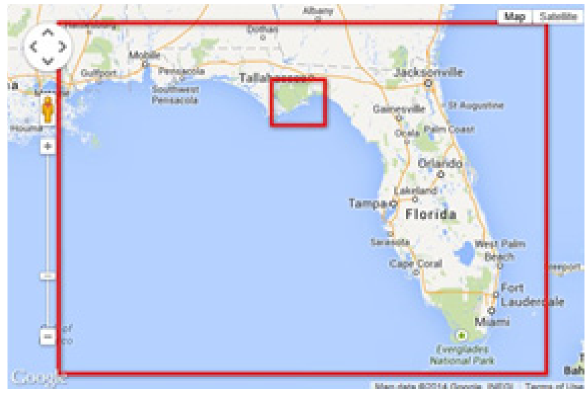


Figure 1 - Study area location. (Source: Google Maps)

the frictional properties of storm tides on barrier islands with respect to coastal circulation modeling. The initial task was detecting an inundated area at a point in time using satellite imagery, which included multiple steps: 1) Apply synergetic method; 2) Simulate tides at that time and produce a raster image of wet and dry cells; and 3) Compare results of harmonic re-synthesis, water level time series analysis, and new method.

For the synergistic method, radar, Landsat assets, and Light Detection and Ranging (LIDAR) data are used as primary data sources. The LIDAR and Landsat data were used to identify flood prone areas and were also compared to the radar data to compute multi-temporal change detection products that were then further processed into false color composite imagery showing flooded areas. The results from the synergistic model were then compared to those generated from the Advanced Circulation (ADCIRC) model to assess for agreement and disagreement. Model simulations were also compared to real observation data on water levels. Specific values of surface roughness were then considered in evaluating model results, and field surveys were conducted to observe, measure, and characterize surface roughness of ground features (Figure 2).

Results

As stated, this project used satellite imagery to assess coastal inundation modeling performance. Comparison between the

Figure 2 - Field survey during project, collecting surface roughness data for evaluating model results.

synergistic and ADCIRC models indicated visible agreement and disagreements between the two (Figure 3). However, areas showcased are examples with disagreements and not necessarily indicative of the products overall for a given date or across all dates.

Synegistic modeling results were computed for several dates. The validation of these is summarized in Figure 4. The field surveys helped to evaluate and reduce the RMSE of surface roughness compared to that obtained with land cover land use look-up tables and other approaches, which helps in improving flood detection modeling results (Figure 5). Results of this research were also used to generate several refereed journal publications as well as multiple presentations given at professional meetings.

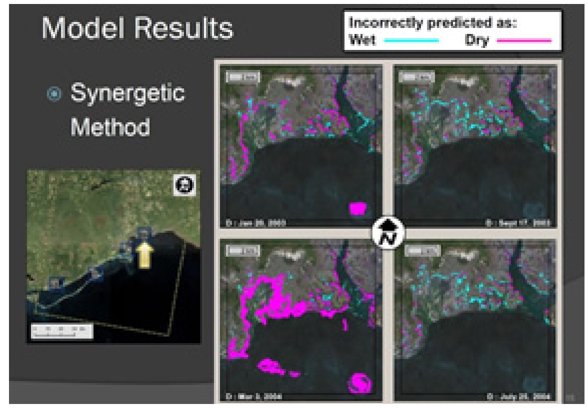


Figure 3 - Example modeling results from the synergistic method showing areas with apparent classification errors.

Figure 4 - Summary of synergistic modeling results for multiple dates of product.

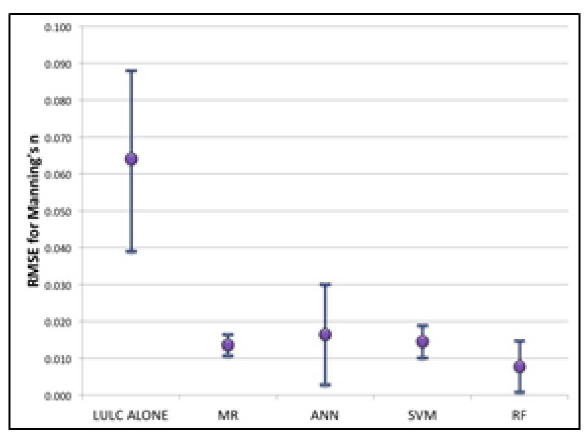


Figure 5 Manning's N roughness coefficient RMSE estimates for various flood detection techniques evaluated during the project.

Oil Slick Detection Using NASA Active and Passive Sensors

PI: Sonia C. Gallegos, Naval Research Laboratory			
Partners: Alabama A&M University; NOAA National Environmental Satellite, Data, and Information Service Center for Satellite Applications and Research; NASA Langley Research Center			
Users: NESDIS Science Advisory Board; NOAA National Ocean Service Office of Response and Recovery Emergency Response Division; NOAA Satellite Analysis Branch, National Marine Monuments; NOAA Marine Sanctuaries; DOI Bureau of Safety and Environment; US Coast Guard			
RFP: 2008 ROSES A.28			
ARL Start	**1**	**ARL End**	**8**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

The Gulf of Mexico (GOM), with 3,800 fixed platforms, and 37,000 miles of pipelines, is the sixth largest hydrocarbon basin on earth (see Figure 1). These platforms and pipelines are vulnerable to hurricanes. Since 1992 hurricanes have destroyed 144 platforms, damaged 165, and have damaged 1,315 pipelines, causing oil spillage into coastal habitats. While natural oil seeps occur in the gulf, man-made oil spills (e.g., the 2010 Deepwater Horizon, or 'DWH' oil spill (Figure 2)) can have catastrophic environmental consequences. Currently, there are no full-time efforts to detect and monitor oil slicks operationally.

The project aimed to develop automated/ interactive algorithms to produce the basis of an operational satellite oil spill monitoring system for the GOM. Specific goals included: 1) Build infrastructure of an oil detection system using available operational and experimental satellite sensors; 2) Acquire, build, and automate algorithms for oil detection; 3) Create a pipeline of oil detection products; and 4) Transition products to the National Oceanic and Atmospheric Administration (NOAA) Satellite Analyses Branch (SAB) in Camp Springs, Maryland.

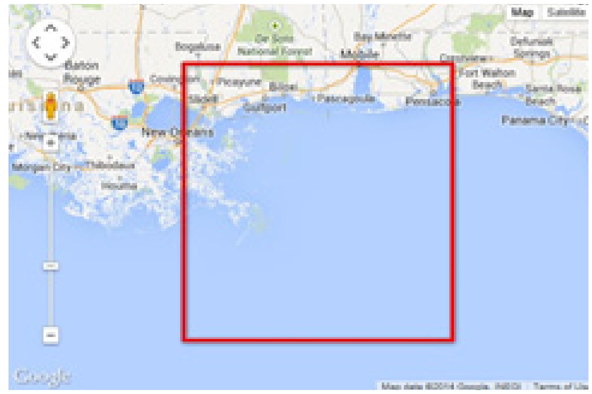


Figure 1 - Study area location within Gulf of Mexico. (Source: Google Maps).

Methods

The project team employed data from passive and active space borne sensors, along with spaceborne oil detection techniques. These resources included NASA-supported Moderate Resolution Imaging Spectroradiometer (MODIS) AQUA, the Cloud Aerosol light detection and ranging (LIDAR) with Orthogonal Polarization (CALIOP), and Landsat data, plus the NOAA Center for Satellite Applications and Research (STAR) Synthetic Aperture Radar (SAR) data.

Figure 2—Aerial view of a DWH oil spill mitigation effort (Source: NOAA).

The Naval Research Laboratory (NRL) implemented and adapted an algorithm, the Texture Classifying Neural Network Algorithm (TCNNA) that employs reflectance thresholds and texture measures based on the Gray Level Co-Occurrence (GLC) matrix to identify edges of oil slicks, using either MODIS or ENVISAT Advanced SAR (ASAR) imagery.

CALIOP data was used for aiding DWH oil spill assessments as a proof of concept.

Results

This project has far-reaching benefits. As a result, the project team demonstrated a novel oil spill detection algorithm (Figure 3) that resulted in additional MODIS-based products for aiding oil spill detection efforts during the DWH oil spill (Figure 4 below).

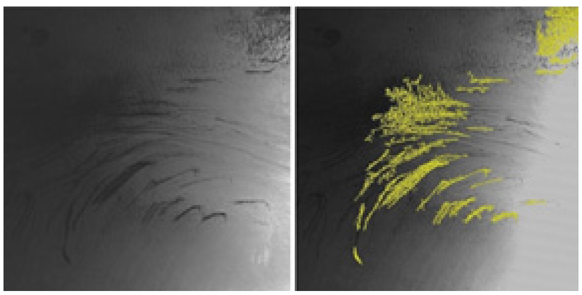


Figure 3 - Detection of oil slicks (on right) based on MODIS data (on left) and NRL slick detection algorithm.

The project assisted in production of mass-produced maps for the NOAA for use in oil spill emergency response, and can be the first warning of a spill. Such maps are assimilated into oil spill trajectory models and help determine which are best in “handling” events. This is highly effective during and after hurricanes when an agency’s ERD is relocated to areas with restricted information access.

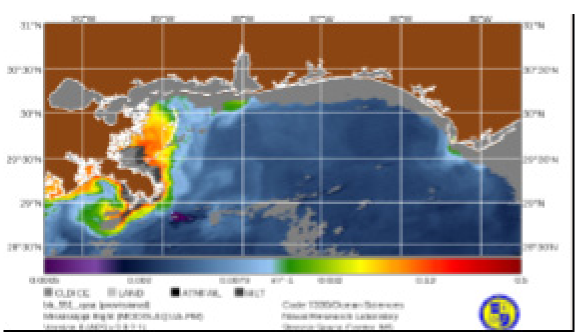


Figure 4 - NRL MODIS-based bb (total backscatter) product acquired during DWH oil spill.

Such a resource saves time and money, allowing experts to better task resources to “rule out” areas that do not require response, relieving unnecessary public concern. Reconnaissance aircraft can be precisely targeted, especially when aircraft are “grounded” by weather conditions.

Figure 5 shows oil fires on the Gulf in 2010 during a CALIOP overpass, upper left; CALIOP data over DWH oil spill impact zone, May 2010, upper right; over transect, lower left; and comparison of CALIOP signal and theory for July 10, 2010.

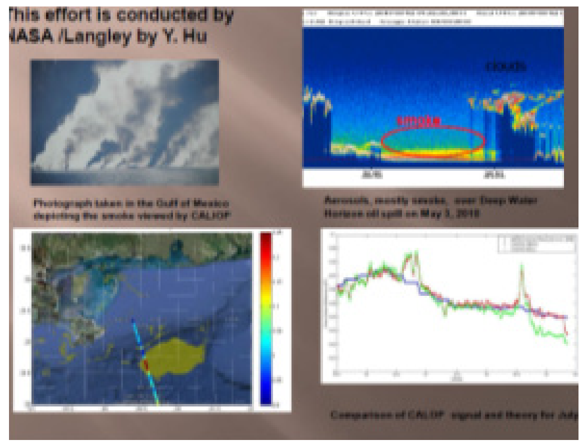


Figure 5 - Oil spill assessment using CALIOP data from proof of concept conducted by NASA Langley, Y. Hu.

This system can also provide illegal oil dumping notifications to the United States Coast Guard in accord with the International Convention for Prevention of Pollution from Ships (MARPOL I). In essence, results of the research now serve as the only efficient way to simultaneously monitor hundreds or thousands of Gulf platforms/rigs. It also serves as the primary means of developing comprehensive pictures of very large oil disasters, which can be helpful as a media resource during high-profile incidents that threaten the protection of sanctuaries, ports, beaches and wetlands.

ECOLOGICAL FORECASTING

Ecological forecasts predict the impacts of environmental change on the ecosystems that provide clean air, fresh water, food security, and economic opportunity. The GOMI ecological forecasting projects provided decision makers with science-based tools to help them understand the environment and to establish effective policies. These projects included both aquatic and terrestrial ecosystems and topics that ranged from fish habitat and seagrass to marsh restoration and forest management.

Projects

Remote Sensing Decision Support for Water Quality Assessment and Seagrass Protection and Management in Florida's Big Bend Region

Monitoring Coastal Marshes for Persistent Flooding and Salinity

Aiding Mobile Bay Alabama Conservation and Restoration with Landsat Data from 1974-Present

Assessing Trajectories, Patterns and Stressors in Marsh Loss at the Landscape Level

Enhancing Estuarine Water Quality Management through Integrating Earch Science Results: A Targeted Project for Tampa Bay Florida

Nutrient Linkages Between South Florida Rivers and Coastal Habitats: Integrating Water Quality Sampling with Satellite Remote Sensing

Sampling with Satellite Remote Sensing to Enhance Management

Seagrass Health Modeling and Prediction with NASA Science Data

A MODIS Based Decision Support Tool for Gulf Coast Salt Marsh Conservation and Restoration

Sustainable Management of Coastal Forest Ecosystems Under a Changing Climate in the Northern Gulf of Mexico

Use of NASA Satellite Data to Improve Coastal Cypress Forest Management

PI: Paul Carlson, Florida Fish and Wildlife Research Institute			
Partners: University of South Florida; Florida Department of Environmental Protection; Florida Fish and Wildlife Conservation Commission			
Users: Florida Department of Environmental Protection; Florida Fish and Wildlife Conservation Commission			
RFP: 2008 ROSES A.28			
ARL Start	**3**	**ARL End**	**3**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

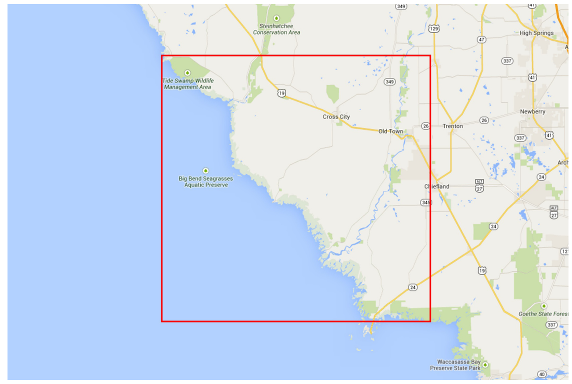


Figure 2 - Study area location. (Source: Google Maps).

Introduction

Florida's Big Bend seagrasses (Figure 1) are one of Florida's most important natural resources, supporting many economically important fish and shellfish species and providing ecological services worth $5 billion each year. However, degraded water quality threatens this valuable resource.

Figure 1 - In-water view of seagrass meadow.

Our project was launched to enhance protection of Big Bend seagrass, the second largest seagrass bed in the continental United States (Figure 2).

We also supported and assessed the development of a numeric transparency criterion for Florida coastal waters by evaluating its effectiveness in the Big Bend region. In this effort, we addressed two Gulf of Mexico Alliance (GOMA) priority issues: 1) Identification and characterization of Gulf habitats and 2) Reduction in nutrient inputs to coastal ecosystems. It also specifically addresses several elements of the water quality and nutrient reduction plans for the GOMA Action Plan. In addition to the Florida Department of Environmental Protection (EDEP) Total Maximum Daily Load (TMDL) program, our project provided decision-making support to the FDEP Coastal and Aquatic Managed Areas (CAMA) program, the Florida Fish and Wildlife Conservation Commission (FWC), and the FDEP water quality standards program.

Methods

To support the TMDL program, we conducted a retrospective analysis of remotely-sensed optical water quality (RSOWQ) for the Suwannee Estuary using novel remote sensing algorithms and Moderate Resolution Imaging Spectroradiometer (MODIS) imagery to determine water column clarity, turbidity, chlorophyll-a concentration, and absorption of colored dissolved organic matter (CDOM).

RSOWQ products were validated using ground-truth data (Figure 3) collected since 2002 as well as data collected during this project. We then established quantitative relationships between Suwannee River nutrient loads and the calibrated RSOWQ dataset. To validate FDEP's new transparency criterion, we related RSOWQ time series data to annual changes in seagrass species composition, distribution, and abundance in the Suwannee Estuary and the larger Big Bend region since 2002.

To assure continuity beyond the project lifespan, we also developed and transitioned user-friendly MODIS-based tools which TMDL staff and other stakeholders now use for ongoing measurement of RSOWQ in the Suwannee Estuary and effects of watershed management actions.

Figure 3 - NASA RSOWQ ground truth sampling sites.

Results

Success for this project was derived from several factors. First, success resulted from the long-term MODIS, seagrass, and optical water quality datasets representing investment and commitment by NASA, USF, FWC, and DEP. Next, the deep and complimentary expertise of the project team was a crucial element of success. The creation of a unique user-friendly knowledge repository of the Suwannee Estuary (www.optics.marine.usf.edu), specifically centralizing the water quality of specific seagrass study sites created by the USF (Figures 4 and 5), as well as the increased efforts of outreach in the establishment of stakeholder workshops and communication were critical to this project.

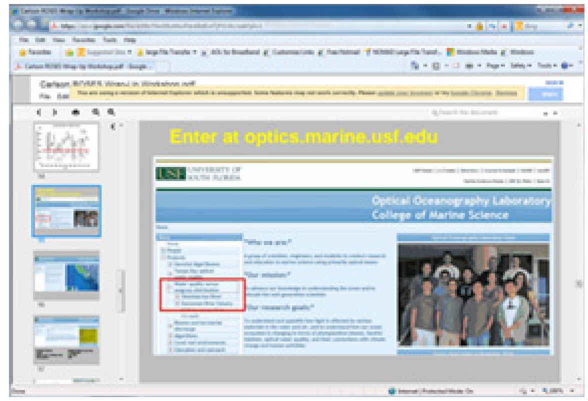


Figure 4 - Web-site for accessing water quality versus seagrass reference data.

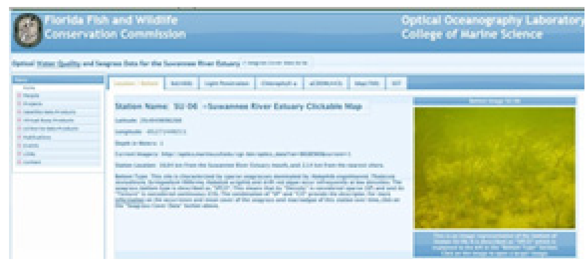


Figure 5 - Subset of web-site shown in Figure 3, providing environmental data for a specific ground truth sampling site. Each station has data on Kd488, bottom light availability (%SI), chlorophyll-a, seagrass density, species composition, a CDOM (443), bbp (700), and SST.

As Florida's Big Bend seagrasses are one of that state's most important resources, it was imperative that this project provided a resource that drastically improves the state's support of so many economically important species and plays such a vital role on Florida's economy.

Monitoring Coastal Marshes For Persistent Flooding and Salinity Stress

PI: Maria Kalcic, Science Systems and Applications, Inc., NASA Stennis Space Center			
Partners: US Geological Survey (USGS) National Wetlands Research Center (NWRC), Lafayette, LA; NWRC Field Station at Louisiana State University			
Users: USGS National Wetlands Research Center and the Louisiana Department of Natural Resources			
RFP: 2008 ROSES A.28			
ARL Start	**3**	**ARL End**	**5**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

Persistent saltwater flooding of coastal marshes by storm surge, rising sea level, and subsidence is a primary cause of wetland deterioration and habitat loss. The objective of this project was to provide resource managers with remote sensing products that support ecosystem forecasting models requiring salinity and inundation data. The results of this work support the habitat-switching modules in the Coastal Louisiana Ecosystem Assessment and Restoration (CLEAR) model, which provides scientific evaluation for restoration management. CLEAR is collaboration between the Louisiana Board of Regents, Louisiana Department of Natural Resources (LDNR), United States Geological Survey (USGS), and U.S. Army Corps of Engineers (USACE).

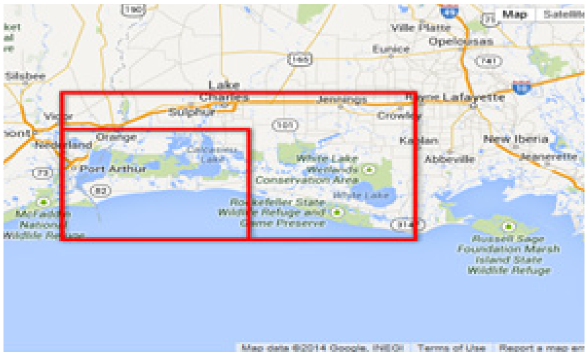


Figure 1 - Study Areas (Source: Google Maps)

Specifically, the work supported the habitat-switching modules which simulate shifts in vegetative community type given long-term shifts in salinity and inundation due to restoration projects.

Methods

The study area in southwest LA is between the Gulf of Mexico and Intracoastal Waterway and between Lake Calcasieu and Sabine Lake in the west (Figure 1 and 2). MODIS-derived time-series of normalized difference water indices were used map flood persistence and were resolution-enhanced by Landsat to better separate marsh and open water; RADARSAT was used to map flooded areas and to derive a dielectric constant as a proxy for salinity; Landsat was used to map varying ranges of marsh salinity.

Persistent flooding was mapped using MODIS NDWI time series (see Figure 2) at 250m resolution with an 81% accuracy (based on CRMS samples); or using fused MODIS-Landsat times series, at 30m resolution with an 77% accuracy (based on CRMS samples).

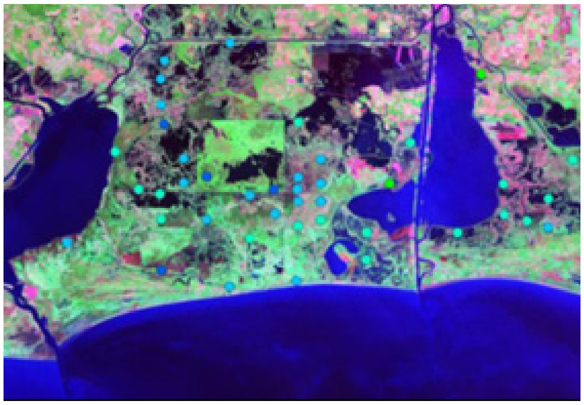


Figure 2 – Landsat view of Calcasieu-Sabine Basin study area in southwestern Louisiana. Coastwide Reference Monitoring System (CRMS) sites are shown by small circles.

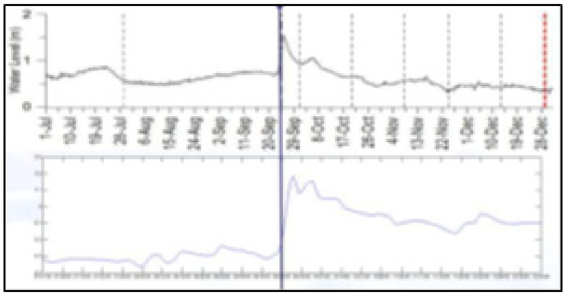


Figure 3 – Water levels before and after Hurricane Rita (vertical bar) in 2005 as tracked by (a) CRMS hydrographic station and (b) MODIS NDWI time series.

Results

Salinity was calculated from Landsat spectral imagery, using multiple regressions, to within 0.6 ppt average, and 7.8 rms error. Additionally, marsh salinity was found to be inversely related to CDOM, which is generally much higher in fresh marshes versus saline Gulf waters. Inundation persistence and salinity data were fused to produce maps of persistent saltwater inundation (see Figure 3).

Residual flood mapping done with Envisat ASAR by USGS is shown in Figure 4. Results show areas flooded from seven days (red) to more than 60 days (yellow).

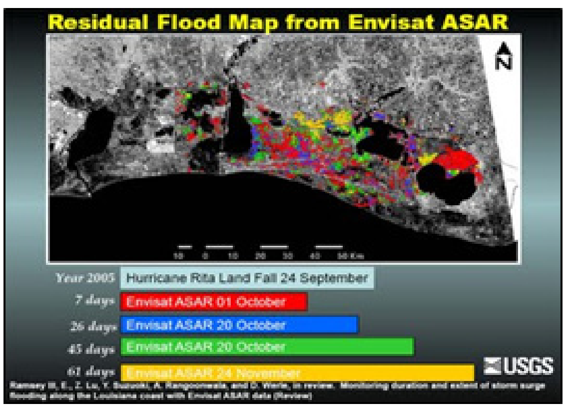


Figure 4 – Residual Flood Map from Envisat ASAR

Figure 5 shows salinity estimates from Landsat-5 before and after Hurricane Ike, in 2008. Salinity intrusion is apparent in the fresher inner marshes following the storm. Salinity data were fused with persistent flooding maps to produce maps of saltwater stressed areas (see Figure 6).

L-band SAR products (PALSAR) data is now used to estimate the dielectric constant and possibly infer salinity in marsh pore water. PALSAR products were more effective at mapping coastal inundation at 83% than C-band products (ASAR) at 61%; however the C-band products performed well in response to major drought or flooding events (76%). A statistical model was developed to predict community structure from observed salinity and inundation hydrologic parameters.

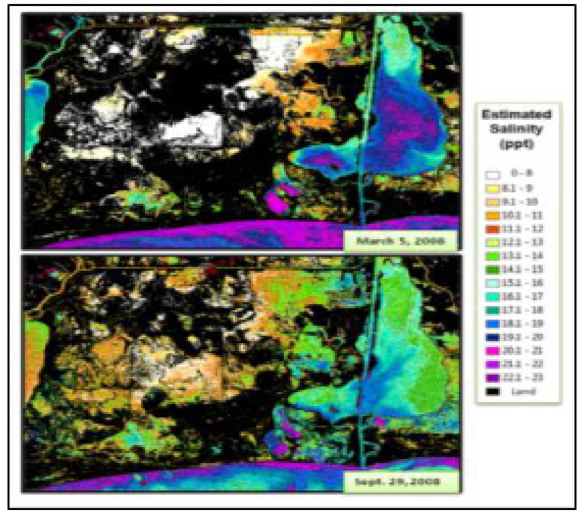


Figure 5 – Estimated salinity levels before and after Hurricane Ike, 2008.

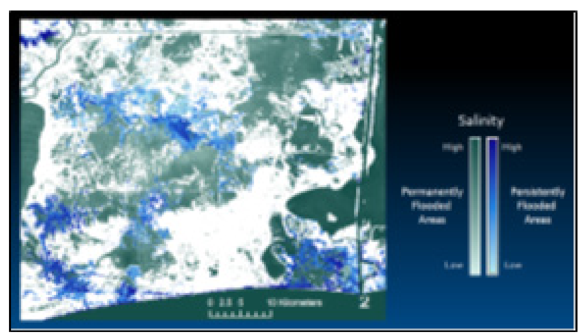


Figure 6 – Salinity Gradients in Flooded Areas

Salinity thresholds obtained were used with assessments of tidal amplitudes to refine habitat switching models developed under the CLEAR model and currently being updated under Louisiana's 2012 State Master Plan modeling effort to predict the 2060 future with and future without restoration/protection vegetation habitat.

PI: Jean Ellis, University of South Carolina			
Partners: NASA Stennis Space Center; Mobile Bay National Estuary Program (MBNEP); Computer Sciences Corporation			
Users: MBNEP; Alabama Dept. of Conservation and Natural Resources; NOAA National Coastal Data Development Center (NCDDC)			
RFP: 2008 ROSES A.28			
ARL Start	**1**	**ARL End**	**8**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

This project applied data and models from the National Aeronautics and Space Administration (NASA) to analyze land-use and land-cover, or "LULC" change in Mobile and Baldwin Counties from 1974 to 2008. This project was conducted to enhance decision-making capabilities for organizations involved with coastal habitat and conservation in the Mobile Bay region (see Figure 1).

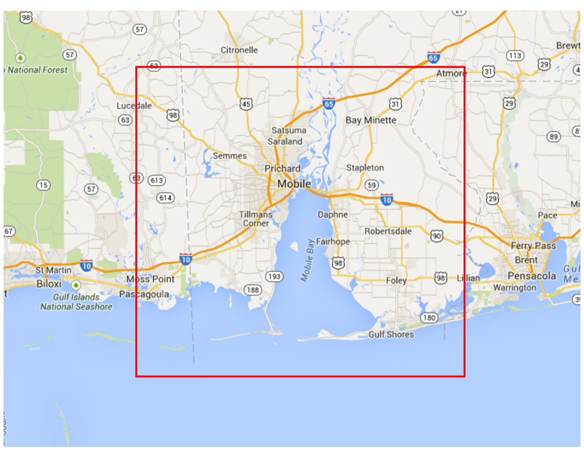


Figure 1 - Study area location. (Source: Google Maps).

Mobile Bay is vital to the environmental vitality and economics of the Gulf of Mexico (GOM) and the nation. In response, several federal agencies/organizations are conducting research- and remote sensing applications-based studies in the region, including this the NASA-funded team. A goal of this project is to help identify and prioritize conservation and restoration efforts within the region, such as work to sustain coastal wetland habitats (see Figure 2 below).

This project pertains to ecological forecasting, agriculture, and water resources applications of NASA's Applied Science Program and addresses multiple GOMA priority issues, including Habitat Restoration and Conservation, Ecosystems Integration and Assessment, and Coastal Community Resilience.

Figure 2 – Three Mile Creek of Mobile Bay region, example location where MBNEP is planning, implementing, and aiding coastal restoration and conservation work (Source: MBNEP).

Methods

Working with the Mobile Bay National Estuary Program (MBNEP) and the Alabama Department of Conservation and Natural Resources, State Lands Division, Coastal Section (ADCNR), the project applied data and models from the National Aeronautics and Space Administration (NASA) to analyze land-use and land-cover, or "LULC" change in Mobile and Baldwin Counties from 1974 to 2008. This project produced and validated these LULC mapping products to aid end-user coastal conservation decision-making needs. It further analyzed these LULC products to characterize the changing urban landscape in the region, assess the permanence of LULC change, and identify locations of interest for conservation and restoration.

Results

Project deliverables included a validated time series of LULC (Figure 3) and impervious cover maps (Figures 4 and 5) with emphasis on key watersheds identified by MBNEP; data products analyzing urban change trends; assessments of the permanence of LULC change of the Lower Fish River watershed (see Figure 6); and model output results to identify parcels with conservation and restoration potential.

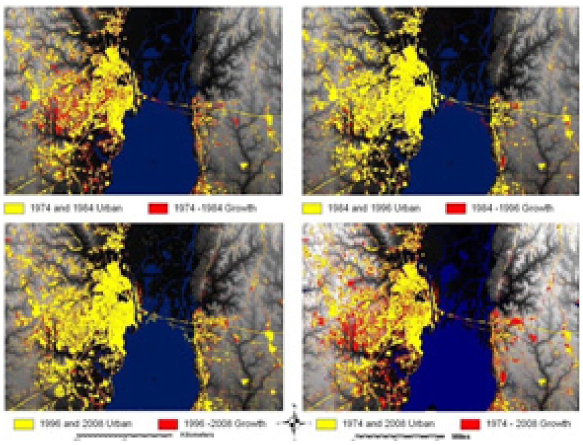


Figure 3 - Urban expansion within upper Mobile Bay, for 1974-2008, based on LULC maps from the project.

In addition, project data was transferred to MBNEP and NOAA for public access and to support their on-going efforts in implementing the Coastal Change Assessment Program (C-CAP) and Habitat Priority Planner (HPP). The project also yielded two peer-reviewed journal articles, plus multiple non-refereed conference publications.

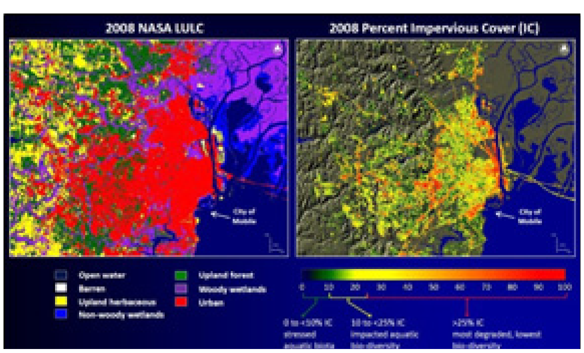


Figure 4 – Example 2008 LULC and percent impervious cover maps for City of Mobile produced during project.

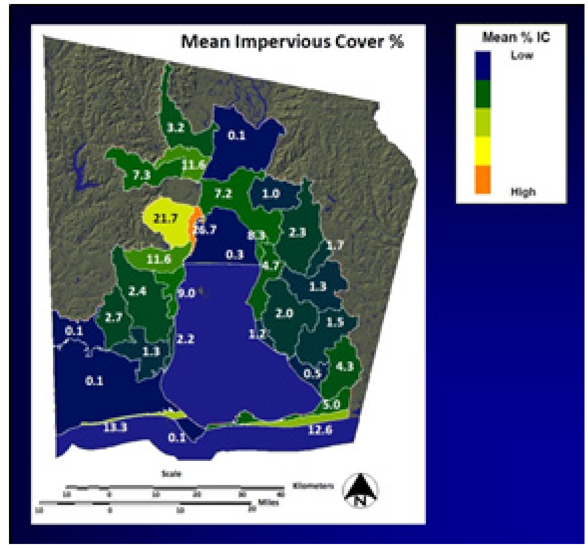


Figure 5 – Average percent impervious cover for priority coastal watersheds identified by MBNEP.

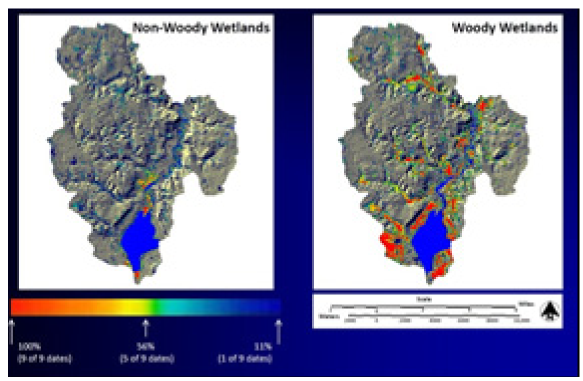


Figure 6 – Habitat stability map for targeted habitats within the Lower Fish River watershed for 1974-2008.

In summary, NASA-based products provided a valuable data resource that was integrated into a Comprehensive Conservation and Management Plan, aiding the Mobile Bay National Estuary Program in improving its decision making and generally benefitting society in regards to conservation and restoration work.

Assessing Trajectories, Patterns and Stressors in Marsh Loss at the Landscape Level: The Impact of Freshwater Diversions

PI: Michael Kearney, University of Maryland			
Partners: Louisiana Department of Natural Resources; US Geological Survey National Wetlands Research Center; NASA Jet Propulsion Laboratory; Louisiana State University			
Users: Louisiana Department of Natural Resources; Louisiana Department of Environmental Quality; US Geologic Survey; US Army Corps of Engineers; US Fish and Wildlife Service			
RFP: 2008 ROSES A.28			
ARL Start	**2**	**ARL End**	**9**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

Marsh loss in coastal Louisiana continues to occur at alarming rates, though efforts have been made to restore prior marsh through restoration practices such as freshwater diversions. The effectiveness of freshwater diversions has been questioned, given that marsh loss continues to occur. In response, this project was conducted in southeast Louisiana (Figure 1), with the following objectives: 1) Adapt for the Gulf of Mexico (GOM) the existing Marsh Surface Condition Index (MSCI) for deriving synoptic observations of delineate how the life cycle of marsh develops; 2) Link the MSCI observations of marsh condition to characteristics of plant physiological structure and other stressors that reveal physiological functioning; and 3) Integrate the satellite and field data into a decision support system for the Louisiana Department of Natural Resource (LDNR) and other agencies that includes tools for data visualization and manipulation.

Methods

This research employed a proven spectral mixing "NDX" model with Landsat TM spectral indices (NDVI, NDWI, and NDSI) to determine long term trajectories of loss for different areas in the Louisiana Coastal Area (LCA). The spectral indices are independent, which is a critical factor in general PCA-based mixture models. Stressors act like triggers, such as hurricanes and marsh fires, whether they initiate the marsh loss cycle or accelerate the marsh loss rate, were analyzed using historical records of the hurricanes in the GOM and the fire data for the LCA. The Moderate Resolution Imaging Spectroradiometer (MODIS) 250 m data and data from a new radar platform technology, the Unmanned Air Vehicle Synthetic Aperture Radar (UAVSAR), were to be used to analyze changes in marsh conditions in high spatial and temporal detail. From the SAR data, wetness, marsh surface elevation, canopy biomass, and other characteristics based on MSCI were to be assessed. Post storm trends were to be examined using MODIS data.

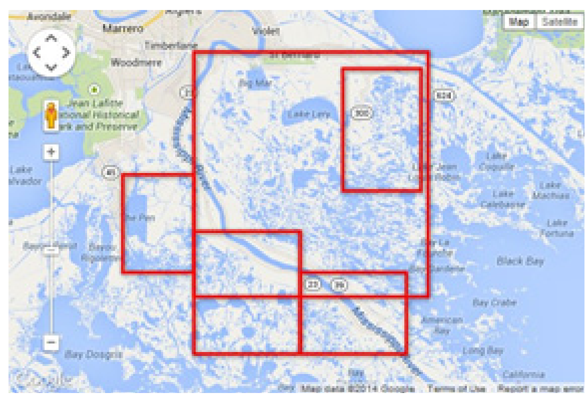


Figure 1- Study area locations. (Source: Google Maps).

Field based indicators of marsh submergence and its effects on plant vigor, such as anoxia, sulfides, and rooting strength were collected at sites differing in degree of degradation to determine what the Landsat-based spectral mixing model and the other remote sensing data mean in terms of marsh plant vigor.

Results

Analysis of the Landsat data for 1984-2005 (Figure 2) indicated that the observed diversions even after 19 years did not lead to increases in coastal marsh vegetation, though sometimes vegetation increases were observed (Figure 3). The latter can be due to floating aquatic vegetation.

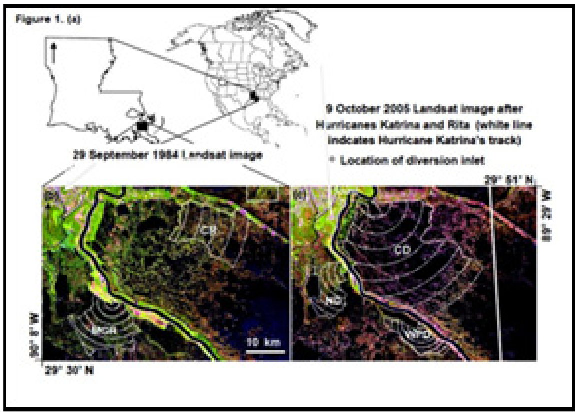


Figure 2 - Comparison of Landsat data for diversion sites before and after Hurricane Katrina (Source: Kearney et al., 2011 in Geophysical Research Letters).

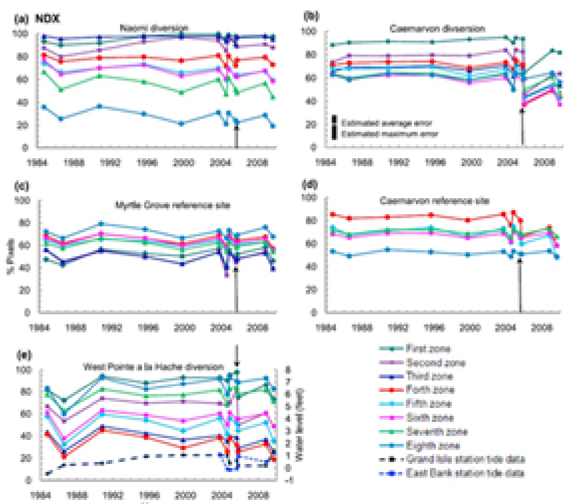


Figure 3 - Example results of NDX spectral mixing models, reporting percent of pixels that are vegetated for a given zone of a given diversion unit (Source: Kearney et al., 2011 in Geophysical Research Letters).

Landsat products acquired after Hurricanes Katrina and Rita can show marsh loss and degradation around these diversions. The diversion areas regardless of hurricanes in some cases showed some increased nutrient levels floating algae that are evident in diversion runoff areas (Figure 4). Such enriched runoff harms marsh root growth and below ground biomass.

Figure 4 - Example of barren area with evidence of nutrient enriched runoff from freshwater diversion.

The project's review of diversion operations, changes in vegetation in the study area, and floating vegetation led to a better understanding about the reasons for the failure of freshwater river diversion in terms of restoring marsh extent. Findings from the project indicate that hypertrophic conditions do not favor marsh plant sustainability. This is due to low root biomass, which happens to diminish marsh substrate integrity and then impairs overall vertical accretion rates in marshes where below ground biomass is the major contributor to maintaining marsh elevation vis-à-vis sea level rise. In addition to low root biomass, another hypertrophic condition is the occurrence of weak stems prone to lodging and low oxygen transport.

The data collected from Landsat was used with success to assess marsh change in and around diversions. Results from the project were developed into a web-based, modeling Decision Support System (DSS) for the LDNR, as they work to stem continuing marsh loss all along coastal Louisiana.

Enhancing Estuarine Water Quality Management Through Integrating Earth Science Research Results: A Targeted Project for Tampa Bay, Florida

PI: Chaunmin Hu, University of South Florida			
Partners: Florida Department of Environmental Protection; Professional University of South Florida; Florida Fish and Wildlife Conservation Commission; Tampa Bay Estuary Program			
Users: Florida Department of Environmental Protection; Tampa Bay Estuary Program; Hillsborough County Environmental Protection Commission; City of Tampa; Charlotte Harbor National Estuary Program; Mobile Bay National Estuary Program			
RFP: 2008 ROSES A.28			
ARL Start	**4**	**ARL End**	**8**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

Present monitoring of estuarine water quality in the Gulf of Mexico (GOM) is largely based on in situ surveys. These costly and labor-intensive efforts can inadequately characterize short-term status and long-term trends, and thus could lead to biased statistics and decisions.

The project included multiple objectives: 1) improve an existing water quality management decision support system, namely a Water Quality Decision Matrix (WQDM), through use of the more frequent synoptic satellite-based observations using the Moderate Resolution Imaging Spectroradiometer instrumentation (e.g., MODIS) of Tampa Bay, Florida's largest estuary (Figure 1); 2) establish a remote sensing based DSS for wider applicability beyond Tampa Bay, by using other estuaries (e.g., Mobile Bay in Alabama) for performance evaluation; 3) provide near real-time water quality information for event response; and extend the approach to other similar estuaries. The work addressed three Gulf of Mexico Alliance priority areas: water quality, nutrients and nutrient impacts, and ecosystem integration and assessment.

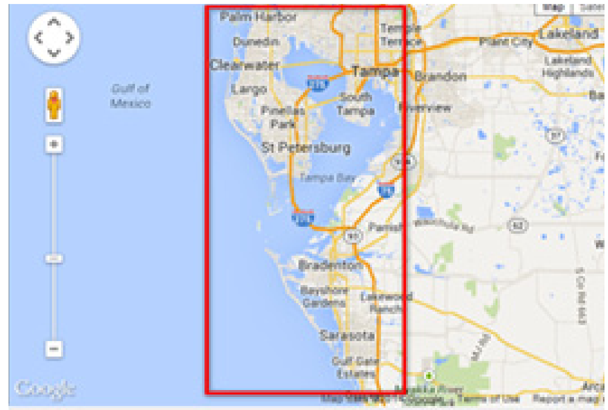


Figure 1 - Location of study area. (Source: Google Maps)

Methods

The main partner for the project was the Tampa Bay Estuary Program (TBEP) whose Nitrogen Management Strategy Paradigm begins with Total Nitrogen Loads affecting chlorophyll. The latter is affected by Light Attenuation. This leads to the seagrass light requirement of the plants receiving at least 20.5% of surface light needed for plant growth and reproduction (Figure 2).

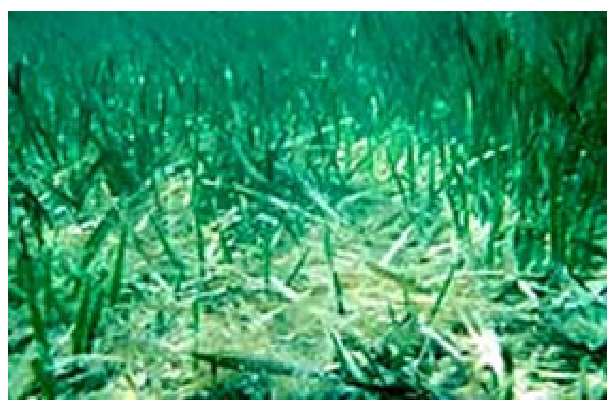


Figure 2 - Turtlegrass, a form of seagrass found in study area (Source: USGS)

The TBEP has an existing Water Quality Decision Matrix (WQDM) to help make decisions on Total Maximal Daily Loads (TMDL) of nutrients. However, the existing WQDM lacks synoptic coverage and a temporal resolution to capture water quality changes quicker than the monthly sampling frequency (Figure 3).

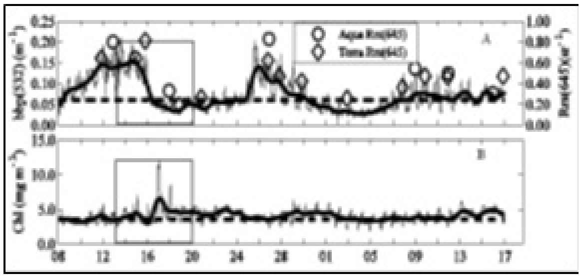


Figure 3 - December 2004 - January 2005 WQDM graph.

Water quality data products of turbidity, clarity (through Sechi disk depth or SDD), and sea surface temperature (SST) were developed and validated for this turbid estuary, while others (concentrations of total suspended sediments, chlorophyll-a, colored dissolved organic matter (CDOM), and light availability for benthos) are being improved through this project and other work. These remotely sensed data products, together with region-specific water quality criteria, were analyzed for water quality status and trends, and the results incorporated in the ongoing monitoring programs and WQDM DSS to reduce spatial/temporal aliasing and thus improve DSS performance.

Results

As a result of twelve targeted cruise surveys conducted since May 2010 (Figure 4), the following was determined: 1) overall, for all wavelengths examined (PAR, 490, 555 nm); and 2) Kd variability was affected mainly by detrital particles, followed by phytoplankton pigments and CDOM. The project also established a new WQDM, developed using validated satellite data products of Chl and water clarity.

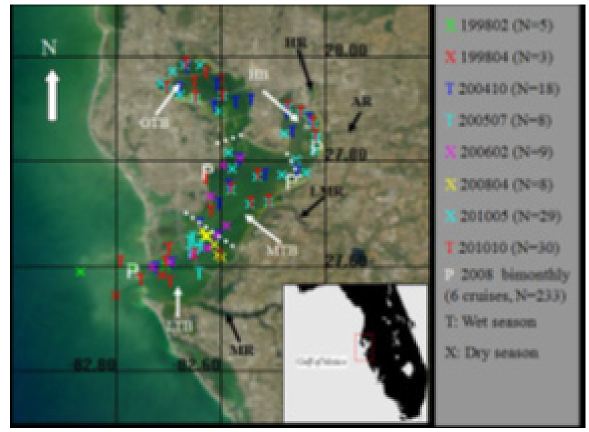


Figure 4 - Location of targeted cruise surveys conducted during project starting in May 2010.

The project enabled: 1) study of several light controlling mechanisms; 2) new algorithms developed, refined, and validated (Figure 5); 3) studies of water quality trends; and 4) several publications.

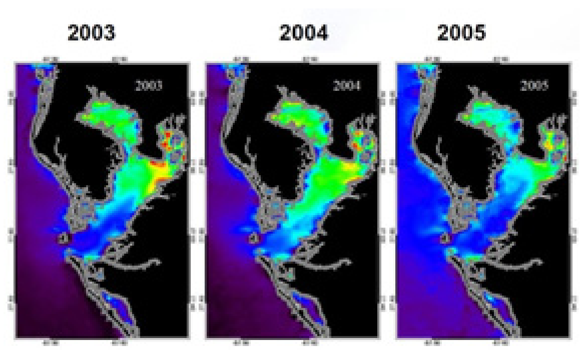


Figure 5 - Example MODIS chlorophyll products that were computed and validated during project.

In summary, the project team developed a satellite-based decision matrix that was shared with TBEP, FDEP, and GOMA. It also produced a near real-time satellite-based Virtual Buoy System (VBS) for Florida DEP and helped support relevant Environmental Protection Agency (EPA) mobile-phone applications. An added benefit is that these products turned out to be portable for use with other estuaries, especially those with limited or no onsite water quality monitoring capabilities.

Nutrient Linkages Between South Florida Rivers and Coastal Habitats: Integrating Water Quality Sampling with Satellite Remote Sensing to Enhance Management

PI: Brian Lapointe, Florida Atlantic University			
Partners: University of South Florida; Florida Department of Environmental Protection; State of Florida; Atlantic Oceanographic and Meteorological Laboratory, NOAA			
Users: Florida Department of Environmental Protection; Florida Keys National Marine Sanctuary; Monroe and Lee Counties Florida; US Environmental Protection Agency			
RFP: 2008 ROSES A.28			
ARL Start	1	**ARL End**	1
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

Nutrient pollution in the Gulf of Mexico (GOM) includes eutrophication, harmful algal blooms (HABs) (see Figure 2), fish kills, shellfish poisonings, seagrass and coral reef die-off, and marine mammal and seabird deaths. Nutrient inputs result mainly from agriculture, ranching, phosphate mining, and urbanization runoff.

This project addresses the connection between south Florida rivers and key water quality parameters to further understand the effect of management practices on coastal habitats; and provides numeric nutrient criteria for improved management of river discharge (e.g., increase/decrease water flows and nutrient loading) in southwest Florida and the Florida Keys. It addresses the GOMA priority issues of water quality, nutrients and nutrient impacts, and ecosystem integration and assessment.

Methods

Study areas included the Charlotte Harbor area that is impacted by the Caloosahatchee River runoff and the lower Florida Keys affected by discharges from Shark River (see Figure 1). In situ nutrient and optical water quality data were collected at the study sites during wet and dry seasons using three MicroLAB nutrient analyzers bundled with a SBE 10 CTD and bio-optical equipment. Ammonium, nitrate, nitrite, soluble reactive phosphorous (SRP), total dissolved nitrogen (TDN), total dissolved phosphorous (TDP), and Chl-a were sampled and used to calculate dissolved inorganic nitrogen (DIN), DIN:SRP, dissolved organic phosphorous (DOP), dissolved organic nitrogen (DON) and TDN:TDP. Carbon and nitrogen fractions were also computed for benthic macroalgae and phytoplankton.

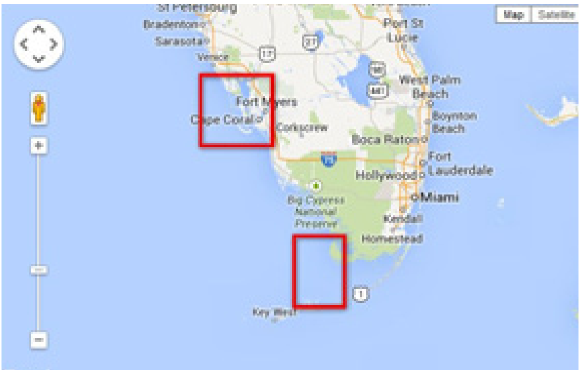


Figure 1– Study area locations with Caloosahatchee River site in upper left red box and Shark River site in bottom middle. (Source: Google Maps)

A total of eight surveys were conducted between 2010 and 2011. Optical parameters such as absorption were also derived for Chl-a, CDOM, and dissolved and particulate matter, as well as remote sensing reflectance. Algorithms were evaluated for the best diffuse attenuation coefficient (Kd490) and evaluated at 0 – 12 km from shore (Figure 3). In situ water quality data were integrated with data from satellite sensors, such as the Moderate Resolution Imaging Spectroradiometer (MODIS), and the Thematic Mapper (TM) from Landsat, and used to derive, for the very time, historical water quality events dating back to the 1980's.

Results

A major finding resulting from this project was determining the best remote sensing Kd (Figure 4) and Zeu algorithms and products. Additionally, in the field of remote sensing, a "Black Water" case study was established, documenting ecosystem connectivity.

Figure 2 - Harmful Algal Blooms; Florida Red Tide

Other major findings regarded nutrients and water quality for the years 2010 and 2011. On the Caloosahatchee River, high P was released into the coastal area near the river mouth, driving N:P ratios down and making this area N-limited during both the wet and dry seasons. It was discovered that inorganic N and P are high enough to promote HABs near the river mouth in the dry season and throughout the study region during the wet season. The release volume from the S-79 correlates with HAB intensity in southwest Florida between the years 1970 and 2012.

Figure 3 – Field measurement equipment used during one of the project field surveys.

In regards to the Shark River, higher DIN and N:P ratios (greater nitrogen and less phosphorus inputs) existed along the Shark River transect that the Caloosahatchee River transect. This is the first coastal eutrophication field study to support the lab-based findings that high DIN and N:P ratios play an important role in coral bleaching.

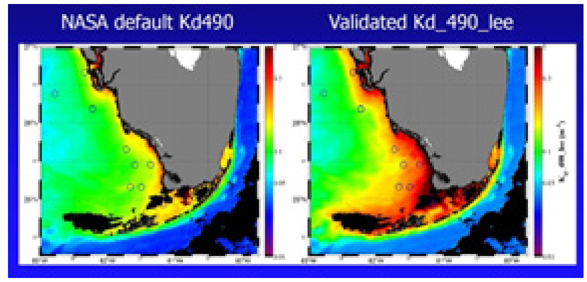


Figure 4 – Validated MODIS derived Kd, based on two methods (field validation sites indicated in circles).

In summary, a direct connection was made between Shark River discharges and water quality and coral reef health in the Florida Keys regions. Nutrient pollution in the Gulf of Mexico links to an array of problems. This project provided useful decision-making tools in the effort to further understand the effect of management practices on coastal habitats; and provides numeric nutrient criteria for improved management of river discharge to help ensure healthy beaches and safe seafood in our coastal areas.

Closeup of Harmful Algal Blooms

PI: Gregory Easson, University of Mississippi			
Partners: Radiance Technologies; NASA Stennis Space Center, Science Systems and Applications, Inc.			
Users: Grand Bay National Estuarine Research Reserve; National Institute for Undersea Science and Technology; Mississippi Mineral Resources Institute			
RFP: 2008 ROSES A.28			
ARL Start	3	**ARL End**	5
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

The Gulf of Mexico Alliance (GOMA) recognizes the importance of seagrass beds (see Figure 1) and other submerged aquatic vegetation (SAV) as critical nursery habitats for many commercial coastal and pelagic fish species, as well as baffles for wave energy and coastal erosion. GOMA also recognizes that Gulf coast coastal zone management agencies are ‘managing their submerged aquatic resources using very sparse data and information. In response, this seagrass modeling project developed a set of tools that use daily and 8-day composite Moderate Resolution Imaging Spectroradiometer (MODIS) data to provide inputs for the Fong and Harwell seagrass productivity model.

Methods

Grand Bay served as the focus area (see Figure 2) with the Grand Bay National Estuarine Research Reserve (GBNERR).

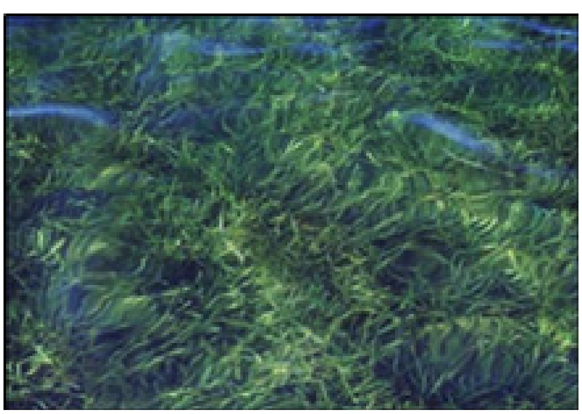


Figure 1 - Photo of seagrass beds found along the nearby Mobile Bay (Source: Mobile Bay NEP).

The project then developed a system to download and process MODIS data (with a similar method created for Visible Infra Red Imaging Radiometer Suite (VIIRS) data once available) to extract MODIS Level 1A and 2 products, plus chlorophyll, sea surface temperature (SST) and normalized water leaving radiance (412nm) products using the SeaWiFS Data Analysis System (SeaDAS) to process the MODIS data. Productivity was then solved for using satellite and ground-based data.

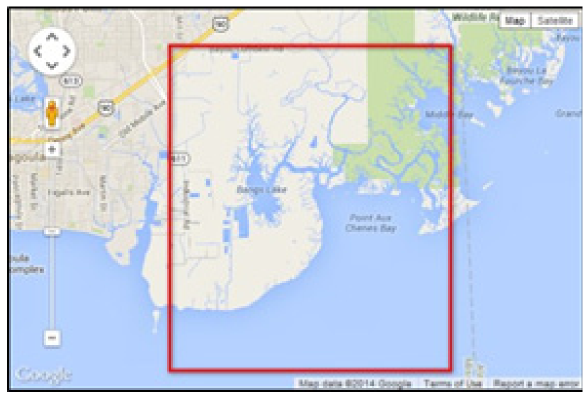


Figure 2 - Study Site Location. (Source: Google Maps).

A final task regarded the development and implementation of an Internet-based tool for integrating NASA science data into the Fong and Harwell (1994) seagrass model, and distributing the results to the managers through Internet mapping sites developed by federal agencies.

The Thematic Real-time Environmental Distributed Data Services system (THREDDS) was used to incorporate the NASA data into the Fong and Harwell model. Integrating data from this system enabled the project team to create an integrated data viewer (IDV), the Seagrass Health Data Portal for users (Figure 3).

Results

MODIS-based data products were used, with some considerations, to provide input parameter products to the Fong and Harwell model for estimating seagrass community productivity. Results from this model indicated positive growth in seagrass productivity during the growing season in the Grand Bay seagrass ecosystem sites shown in Figure 4. Use of the MODIS-based products revealed certain issues that have the ability to affect the interpretability of the results, including: 1) The land mask sometimes eliminated useful coastal water-related pixels from consideration; 2) Some of the pixels at the resolution of the MODIS products were actually mixtures of water and sea floor; 3) Some data was missing due to poor data quality (e.g., due to QA masked cloud cover); and 4) The cloud cover frequency necessitated use of 8 day composites (as opposed to daily data).

Project results indicated that in-situ data provided finer scale resolution of real world conditions, but the logistics in collecting such data offsets some of this benefit.

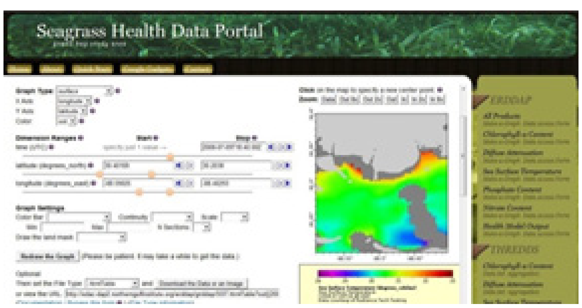


Figure 3 - Project developed Seagrass Health Data Portal, showing example MODIS SST product.

The project produced useful results for assessing the potential in deriving seagrass assessment products from MODIS satellite data. While it demonstrated technical feasibility in using such products as inputs for modeling seagrass productivity, it does not appear that the capability was adopted by the potential end-user organizations, such as the GBNERR.

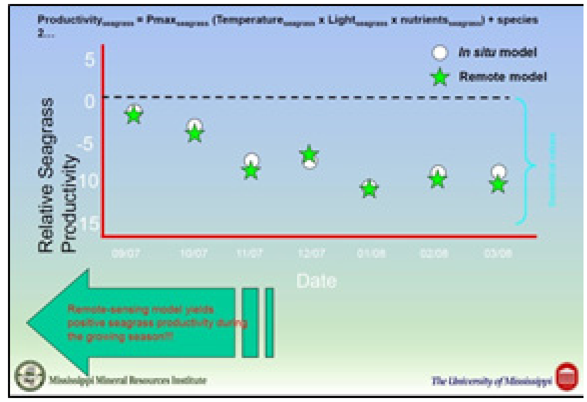


Figure 4 - Comparison of in-situ and remote sensing based modeling of seagrass productivity, based on data from 2007 and 2008.

In summary, seagrass beds and other submerged aquatic vegetation (SAV) are recognized as critical nursery habitats for many commercial coastal and pelagic fish species. As a result of this project it was made clear that remote sensing platforms can be used to populate parameters of the Fong & Harwell model of seagrass community productivity. This highlighted the benefit of using cooperative work between satellite-based and ground-based acquisition teams, increases the likelihood for providing the most useful satellite-based information on seagrass conditions to coastal resource managers.

A MODIS Based Decision Support Tool for Gulf Coast Salt Marsh Conservation and Restoration

PI: Deepak Mishra, Mississippi State University			
Partners: University of Nebraska at Lincoln; University of New Orleans; University of Georgia			
Users: Coastal Protection and Restoration Authority of Louisiana; Louisiana Applied Coastal Engineering and Sciences Division; Grand Bay National Estuarine Research Reserve – Mississippi; United States Department of the Interior; Fish and Wildlife Service; Division of Ecological Services – Texas.			
RFP: 2008 ROSES A.28			
ARL Start	**2**	**ARL End**	**4**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Figure 1 - Photo from in-situ spectroradiometer surveys conducted during projects

Introduction

Coastal marsh degradation and loss across the northern Gulf of Mexico (GOM) is a growing local and national concern. These coastal marsh habitats are threatened by multiple factors, such as development, storm damage, and sea-level rise.

The Gulf of Mexico Alliance (GOMA) identified Wetland and Coastal Conservation and Restoration as one of its five priority issues. This project used several NASA products to develop specific tools that directly support the Gulf States as they plan, implement, and monitor coastal salt marsh restoration efforts.

The project had two primary objectives: 1) Develop and test a suite of Moderate Resolution Imaging Spectroradiometer (MODIS)-based indices as decision-support tools allowing coastal managers to monitor the 'health' of coastal salt marshes; 2) Use MODIS 250 and 500m data to develop prototype weekly composite salt marsh biophysical products including distributions of Chlorophyll (CHL) and Vegetative Fraction.

Methods

The project team used atmospherically corrected MODIS 8-day surface reflectance products (250m and 500m), and in situ sensor systems (shown in Figure 1) for measurements of biophysical data from 171 locations covering Louisiana, Mississippi, Alabama, and Florida (See Figure 2).

The project applied 15 Vegetation Indices (Vis) for predicting GBM estimation per marsh species (Figure 3); five modules with three variants of each model using 760, 800, and 1100 nanometers (nm) for near-infrared (NIR).

Figure 2 - Study area location. (Source: Google Maps)

The project computed MODIS CHL, VF, Green Biomass (GBM), and Leaf Area Index (LAI) products for addressing three important issues: including: 1) Identification of critical hotspots of marsh stress; 2 Prioritization of areas in need of immediate restoration; and 3) Development of baseline datasets for future analyses of habitat restoration, public education, and monitoring activities.

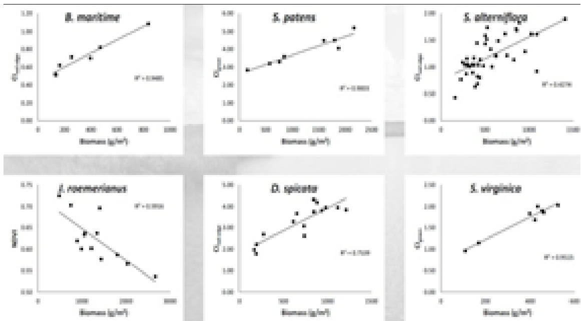


Figure 3 - Predicted GMB for six targeted marsh species, based on in-situ data.

The project later generated in-situ-based VF products used to help develop and assess satellite-based products (Figure 4).

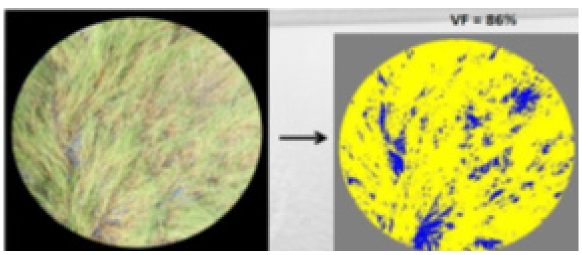


Figure 4 – Field photo (left) versus in-situ VF product (right image) for marsh location surveyed during project (yellowvegetated and blue is non-vegetated).

Results

MODIS-based time series products depicting CHL, VF, GBM, and LAI at 250m and 500m resolutions at 7 day intervals (Figure 5) were used, along with MODIS-based NDVI phenology profiles (Figures 5 and 6) to assess marsh decline after hurricanes. These MODIS products help resource managers to assess and monitor coastal marsh health, thereby aiding ongoing restoration and carbon sequestration monitoring work.

A result of this study included an efficient and non-destructive mapping protocol for emergent coastal salt marshes for use in restoration decision-making.

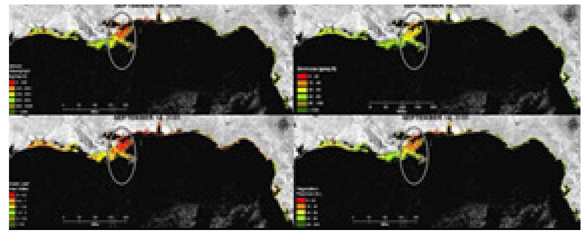


Figure 5 – Example MODIS 500m CHL, VF, GBM, and LAI products regarding northern Gulf of Mexico coastal marsh for date ending 9/14/2005, shortly after Hurricane Katrina.

Finally, the ~2500 MODIS-based marsh condition maps generated from the project cover 10 years and 4 Gulf States. The project yielded 10 years of MODIS phenological analyses for any given salt marsh location. Project results were also used to prepare two manuscripts.

In conclusion, decision-makers now have robust decision-support tools allowing coastal managers to monitor the 'health' of coastal salt marshes, directly addressing GOMA's goal of enhanced monitoring to conserve and restore coastal wetlands throughout the Gulf of Mexico.

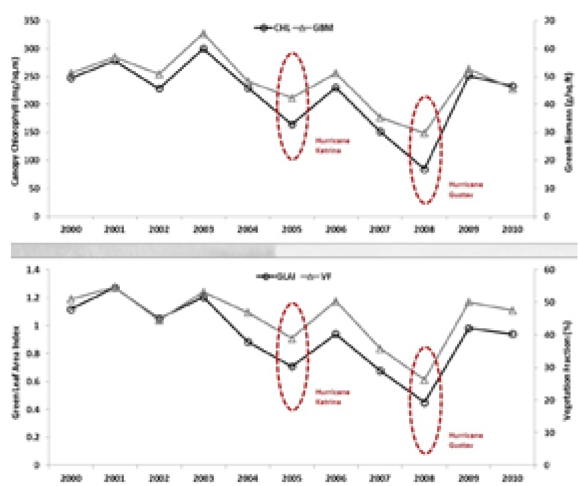


Figure 6 – Example monthly MODIS CHL, VF, GBM, and LAI phenology products for Plaquemines Parish used to assess impacts to coastal marsh from hurricanes.

PI: Xingang Fan, Western Kentucky University			
Partners: Mississippi Institute of Forest Inventory (MIFI) Measurement and Spatial Technology Lab; Mississippi State University; University of Missouri			
Users: US Department of Agriculture; US Forest Service; Mississippi Forestry Commission; NOAA Ecosystems data Assembly Center; Longleaf Alliance; Caribbean Community Climate Change Center; Mississippi Sandhill Crane Wildlife Refuge			
RFP: 2008 ROSES A.28			
ARL Start	**1**	**ARL End**	**4**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

Forest ecosystems along the coasts of the northern Gulf of Mexico (GOM) are still recovering from recent hurricanes (e.g., Hurricane Katrina) and threatened with increased stress due to changing climate (see Figure 1 for the area of study).

Figure 1 - Study area location. (Source: Google Maps)

To develop appropriate adaptation strategies, forest management specialists needed relevant regional future climate projections at meaningful spatial scales. Climate models and global reanalysis datasets have provided long term climate simulations and reanalysis of past, present, and future climate change (see Figure 2). Available climate assessments were at spatial scales too coarse for aiding many specific decision making needs of the Gulf Coast.

Methods

The project team performed dynamic downscaling of selected Intergovernmental Panel on Climate Change Fourth Assessment Report (IPCC AR4) climate projections data

Figure 2 – Example of GOM coastal forest mortality caused by Hurricane Frederic (Source: US Forest Service).

for the southeast U.S. (at 10-km) and the contiguous U.S. (at 30-km). Two sets of downscaling were employed.

One is the downscaling of the North American Regional Climate Change Assessment Program (NARCCAP) data, of which the resolution is 50-km. NARCCAP is an international program that serves the high resolution climate scenario needs of the U.S. Canada, and northern Mexico, using regional climate model, coupled global climate model, and time-slice experiments. The other is the downscaling of the NASA.

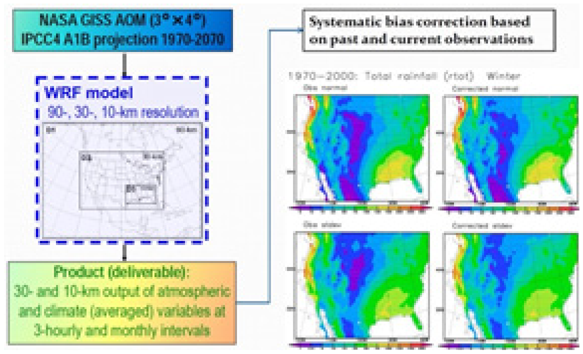


Figure 3 - Example of climate downscaling product using NASA GISS AOM in conjunction WRF model.

We incorporated the downscaled scenarios into LANDIS, a landscape decision support tool (DST) for aiding forest management (Figure 4).

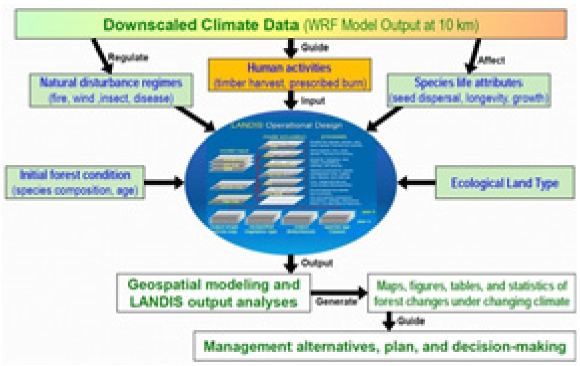


Figure 4 - Work flow in using LANDIS for forecasting forest change.

Goddard Institute for Space Studies (GISS) - Atmosphere Ocean Model (AOM) model under the A1B SRES scenario (see Figure 3). This approach involves: 1) dynamically downscaling of the IPCC AR4 climate projections by the global scale NASA GISS AOM and the continental scale simulations from the NARCCAP using the Weather Research and Forecasting (WRF) model to 10x10 km2 resolutions; 2) produced consistent land surface states and fluxes using the NASA Land Information System (LIS) at 1x1 km2 resolutions; 3) simulated forests ecosystem changes under the projected regional climate using LANDIS; and 4) generated and evaluated a suite of hypothetical forest management decisions for at least two IPCC emission scenarios. The two downscaled data products enabled the inter-comparisons of global and regional climate projections, as well as for their impacts on regional forest simulation and projection. All downscaled data and modeling data were disseminated through Ecosystems Data Assembly Center (EDAC).

Results

LANDIS was used to visualize future risk of invasion by Chinese tallow, an invasive exotic tree species (see Figure 5). It was also able

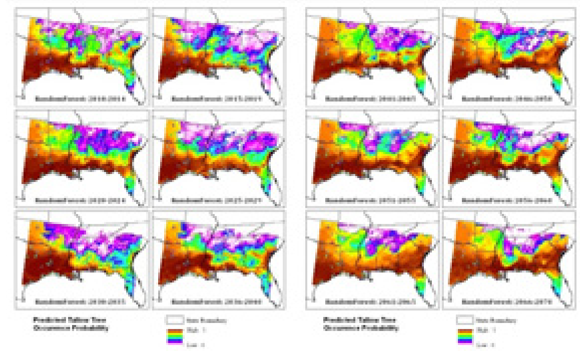


Figure 5 - Example result from Random Forest in conjunction with LANDIS - a series of maps forecasting probability of Chinese tallow occurrence.

to predict tree species distributions in relation to longleaf forest restoration (see Figure 6). As a result of this research, the DeSoto National Forest used the LANDIS simulation results to provide guidance on longleaf pine ecosystem on the coastal plans.

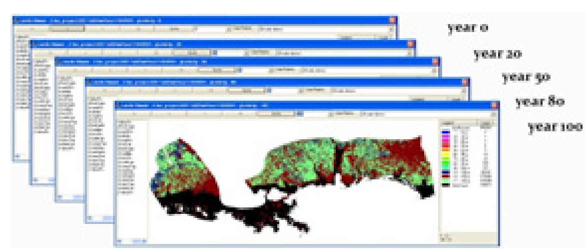


Figure 6 - LANDIS output from project used to assist longleaf pine restoration work for coastal forested landscapes in the northern Gulf of Mexico.

Use of NASA Satellite Data to Improve Coastal Cypress Forest Management

PI: Joseph Spruce, Computer Sciences Corporation			
Partners: NASA Stennis Space Center, US Geologic Survey, National Wetlands Research Center (NWRC); US Army Corps of Engineers; Louisiana Department of Natural Resources (LDNR); Louisiana Department of Environmental Quality (LDEQ); University of Maine			
Users: US Geological Survey NWRC; LDNR; LDEQ ; Barataria – Terrebonne National Estuary Program; US Department of Agriculture Forest Service; Louisiana Department of Agriculture and Forestry			
RFP: 2008 ROSES A.28			
ARL Start	**3**	**ARL End**	**7**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

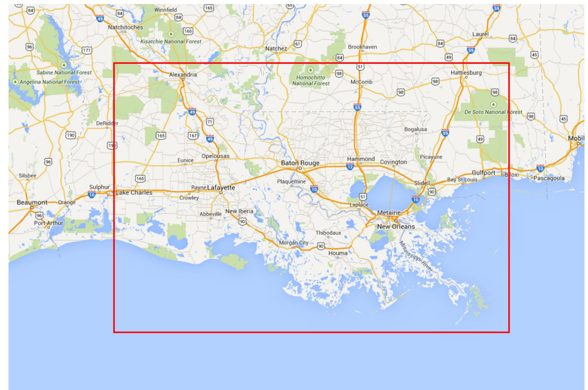


Figure 1 - Study area location. (Source: Google Maps).

Introduction

The cypress swamp forests of coastal Louisiana (LA) offer many important ecological and economic benefits, including wildlife habitat, forest products, storm buffers, water quality, and recreation (see Figure 1). Such forests are threatened by subsidence, salt water intrusion, sea level rise, persistent flooding, hydrologic modification, hurricanes, insect and nutria damage, timber harvesting, and land use conversion. Unfortunately, there are many information gaps on the type, location, extent, and condition of these forests. Complex phenology and poor access make this region's swamp forests difficult to map.

In response, this project applied NASA remote sensing assets to assist relevant coastal forest management organizations working to manage, conserve, and restore cypress-tupelo forests (see example in Figure 2). This project pertains to the following Gulf of Mexico Alliance (GOMA) priority issues: 1) Habitat Conservation and Restoration; 2) Coastal Community Resilience; and 3) Ecosystems Integration and Assessment. It also regards the Ecological Forecasting and Water Resources Societal Benefit Areas of NASA's Applied Sciences Program.

Project objectives included: 1) Develop, test, demonstrate, and transfer cypress forest mapping products using NASA owned or supported remote sensing assets; and 2) Contribute above mapping products and information on methods to government agencies involved with Louisiana and GOM coastal forest management.

Figure 2 - Boat-side view of persistently flooded cypress forest in vicinity of Lake Verret, Louisiana.

The main project end-user was the United States Geological Survey (USGS) National Wetland Research Center (NWRC), who supports the LA Coastal Forest Conservation Initiative (CFCI), the Louisiana Coast-wide Reference Monitoring System (CRMS), and the USGS Northern Gulf of Mexico (NGOM) Ecosystem Change and Hazard Susceptibility project.

Methods

The project team produced and validated: 1) Cypress type maps using Landsat and Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) data;

2) Swamp change maps using Landsat data forest from 1972-2010; and 3) Swamp forest defoliation and flooding maps using multi-temporal Moderate Resolution Imaging Spectroradiometer (MODIS) data, using the Time Series Product Tool (TSPT). The Landsat-based cypress type and swamp forest change maps, plus the MODIS forest defoliation products were validated via image analyst interpretation of randomly selected locations observed on higher spatial resolution satellite, aerial, and field reference data.

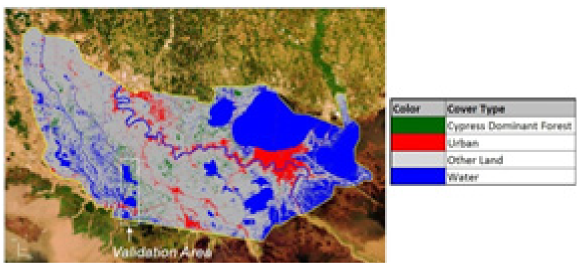


Figure 3 - Landsat-based map of cypress dominant forest.

Results

The final Landsat-based cypress type and change mapping products (Figures 3 and 4) were supplied to USGS NWRC and LDEQ for effectively aiding the CFCI in land acquisition and conservation easement work. MODIS forest defoliation products were provided to USFS and Louisiana Department of Agriculture and Forestry (LDAF) for planning annual aerial disturbance detection surveys (see Figure 5). Each of these mapping products produced a high overall agreement (90%+) with reference data.

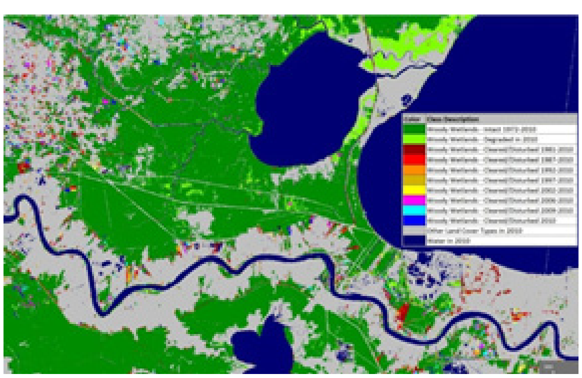


Figure 4 - Landsat-based swamp forest change map for 1972-2010. Most forest loss was due to urbanization.

The project also yielded: 1) 1972 woody wetland cover type map that was derived primarily from Landsat Multi-Spectral Scanner (MSS) data; 2) MODIS-based flood map for viewing 2011 Mississippi River flooding impacts; 3) End of year cumulative MODIS-based Normalized Difference Vegetation Index (NDVI) products with the potential for monitoring change in annual vegetation productivity; and 4) Landsat-based percent cypress canopy cover map. These other products were only validated qualitatively by comparison with available high spatial resolution reference data.

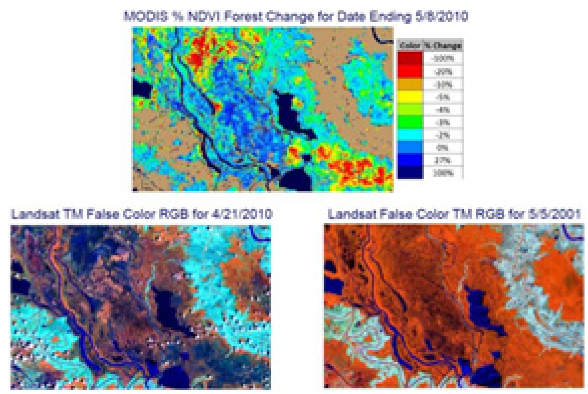


Figure 5 - MODIS map (top) of forest defoliation from caterpillars (shown in hot colors) versus Landsat imagery (bottom) of defoliated and non-defoliated spring dates.

HEALTH & AIR QUALITY

The Health & Air Quality SBA supports the use of Earth observations to address public health and air quality issues. Therefore, these projects tend to have a very direct impact on the public. The GOMI Health & Air Quality projects created a variety of tools to detect public health problems in coastal waters and to alert public health officials of air quality conditions dangerous to people with respiratory problems.

Projects

Remote Sensing to Assess Microbial Water Quality at Beaches and Shellfish Beds

Development of Sensor Assisted Water Quality Nowcasting and Forecasting Environment for Coastal Beaches

Multi-Model Simulations with Data Assimilation for Harmful Algal Blooms in the Eastern Gulf of Mexico

Origins and Mechanisms of *Karenia Brevis* Bloom Formation Along the Texas Coast

Application of Satellite Observations to Ozone Attainment Planning in Texas

Asthma and Air Quality in the Presence of Fires – A Foundation for Public Health Policy in Florida

Satellite Data Driven Modeling System for Predicting Air Quality and Visibility During Wildfire and Prescribed Burn Events

PI: Jay Grimes, University of Southern Mississippi			
Partners: Johns Hopkins University; NASA/SSC			
Users: NOAA; US Environmental Protection Agency; Mississippi Department of Marine Resources; Naval Research Laboratory; Grand Bay National Estuarine Research Reserve; US Food & Drug Administration; Center for Disease Control; National Center for Atmospheric Research; National Science Foundation; Dauphin Island Sea Lab; Mississippi-Alabama Sea Grant Consortium; Dauphin Island Sea Lab			
RFP: 2008 ROSES A.28			
ARL Start	**4**	**ARL End**	**8**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

Several species of pathogenic bacteria occur naturally in coastal waters worldwide, some of which can cause disease outbreaks in marine animals and in humans during specific environmental conditions. Death and illness as a result of eating raw or undercooked seafood or from ingesting or contacting water containing high levels of *Vibrio cholerae* and other pathogenic *Vibrio* spp. are a major concern worldwide.

The overall objective of this project was to use remotely sensed data to help prevent the spread of health risks from Marine *Vibrio*. Our research focuses on *Vibrio cholerae, Vibrio vulnificus, and Vibrio parahaemolyticus.* Over 90 *Vibrio* species have been identified, 11 of which are human pathogens. This research was expected to help regulatory agencies fulfill their public health mission to monitor microbial water quality at beaches and shellfish beds in the Gulf of Mexico (GOM).

Methods

Building on pioneering research directed at *V. cholerae* distribution and abundance in the Bay of Bengal, we have been able to predict the abundance and distribution of *V. parahaemolyticus (Vp)* in oyster reefs in the Mississippi Sound by using remotely sensed (RS) data. Our success in the prediction of *Vp* levels is actually an example of "nowcasting" and is based on populating a modified U.S. Food and Drug Administration (FDA) mathematical model with RS data, specifically sea surface temperature (SST), obtained with NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) sensor assets.

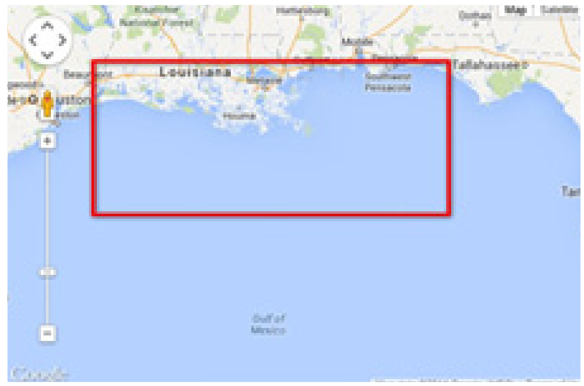


Figure 1 - Study area location. (Source: Google Maps)

The project team used several water quality parameters that were collected simultaneously with *Vibrio* isolations. These data was used to improve the ability to nowcast the abundance of *Vp* in the northern GOM (see Figure 1). Further, we expanded this nowcasting ability to incidence of the other two major *Vibrio* human pathogens, *V. cholerae* and *V. vulnificus*, in both oysters and recreational bathing beaches.

This project worked to prevent the spread of health risks from Marine *Vibrios*. Our research focused on the "big three": *Vibrio cholerae, Vibrio vulnificus, and Vibrio parahaemolyticus.* Over 90 *Vibrio* species have been identified, 11 of which are human pathogens. This research was expected to help regulatory agencies fulfill their public health mission to monitor microbial water quality at beaches and shellfish beds in the GOM.

Results

Using data from MODIS Aqua, we discovered that predicted *Vp* versus observed *Vp* correlated (Figure 2); that RS versus in situ chlorophyll and turbidity did not correlate;

and that the relationship between total *V. parahaemolyticus* and salinity was correlated.

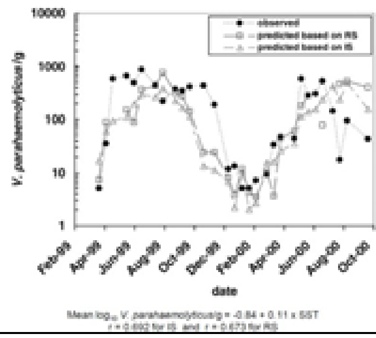


Figure 2 - Predicted Vp versus observed Vp.

Early results showed that sea surface temperature acquired from MODIS AQUA data was usable to derive *Vp* maps (Figure 3). Results from the project indicated that that when hand measured salinity values were added to a modified FDA model driven by SST, the ability to nowcast *Vp* was greatly improved (Figure 4)

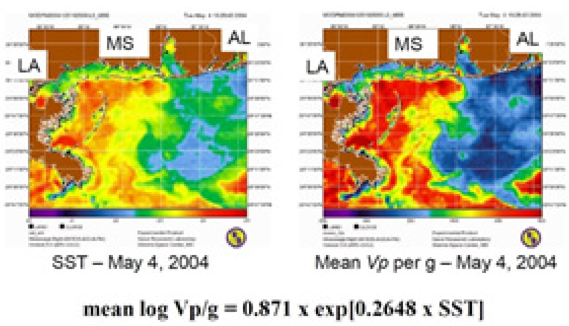


Figure 3 – Vp prediction map (right) based on MODIS SST (left).

The relationship between total *V. parahaemolyticus* and temperature and salinity is explained by the FDA model we refined, improving its rigor. As a result of this research, a website initially developed with support from NASA, Naval Research Laboratory (NRL) at Stennis Space Center and National Oceanographic and Atmospheric Administration (NOAA) funds was improved as a result of this project. Its purpose was to serve as a repository and a graphical interface for remote sensing reporting. It underwent beta testing on the way to become operational, though the site has since become obsolete and was no longer being updated as of early 2013. See http://www.eol.ucar.edu/projects/ohhi/vibrio/.

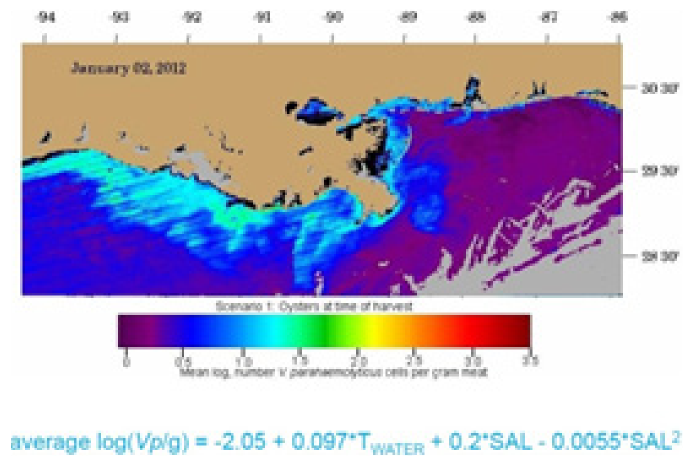


Figure 4 - Vp prediction map from project using water temperature and salinity as inputs.

The project team also produced an informational brochure entitled “Remote Sensing: New Applications for Shellfish Safety” for distribution to area seafood dealers, restaurants, and tourist information sites around coastal Mississippi. This brochure was produced to better inform the seafood industry and the public as to the potential dangers related to shellfish.

Development of Sensor Assisted Water Quality Nowcasting and Forecasting Environment for Coastal Beaches

PI: Zhiqiang Deng, Louisiana State University			
Partners: Louisiana Department of Environmental Quality; Southern University			
Users: Louisiana Department of Health and Hospitals; Louisiana Department of Environmental Quality, Nonpoint Source Pollution Unit			
RFP: 2008 ROSES A.28			
ARL Start	**1**	**ARL End**	**6**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

The objective of this project was to demonstrate whether NASA Earth science products can address the issue of "Water Quality for Healthy Beaches and Shellfish Beds," identified by the Gulf of Mexico Alliance (GOMA) to improve the quality of beach water management in coastal Louisiana and in the Gulf of Mexico region as well. The study area for this effort was southwestern Louisiana (Figures 1 and 2).

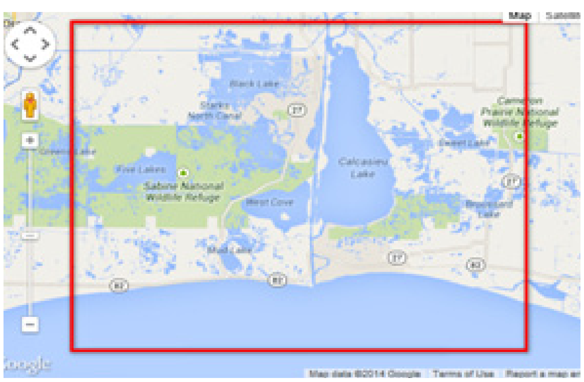


Figure 1 - Study area location, Southwestern Louisiana (Source: Google Maps).

Methods

In order to achieve the objectives of this project, two decision-making support tools were developed: (1) Sensor-Assisted Nowcasting Environment for Beachgoers (SANE Beachgoers) and (2) Sensor-Assisted Forecasting Environment for Beaches (SAFE Beaches). The SANE Beachgoers is a collection of datasets, an onsite water quality monitoring sensor station, statistical models, a Geographic Information System (GIS) platform, and an internet website. These all work together to provide information on current beach water quality and weather conditions for beachgoers. SAFE Beaches is a collection of datasets including remote sensing imagery, in-situ water quality monitoring sensor station, mathematical models, GIS platform, and internet which work together to produce beach water quality forecasts in a probabilistic fashion like weather forecasts. Use of this environment was hoped to advance decision-making time sooner than the current 2 - 3 days ahead of actual use of beaches due to the identification of priority beach water quality areas and mapping of watershed time of bacterial concentrations and the use of weather forecast information. This bacterial concentration data is estimated from Moderate Resolution Imaging.

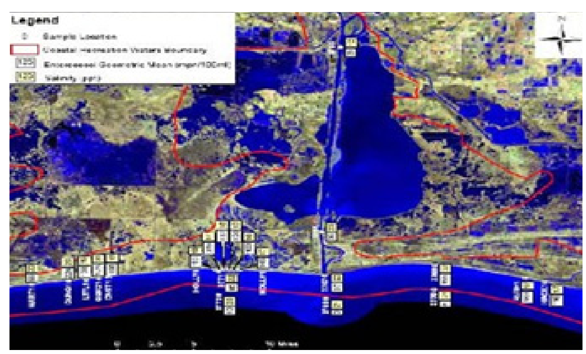


Figure 2 – Landsat view of Lake Calcieu study area Southwest Lousiana.

NASA MODIS Terra and Aqua data are used for bacterial source area-tracking at watershed-scale and for linking beach water quality parameters to MODIS surface reflectance. Water quality data is gathered using a wireless sensor station for continuous monitoring of surrogate water quality parameters (Figures 3 and 4). The sensors measure temperature, specific conductance / conductivity, salinity, pH, dissolved oxygen, turbidity, chlorophyll, and depth. Nowcasting and forecasting models for predicting fecal indicator bacterial concentrations using surrogate water quality parameters from the sensor system have been developed.

Figure 3 - SAFE/SANE Components: wireless water quality monitoring sensor station

Results

An essential component of SAFE Beaches and this project was priority source-area tracking of fecal indicator bacteria using the novel runoff fingerprinting (ROF) method (see Figure 5). The ROF method is based on mapping of information computed using temporal changes in multiple band surface reflectance values of consecutive MODIS Aqua and Terra visits.

Newly defined information from Fisher provides a valuable tool that is able to link various band reflectance values together and form an integrated remote sensing information system for coastal systems like beaches and watersheds. Consequently, this project provides an innovative and practicable application of NASA Earth Observing System (EOS) MODIS data in supporting beach management, recreational planning, and decision-making activities in the Gulf of Mexico Region, particularly the Louisiana coastal areas.

The SANE Beachgoers system reduces the decision-making time from 2 - 3 days to near real-time, significantly improving the decision-making in beach management and use. SAFE Beaches changed the decision-making time from 2-3 days behind to 1-3 days ahead of planned beach use to produce beach water quality forecasts.

Figure 4 – SAFE/SANE Components of water quality monitoring sensor station.

Since this project is ongoing, there are several anticipated results expected. A novel runoff fingerprinting method, based on NASA MODIS Aqua and Terra, for tracking priority source-area of fecal indicator bacteria is under development; an additional result is a web-enabled and user-friendly GIS platform for linking the SANE Beachgoers and SAFE Beaches together to form a truly integrated decision support system for beach water quality management.

November Sampling Results: Lab Data

Site	Replicate	MPN per 100 mL of Sample				Chlorophyll-a (mg/m^3)
		Coliforms	Fecal Coliforms	E. Coli	Enterococci	
Regulatory Standard (geometric mean)		*NA*	*200.0*	*NA*	*35.0*	*NA*
Little Florida Beach	*A*	2.0	2.0	0.0	80.1	7.308
Little Florida Beach	*B*	0.0	0.0	0.0		7.140
Holly 6	*A*	2.0	0.0	0.0	73.8	4.554
Holly 6	*B*	0.0	0.0	0.0		4.410
Holly 2	*A*	7.8	0.0	0.0	62.7	6.380
Holly 2	*B*	7.8	0.0	0.0		7.400
LA-82	*A*	540.0	170.0	0.0	298.7	9.291
LA-82	*B*	NS	NS	NS		7.720
FD (Holly 2)	*A*	7.8	0.0	0.0	62.0	3.120
FD (Holly 2)	*B*	NS	NS	NS		4.068
FS-1 (LA-82)	*A*	NS	NS	NS	248.9	6.920
FS-2 (LA-82)	*B*	NS	NS	NS	298.7	6.498

NA = Not Applicable
NS = No Sample Analyzed due to lack of LT Broth

Figure 5 - Sampling Results

Multi-Model Simulations with Data Assimilation for Harmful Algal Blooms in the Eastern Gulf of Mexico

PI: Jason Lenes, University of South Florida			
Partners: Florida Fish and Wildlife Commission; Mote Marine Lab			
Users: Florida Department of Health; Sarasota Bay Estuarine Program; Pinellas County Department of Environmental Management; Florida Fish and Wildlife Commission			
RFP: 2008 ROSES A.28			
ARL Start	1	**ARL End**	3
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

Harmful algal bloom (HAB) is the proliferation of a toxic or nuisance algal species that negatively affects natural resources or humans (see Figure 1 below). There are several main groups that form HABs: flagellates (includes dinoflagellates), diatoms, and blue-green algae. Each group has unique characteristics, life cycles, nutrient requirements, motility, and toxins. Approximately 85 HAB species are currently documented.

Figure 1 – Aerial view of harmful algal bloom.

This project addresses two elements of the water quality priorities: 1) reducing risk of exposure to disease-causing pathogens, and 2) minimizing occurrence and effects of HABs. It's estimated that losses due to HABS equal ~$50 million per year, with >50% from Florida red tides, predominantly the toxic dinoflagellate *Karenia brevis*. Brevetoxin, the neurotoxin produced by *K. brevis*, frequently causes respiratory irritation in humans, as well as mass mortalities to fish, marine mammals, and sea birds.

The overall objective of this project was to develop a predictive model to forecast HABs in the eastern Gulf of Mexico, or GOM (see Figure 2) focusing on *K. brevis*. In order to forecast HABs, we required a multi-disciplinary approach (physical biochemical, atmospheric, and fisheries science). We utilized data assimilation tools to improve the model fidelity by incorporating satellite and in situ measurements. Data assimilation is a process for optimally combining observations with models for the purpose of reducing errors in state variable estimation.

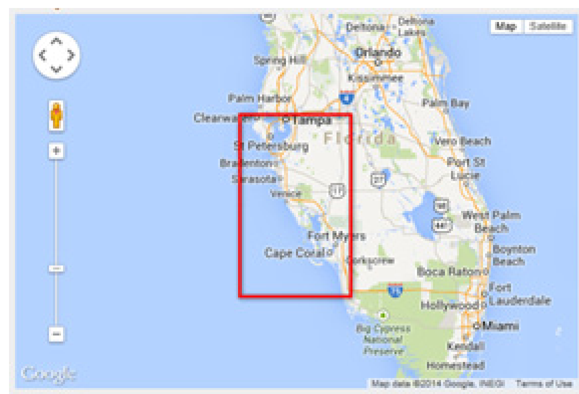


Figure 2 - Study area location. (Source: Google Maps)

Methods

We applied a multivariate sequential data assimilation algorithm, the Ensemble Kalman Filter (ENKF) to assimilate in situ and satellite data such as high-frequency radar currents, optimal interpolated sea surface temperature (OI SST), chlorophyll a, species-specific phytoplankton retrievals, and phytoplankton cell counts into a multi-model simulation of HAB in the eastern GOM. The ENKF is a deterministic class of filters that moves the model forward until a new observation is available, then performing assimilation to arrive at a consistent, best estimate of ocean fields, parameters and processes. To accomplish this goal, we combined our biophysical models (Regional

Oceanic Modeling System (ROMS), Finite Volume Coastal Ocean Model (FVCOM) and South Atlantic Bight and Gulf of Mexico (SABGOM)), with data assimilation algorithms and observational data to improve error estimation, subsequently improving the HAB predictive efficiency and adaptive sampling protocols on the eastern GOM.

Figure 3 - Nested Grids of the circulation models

Figure 3 above illustrates byproducts of nested grids of the circulation models, FVCOM, ROMS, and SABGOM, driving HAB Simulation (HABSIM) over the GOM and downstream South Atlantic Bight.

Results

As a result of this research, the project team discovered that data assimilation improved the predictive efficiency of HABSIM by ~30%. Additionally, the project team determined that scientifically defensible model simulations for HABs must be predicated on connections that occur across space, time and trophic levels (see Figure 5).

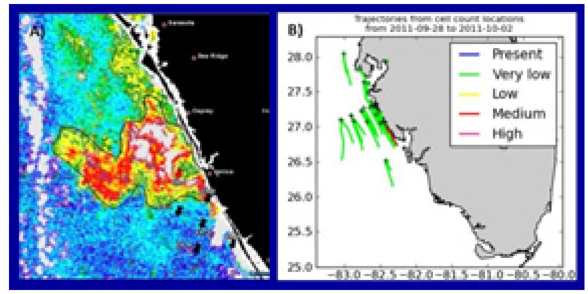


Figure 4 - Example HAB detection and monitoring using MODIS and MERIS data in conjunction with modeling for forecasting spread.

As an example, in tracking a bloom first detected in late September 2011, the bloom was tracked with Moderate Resolution Imaging Spectroradiometer (MODIS) and Medium Resolution Imaging Spectrometer (MERIS) assets, and the HAB tracking tool provided forecasts from cell counts (Figure 4). Up to this point, the bloom had been moving north by northwest, but the model successfully predicted a reversal. More impressive was the fact that the model successfully predicted that the bloom was scheduled to impact the middle of the Florida Keys on 12/7/2011.

In our ongoing efforts to reduce the risk of exposure to disease-causing pathogens, and to minimize occurrence and effects of HABs, results like the Florida Keys example are an extraordinary sign that our research has impacted the safety of the Eastern GOM.

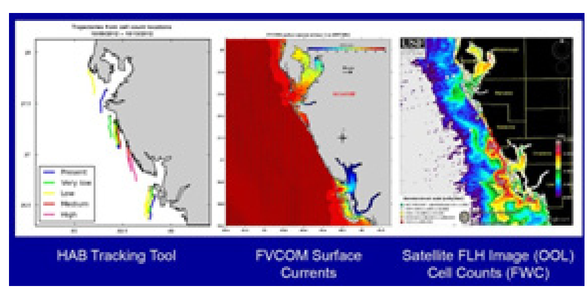


Figure 5 – Example products from project, illustrating that the next generation HAB tracking tool will combine FVCOM with satellite imagery and in-situ cell counts.

PI: Robert Hetland, Texas A&M University			
Partners: National Oceanographic and Atmospheric Administration (NOAA); I.M. Systems Group (IMSG)			
Users: NOAA			
RFP: 2008 ROSES A.28			
ARL Start	**1**	**ARL End**	**1**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

Harmful algal blooms (HABs) are more frequent worldwide and pose a significant threat to human and environmental health. These risks can include concentrations of dead fish, and dangerous adjustments of the amount of chlorophyll in the waters.

The toxic dinoflagellate *Karenia brevis* is the primary HAB species in the Gulf of Mexico (GOM) where it appears to be common at low concentrations (less than 1000 cells/L). Accumulations, or blooms (up to 10^6 cells/L), of *K. brevis* have occurred almost annually off the west coast of Florida for the past 30 years, but occur only sporadically in the western GOM (see Figure 2) along an unexpected pattern, as the eastern and western GOM are roughly similar in terms of temperature, daylight, and nutrients.

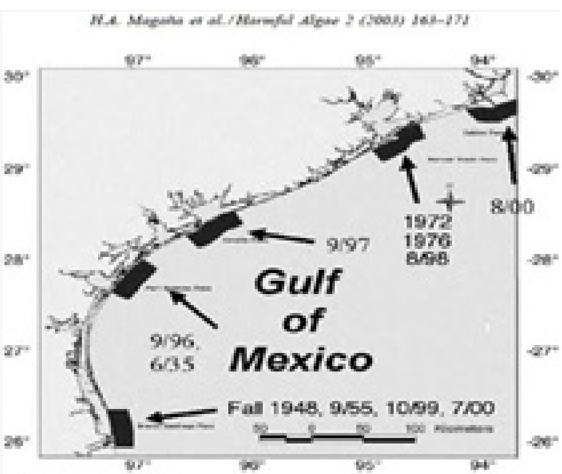


Figure 1 – Example areas in Texas GOM where HABs have occurred.

Differences in origins and mechanisms that cause blooms along the Texas coast (see Figure 1) are poorly understood, and represent a large gap in our knowledge of GOM HABs.

Without this knowledge, the prediction of toxic and algal blooms concentrations is nearly impossible, and managers must resort to detection of a well-formed bloom before taking needed countermeasures, which currently focuses on awareness of developing conditions.

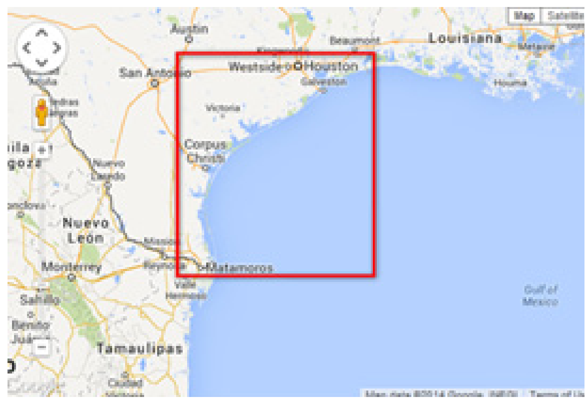


Figure 2 - Study area location. (Source: Google Maps)

Methods

The goal was to generate a primary product based on a rule-based algorithm that couples a downwelling wind index, satellite imagery, source area indicators, and standard sampling into a HAB bulletin, and periodically distributed to management and research communities detailing current oceanographic conditions along the Texas coast. The result will relate the probability of a *K. brevis* bloom along the Texas-Louisiana shelf to the local wind history. This in turn will produce a rule-based analysis of conditions that indicate the likelihood that a bloom (observed from satellite) is *K. brevis*, and the likelihood of bloom intensification.

We began by using numerical models, in situ measurements, and remote sensing to predict *K. brevis* blooms along the Texas coast at various spatial and temporal scales (Figure 3). Wind data for 1996-2011 were taken from the National Oceanic and Atmosphere Administration's (NOAA) National Data Buoy Center (NDBC) for buoy PTAT near Port Aransas (Figure 4) and rotated into the along- and across-shore directions.

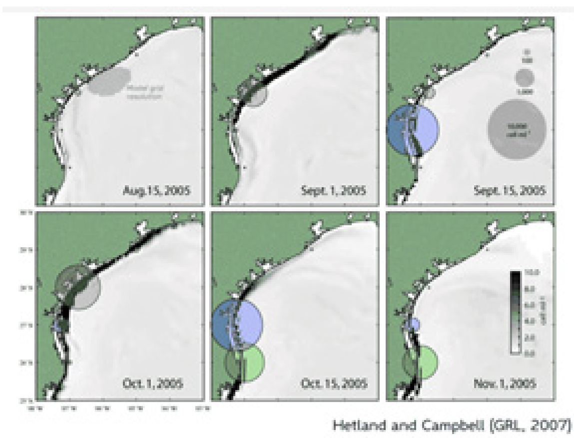
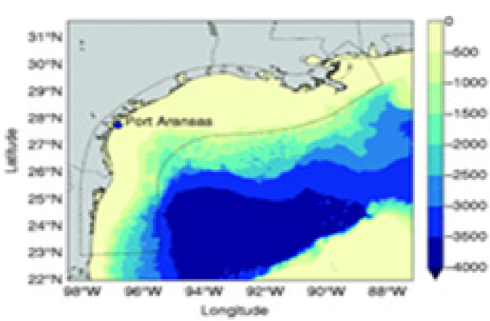


Figure 3 - K. brevis blooms

The numerical model was run using the Regional Ocean Modeling System (ROMS), a three dimensional free surface solver of the primitive equations, with terrain-following vertical coordinates. The model was initialized and forced at the open and surface boundaries by output from the Gulf of Mexico Hybrid Coordinate Ocean Model (GOM-HYCOM), which was run by the Naval Oceanographic Office (NAVOCEANO).



View larger version:

Figure 4 - The bathymetry of the Gulf of Mexico (color) with land (gray) and state and country lines (black)

Lagrangian drifters, calibrated instruments designed to measure water currents and collect environmental data, were simulated using model output to help understand and visualize relevant circulation patterns.

Results

Several resulting paradigms were revealed as this research progressed. First, the summer upwelling winds bring water carrying a seed population of *K. brevis* from the southern Gulf of Mexico into offshore Texas coastal waters. As the wind pattern shifts from up coast to down coast with the seasonal change from summer to fall, weak down coast winds cause a weak down coast flow with a simultaneous onshore flow and an aggregation of *K. brevis* near the coast.

Once a bloom is initiated, it may advect downcoast with the typical down welling winds. In contrast, strong down coast winds generate a strong down coast current that sweeps the cells back to the south before a bloom can form. The near-shore currents are much lower in years with HAB events occur versus years without blooms.

Contrary to our expectations, short term forecasts have been very difficult; Seasonal forecasts, on the other hand, (i.e., annual presence/absence) appear to be simpler, and more robust; and more in situ sampling is required to improve remote detection algorithms, and test short term forecast models based on transport.

In summary, a new paradigm in regards to harmful algae has been realized. The source of *K. brevis* was discovered to be to the south, in Mexican coastal waters and summertime upwelling consistently bring these cells northward, just off the coast of Texas.

PI: Daniel Cohan, Rice University			
Partners: University of Alabama - Huntsville			
Users: Texas Commission on Environmental Quality			
RFP: 2009 ROSES A.40			
ARL Start	1	**ARL End**	3
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

The Clean Air Act mandates that tropospheric ozone levels are sufficiently low not to cause public health issues. However, there are many areas in the country that can have "ground" ozone at non-attainment levels in regards to this legislation (Figure 1). Such areas exist along the Gulf of Mexico and include east Texas.

Figure 1 – Example of urban ozone and smog pollution reducing visibility in urban areas and causing potential public health issues (Source: NASA JPL).

This project regards the application of satellite data to address two leading causes of uncertainty in the photochemical modeling in order to help inform ozone attainment planning in Texas: 1) photolysis rates; and 2) nitrogen oxide (NOx) emissions inventories. The project includes the following objectives: 1) Assimilate Geostationary Operational Environmental Satellite (GOES) satellite cloud data to improve the photolysis rates in actual ozone modeling episodes used for Texas attainment planning; 2) Conduct inverse modeling using Ozone Monitoring Instrument (OMI) satellite Nitrogen Dioxide (NO2) measurements and other data to create an a posteriori NOx emissions inventory for the region; 3) Conduct photochemical modeling in Texas with high-order sensitivity analysis to assess how the satellite-derived model inputs influence predictions of ozone responsiveness metrics used in attainment planning; and 4) work with Texas Commission on Environmental Quality (TCEQ) on potential applicability to ozone attainment modeling efforts in Texas. The primary demonstration area for the project was eastern Texas (Figure 2).

Figure 2 - Location of demonstration area. (Source: Google Maps)

Methods

Baseline model inputs were taken from recent regulatory modeling by the TCEQ, focusing on the period coinciding with the 2006 Texas Air Quality Study (TexAQS-II) field campaign.

Satellite observations were applied to ozone attainment planning as follows: GOES satellite data for cloud radiative and optical properties was assimilated to improve the photolysis rates in the Comprehensive Air Quality Model with Extension (CAMx). An iterative inverse method using a Kalman filter was applied to adjust various components of the NOx emissions inventory for optimal agreement with OMI-retrieved NO2 tropospheric column densities and other NOx measurements available during TexAQS-II.

Resulting models were then tested to assess how inputs affect ozone responsiveness (Figure 3).

The satellite-based input data and associated modeling results were provided to TCEQ staff and interested stakeholders for use in in order to help inform ozone attainment planning in Texas.

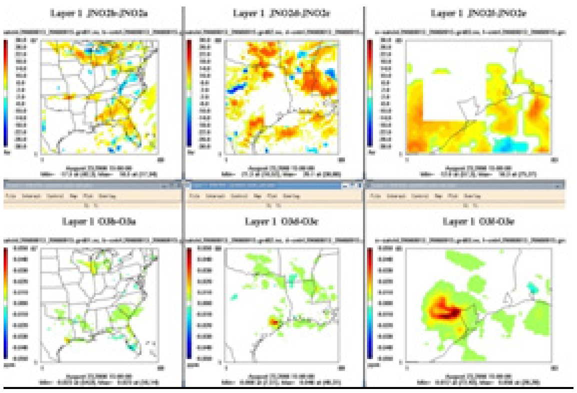


Figure 3 - Impact of satellite clouds on photolysis rates and O3 mixing ratios.

Results

This project yielded useful insights into the potential of NASA remote sensing and modeling capabilities for aiding tropospheric ozone attainment planning. Applying satellite data and modeling to actual Texas attainment modeling episodes using field data revealed that large uncertainties and discrepancies existed in the retrieval of OMI NO2 data. These uncertainties were shown to lead to errors. On the other hand, this effort proved that the Kalman Filter is a reliable inversion method with CAMx-High Order Decoupled Direct Method (HDDM).

It also demonstrated that the cloud approach in regards to GOES data usage was ready for application, and was improved with treatment of liquid water content. However, the work revealed large uncertainties and discrepancies in OMI NO2 retrievals (Figure 4). Based on this project, satellite-based NOx emission inversions are informative but unlikely to replace traditional inventories, because uncertainties in models and even the satellite data may lead inversions to err in emission estimates.

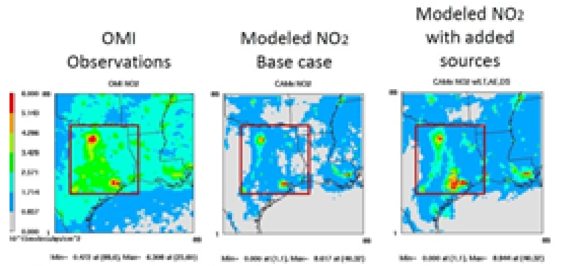


Figure 4 - Observed vs. Modeled NO2: Impact of adding lightning, aircraft, and soil to inventory. Even for the rural versus urban discrepancy, the added sources only partially resolve.

By addressing the two leading causes of uncertainty in ozone sensitivity modeling, the modeling conducted within this study enabled an improved understanding into the challenges and current capabilities in modeling tropospheric ozone and of satellite-based NOx inversion.

PI: Linda Young, University of Florida			
Partners: National Space Science and Technology Center; Universities Space Research Association, NASA Marshall Space Flight Center; US Centers for Disease Control; Florida Department of Health; Florida Department of Environmental Protection; Florida Department of Forestry			
Users: Florida Department of Health; Centers for Disease Control: Public			
RFP: 2009 ROSES A.40			
ARL Start	**2**	**ARL End**	**8**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction
Wildfires can negatively affect outdoor air quality in Florida (see Figure 1). Air quality is especially poor during periods of little rainfall or during the extended wildfire seasons, threatening persons with compromised respiratory systems each year. Increased levels of Particulate Matter (PM) can lead to increased hospitalizations. However, information on the association between reduced air quality resulting from fires and the incidence of asthma was lacking, prior to this project.

Figure 1 - Bugaboo fire in Florida on May 17, 2007 (Source: FEMA).

In response, this project was conducted with the following main objectives: 1) Develop forecast model of number of weekly asthma cases presenting to the Emergency Departments and Hospitals for each county in Florida; and 2) Use modeling results to provide early warnings of exceedances that county health offices can act upon and that citizens can use. These objectives could lead to the creation of new public health policy for the State of Florida.

This proposal is relevant to the Air Quality and Public Health application areas of the National Aeronautics and Space Administration's (NASA) Applied Sciences Program.

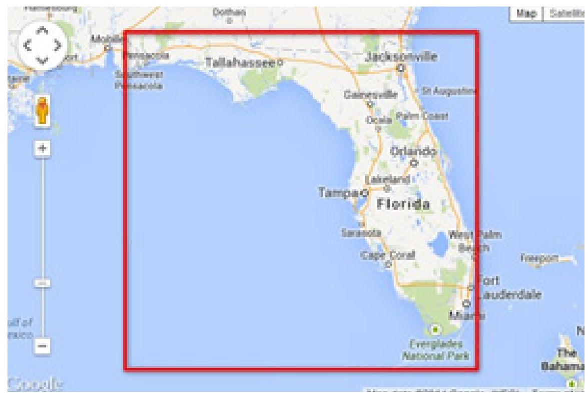


Figure 2 - Study area location. (Source: Google Maps)

Methods
In this project, asthma hospital/emergency room (patient) data from 2007 and 2011 were the foundation for creating a health outcome indicator of human response to environmental air quality. NASA derived environmental data from the Environmental Protection Agency's Air Quality System (EPA AQS), and Moderate Resolution Imaging Spectroradiometer (MODIS) measurements and models associated with those measurements (Figures 3 and 4), with special attention being given to the effect of wildfires and prescribed burns on particulate matter.

After linking existing air quality and health data that assessed the effectiveness of determining the actual levels of decreased air quality in the presence of fires, space-time models of asthma rates as a function of NASA-derived air quality data and socio-demographic variables were developed and validated. Socio-demographic variables included data from the U.S. Census Bureau, various meteorological data and the Centers for Disease Control and Prevention's (CDC's) Behavioral Risk Surveillance Survey. These models were applied to investigate whether hospital or emergency room cases with asthmas as the cause could be an indicator of human response to environmental air quality indicators. The Florida Department of Health (FDOH) worked with county health department staff and representatives from the medical community to establish a protocol with triggers for issuing public health advisories/alerts based on the developed and validated health outcome indicators.

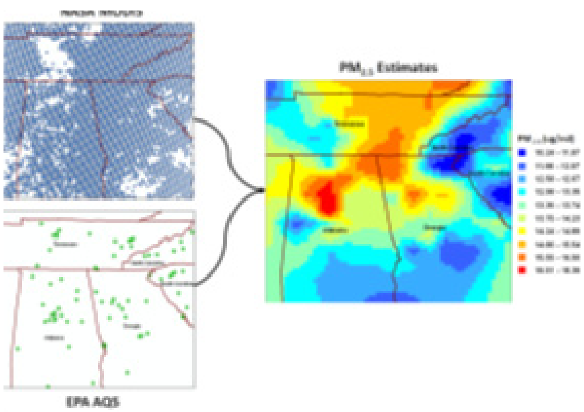


Figure 3 - Example illustration from project depicting use of MODIS and EPA AQS data for geo-modeling PM2.5.

Results

As a result of this project, it was discovered that, for most counties, the model with only time and random effects involving county and week fit as well as the model that also included environmental variables such as PM2.5, smoke, and fire (Figure 5).

The model validation showed there was an improvement in predictive accuracy in 28 out of the 67 counties recorded in 2011, compared to 2007 data. Based on the model validation, the models are integrated into Florida's Environmental Public Health Tracking (FEPHT) website (found at www.floridatracking.com.) This portal is part of the CDC's own Environmental Public Health Tracking (EPHT) network.

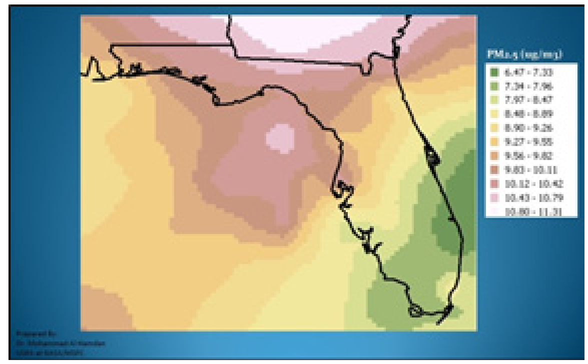


Figure 4 – Model output depicting annual PM2.5 for 2007

From this effort, a science-based public health policy for issuing public health advisories/alerts for asthma relating to air quality was developed, giving FDOH the ability to:

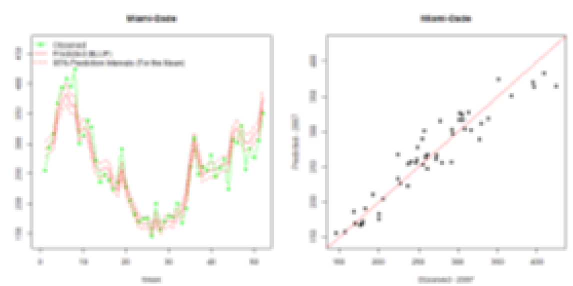


Figure 5 - Model result for Miami-Dade county illustrating ability to predict number of asthma incidents in 2007 according to time of year (weekly time steps).

1) predict, with stated levels of uncertainty, case load of hospital admissions based on air quality; 2) reduce asthma exacerbations by forewarning asthmatics to limit outside activities on poor air quality days; 3) apply management practices on rates of hospital/emergency room visits for asthma; and 4) provide information to help advance research on the possible linkages between environmental hazards and disease and translate interventions into policy decisions for posting advisories and alerts of poor air quality.

Satellite Data Driven Modeling System for Predicting Air Quality and Visibility during Wildfire & Prescribed Burn Events

PI: Udaysankar Nair, University of Alabama at Huntsville			
Partners: Johns Hopkins University; Alabama Forestry Commission			
Users: Alabama Forestry Commission; National Weather Service; US Forest Service; Alabama Department of Homeland Security			
RFP: 2009 ROSES A.40			
ARL Start	**3**	**ARL End**	**8**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

Two concerns associated with smoke from wildfires and prescribed burns are adverse health impacts and visibility reduction. Alabama, a member state of the Gulf of Mexico Alliance (GOMA), is often impacted by episodic smoke transport from within the state, surrounding states and also Central America and Mexico (see study area indicated in Figure 1). A typical example is the massive Georgia-Florida forest fires of 2007 that impacted Alabama, during which respiratory illness among sensitive groups was exacerbated. There are also instances of smoke from forest fires causing highway accidents in Alabama.

Figure 1 - Study Area Site (Source: Google Maps)

The National Weather Service (NWS) and the Alabama Forestry Commission (AFC) are two agencies that require prognostic air quality and visibility information during wildfire and prescribe burn events.

Enhancements needed by AFC decision makers include better predictions of air quality and visibility during wildfire events and an enhanced interactive modeling capability for hypothetical prescribe burn scenarios.

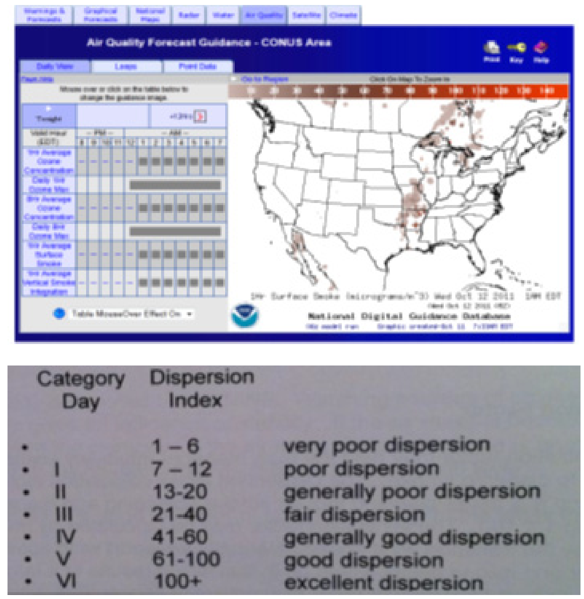


Figure 2 - Tool Currently Available to AFC - Air Quality Forecast Guidance

Methods

The interactive modeling capability was implemented within the Virtual Alabama environment, a Google Earth-based system developed by the Alabama Department of Homeland Security (ALDHS) with the express purpose of decision support through sharing of information between different government agencies. Our research worked to enhance existing smoke transport capabilities of NWS to include consideration of contributions from other aerosol species, constraining of modeled aerosol fields using Moderate Resolution Imaging Spectroradiometer (MODIS)-derived aerosol optical depth and explicit visibility estimates all implemented within the Advanced Weather Interactive Processing System (AWIPS). This project proposed to transition AERO-RAMS, a mesoscale smoke transport modeling system driven by NASA Earth Science Research Results (NASA ESRR) to predict smoke concentration, air quality and visibility degradation during wildfire and prescribe burn events. The existing NOAA Smoke forecasting system, driven by satellite derived smoke emissions is available, but does not include background aerosols, visibility estimates or contextual information of relevance to smoke management. Also this system does not have interactive capabilities (see Figures 2 and 3).

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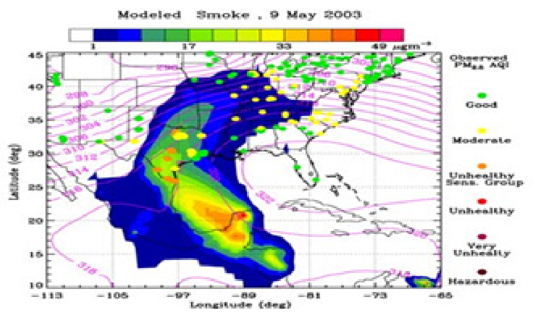


Figure 3 - Smoke Modeling in the Southern United States (2003)

Results

The Alabama Forestry Commission (AFC) is responsible for wildfire control and also prescribed burn management for which assessment of visibility and air quality degradation is required. AFC relies on information provided by NWS, including a dispersion index for providing guidance and making smoke management decisions. Development of an interactive modeling system for burn smoke management decisions using the "Virtual Alabama" decision support system (see Figure 4) was the primary result of this project.

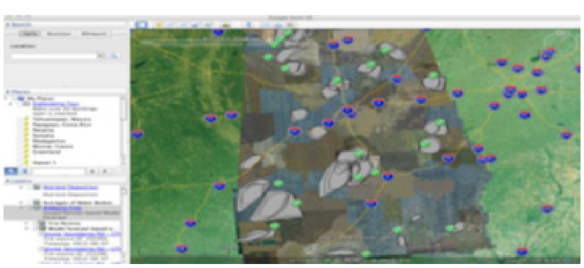


Figure 4 - Decision Support System: Virtual Alabama

The system enhances decision support related to NWS issuance of advisories during wildfires events and prescribed burns, and wildfire control activities of AFC.

As a result of our efforts, enhancements sought over existing smoke transport capabilities of NWS were realized, such as constraining of modeled aerosol field and explicit visibility estimates implemented within AWIPS. We saw an increase in the interactivity through mobile devices with georeferencing capabilities (see Figure 5). Also, we now have smoke and visibility forecasts available at higher spatial resolutions than before.

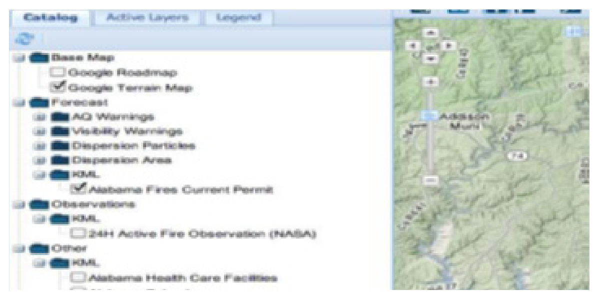


Figure 5 – Web Interface of Final Product Developed

Decision-makers now have at their disposal a tool that can more effectively and efficiently guide them in their efforts in burn and smoke management in the Southern United States.

WATER RESOURCES

The Water Resources SBA integrates Earth observations and technologies to provide management tools for policy makers, industry and the public. The coast is where society meets the sea. When the coastal zone is healthy, it provides natural resources, recreational opportunities and economic livelihood for residents and visitors. As populations migrate to the coasts, maintaining acceptable water quality becomes increasingly difficult. Four GOMI projects addressed coastal water quality and demonstrated both the opportunities and the challenges posed by this dynamic environment.

Projects

Managing Runoff: A Tool to Evaluate Potential Impacts of Climate and Land Change on Pathogen and Nutrient Concentrations in Weeks Bay

Establishing Standard Water Quality Criteria Using Satellite Products for Texas

A Collaborative Geospatial Decision Support System for Managing Coastal River Basins

Enhancing NASA's Coast Online Application for Agricultural Best Management Practices Decision Support

Managing Runoff: A Tool to Evaluate Potential Impacts of Climate and Land Change on Pathogen and Nutrient Concentrations in Weeks Bay

PI: Douglas Mooney, Battelle			
Partners: Universities Space Research Association (USRA) (NASA MSFC)			
Users: Weeks Bay Foundation; Weeks Bay National Estuarine Research Reserve (NERR); Alabama Coastal Foundation; Baldwin County (AL) Soil and Water Conservation District; and Mobile Bay National Estuary System			
RFP: 2009 ROSES A.40			
ARL Start	**1**	**ARL End**	**2**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

Weeks Bay, Alabama is a coastal estuary impacted by runoff-related water quality issues, primarily nutrients and pathogens (see Figure 1). Water quality can be impacted by land and climate change.

There are no regulations at the state, county, or municipal levels that address runoff or water quality at the planning stage. Most of Baldwin County is unincorporated and has no zoning laws. Housing developers in this area have very basic regulations, but developers of business and agricultural projects have zero requirements. As a result, development decisions are often based on the judgment of volunteer planning boards.

Figure 1 . Runoff-related eutrophication in Weeks Bay, Alabama (Source: NOAA).

In response, this project was performed to create a decision support system (DSS) tool to evaluate and view impacts of potential future climate and land use changes on runoff and concentrations of total suspended solids (TSS), nutrients, and pathogens in Weeks Bay (Figure 2).

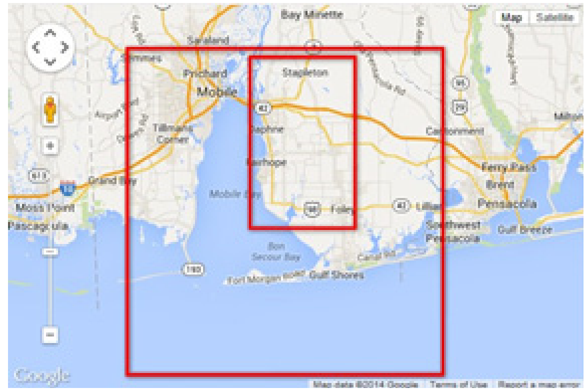


Figure 2 - Study area locations. (Source: Google Maps)

Methods

The project made use of data from the Weeks Bay National Estuarine Research Reserve that has long-term sets of in situ data. Detailed watershed and hydrological models was used to provide gridded daily runoff, water properties, and TSS (Figure 3) for multiple land use and climate scenarios. Model output was correlated with existing in situ and remote sensing data using multivariate regression and spatial analysis. A statistical model was built to describe the relationships between water properties and watershed factors. Finally, a DSS visualization tool based on this statistical model was developed for evaluating the impacts of potential changes in land use and climate change on concentrations in Weeks Bay of TSS, nutrients, *E. coli*, and fecal coliform. To evaluate the performance of the DSS tool for future predictions, additional watershed and hydrological modeling with future land use and climate scenarios were conducted for comparison. End users in Weeks Bay were involved throughout the activity to ensure that the tool is framed to best address their needs.

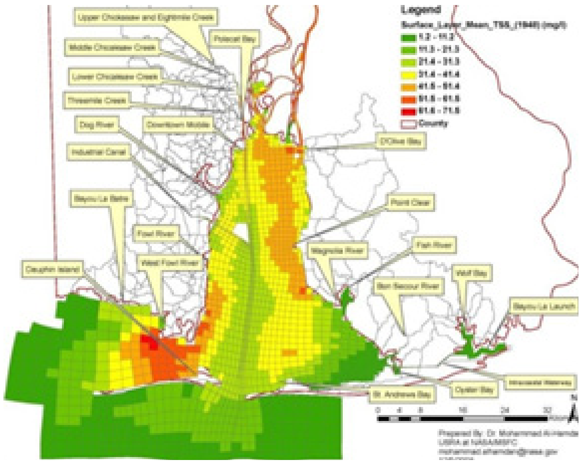


Figure 3 – Example TSS modeling output used in project. Weeks Bay is the estuary that receives flow from the Fish and Magnolia Rivers.

Results

Some challenges faced during this project regarded the modeling efforts. First, the data available was sparse and noisy. There was a lot of general data, but it was difficult to link up to and there was the issue of different resolution and data from different sites. There was very limited land use change seen in the data generated during this project (Figure 4). The original plan for a detailed spatial model was simplified to focus on modeling dominant trends.

As a result of this research effort, end users now have a tool to describe, predict, and prevent the causes of problems such as pathogen pollution, algal blooms, and fish kills, the project activities were responsive to the Ecological Forecasting and Public Health application areas. For each set of parameter inputs (land use by basin, temperature, and precipitation), the statistical model produced outputs for water quality, nutrients, and pathogens.

The project team also found a way around the fact that the statistical model runs take about 20 minutes each. Instead of running the statistical model, a response surface meta-model was run that very closely approximates the statistical model but can be computed in real time. Users can interact with this meta-model (i.e., a model of a model) using an intuitive graphical user interface (GUI). See Figure 5 for an example of this interface. Using this interface, users can now mimic the functions of the more computationally expensive statistical model for scenario analysis as well as assess model sensitivities to changes in model inputs.

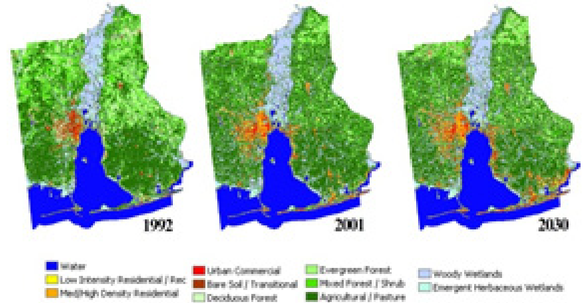
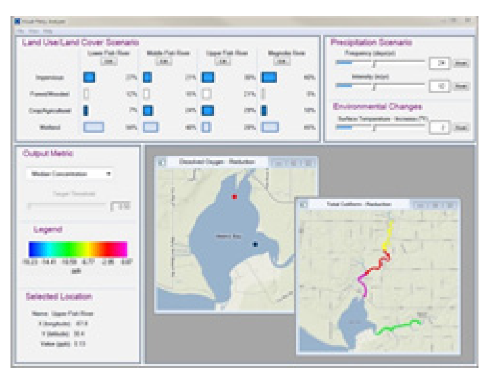


Figure 4 - Figure 4 - Historical and projected LCLU change products used in project.

Recognizing that there are no current regulations that address runoff or water quality in the Weeks Bay area, the tool resulting from this research can be a critical tool for end users in planning scenarios, anticipating potential impacts on nutrient and pathogen concentrations (i.e., land and climate change), and understanding uncertainty associated with future scenarios.

Figure 5 - Intuitive GUI for quickly running model scenarios.



Establishing Standard Water Quality Criteria Using Satellite Products for Texas

PI: Paul Montagna, Texas A&M University-Corpus Christi			
Partners: Texas Water Development Board; Texas Commission on Environmental Quality; NASA Stennis Space Center; Harte Institute			
Users: Texas Water Development Board; Texas Commission on Environmental Quality			
RFP: 2008 ROSES A.28			
ARL Start	**1**	**ARL End**	**2**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

There are many locations across the northern Gulf of Mexico with coastal water quality concerns and the state of Texas is no exception. In fact, there are seven major estuarine systems along its 370-mile coast.

This project was designed to develop integrative decision-support tools for providing useful information for reducing and managing nutrient inputs to estuaries in the coastal zone.

In particular, the project aimed to: 1) Facilitate a regional integration of resources, knowledge and expertise for an assessment of water quality and nutrient data at local and regional scales; 2) Increase states' capacity to identify current nutrient concentration baselines; 3) Determine effects stressors (e.g., nutrients, total suspended solids, colored dissolved organic matter) with newly established methodology that uses National Aeronautic and Space Administration (NASA) Earth science data products (remotely-sensed data); and 4) Support the Gulf of Mexico Alliance (GOMA) Regional Partnership's goal of establishing nutrient criteria for Gulf coastal ecosystems.

These activities attempted to enhance the ability to establish nutrient assessment and management criteria for coastal and estuarine waters. Specific project goals included: 1) Support GOMA priority objective to establish nutrient criteria; 2) Assess water quality on local and regional scales; and 3) Determine stressor effects and Facilitate integration of resources.

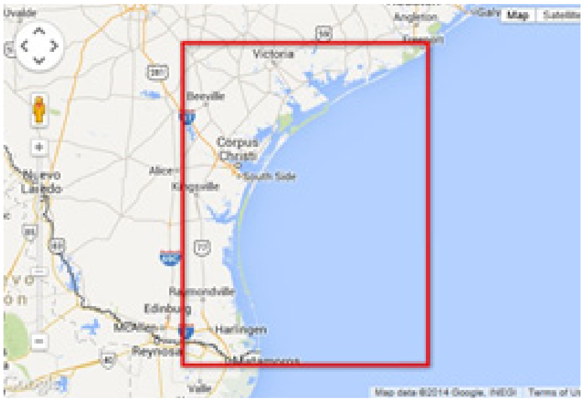


Figure 1 - Study area location (Source; Google Maps).

Methods

The project attempted to address the following questions: 1) Can we use the Texas coast as a test-bed? 2) Can we derive nutrient concentrations from satellite data? and 3) Can nutrient criteria be developed from NASA products? The project also worked to address the use of NASA products to support GOMA objectives to monitor nutrients and develop nutrient criteria. The study focused on development of methods and products for the coastal estuaries of southwestern Texas (Figures 1 and 2).

The project was initiated with onsite sampling of water quality and reflectance data within the study area to be cataloged and establish a baseline. Next, the project utilized nutrient and other data acquired from several NASA Earth Science products, including the Moderate Resolution Imaging Spectroradiometer (MODIS), deployed on the Aqua and Terra; Thematic Mapper (TM); and Enhanced Thematic Mapper Plus (ETM+) on the Landsat 4/5 and Landsat 7 spacecraft. SeaWiFS Data Analysis System software (known as SeaDAS) was utilized to process the MODIS data.

Figure 2 - Example coastal habitat within study area.

Results

The project encountered several challenges that prevented development of mature and fully adopted products. Some challenges from this project included: 1) NASA SeaDAS processing drops all turbid events; Shallow water bottom reflectance - confounds reflectance and turbidity algorithm; 2) Problems with deriving reflectance values; 3) Salinity Input was needed, which is easy to solve by bringing in more onsite data or hydrodynamic modeling; Re-suspension of sediments and ammonium (wind, and not inflow, can drive nutrient conditions).

The project demonstrated the technical feasibility of using simulated MODIS data to produce viable Total Sediment Suspended (TSS) products. This was done using onsite spectrometer (MODIS simulated) and water sample data (Figure 3).

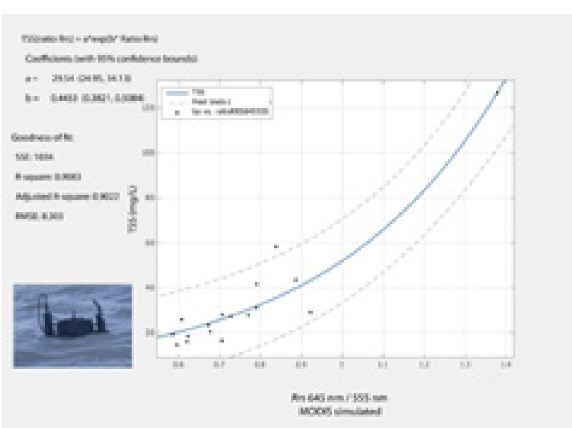


Figure 3 - Simulated MODIS TSS versus reference water sample data.

However, attempts to generate TSS products were met by technical obstacles that included cloud cover (Figure 4).

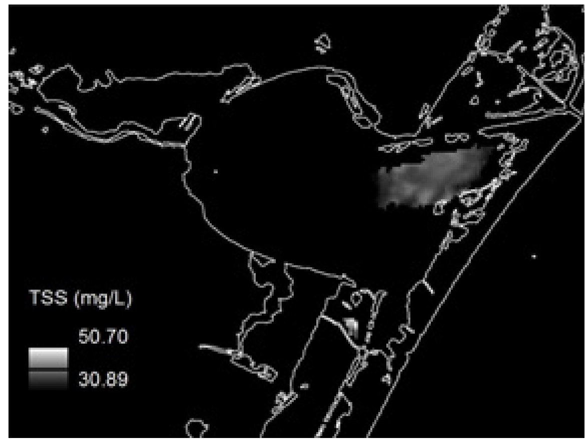


Figure 4 - Example satellite based TSS product from product showing incomplete coverage over water body of concern.

Despite the challenges encountered that kept the products in a prototype stage, the project team learned valuable lessons such as the need to continue technological development to improve SeaDAS processing, the need to recalibrate during the wet period; and the need for validation of nutrient algorithms used for reducing and managing nutrient inputs to estuaries within the coastal zone.

Figure 5 - Planned workflow versus obstacles encountered.

PI: Olufemi Osidele, Southwest Research Institute			
Partners: University of Texas at San Antonio; University of Texas at Austin			
Users: Texas Commission on Environmental Quality; Arroyo Colorado Watershed Management District			
RFP: 2008 ROSES A.28			
ARL Start	**3**	**ARL End**	**6**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

The northern Gulf of Mexico (GOM) faces multiple stressors and impacts from hurricanes and tropical storms, occasional spills from offshore oil and gas drilling, and nutrient enrichment from upstream agricultural river basins. Nutrient enrichment (e.g., from nitrogen and phosphorus compounds) has created extensive hypoxic oxygen depletion ("dead zones") in the region. Nutrient load reduction for waterways draining into the GOM is a key planning and decision-making activity needed for more effectively managing GOM watersheds.

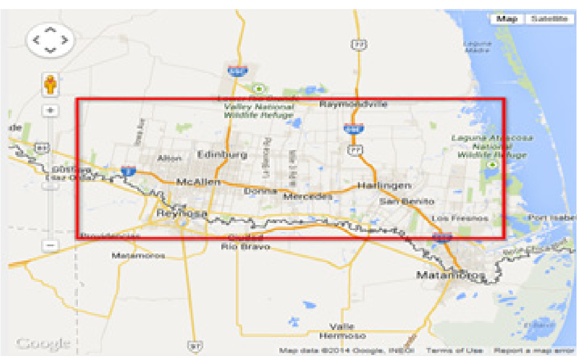


Figure 1 - Study Area (Source: Google Maps)

The Total Maximum Daily Loading (TMDL) program of the Texas Commission of Environmental Quality (TCEQ) is used to manage the quality of its surface waters. A TMDL estimates the amount of a specific pollutant, from point, nonpoint, and natural background sources, including a margin of safety that may be discharged to a water body while still meeting existing water quality standards. The effectiveness of the current TCEQ decision making for watershed management is hindered by multiple factors including the lack of resources to assist TMDL decisions via fusion of up-to-date satellite Earth observation and in-situ monitoring data. In response, this project was conducted to develop and demonstrate a Collaborative Geospatial Decision Support System (CGDSS) for managing coastal river basins.

Figure 2: Location of the Arroyo Colorado, Texas coastal watershed study site in yellow.

Methods

The main project objective revolved around development of a CGDSS to effectively manage TCEQ's TMDL projects. The project employed various GIS datasets and spatial database files to generate input in order to integrate meteorology, hydrology, land use practice, and nutrient loading into the decision-support system for the Arroyo Colorado watershed (ACW) (Figure 1 and 2). The CGDSS is a web-based decision support system that uses and integrates geospatial information to: 1) more pro-actively and better inform environmental decision-making in lieu of expected future human-induced and natural changes in the ACW; 2) expand societal benefits of NASA earth observation data products and research results to ACW communities; 3) improve stakeholder participation in decision-making through access to place-based ACW information with enhanced visualization; and 4) improve understanding of watershed stressor-response characteristics regarding nutrient loading in the ACW. These plan objectives are consistent with Gulf of Mexico Alliance (GOMA) priorities.

Our CGDSS development included various geospatial data (e.g., MODIS-based land cover data) displayed within an on-line geospatial data viewer (Figure 2).

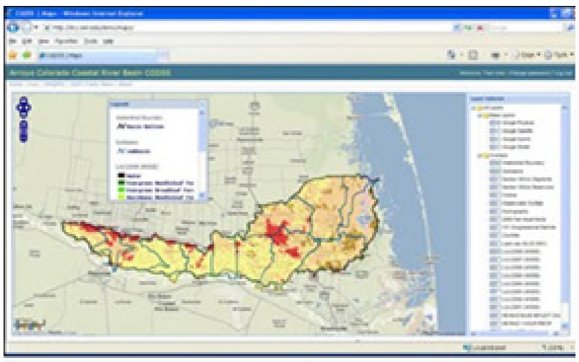


Figure 3: The enhanced web-GIS in CGDSS 1.0. The screenshot shows the MODIS-derived land use/land cover data for 2008.

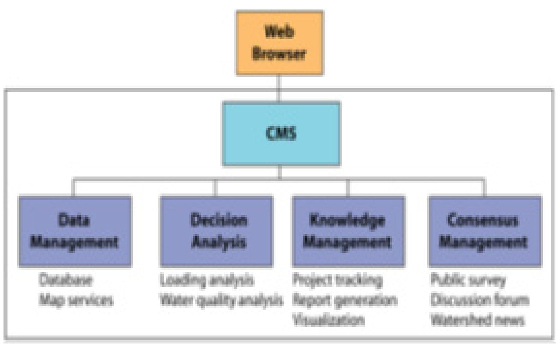


Figure 4: CGDSS Modules are integrated through a Content Management System (CMS)

Development of CGDSS involved the following: 1) built a Soil and Water Assessment Tool (SWAT) model for the ACW to verify geospatial attributes and input data; 2) developed insights into potential impacted of climate change within the ACW; 3) synthesized ACW data into an artificial neural network (ANN) model for next-period nutrient load forecasting; and 4) used non-stationary time-series analysis of ACW data to forecast nutrient loading. CGDSS modules were integrated using a Content Management System (Figure 3) and a client-server applications open-source web-GIS framework (Figure 4).

An advanced prototype of the CGDSS in a simulated environment was created on Southwest Research Institute web servers and its functionalities were then demonstrated to the TCEQ staff and ACW stakeholders' representatives.

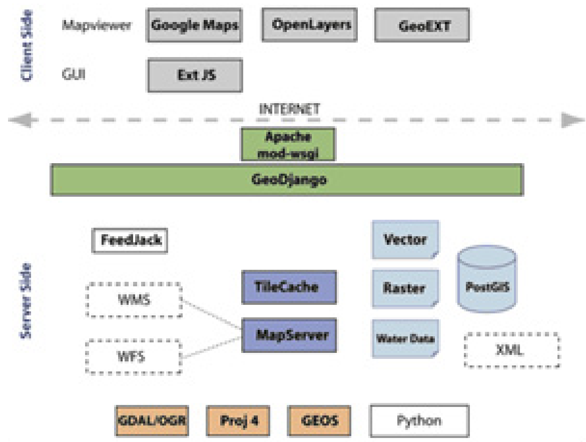


Figure 5: CGDSS Client-Server Application Uses Open-Source Web-GIS Framework

Results

Our CGSDSS development resulted in a seamless integration of data acquisition, visualization, geospatial analytics, and stakeholder participation using cost-effective and open-source web-based tools. This provides decision-makers with a comprehensive tool to help generate an integrated management approach for sustainable use of water and focuses on Earth science applications to water resource management for coastal river basins, as well as reducing nutrient inputs to coastal ecosystems.

Enhancing NASA's Coast Online Application for Agricultural Best Management Practices Decision Support

PI: Katherine Milla, Florida A&M University			
Partners: Florida Soil and Water Engineering Technology, Inc.; NASA Stennis Space Center; Computer Sciences Corporation			
Users: Florida Department of Agriculture and Consumer Services; Office of Agricultural Water Policy; NASA			
RFP: 2008 ROSES A.28			
ARL Start	**2**	**ARL End**	**4**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

In this project, we proposed to enhance NASA's Coastal On-line Assessment and Synthesis Tool (COAST) as a visual interface for modeling and reporting. Effective modeling can greatly assist in selecting appropriate programs, which depends on availability of accurate and up-to-date spatial data, including landscape features, land cover and use, and soil types.

This project addressed the Gulf of Mexico Alliance (GOMA) priority issue as outlined in the Governors' Action Plan for Healthy and Resilient Coasts: Reducing Nutrient Inputs to Coastal Ecosystems. Florida Department of Agriculture and Consumer Services (FDACS) Office of Agricultural Water Policy (OAWP) implements agricultural Best Management Practices (BMPs), which reduces inputs of agricultural nutrients to surface waters that empty into the Gulf of Mexico. Because the adoption of BMPs is voluntary, it is crucial that FDACS personnel be equipped with tools to effectively communicate benefits of nutrient management to producers and can assist in selecting the practices appropriate for site-specific conditions.

The site location for this pilot project is the Lower Suwannee River Basin in Central Florida, as seen in Figure 1. The watershed has been subjected to increased use of pesticides and fertilizers, runoff from dairy and poultry farms (Figure 2), and contaminants from pulp mills and phosphate mines. It has experienced large inputs of nitrogen from fertilizers, animal waste and atmospheric deposition. This is a highly collaborative project with partners from a number of stakeholder organizations.

The intent at the project outset was for the resulting products to be used as a prototype that can be adapted for different geographic regions that contribute nutrient inputs to the Gulf of Mexico.

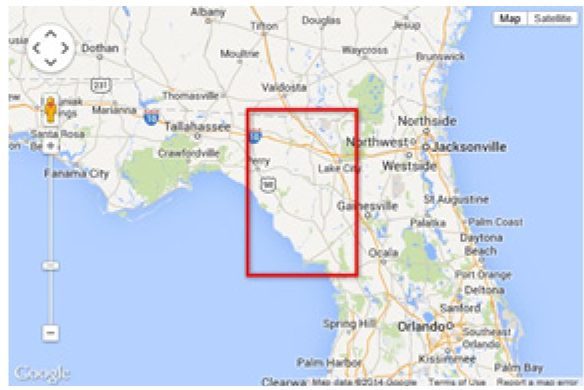


Figure 1 - Study area location. (Source: Google Maps).

It was also intended to establish more efficient agricultural production practices; reduction of nutrient inputs to watershed surface waters, and reduce the input of nutrients to the Gulf of Mexico through better agricultural management practices.


Figure 2 - Example of cattle impacted runoff potentially degrading coastal water quality.

Methods

In this project, the NASA's Coastal On-line Assessment and Synthesis Tool (COAST) was enhanced with a visual interface for examining agricultural sites, developing a suite of recommended Best Management Practices, collecting data for input into a BMP watershed hydrologic nutrient runoff model, and displaying model results back to the end user (Figure 3).

A system interface was then created, tying the COAST to the Watershed Assessment Model (WAM) Tool. The WAM is a Geographic Information System (GIS)-based hydrologic model developed by Del Bottcher of Soil and Water Engineering Technology, Inc. (SWET). A major focus of its functionality is the ability to model the potential impacts of implementing BMPs. A user can now navigate to a specific area of interest (AOI) within which land use attributes can be edited or BMPs applied. The AOI is user-defined and can be as small as a field or farm or as large as a sub-basin or basin.

This prototype was configured to allow data conversion and transfer to the WAM for model runs, as well as to transfer resulting WAM output back to COAST for visualization. Additionally, the necessary functionality was added to the WAM for receiving COAST output, processing and then returning to WAM. The system was tested on different locations within the project pilot basin (see Figure 4).

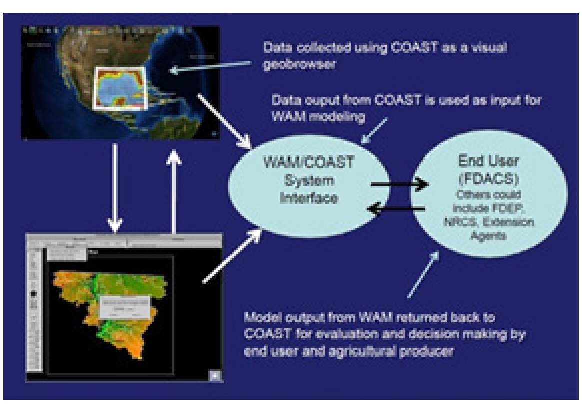


Figure 3 – Work flow for using WAM and COAST tools.

Results

As a result of this project, the necessary functionality has been added to COAST and the necessary functionality has been added to WAM for receiving COAST output, processing and returning to WAM. Using this new functionality, the system has been tested on different locations within the project pilot basin (Figure 4), but has not yet been transferred to the end-users.

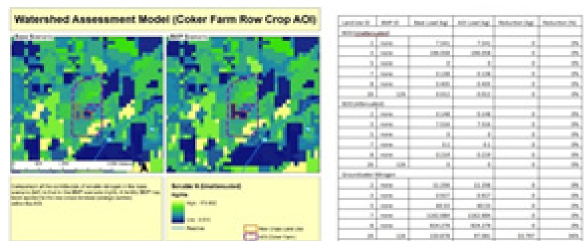


Figure 4 - Example of WAM DSS interacting with COAST system in regards to field survey.

This tool allows in-situ BMP assessments, selection, and placement, which is essential for OAWP BMP implementation efforts. In addition to the larger Suwannee Basin, this new prototype tool can be utilized in other areas that contribute nutrient inputs to the Gulf of Mexico.

As a result of our research, the COAST/WAM tool provides users increased confidence in their information used to encourage agricultural producers to adopt and implement appropriate management practices.

AGRICULTURE

The Agriculture SBA promotes innovation application of Earth observations, computational models, and scientific findings to agricultural management. Science-driven tools provide farmers and governments with accurate, timely information that increase yields and reduce the serious problems caused by excess nutrients in runoff. Two GOMI projects focused on agricultural issues and demonstrated the power that satellite-derived information can have on policy and industry.

Projects

Climate Decision Support in the Gulf States: Assessing the Impacts of Key Uncertainties in End-to-EndAssessments

Use of Satellite Data and Model Products in Improving the Categorization, Delineation and Mitigation of Agricultural Drought

Climate Decision Support in the Gulf States: Assessing the Impacts of Key Uncertainties in End-to-End Assessments

PI: Alex Ruane, NASA Goddard Institute for Space Studies			
Partners: Southeast Climate Consortium; Columbia University Center for Climate Systems research; Univ. of Florida-Gainesville; NOAA Climate Services, Western Region; University of Nebraska-Lincoln; Global Science and Technology, Inc.			
Users: Southeast Climate Consortium Stakeholders			
RFP: 2009 ROSES A.40			
ARL Start	**1**	**ARL End**	**3**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

Demand for a computer-based information system to support agricultural decision making activities serving a climate change time scale has increased for the Gulf States (Figure 1), yet lingering uncertainties regarding investment and adaptation decisions to be made confound the effectiveness of climate impacts assessments and the decisions that result from these assessments.

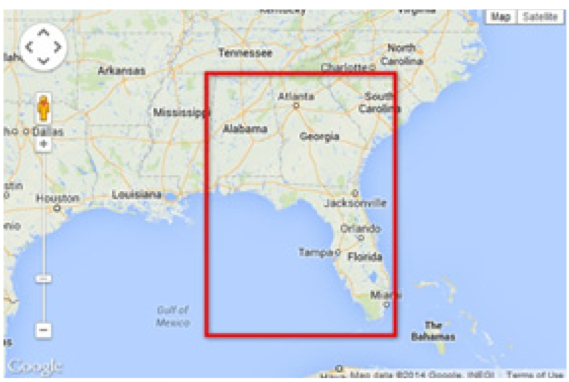


Figure 1 - Study area location. (Source: Google Map)

Given the economic importance of agriculture in the region, this project was conducted to assess the uncertainties of climate change impact assessments. In doing so, it featured the following: 1) impacts of climate variability and change on Gulf Coast peanut production simulations (Figures 2 and 3); and 2) demonstrating the potential for a wider application of climate modeling and reporting products in assessing the impacts of climate change. The project helps to address the interest in the Agricultural Model Inter-comparison and Improvement (AgMIP) Cross-Cutting Theme on Uncertainty.

Figure 2 - Gulf Coast agricultural crop (peanut) potentially at risk to climate change (Source: USDA NRCS).

Methods

This project addressed three major steps of the climate impacts assessment process for agricultural decision support and adaptation: 1) An accurate historical baseline climate was required and developed to characterize present-day mean climate and variability; 2) A climate impacts assessment model was calibrated to capture climate impacts on agriculture during the historical period, providing justification for acceptance of the model as representative of farm-level conditions; and 3) Future climate scenarios were generated as input to the assessment model, simulating agricultural output under plausible future conditions for comparison to the baseline.

A wide range of approaches in each of these steps led to many possible permutations and potential results even for the same assessment task. This project assessed uncertainties throughout the end-to-end climate assessment process, distinguishing between factors and choices with minimal consequences and factors and choices that determine actionable outcomes.

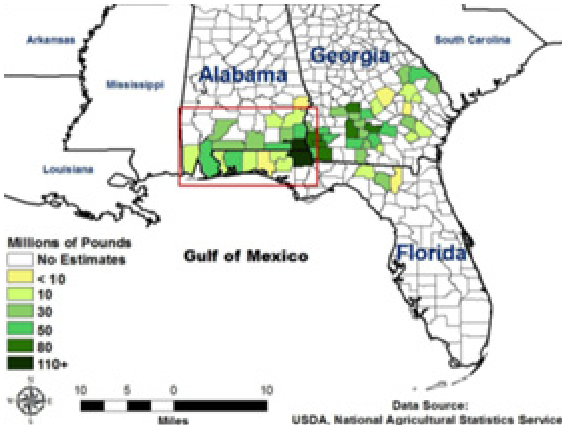


Figure 3 - 2008 county level peanut production map (Source: USDA NASS).

Project evaluations focused on climate impacts, decision support, and adaptation strategy development for peanuts and the broader agricultural sector of Florida and Alabama; Gulf Coast States where the project team has long-standing relationships providing decision support to stakeholders through the Southeast Climate Consortium (SECC). This project used impacts assessment models to span time scales in a manner informative to the weather applications area as well.

Results

Project results showed an improvement in decision support by increasing the efficiency of climate impact assessments and presenting enhanced charting and graphing tools that more clearly present risk uncertainties (Figure 4), enabling the development of adaptation strategies to reduce risk. However, the project revealed certain challenges in doing this type of research, notably: 1) Station "observations" proved to be imperfect standards; and 2) Updated climate and crop models were released mid-way in the project.

In this study, climate data sets, simulated farm types, and future scenario generation represented key sources of uncertainty (Figure 4). In particular, overall warm bias occurred among gridded climatic datasets, but mean yield change differences were not found to be directly related to historical biases. The results indicated that intra-seasonal variability and extreme characteristics were important particularly for irrigated peanuts (Figure 4).

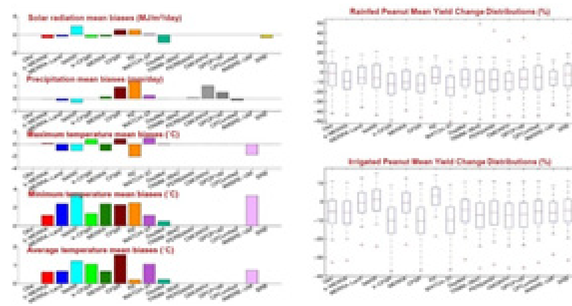


Figure 4 – Precipitation and temperature bias (left) compared to uncertainties in projected rain-fed and irrigated peanut yield (right).

Future climate scenarios created using only mean climate changes produced very similar yield change distributions to those created with projected variability changes. Regarding inter-annual variability of yields, increases in the yield coefficient of variation were substantially greater when variability changes were included. Given the economic importance of agriculture in the region, such climate change impact tracking aids in the effectiveness of decision support available to the SECC.

Use of Satellite Data and Model Products in Improving the Categorization, Delineation and Mitigation of Agricultural Drought

PI: Richard T. McNider, University of Alabama-Huntsville			
Partners: National Drought Mitigation Center; US Department of Agriculture -National Agricultural Statistical Service; Natural Resources Conservation Service; NASA Marshall Space Flight Center; University of Nebraska-Lincoln; Washington State University			
Users: US Department of Agriculture; National Drought Mitigation Center; Alabama Water Resources Commission; State Climatologists for Alabama, Florida, and Georgia; National Resources Conservation Service			
RFP: 2009 ROSES A.40			
ARL Start	4	**ARL End**	7
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

Drought losses have changed the face of agriculture in the Southeast (see Figure 1), due to a lack of competitiveness with western irrigated agriculture and deep water holding soils of the midwestern United States. Droughts are also significant economically. Row crop agriculture in Gulf of Mexico (GOM) states has declined precipitously since 1900 (see Figure 2).

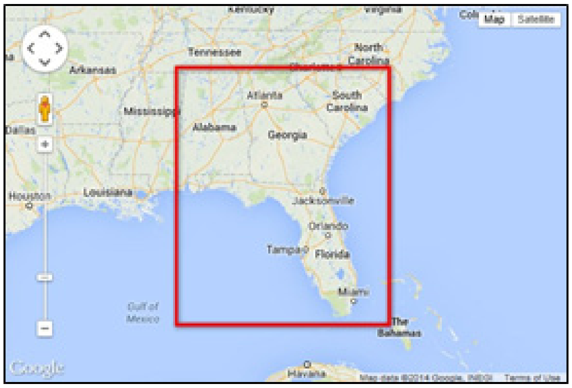


Figure 1 - Study area location. (Source: Google Maps).

This decline was largely due to drought losses (Figure 3) that compromised the region's competitive position compared to western irrigated agriculture and grain production in deep water holding soils in the mid-west. In order for the Gulf States to reclaim productive capacity and respond to the Nation's need for food, fiber and energy security, they must deal more effectively with drought.

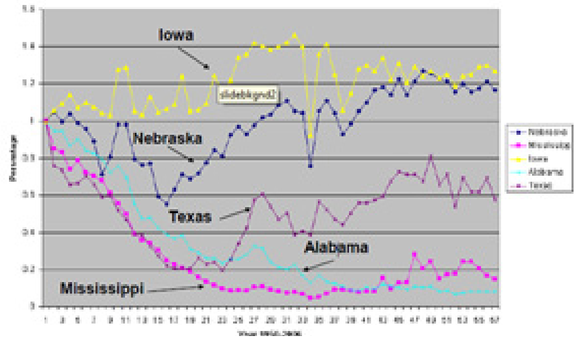


Figure 2 – Corn acres planted as fraction of 1950 for years 1950-2006.

The official designation of drought impacts many government agricultural assistance programs. Some examples include: The designation of areas for which States make disaster declarations for payments to agricultural producers; Eligibility for Small Business Administration Loan Program; Livestock Assistance Grant Program (2006); CRP Emergency Haying and Grazing (2004-current), Internal Revenue Service Income Deferral in Drought Areas; and 2008 Farm Bill Assistance Programs. The focus of this research was to improve response and mitigation of drought in the GOM.

Methods

Four partner organizations were included that have different decision roles in the mitigation and response to drought: (1) State Climatologists (SCs) in Alabama and Florida and (2) The National Drought Mitigation Center (NDMC) have major roles in defining drought delineation lines in their States. Correct drought delineation is critical to fair and accurate response. (3) The United States Department of Agriculture (USDA) National Agricultural Statistics Service (NASS) has a role in tracking crop evolution and drought impacts. Finally the (4) USDA National Resources Conservation Service (NRCS) has a role in expanding irrigation in a sustainable manner.

Figure 3 – Average Inches of Annual Precipitation in the U.S. (1961-1990)

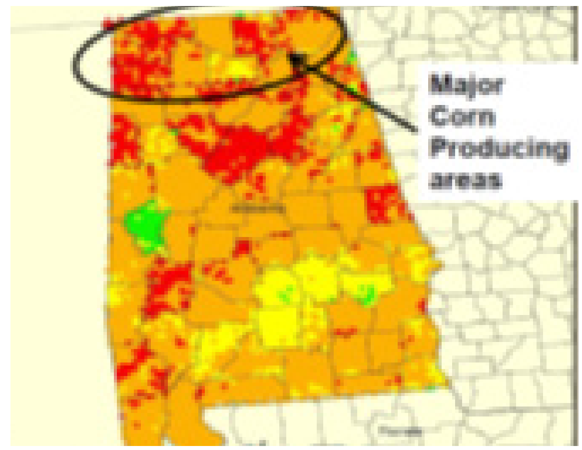


Figure 4 - Final Crop Model Yields - Corn

A new gridded crop model was run in real-time using National Aeronautics and Space Administration (NASA) products to provide stress maps up to the current time and to final yield for specific crops at spatial resolution of 4 km to estimate impacts of drought and water needs for irrigation.

Results

This project provided an array of satellite observations, NASA Earth Science products and model products to provide improved spatial resolution in the delineation of drought in the southeastern United States.

Products delivered to drought decision makers include: a real-time gridded crop model for corn (see Figure 4) using the NASA GSFC Land Surface Information System inputs, combined with readings from the NASA Short-term Prediction Research and Transition Center (SPoRT) LIS Soil Moisture and NASA SPoRT Moderate Resolution Imaging Spectroradiometer (MODIS) Greenness Product, all input into a common projection via the Arc Geographic Information System (ARCGIS).

As a result, drought products, such as a Gridded Real Time Crop Model, are available from State Climatologists and Southeast Climate Consortium NOAA Regional Integrated Sciences and Assessments (RISA) funds (Figure 5). Utilizing these new capabilities, the southeastern United States deals with drought more effectively. The improved characterization and delineation of drought helps improve government and insurance responses as well as increase fairness in designating a space as drought-ridden. To mitigate drought, this research helps in development of tools that encourage expanded irrigation in a sustained manner and highlights the role that severe, short-term droughts can have in reducing even average agricultural yields.

Lastly, this research has a broader impact than just the Southeastern United States. In addition to the recent enacting of an irrigation tax credit in the state of Alabama in 2012, this research contributed to the Nation's adaptation and mitigation of climate change, by providing an adaptation strategy to address the loss of agriculture in the Midwestern United States.

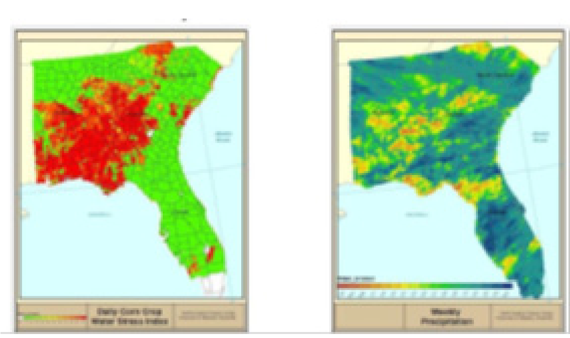


Figure 5 – Gridded Real Time Crop Model. Daily Corn Crop

CLIMATE

Coping with climate change and variability requires a sound scientific understanding based on reliable observations of climate trends and impacts. As sea levels rise on the states that border the Gulf Coast, it is important to understand the impact that will have on critical ecosystems and critical infrastructure. Two GOMI projects focused on the impacts of climate on this region.

Projects

Decision Support for Vulnerability to Future Storms at NASA Kennedy Space Center

The Application of Remotely Sensed Data and Models to Benefit Conservation and Restoration along the Northern Gulf of Mexico Coast

Decision Support for Vulnerability to Future Storms at NASA Kennedy Space Center

PI: Nathanial Plant, US Geological Survey			
Partners: NASA Kennedy Space Center (KSC); NASA/ Goddard Institute for Space Studies; US Army Corps of Engineers; Coastal Planning & Engineering of Boca Raton			
Users: US Army Corps of Engineers, NASA/KSC			
RFP: 2009 ROSES A.40			
ARL Start	**2**	**ARL End**	**6**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

The space program infrastructure at the John F. Kennedy Space Center (KSC) is dangerously vulnerable to climate change-related storm wave, inundation, and erosion-induced losses. This concern has grown, given that recent measures to reduce this vulnerability have failed.

Using NASA-developed models for future climate and storm projections, we undertook the project to estimate: 1) the vulnerability of KSC's infrastructure and habitat to storm hazards such as coastal erosion and inundation, 2) the risk probabilities that include climate modeling uncertainty, and 3) model uncertainties associated with erosion and inundation predictions. In addition, engineering guidance was prepared for remediation of such vulnerabilities.

Methods

Monte Carlo beach behavior modeling of several climate change and sea level rise scenarios was used to help test our hypotheses, which included: 1) storm characteristics (frequency / intensity) and sea level stage changed significantly compared to the historical record; 2) modern observation and modeling capability translates anticipated climate changes into tangible decision support guidance supporting management issues; and 3) the projection of erosion risk into risk-mitigating engineering designs enable more effective management activities for current and anticipated future climates.

Figure 1 - Logger Sea Turtle, whose existence at KSC is threatened by storm-induced habitat loss.

Risks associated with ignoring the vulnerability of KSC infrastructure to storm events include: 1) destruction of the wildlife habitat for threatened and endangered species, such as the Southeastern Beach Mouse and three types of Sea Turtles (Figure 1); 2) degrading the United States space flight launch capability.

Our approach provided decision support to address climate change impacts and climate adaptation. The targeted decisions are those associated with coping with episodic and long-term erosion and inundation at this coastally-located center.

Considering data from 1887-1999, we identified 42 historical events that produced a 1-foot storm surge and offshore wave heights exceeding 12-feet. The historical population of tropical storms was expanded by combining the storm surge hydrograph with three statistical ranges at 4 phases of the tide. This resulted in a plausible tropical storm suite involving 504 storms. From 1980-1999, 33 extratropical storm events from 1980-1999 with offshore wave heights exceeding 12 feet were identified and expanded to a plausible total of 396 plausible extratropical storms.

Results

We delivered detailed visualizations of climate-driven coastal response scenarios and spatially explicit risk analysis summaries that support short-term (i.e., present) and longer-term (10 year) coastal decision-making processes.

We discovered dune failure at KSC is episodic and driven by major storm events. Dunes at KSC are highly vulnerable to over-wash processes (rate of sea-level change), with between 30-50% dune failure at several beaches within 10 years. Dune failure is sensitive to both storm frequency and storm intensity. Storm intensity is a more influential driver of dune failure than is storm frequency. Interestingly, more robust dunes are more sensitive to future sea level change than more vulnerable dunes – the more vulnerable dunes failed regardless of the rate of sea level change.

We also developed three restoration alternatives: 1) restore beach and dunes to a condition that existed 15-20 years ago; 2) generate robust shore protection involving a healthy dune, a 50-foot design berm width and 10-year advanced nourishment of that berm; and 3) a state of managed retreat, where reconstruction of a healthy dune at 50 feet landward of existing dune.

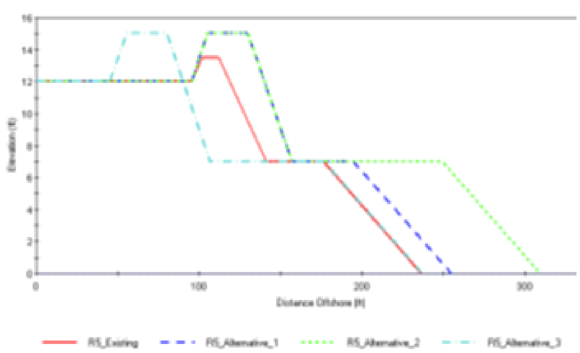


Figure 2 – KSC Restoration Alternatives

Project modeling results suggest that the “Managed Retreat” alternative is the most cost effective approach for reducing the probability of dune failure over the next 25-years (Figure 2). Nourishment volume for this alternative is 1/5 that of Alternative 1 and 1/12 that of Alternative 2. A managed retreat approach was found to reduce current vulnerabilities at a comparatively low cost, but is not a one-time solution to ongoing coastal erosion at KSC (Figure 3).

This study quantified changes in the vulnerability of coastal dunes that protect space program infrastructure at KSC from waves and storm surge. Chronic erosion continues to impact coastal dunes at KSC. If sea level change rates accelerate and/or storm climatology changes significantly in the next two decades, decisions regarding climate risk mitigation measures are needed, including potential full retreat/abandonment or more robust and costly shore protection schemes.

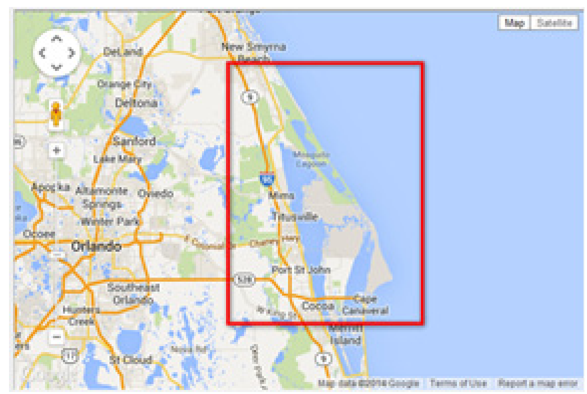


Figure 2 - Location of Kennedy Space Center. (Source: Google Maps)

The Application of Remotely Sensed Data and Models to Benefit Conservation and Restoration along the Northern Gulf of Mexico Coast

PI: Maurice Estes, Universities Space Research Association			
Partners: NOAA; NASA; Dauphin Island Sea Lab; National Coastal Data Development Center; University of South Carolina; Battelle Memorial Institute; Prescott College; Universities Space Research Association, DISL			
Users: Mobile Bay National Estuary Program; Weeks Bay Foundation; Weeks Bay National Estuarine Research Reserve; ADCNR; Dauphin Island Sea Lab; Barry Vittor & Associates; Fenstermaker and Associates			
RFP: 2008 ROSES A.28			
ARL Start	**1**	**ARL End**	**8**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

Climate and other environmental change impacts threaten Mobile Bay sub-merged aquatic vegetation habitats important to coastal fisheries, though specific spatio-temporal information on these impacts is often less than desired (Figure 1). In response, the project addressed the following objectives: 1) determine the effects of climate change on shallow aquatic ecosystems; 2) evaluate how these changes in the physical environment affects the health of sea grasses and other submerged aquatic vegetation in shallow aquatic ecosystems; and 3) provide potential recommendations to enhance decision-making for coastal resources in the region. The project aimed to support the National Aeronautic and Space Administration's (NASA) Earth Science Mission Directorate and its Applied Science Program and the Gulf of Mexico Alliance (GOMA) by producing and providing NASA data and data products that benefit decision making by coastal resource managers and others in the Gulf region.

This project addressed the GOMA Priority Issues of: 1) Habitat Conservation and Restoration, engaging a diverse group of stakeholders from state, federal and international agencies as well as business and industry and providing improved conservation and restoration management tools through the application of science and technology; 2) Ecosystem Integration and Assessment, specifically establishing strategic partnerships to fill environmental and ecological data gaps; and 3) Environmental Education, to promote stewardship of the Gulf Region.

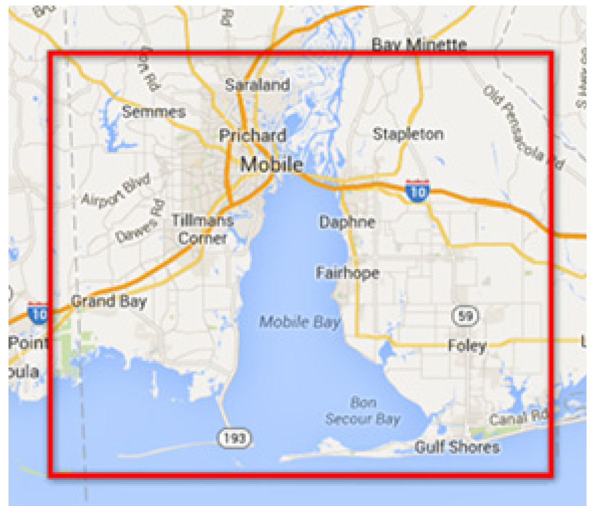


Figure 1 - Study region location. (Source: Google Maps)

Methods

This project aimed to assist coastal resource managers plan and adapt for changing conditions by: 1) evaluating projected climate changes and development impacts, land cover/land use (LCLU), hydrodynamics and water properties, and shallow water habitats: 2) identifying priority areas for conservation and restoration; 3) distributing datasets to end-users; and 4) facilitating user interaction with various models. Watershed and hydrodynamic models were coupled with a Habitat Suitability Model to evaluate the impact of climate scenarios on Mobile Bay aquatic ecosystems. The data provided by Intergovernmental Panel on Climate Change (IPCC) of the future changes in temperature and precipitation was used to create the climate scenarios for the modeling.

The host sites for final project data products were NOAA's National Coastal Data Development Center (NCDDC) Regional Ecosystem Data Management (REDM) (Figure 2), and the Mississippi-Alabama

Habitat Database.

Models employed in the project depended heavily on NASA remote sensing products (e.g., from the Moderate Resolution Imaging Spectroradiometer, or “MODIS” and Landsat). Tools were provided on the Gulf of Mexico Regional Collaborative (GoMRC) website with links to data portals for enabling end users to use models and datasets used to develop and evaluate LCLU and climate scenarios of particular interest.

Figure 2 - NOAA National Coastal Data Development Center web-site containing project data for GOMA end-use.

Results

The application of remotely sensed data and models assisted tend-users (e.g., Mobile Bay National Estuary Program (MBNEP) in their efforts to promote improved aquatic habitat conservation and restoration within the region. In particular, it aided the MBNEP’s efforts to protect and restore the Fish River watershed and Weeks Bay National Estuarine Research Reserve.

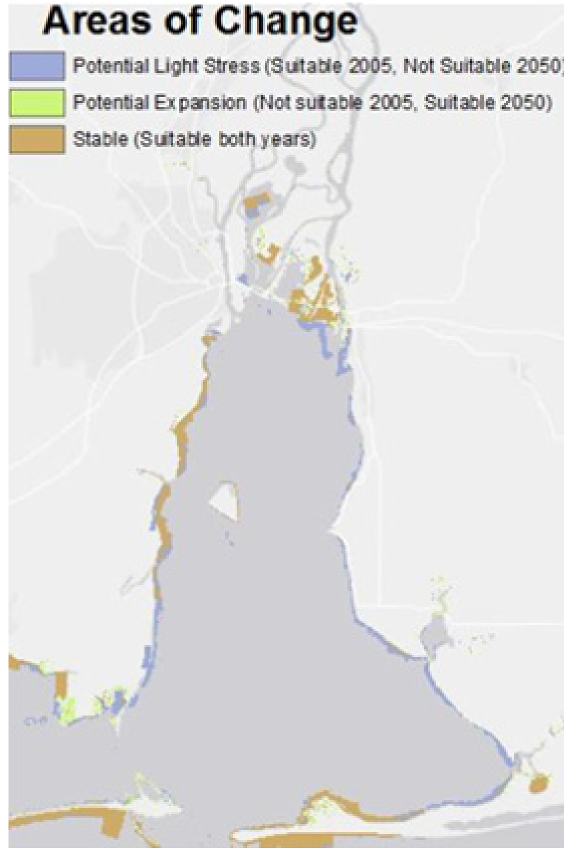


Figure 3 - Project product showing sea grass and other SAV areas, each rated for habitat stability for 2005 versus 2050.

Results of this study suggested that higher temperatures and lower precipitation typically decreases runoff, sediment load and freshwater mixing in the estuary; and secondly, climate-driven bottom salinity changes of 2-3 PSU or more impacted habitat ranges for sea grasses and other SAV in some areas, such as the Bon Secour and Wolf Bay areas (see Figure 3). It was also realized that changes in LCLU were more closely linked to total suspended solids (TSS) changes and climate change than it was to changes in salinity.

OCEANS

The Oceans SBA undertakes efforts to improve understanding of the ocean system using NASA satellite data, computational models and other scientific findings. This SBA helps emergency planners, coastal communities, and others, by providing information on, and insight into, the role oceanic systems play in weather, seismic, and economic systems that directly affect human welfare. The GOMI ocean projects addressed topics such as water quality and analysis techniques to improve our understanding of this complex system.

Projects

Mapping and Characterization of Seagrass Habitats Using Spacecraft Observations

Mapping and Forecasting of Pelagic Sargassum Drift Habitat in Gulf of Mexico and South Atlantic Blight for Decision Support

SANDS – Sediment Analysis Network for Decision Support

Building a Database for a Coastal Carbon Synthesis Project

Decadal-Scale Changes in Oceanic Heat Content for the Gulf of Mexico: A Model Study with Multi-Disciplinary Implications to Climate Change

DEMAND: DSS Environment for Modeling of Atmospheric Nutrient Deposition

High-Resolution Subsurface Physical and Optical Property Fields in the Gulf of Mexico: Establishing Baselines and Assessment Tools for Resource Managers

Improved Hypoxia Modeling for Nutrient Control Decisions in the Gulf of Mexico (Hypo-G)

Demonstration of Innovative Satellite Products for Improving Decision Making

Characterizing Pelagic Habitats within US Gulf of Mexico Coastal Waters Using Satellite Derived Data and Machine Learning Algorithms.

PI: Susan Bell, University of South Florida			
Partners: Florida Department of Environmental Management			
Users: Pinella County, Department of Environment Management			
RFP: 2008 ROSES A.28			
ARL Start	**5**	**ARL End**	**5**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

Seagrass habitats are characteristic features of many coastal shallow waters worldwide and provide a variety of ecosystem functions. Seagrass habitat (Figure 1) provides a home to many types of fish and an infinite number of invertebrates that live in this marine ecosystem. Thus assessment and monitoring of seagrass habitats are priorities of coastal managers.

Figure I – Underwater view of example seagrass bed.

This project focuses upon the Gulf of Mexico Alliance priority issue: Identification and characterization of Gulf habitats. The overall objective of this project was to evaluate the potential for using NASA products to improve the decision-making concerning the status of seagrass beds.

Methods

The project team examined the capability of existing tools and methods for decision-making activities on rapidly mapping and

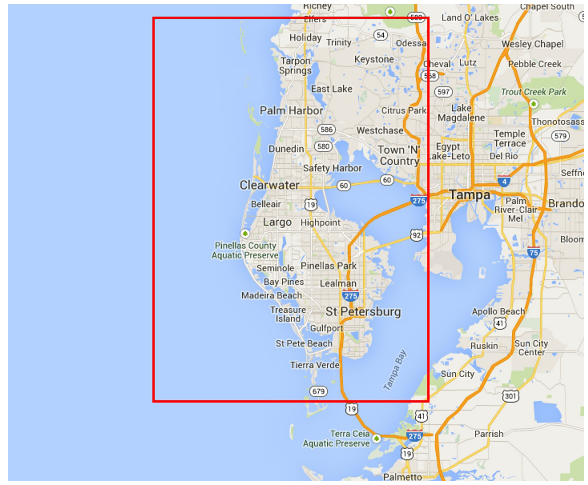


Figure 2 – Study area location (Source: Google Maps).

characterizing seagrass habitat using optical remote sensing for the Identification and characterization of Gulf habitats for Pinellas County, Florida (Figure 2). In doing so, the project team worked to assist Pinellas County decision-making activities regarding seagrass habitat assessment, monitoring and management, including validation of tools used to conduct a change analysis of seagrass habitat after a major hurricane.

Data from Landsat-5 Thematic Mapper (TM), plus Earth Observing-1 Advanced Land Imager (ALI) and Hyperion (HYP) were used to compare the capability of the three 30 m resolution satellite sensors for mapping seagrass and to test regression models based on two seagrass metrics (percent cover of submerged aquatic vegetation (%SAV) and leaf area index (LAI)). These products were demonstrated for mapping and assessing seagrass habitats within a shallow coastal area along the central western coast of Florida (Figure 2). In doing so, the project team evaluated a water depth correction approach to create water depth-invariant bands calculated from the three sensors' data. Then a maximum likelihood classifier was used to classify the %SAV cover using two classification schemes of 3 and 5 classes respectively.

Based upon the two seagrass metrics

measured in the field, six multiple regression models were developed and %SAV and LAI were estimated with the spectral data from the three sensors to assess the seagrass habitats in the mapped units. Field data was collected in several sites across the study area to help develop and validate the remote sensing-based seagrass maps.

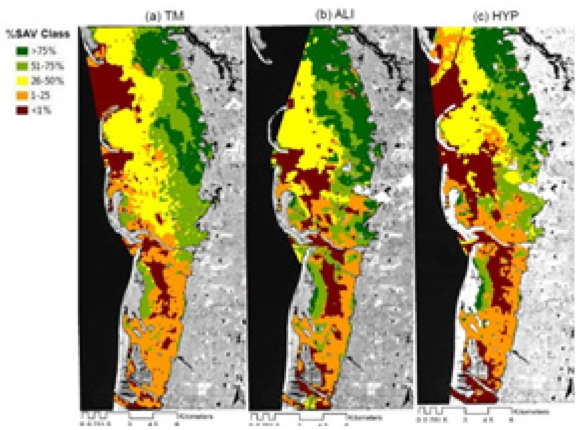


Figure 3 - SAV classification results for the 5-class scheme in regards to Landsat TM (left), ALI (middle), and Hyperion data (right).

Results

The results of this project are as follows. In terms of classifying %SAV, the Hyperion sensor produced the best results of the 5-class classification (Figure 3) of %SAV cover (overall accuracy = 87% and Kappa = 0.83 versus 82% and 0.77 by ALI and 79% and 0.73 by TM) and better multiple regression models for estimating the three biometrics (R2 = 0.66, 0.62 and 0.61 for %SAV, LAI (Figure 4) and Biomass versus 0.62, 0.61 and 0.55 by ALI and 0.58, 0.56 and 0.52 by TM) for creating seagrass abundance maps, along with two environmental factors.

The results collectively demonstrate that the image optimization algorithms and the fuzzy synthetic evaluation technique were very effective in mapping detailed seagrass habitats and assessing seagrass abundance (Figure 4) with the 30-m resolution data collected by the three sensors.

Our findings also demonstrate that the water depth correction approach was useful in enabling the detailed seagrass habitat maps from the three sensors. The protocol developed and utilized here represents a new contribution to the existing set of tools used by researchers for seagrass assessments which is now available for guiding future studies.

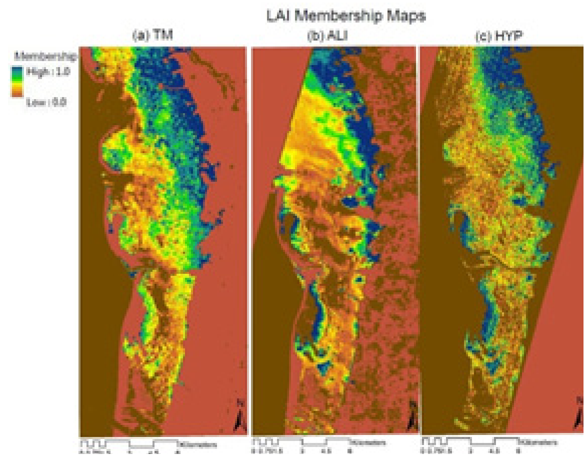


Figure 4 - Seagrass LAI membership maps – derived using Landsat TM (left), ALI (middle), and Hyperion data (right).

Mapping and Forecasting of Pelagic Sargassum Drift Habitat in Gulf of Mexico and South Atlantic Blight for Decision Support

PI: Chuanmin Hu, University of South Florida			
Partners: Texas A&M University; Florida Atlantic University; Florida Fish and Wildlife Conservation Commission			
Users: Florida Fish and Wildlife Conservation Commission; South Atlantic Fishery Management Council; Galveston Beach Maintenance & Island Parks; University of Southern Mississippi; Gulf and Caribbean Fisheries Institute Network			
RFP: 2009 ROSES A.40			
ARL Start	2	**ARL End**	7
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

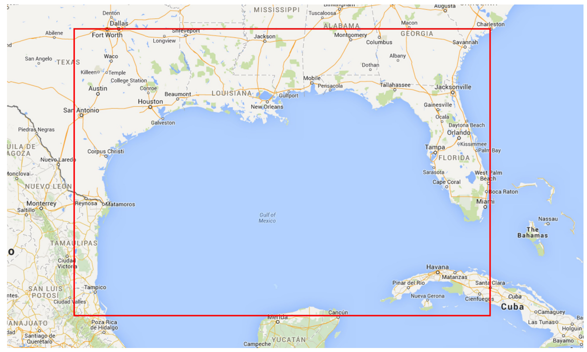


Figure 2 - Study area location (Source: Google Maps).

Introduction

Pelagic Sargassum species provides important habitat (food, shade, shelter) to fish, shrimp, crabs, turtles, and other marine organisms but Macroalgae can also cause nuisance beach accumulations (Figure 1). Our knowledge on Sargassum abundance and distributions, and future trending is limited. This project sought to fill this gap for areas in the Gulf of Mexico (Figure 2) to help make management and research decisions and reduce cost in making these decisions by using the most recent advances in algorithm development and NASA Earth Observing System (EOS) data.

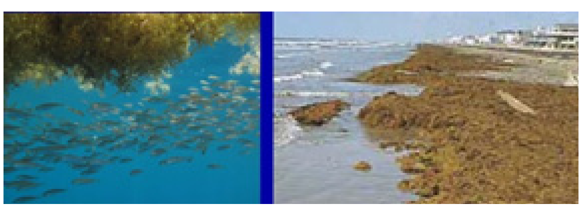


Figure 1 - Sargassum mats in-water (left) and deposited on-shore (right).

Our project addressed three main objectives: 1) To fill knowledge gaps on Sargassum abundance/distributions in the Gulf of Mexico and South Atlantic Bight; 2) To improve existing decision making (beach management, Sargassum harvesting, and research planning) by using the new Sargassum data products; and 3) To understand whether and how trends in Sargassum abundance/distributions are influenced by climate change.

Methods

The project was aimed to produce the following: 1) Geo-referenced time series Sargassum abundance/distribution maps since 2000, including products provided online in near real-time to assist decision-making; 2) Improved decision making on Sargassum harvesting and beach management; 3) Improved understanding of turtle and fish distributions in relation to Sargassum; 4) Technical reports and publications to facilitate use of NASA products, and increased use of NASA data products, such as the Moderate Resolution Imaging Spectroradiometer (MODIS) for management and research decisions; and 6) Reduced cost for research and management planning.

End users of the above products range from Federal and state agencies to educational institutions. The significance of this project comes from three aspects: 1) Novelty - there is no data product specifically designed to map Sargassum from space; 2) Various user groups have critical need for quantitative and timely information on Sargassum; and 3) NASA ocean color products are used mainly by researchers. The project team worked to expand the use to a variety of user groups, which range from Federal and state agencies, educational institutions, private industry, to the general public.

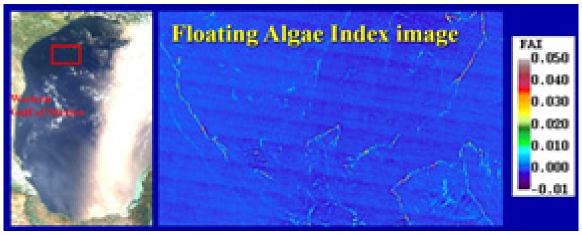


Figure 3 - MODIS-based detection of in-water Sargassum mats using the Floating Algae Index (FAI).

Results

Project results included processing and archiving of all MODIS data covering the western Gulf and northern Caribbean for 2000 – 2010 (Figure 3). GOM Landsat data has been downloaded, and those for 2010 have been processed and interpreted (Figure 4). Landsat data covering the Les Antilles Islands for 2011 have been processed and interpreted.

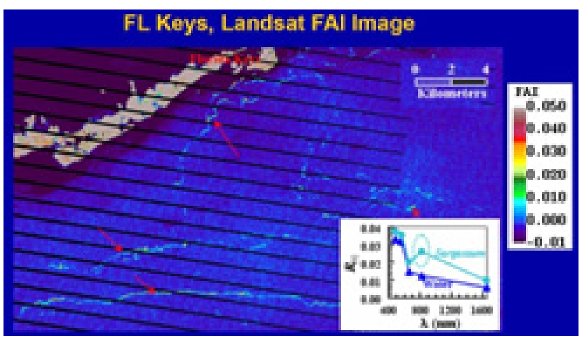


Figure 4 - Landsat-based detection of in-water Sargassum mats using the FAI.

A web portal has been implemented specifically to broadcast satellite imagery about Sargassum distributions in the western GOM, eastern GOM, Atlantic Ocean, and Southern Caribbean (Figure 5). Lastly, several publications were produced directly or indirectly from project activities, including those in addressing the recent accidental Deepwater Horizon oil spill.

This project sought to help make management/research decisions regarding Sargassum abundance and distributions in the GOM and South Atlantic, and reducing cost in making decisions by using the most recent advances in algorithm development and EOS data.

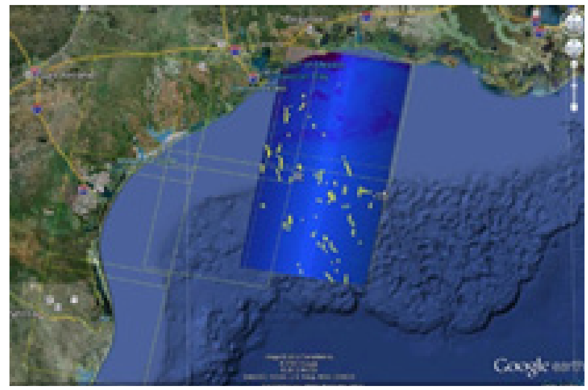


Figure 5 - Contribution of Sargassum maps from analyst delineated Landsat FIA products to Google Earth - based near real time system.

PI: Sara Graves, University of Alabama-Huntsville			
Partners: Geological Survey of Alabama			
Users: Dauphin Island Sea Lab; US Department of the Interior Fish and Wildlife; Alabama Department of Conservation and Natural Resources; Mobile Bay National Estuary Program; Geological Survey of Alabama			
RFP: 2008 ROSES A.28			
ARL Start	**1**	**ARL End**	**4**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

Since the year 2000, Eastern Louisiana, coastal Mississippi, Alabama, and the western Florida panhandle have been affected by 28 tropical storms, seven of which were hurricanes. These tropical cyclones have significantly altered normal coastal processes and characteristics in the Gulf of Mexico (GOM) region through sediment disturbance. Sediment deposits are changed in very short periods of time by these tropical storms.

The importance of sediments upon water quality, coastal erosion, habitats and nutrients has made the study and monitoring vital to decision-makers in the region. Currently, agencies such as the United States Army Corps of Engineers (USACE), the National Aeronautics and Space Administration (NASA), and Geological Survey of Alabama (GSA) are employing a variety of in-situ and airborne based measurements to assess and monitor sediment loading and deposition. These methods provide highly accurate information but are limited in geographic range, are not continuous over a region and, in the case of airborne light detection and ranging (LIDAR), are expensive and do not recur on a regular basis.

The overall objective of the Sediment Analysis Network for Decision Support (SANDS) project was to generate decision support products using NASA satellite observations from the Moderate Resolution Imaging Spectroradiometer (MODIS), Landsat and Sea-Viewing Wide Field-of-View Sensor (SeaWiFS) instruments to address the impacts of tropical storms and hurricanes on sediment disturbance, suspension, transport, and deposition in the north central GOM. See Figure 1 for the study area used in this project.

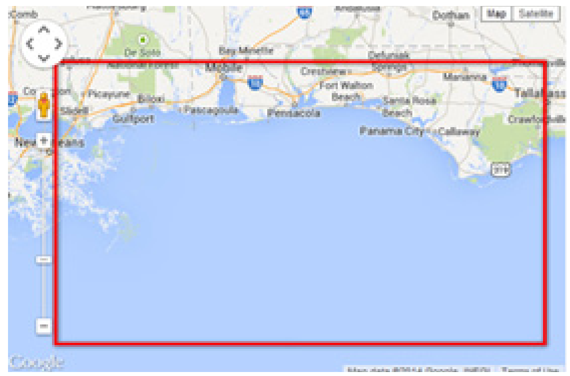


Figure 1 - Study area location (Source: Google Maps)

Since tropical storm-induced sediment disturbance plays a part in each of the four GOM Alliance priority issues; the products generated by the SANDS project have broad application to end users in the Gulf States.

Methods

Data employed in this project came from Landsat 7 Enhanced Thematic Mapper Plus and Landsat 5 Thematic Mapper data for the years 2000-2002 and 2003-2008, respectively. Additional data sources were MODIS data for years 2000-2008 and Space Shuttle RADAR Topography Mission (SRTM) data which were used for delineating coastlines. Analysis of data was acquired, pre-processed and then forwarded to GSA for further analysis using ESRI ArcGIS 9.0 and ERDAS IMAGINE 9.3 software.

Products were managed and accessed through the SANDS Portal (Figure 2); an on-line data repository with a user interface customized to provide data and information for specific storm events. All products are registered with the GOMA metadata portal, Virtual Alabama decision support system (DSS), and other regional geospatial information systems relevant to coastal issues. Making multi-spectral satellite products available for multiple common storm events allowed SANDS to provide end users the opportunity to better analyze, detect, and identify compositions and patterns of suspended sediment and sediment deposits.

Figure 2 - SANDS data portal - on-line at: http://sands.itsc.uah.edu. 13

There was difficulty with some MODIS data involved in this project. Along-track and cross-tracking striping was a problem, especially for data from the half-kilometer (HKM) and quarter-kilometer (QKM) bands.

Results

As a result of this project, the extent and distribution of suspended sediments – both pre-landfall and post-landfall was discovered to correlate generally with bathymetric patterns. On a regional level, much of the detected suspended sediment overlies the continental shelf and extends only a short distance past the slope break. On a more local level, patterns of detected suspended sediment from pre-landfall data matched the patterns of bathymetric contours of sand ridges. A compilation of all pre-landfall and post-landfall suspended sediment data gives a generalized view of suspense concentration.

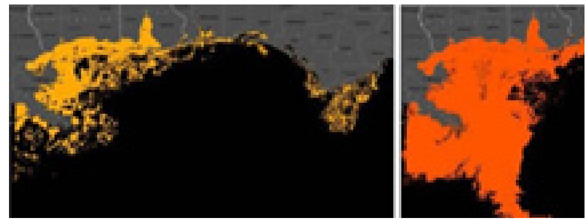


Figure 3 – Project product show pre (yellow) versus post (orange) Hurricane Katrina in-water suspended sediment.

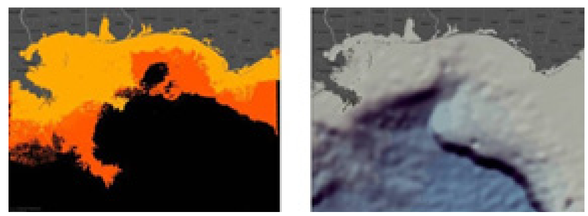


Figure 4 – Project product on left showing pre and post storm suspended sediment versus bathymetry on right.

The greatest concentration of suspended sediment occurs around the Mississippi River delta, Mobile Bay and Apalachicola Bay. A difference in both concentration and spatial reach of the detected suspended sediment can be seen in the pre-landfall and post-landfall data, with a significantly more southern extent shown in the post-landfall suspended sediment. This is to be expected given the increased coastal erosion and river discharge during and following a tropical cyclone.

As stated previously, the importance of sediments upon water quality, coastal erosion, habitats and nutrients has made the study and monitoring of sediments absolutely vital to decision-makers in the region of the United States.

Geospatial Synthesis of Chromophoric Dissolved Organic Matter Distribution in the Gulf of Mexico for Water Clarity Decision Making

PI: Christopher Osburn, North Carolina State University			
Partners: Louisiana State University; Texas A&M University; University of Massachusetts Boston; University of South Florida; Biological and Chemical Oceanography Data Management Office; US EPA, Gulf Ecology Division; Louisiana Dept. of Natural Resources			
Users: Florida Department of Environmental Protection; Charlotte Harbor National Estuary Program			
RFP: 2008 ROSES A.28			
ARL Start	**4**	**ARL End**	**4**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

Chromophoric Dissolved Organic Matter (CDOM) is a controller of water clarity, a discriminator of river influence, an indicator of wetland influence and petroleum contamination, and is correlated to nutrients. Remote sensing-based CDOM absorption products exist, but counterpart in-water CDOM measurements in the Gulf of Mexico (GOM) are often lacking.

This project addresses two objectives for providing resource managers and decision makers with a support tool that can predict CDOM concentration in coastal waters and estuaries of the GOM: 1) construct a single, integrated CDOM database spanning 10 years of absorbance, fluorescence, and ancillary oceanographic observations for the northern GOM, used to validate existing ocean color algorithms that predict two important properties of CDOM: its absorption coefficient at 412 nm (a412) and the slope coefficient of the CDOM absorption spectrum (S); 2) validate two algorithms that compute a412 and S from Sea-Viewing Wide Field-of-View Sensor (SeaWiFS) and Moderate Resolution Imaging Spectroradiometer (MODIS) remote sensing imagery for the northern GOM (Figure 1).

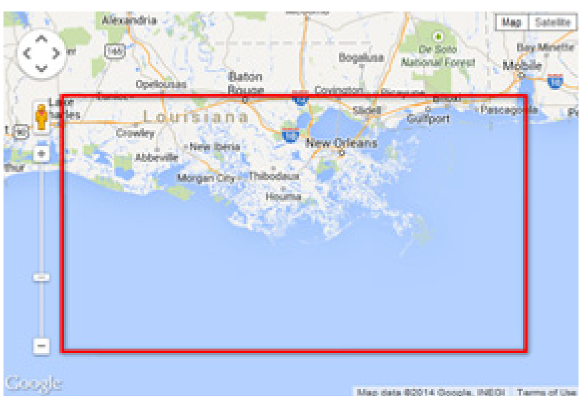


Figure 1 - Location of project demonstration area. (Source: Google Maps)

The project is relevant to the National Aeronautics and Space Administration's (NASA) Water Resources societal benefit area and water quality related priority issues of the Gulf of Mexico Alliance. This database and the resulting water clarity decision support tool can potentially serve as a model for coastal areas beyond the GOM demonstration area (Figure 1).

Methods

Information from the project was incorporated into an on-line web portal, the Gulf Coast Information System (GCIS) with CDOM data products also generated.

The performance evaluation measures used in the project considered feedback from potential end-users to evaluate the usefulness of the database and of a CDOM data support tool.

Before the project work could begin, the research team had to define the data submission structure to be utilized. Next, the project work included the building of a publicly accessible, geo-referenced database of CDOM absorption, Desolved Organic Carbon (DOC) concentration, and other oceanographic variables for the northern Gulf of Mexico; and 2) collating different pieces of information useful to coastal decision makers and researchers. This resulted in a "data rescue": compiling disparate data sets from multiple cruises into one "megacruise".

Results

The Biological and Chemical Oceanography Data Management Office (BCO-DMO) platform and data metadata were used and available for improving studies of satellite-based CDOM time series (Figure 2), including 12 years of SeaWiFS CDOM products within the GCIS (Figure 3).

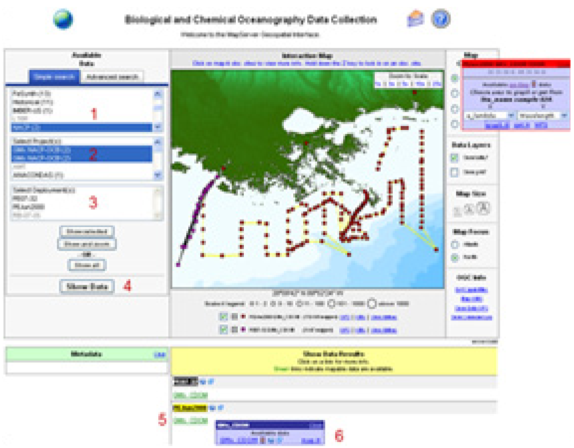


Figure 2 - GIS interface output from BCO-DMO web-site, showing project relevant data.

The project helped promote data sharing, including the generation of data casting (GeoRSS) feeds and Keyhole Markup Language (KML) files of data and data products; such a capability is also accessible by wireless devices. The project also helped in maintaining a satellite-based time series of CDOM products in the GCIS.

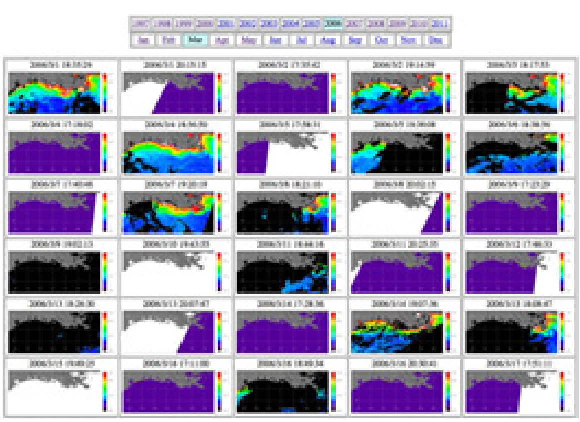


Figure 3 – GCIS screen display showing some of the SeaWiFS CDOM products for 2006.

The project helped the research team to evaluate the performance of satellite CDOM algorithms compared to in-situ data (see Figure 4 below and Figure 5 at the bottom of the page).

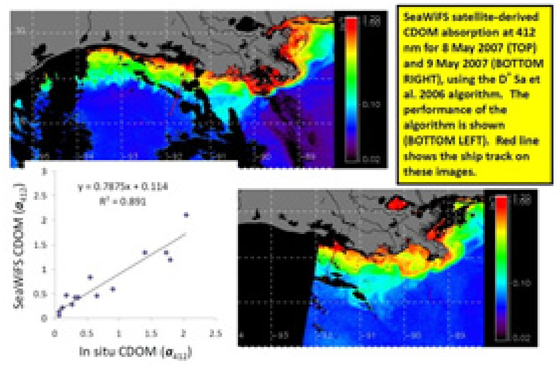


Figure 4 - Example SeaWiFS CDOM algorithm specific products that were evaluated with in-situ data acquired during the project.

In particular, it helped researchers determine that one or two remote sensing-based CDOM algorithms are not sufficient to produce optimally useful results for all coastal areas. The archived satellite-based CDOM absorption product is apparently available on the web via GCIS (latter was not working when last checked) and CDOM in-situ data from the project is found on the BCO-DMO web site found at: http://www.bco-dmo.org/. In addition, there are manuscripts discussing project results that are either in preparation or else submitted for publication, as of 2013. While the project study area focused on the northern central GOM area, the results are potentially relevant to other GOM areas.

Coefficients resulting from regression analysis between $a_{CDOM}(412)$, DOC, and salinity

Parameter	Season	Slope (a)	Intercept (b)	R^2	N
DOC vs. a_{CDOM}(412)	Summer	137.22	124.20	0.90	39
DOC vs. a_{CDOM}(412)	Spring-winter	127.02	77.97	0.90	40
a_{CDOM}(412) vs. salinity	Summer	-0.079	2.62	0.77	39
a_{CDOM}(412) vs. salinity	Spring-winter	-0.076	2.78	0.86	40
DOC vs. salinity	Summer	-11.48	497.82	0.77	39
DOC vs. salinity	Spring-winter	-11.84	482.64	0.90	40

Figure 5 - Relationships between in site CDOM absorption, DOC and salinity

Decadal-Scale Changes in Oceanic Heat Content for the Gulf of Mexico: A Model Study with Multi-Disciplinary Implications to Climate Change

PI: Sergio DeRada, Naval Research Laboratory			
Partners: University of Southern Mississippi; Northern Gulf Institute; Gulf of Mexico Alliance, Mineral Management Service			
Users: Flower Garden Banks National Marine Sanctuary (FGBNMS); US Army Corps of Engineers			
RFP: 2009 ROSES A.40			
ARL Start	**1**	**ARL End**	**4**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

The Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4) forecasts that increases in air temperatures for the remainder of this century are due to human-induced or anthropogenic greenhouse gas emissions.

Figure 1 - Study area location. (Source: Google Maps)

It is commonly presumed that projections of warmer air temperatures in the Gulf of Mexico (GOM) suggest a warmer surface ocean with the associated potential for increased hurricane intensity, sea-level rise, and the loss of ecosystems due to thermal stress. Since the ocean is generally a heat source for the atmosphere, and solar radiation is the principal heat source for the ocean, climate change projections for ocean temperatures have to be rigorously evaluated in the context of air-sea heat energy exchange processes and the regional variability of coupled air-sea interactions.

Project objectives focused on the GOM (see Figure 1) and involved an ocean model that uses a ten-year scale to perform simulations to quantify and forecast changes of in ocean temperatures. Specifically, to: 1) obtain the best estimate of interannual trends for upper ocean heat content for the previous 30-years; (2) examine ocean model sensitivity to variables such as atmospheric pressure, temperature, humidity, wind speed, precipitation, etc.; and (3) provide quantitative estimates of how ocean variables change over the last ~30-years, given reasonable changes in atmospheric forcing.

Methods

To satisfy these objectives, we employed the Navy Coastal Ocean Model (NCOM) physical formulation coupled to a 13-component (COSINE) ecosystem (see Figure 2).

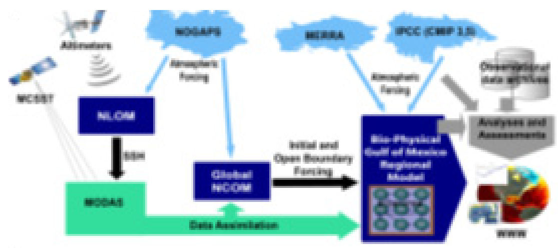


Figure 2 – Snapshot of Model Configuration of the Navy Coastal Ocean Model

We leveraged numerical modeling expertise and operational ocean forecasting systems to conduct decadal-scale ocean model ensemble simulations to quantify changes of oceanic heat content and estimate projections therein. First, we conducted a thirty-year reanalysis of upper ocean heat content for the GOM using state-of-the-art numerical ocean models with NASA's Modern Era Retrospective-analysis for Research and Applications (MERRA) atmospheric data. Second, we ran thirty-year forecast and sensitivity experiments to examine simulated upper ocean heat content sensitivity to persistence and reasonable perturbations in pertinent atmospheric variables (e.g., wind stress, air temperature, and specific humidity). Third, we provided projections of upper ocean temperatures in the GOM for the following thirty years with a quantitative description of the uncertainty inherent in those estimates (Figure 3).

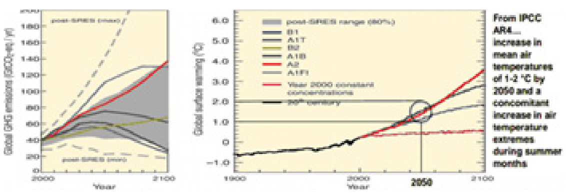


Figure 3 – Graph showing estimates of how ocean variables may change over ~30 years, given reasonable changes in atmospheric forcing.

Results

Oceanic products resulting from our study complement the data from MERRA to form a comprehensive 3D oceanic-atmospheric dataset, which, along with our regional oceanic heat content climate projections, contributed to the IPCC AR4. Comparison of model temperature fields (red=4Km GOM, blue=1Km inner nest) to selected CTD casts (black) taken during the Mixing Over Rough Topography (MORT) June 2011 field program in the (see Figure 3) Flower Garden Banks Marine Sanctuary (FGBMS). A bathymetry map was used to view the locations of the casts (see Figure 4). In general, the model reproduces the vertical temperature gradient well, but it is slightly cold biased and does not capture the small scale structure clearly present in the observations (Figure 5). It is visually evident that the higher horizontal resolution (both GOM and its inner nest have the same vertical structure) has better skill (metrics computed using 1Km nest).

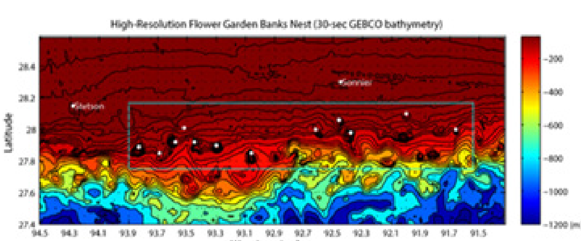


Figure 4 - Example bathymetric data base constructed for Flower Garden Banks Marine Sanctuary in support of project.

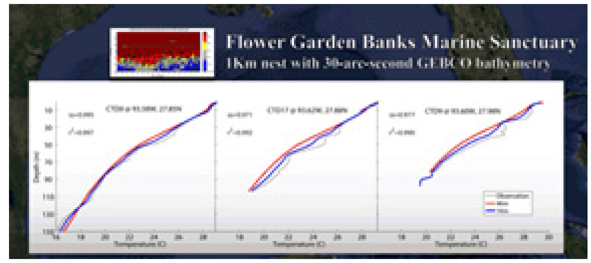


Figure 5 - Model temperature fields comparison of the FGBMS.

Another result of this project was the discovery that, while the annual means and winters are nearly flat in terms of temperature fluctuation, the summers are consistently warmer. The project also leveraged other GOM coastal water application development work, including efforts on FGBMS data base development, oil spill assessments, ecosystem models, coupling of optical and physical models, and hypoxia assessments (see Figure 6).

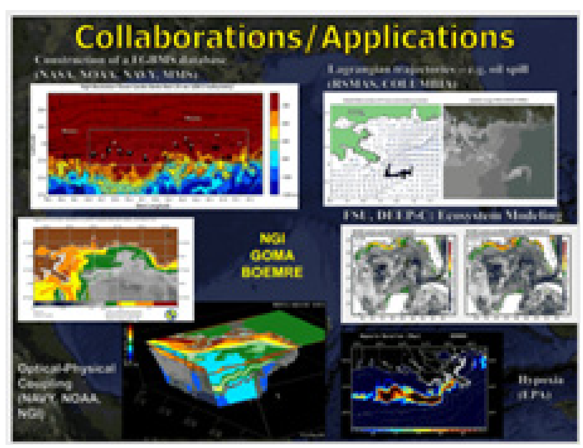


Figure 6– Chart showing applications of collaborative efforts.

PI: Udaysankar Nair, University of Alabama in Huntsville			
Partners: Alabama Department of Homeland Security			
Users: Mobile Bay National Estuary Program; Alabama Department of Environmental Management (ADEM)			
RFP: 2008 ROSES A.28			
ARL Start	**2**	**ARL End**	**6**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

Using satellite data from National Aeronautics and Space Administration (NASA) assets and recent NASA Earth Science Research Results (NASA ESRR), this project was conducted to aid in decision-making processes related to water quality and nutrient inputs into aquatic ecosystems in coastal and inland areas in the state of Alabama (see Figure 1).

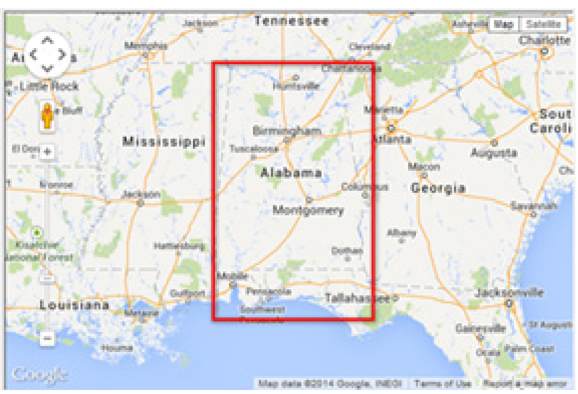


Figure 1 - Location of study area. (Source: Google Maps)

Atmospheric nutrient deposition plays a role in the formation of hypoxic zones in the Gulf of Mexico (GOM) coastal waters. For example, pollutants from biomass burning potentially translate into nutrient inputs to waterways (Figure 2). Nutrient inputs into inland water bodies and oceans are an important modulator of aquatic ecosystem functions and services.

Methods

To address end-user needs, data retrieved from the Moderate Resolution Imaging Spectroradiometer (MODIS) coupled with output from the chemical/aerosol transport model Community Multi-Scale Air Quality (CMAQ) / Aerosol Regional Atmospheric Modeling System (AERO-RAMS) were used to estimate wet and dry deposition of nutrients Nitrogen, Sulfphur, Iron and Phosphorus (N, S, Fe and P) over land, inland water bodies, estuaries and the GOM region. Output from the models were used to partition observed aerosol column loading into different categories and deposition potentials were computed for end user decision support related to nutrient mitigation.

Figure 2 – Airborne pollutants from wildfires can contribute nutrient inputs to waterways.

CMAQ/AERO-RAMS was used during this project to simulate sulfate, nitrate, dust and biomass burning aerosol transport. We utilized satellite derived smoke emission, MODIS Aerosol Optical Depth (AOD) and fine mode fraction to constrain simulated aerosol fields.

To aid interactions with state and regional stakeholders, the project used a proven Decision Support System (DSS), the Virtual Alabama (VA) system (see Figures 3 and 4), with broad state and regional acceptance as a repository of products utilized by this project.

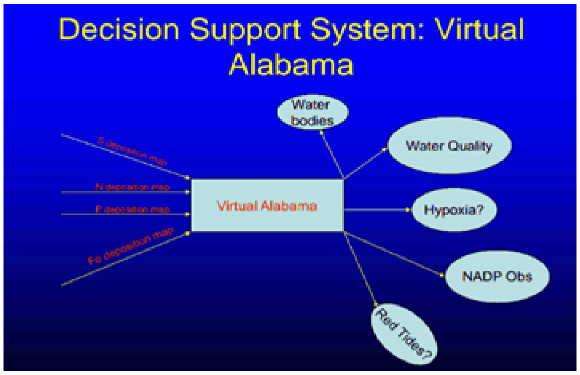


Figure 3 - Structure of Virtual Alabama (VA) Decision Support System

This VA system is Google Earth-based and was developed by the Alabama Department of Homeland Security (ALDHS) in order to share information between government agencies in the state of Alabama.

The project also leveraged advanced computational resources at the University of Alabama at Huntsville, specifically the Alabama Supercomputer Center.

Figure 3 - Example DEMAND DSS display, as part of the Virtual Alabama system.

Results

As a result of this research, detailed deposition maps for the state of Alabama and nearby Gulf Coast areas were established. In addition, the project enabled an evaluation of the potential of NASA earth science research results of monitoring deposition. As a result, the research enabled an improvement in the estimates available of atmospheric deposition from numerical models utilizing satellite emission fluxes and AOD.

The study helped the project team to better understand the relative importance of nutrient inputs and understanding potential ecosystem responses. In addition, the study provided information on biomass burning episodes and aerosol transport.

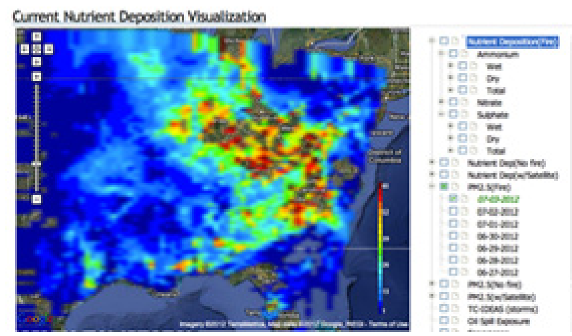


Figure 5 - DEMAND DSS screen display for an on-line animation view of example NASA ESR air quality product.

The project team developed extensive models that incorporated NASA data sets to predict specific air quality parameters. These models were run daily, taking into account current atmospheric conditions with the results collected in a GIS database for long-term averaging of depositional values. The project team also produced retrospective studies for previous years and locations of interest based on input from project end users (Figure 5).

Efforts to improve the monitoring quality of atmospheric nutrient disposition served the State of Alabama as well as the Gulf Coast region well. This research was conducted to aid in the development and enhancement of decision-making processes related to water quality and to help address issues detrimental to aquatic ecosystems of this region.

High-Resolution Subsurface Physical and Optical Property Fields in the Gulf of Mexico: Establishing Baselines and Assessment Tools for Resource Managers

PI: Jason Jolliff, Naval Research Laboratory			
Partners: National Oceanographic and Atmospheric Administration National Coastal Data Development Center (NCDDC)			
Users: Flower Garden Banks National Marine Sanctuary; US Army Corps of Engineers			
RFP: 2008 ROSES A.28			
ARL Start	**2**	**ARL End**	**7**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

Coastal resource managers along the Gulf of Mexico know that water characteristics are important for management, but unfortunately there is limited baseline information on these characteristics and uncertainties about data quality.

In response, this project was conducted with the main objective of providing high spatial resolution subsurface physical and optical property distribution map to coastal resource managers. In doing so, the project team worked to address the following questions: 1) How much light is reaching the bottom? 2) What is the temperature? 3) How fast are the currents? 4) Is the water turbid? and 5) What are the sediment loads?

The project aimed to produce a database of subsurface physical and optical property fields for specific local areas within the Gulf of Mexico (Figure 1) using a blend of data assimilative ocean modeling tools and ocean color remote sensing products. These three-dimensional property fields are needed to inform the decision-making process of resource managers, with particular emphasis on: 1) habitat identification and characterization, 2) assessment of the environmental impact of various permitted activities, such as dredging; and 3) water quality assessment.

The potential for expanding the boundaries of the Flower Garden Banks National

Figure 1 - Study area location. (Source: Google Maps).

Marine Sanctuary (FGBNMS) has been identified as a priority. Boundary expansion proposals and deliberations on this idea would be significantly enhanced by greater knowledge of baseline environmental conditions for relevant coastal waters, such as light, temperature, and salinity, for benthic biological communities ecologically linked to the presently protected areas.

Before the project, the natural variability of coastal turbidity (suspended sediment load) was not well known for local areas where the United States Army Corps of Engineers (USACE) are required to monitor during dredging, flood protection, and coastal restoration activities. More baseline information on this natural variability was needed for comparison to other monitoring data sets.

Methods

The project engaged the FGBNMS as an end-user. This group also works with the Sanctuary Advisory Council, constituents, and users to conduct periodic management reviews of current regulations. The FGBNMS is currently going through a review, and potential boundary expansion has been identified as a priority management issue. There are geologic features in the FGBNMS region that support critical biological habitats, i.e. Habitat Areas of Particular Concern (HAPC) (Figure 2).

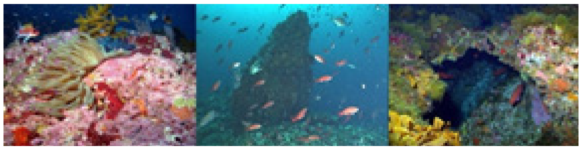


Figure 2 - Examples of HAPCs associated with FGBNMS (Source: NOAA).

Baseline conditions for the Flower Garden Banks Sanctuary were established. These included deliverables (products), such as NCOM-GOMMS Bottom Temperature Climatology (also salinity and current vectors); Ocean Atmosphere Spectral Irradiance Model (OASIM) -SeaWIFS Bottom Light (PAR) Climatology; as well as several monthly means and daily means computed. With help from FGBNMS-NOAA and USACE, we developed and provided high-resolution and three-dimensional light, temperature, salinity, and current field estimates, and surface maps of suspended sediment load, made from a fusion of satellite remote sensing and ocean modeling products.

Results

This project results in the development of several products as deliverables. Reports covering topics including NCOM-GOMMS Bottom Temperature Climatology for the years 2000-2008. A Climatology report on OASIM-SeaWiFS Bottom Light (PAR) for the years 1998-2006). These products provided a regional context and local-scale details. These products were added into a data portal monitoring site for the NOAA-NCDDC Flower Garden Banks (Figure 3). This is an interactive, web-based portal built upon the “Google Maps” graphical user interface (GUI) to centralize the findings (e.g., baseline products). Features include: 1) high-resolution, multi-beam echo-sounder data; 2) FGBNMS research staff monitoring survey data; 3) FGBNMS Research Vessel Manta Conductivity, Temperature and Depth (CTD) data; 4) Data from buoy stations and monitoring stations on oil and gas platforms; 5) FGBNMS boundaries and HAPC boundaries; and 6) Benthic habitat maps / Remote Operated Vehicle (ROV) survey tracks and photographs.

To support the USACE water turbidity assessments, other water property baseline products were produced for several estuaries in the northern GOM (Figure 4).

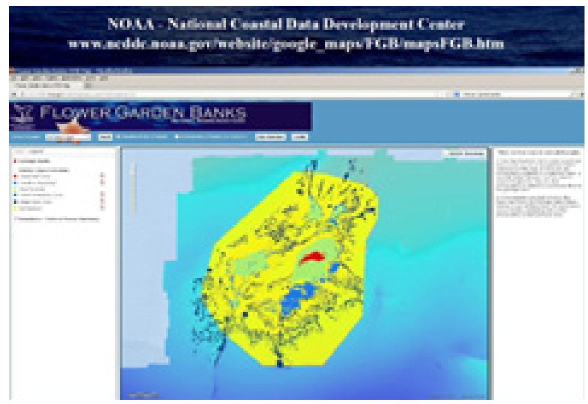


Figure 3 - GUI to FGBNMS Data Viewer.

This project’s primary objective of producing a high-resolution subsurface property map of specific areas within the Gulf of Mexico was achieved, providing greater knowledge of baseline environmental conditions that is being used to determine the feasibility of expanding the boundaries of the National Marine Sanctuary at Flower Garden Banks.

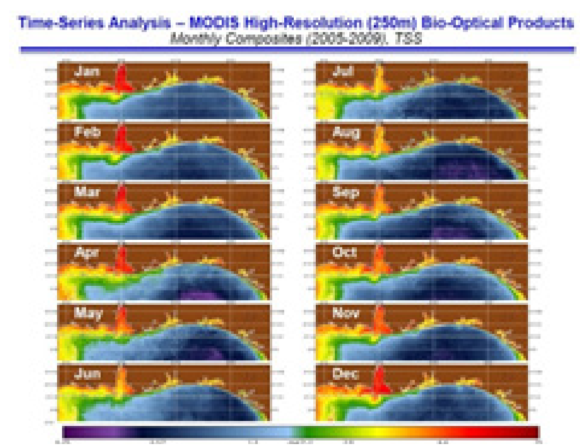


Figure 4 – Example MODIS 250m 2005-2009 monthly TSS time series for estuaries along the northern GOM.

PI: Shahid Habib, NASA Goddard Space Flight Center			
Partners: University of Maryland, College Park and Baltimore County; US Environmental Protection Agency; Science Systems and Applications; Oregon State University PRISM Group; National Atmospheric Deposition Program			
Users: Gulf of Mexico Alliance and federal, state and local agencies			
RFP: 2008 ROSES A.28			
ARL Start	**3**	**ARL End**	**3**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

The water quality of the Gulf of Mexico (GOM) is being impaired by excessive nutrients in river runoff, resulting in a phenomenon known as hypoxia. Hypoxia equates to a lack of oxygen in coastal waters, leading to dead zones along the GOM. This project was launched to examine the potential benefits of using NASA satellite remote sensing data products within the Environmental Protection Agency's (EPA) Gulf of Mexico Modeling Framework as it pertains to GOM hypoxia assessment (Figure 1).

Figure 1 - Study area location. (Source: Google Maps).

Generally, hypoxia kills fish, which depletes valuable fisheries, disrupts ecosystems along with closed beaches, and causes economic and natural disruption (Figure 2). The identified hypoxic zone kills all oxygen-dependent sea creatures within its zone. The size of this zone varies each year. In 2007, the measured hypoxic zone was 20,000 km2. The ultimate goal is to reduce the hypoxic area to less than 5,000 km2. The hypoxic zone in this area of the GOM has been observed to be as large as 22,000 sq. km, an area the size of Massachusetts.

Hypoxia is caused by a number of factors, including excess nutrients, primarily nitrogen and phosphorus, and water body stratification due to salinity or temperature gradients. Fertilizers have been identified as a source of this problem. Fertilizers from agriculture, golf courses, and suburban lawns; erosion of soil; nutrient discharges from sewage treatment plants; and disposition of atmospheric nitrogen.

Figure 2 - Commercial fisheries in the GOM are commonly negatively impacted by hypoxia.

Methods

The project aimed to support the EPA Gulf of Mexico Modeling and Monitoring project whose purpose is to provide the scientific basis to guide a reduction in the frequency, duration, size, and degree of oxygen depletion in the northern GOM as outlined in the recently released Hypoxia Action Plan. The Gulf of Mexico Modeling Framework is a suite of coupled models linking deposition and transport of sediment and nutrients to subsequent bio-geo chemical processes and the resulting effect on concentrations of dissolved oxygen in the coastal of waters of Louisiana and Texas.

The project examined products from NASA sensors in operation during this effort, including TRMM precipitation, Moderate Resolution Imaging Spectroradiometer

(MODIS) Aerosol (AOT), CALIPSO Aerosol, MODIS Ocean Color, SeaWIFS Ocean Color, and Ozone Monitoring Instrument (OMI) NO2 and SO2.

Some of the data sets reviewed during this project included: Parameter-elevation Regressions on Independent Slopes (PRISM) for precipitation; the National Atmospheric Deposition Program (NADP) for nitrogen and sulfate deposition; and In-situ oceanographic data from field intensives.

The project team investigated use of NASA precipitation products, atmospheric constituent measurements, and Ocean Color data products separately and in combination to determine if these can be used to improve modeling of the Gulf of Mexico hypoxic zone. The project also included research on the use of satellite data on atmospheric NO2 concentrations and aerosol levels for improving estimates of both wet and dry deposition. It also assessed use of NASA satellite-based Chlorophyll measurements to validate calculation of photosynthetically active biomass within the modeling framework.

NASA satellite products were compared with in-situ observations of chlorophyll, total suspended matter (TSM), particulate organic carbon (POC) and dissolved organic carbon (DOC) from field campaigns. The project team used these comparisons to generate a level 2 satellite retrieval system.

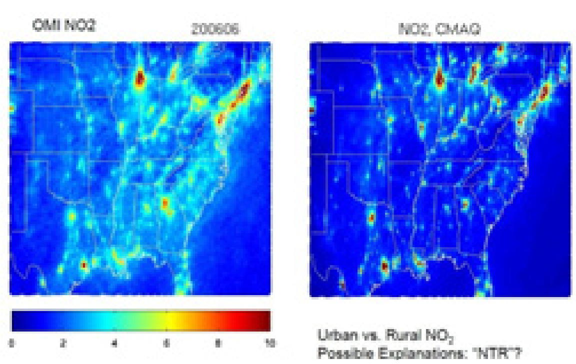


Figure 3 - Comparison of OMI and CMAQ NO2 products from June 2006.

Results

In regards to nitrogen, project results show satellite-based NO2 emissions as being too high and that a compensating error in Community Multi-Scale Air Quality (CMAQ) makes NTR lifetime too long (see Figure 3). The nitrogen was also found to release NO2 outside the model domain and essentially turned what should have been a reservoir into a sink, as sequestered N is "blown out" of the modeling domain. These facts are possible reasons why CMAQ's nitrogen deposition output appeared to be too high.

In summary, the project proved that already existing NASA satellite remote sensing data products are useful working with the EPA water quality grid to help produce useful water quality models to assess the hypoxic zone in the Gulf of Mexico (see Figure 4 below).

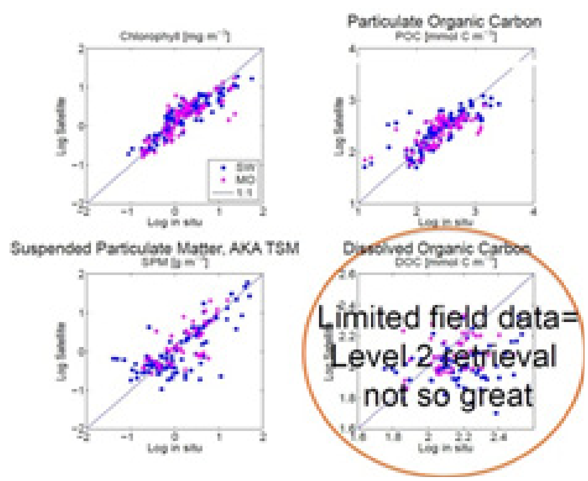


Figure 4 - Correlation between satellite ocean color products and in-situ data.

PI: ZhongPing Lee – Mississippi State University/University of Massachusetts Boston			
Partners: National Oceanic and Atmospheric Administration; Florida Fish and Wildlife Conservation Commission; Naval Research Lab			
Users: Florida Department of Environmental Protection; National Oceanic and Atmospheric Administration			
RFP: 2009 ROSES A.40			
ARL Start	**3**	**ARL End**	**1**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

The status and trend of phytoplankton biomass (traditionally measured by concentration of chlorophyll, Chl) are important information regarding marine ecosystems, and Chl products derived from satellite ocean color sensors, such as the Moderate Resolution Imaging Spectroradiometer (MODIS) of NASA, and the Medium Resolution Imaging Spectrometer (MERIS) of the European Space Agency (ESA), are widely used for studies of marine ecosystems and for decision making. At present these research activities (such as the National Oceanic and Atmospheric Administration, or NOAA's Harmful Algal Blooms Observing System) use near-daily and subsequent temporal Chl products obtained directly from satellite sensors, of which advection impacts from currents and tides are ignored. Such time series can result in ambiguous conclusions about temporal changes (or trends) of phytoplankton in marine ecosystems, thus limiting the success of correct decisions and accurate assessment of marine ecosystems. Our objectives were to improve the measurement of phytoplankton growth/ bloom; improve the detection of harmful algae bloom (red tide or *K. brevis*)) (see Figure 1); demonstrate the feasibility of using properly aligned (remapped) satellite products to analyze temporal changes of phytoplankton; and improve decision making in the Gulf of Mexico.

The project study area was the western or Gulf-side of the state of Florida (Figure 2).

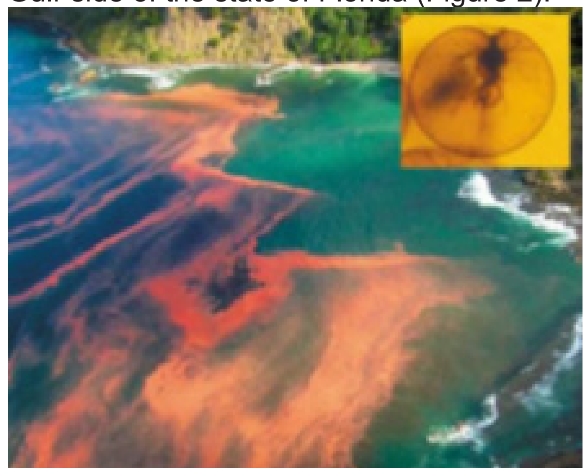


Figure 1 – Aerial view of harmful algal bloom known as the red tide (*K. brevis*).

and was designed to provide a concept feasibility study for potential application(s) of specific NASA Earth science research results to improve decision-making."

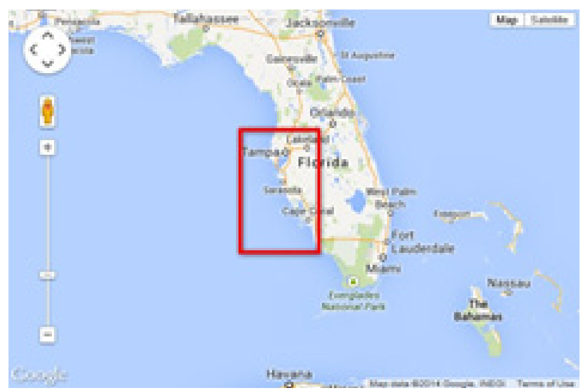


Figure 2 - Study area location (Source: Google Maps).

Methods

Specifically, we 1) demonstrated the feasibility of generating new CHL products by coupling existing satellite products with widely used circulation models, 2) demonstrated the applications of such new products in analyzing phytoplankton dynamics and in decision making activities, and 3) characterized quantitatively the resulting improvements in decision making.

Our approach was to generate local Chl product from the ocean color satellite, and then remap that product, producing something new that would separate advection from phytoplankton growth for the study area (Figure 3). We utilized the NRL ocean nowcast/forecast system (ONFS) and the ONFS for West Florida (WFLNFS). We then optimized the model for remapping satellite Chl products, with onsite data acquisition, MODIS CHL product generation and preparation, and optimized remap schemes.

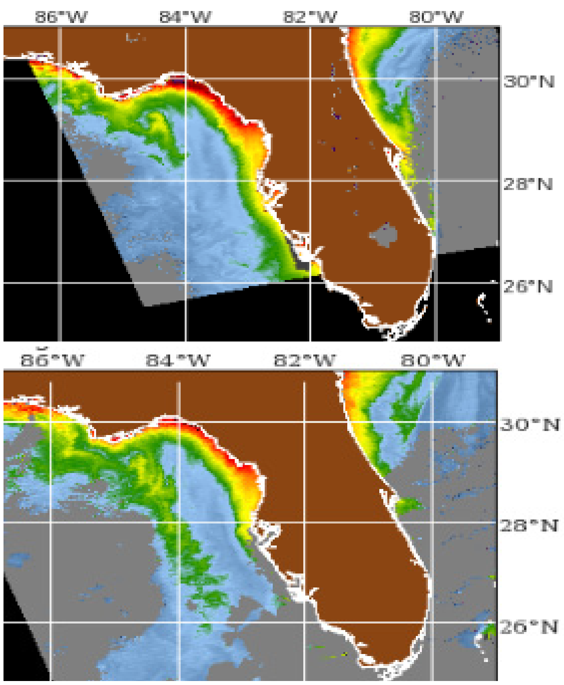


Figure 3 – Example of algal growth and bloom, often confused with advection.

Results

Results from this effort include improved measurement of algae growth and bloom, the optimization of the Intra-American Seas Nowcast Forecast System (IASNFS) model for remapping satellite CHL product as well as acquisition. We also were able to test, analyze, and optimize remap schemes and evaluate the remapped products with satellite products and data from in situ measurements. We were able to compare CHL temporal variations of selected locations using remapped and traditional CHL products, see Figures 4 and 5, and we demonstrated the application and improvement of remapped CHL products in decision making.

Our research revealed that phytoplankton (water parcel) are moving targets; that the correction of advection significantly improves the measure of algae growth/bloom; that improvement on HAB (*K. brevis*) detection is marginal; and that an integrated approach for the monitoring of harmful algae bloom is necessary.

This project served to demonstrate that innovations in the measurement of advection impacts from currents and tides, developed for satellite products, can play an important role in the monitoring the status of marine ecosystems, particularly harmful algal growth and bloom, along the coastline of the United States.

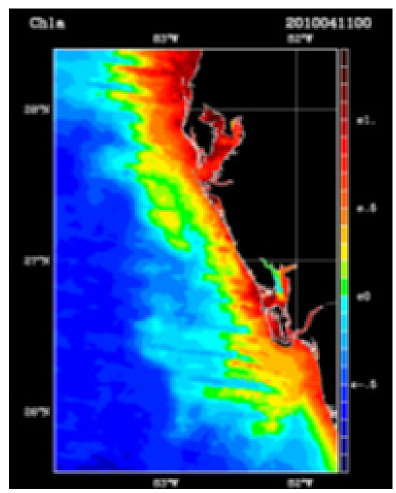


Figure 4 - Traditional Composite of Chl Product

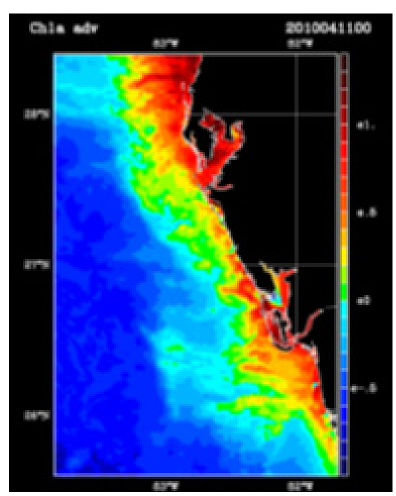


Figure 5 - Composite of Chl Product after Re-Map

Characterizing Pelagic Habitats within US Gulf of Mexico Coastal Waters Using Satellite Derived Data and Machine Learning Algorithms

PI: Rebecca Allee, National Oceanic and Atmospheric Administration			
Partners: US Environmental Protection Agency; US Naval Research Laboratory; NatureServe; South Florida Water Management District; University of Texas – Dallas; University of Maryland, Baltimore County; NASA			
Users: Gulf of Mexico Fisheries Management Council; Gulf States Marine Fisheries Commission; State Fisheries Management Agencies; National Estuary programs			
RFP: 2008 ROSES A.28			
ARL Start	**2**	**ARL End**	**8**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

For this project we proposed to delineate and map pelagic habitats and assess habitat condition for select estuaries and coastal waters within the Gulf of Mexico (Figure 1) using ocean color data from Moderate Resolution Imaging Spectroradiometer (MODIS) and the Sea-Viewing Wide-Field-of-View Sensor (SeaWiFS) data, Sea Surface Temperature (SST) and salinity products from MODIS, and JASON-1 altimetry data.

Figure 1 – Primary study location. (Source: Google Maps)

The Governors' Action Plan for Healthy and Resilient Coasts identified the need to map coastal and marine habitats (Figure 2) and make those maps accessible to managers. This project directly supported several GOM Alliance actions, including the creation of, and providing access to, interactive habitat maps for priority GOM habitats, as well as implementation of the Coastal and Marine Ecological Classification Standard (CMECS) in the GOM.


Figure 2 - Example pelagic marine habitat utilized by school of Bluefin tuna (Source: NOAA).

Methods

This project's objectives included: 1) Identifying and assessing water column classifiers for usefulness in delineating pelagic habitats; 2) assessing the utility of satellite remote sensing data and modeling to delineate and classify pelagic habitat types in select areas of the GOM; 3) assessing the utility of self-organizing map technology for delineating coastal habitats; and 4) further developing classification standardization in the GOM. End-users included Gulf of Mexico Fisheries Management Council, Gulf States Marine Fisheries Commission, and State Fisheries Management Agencies.

The use of data from the Southeast Area Monitoring and Assessment Program (SEAMAP) was evaluated as a source of input to the classification into water column component categories (see Figure 3), based on a coastal and marine ecological classification standard. These categories include Salinity Subcomponent (Figure 4), Temperature Subcomponent, Productivity Modifier, Water Column Stability Modifier, and Turbidity Modifier (using Secchi Depth readings).

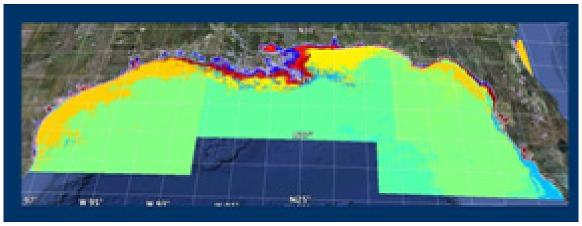


Figure 3 - Project example of SOM-based classification of GOM water using SEMAP data products as inputs.

Results

The results of this research indicated that temperature and salinity are essential inputs to deriving needed classifications of various coastal habitats. The satellite remote sensing data was found to be very useful for estimating the studied environmental parameters on a larger scale than is able available on land.

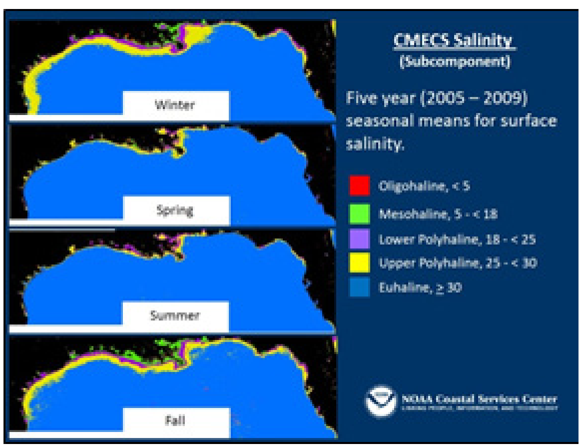


Figure 4- CMECS salinity sub-component maps from project.

Self-organizing map technology was discovered to offer an efficient, less labor-intensive approach to classification into Coastal and Marine Ecological Classification Standard (CMECS) categories (Figures 4 and 5). Finally, as a result of this research, it was determined that self-organizing map technology is useful to resource managers to identify coastal areas where species are more likely to be present, based on factors such as salinity, nutrients present, and water temperature.

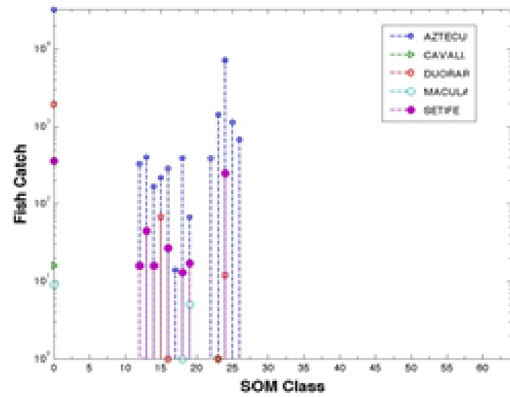


Figure 5 – Fish catch versus SOM classes based on only salinity, temperature and 40 m depth restriction.

Results of this project included the assessment of using remote sensing data from the MODIS and JASON-1 satellite assets as well as the modeling to delineate and classify pelagic habitat types in select areas of the Gulf of Mexico.

WEATHER

The Weather SBA uses Earth Science observations to improve weather-related decision-making, including aviation and space weather. Three GOMI projects focused on aviation-related weather issues. These projects advanced the state of the art storm forecasting, lightening alerts, and have increased the safety of flights over the Gulf of Mexico.

Projects

Short-term Storm Forecasting Over the Gulf of Mexico by Blending Satellite-Based Extrapolation Forecasts with Numerical Weather Prediction Results.

Improved Convective Initiation Forecasting over the Gulf of Mexico

Demonstration of Satellite-Based Lightning Initiation Nowcasts Toward Enhancing FAA Tactical Forecasts for Improving Ground-based Airport Operations

Short-term Storm Forecasting Over the Gulf of Mexico by Blending Satellite-Based Extrapolation Forecasts with Numerical Weather Prediction Results

PI: Huaqing Cai, National Center for Atmospheric Research (NCAR)			
Partners: Naval Research Laboratory at Monterey; Northern Gulf Institute; MIT Lincoln Laboratory			
Users: Federal Aviation Agency (FAA)'s Aviation Weather Research Program (AWRP)			
RFP: 2009 ROSES A.40			
ARL Start	**1**	**ARL End**	**3**
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

The primary motivation behind this project was general aviation safety. The study area for this research project was the Gulf of Mexico (GOM). Unexpected turbulence, especially convectively induced turbulence (CIT), causes passenger and crew injuries and aircraft damage. Transoceanic pilots have reduced weather information due to sparse flights, few weather observations and limited communications bandwidth.

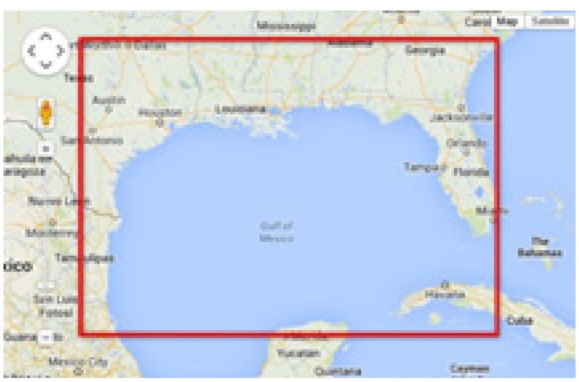


Figure 1 - Study area location. (Source: Google Maps).

The National Oceanic and Atmospheric Administration's (NOAA) World Area Forecast System (WAFS) provides weather products for the international aviation community. However, these products have low temporal and spatial resolution which means that Large SIGMET (Significant Meteorological information) areas are difficult to circumnavigate. Convection over the ocean poses a potentially great danger for trans-oceanic flights, as tragically demonstrated in the Air France 447 accident of 2009.

Methods

Our research team performed a feasibility study of producing 0-12 hour convective forecasts over the GOM, for aviation planning and situational awareness. These forecasts were produced by blending extrapolated satellite data (precipitation rate and cloud tops) with Numerical Weather Prediction (NWP) model forecasts. While observation-based extrapolation forecasts generally outperform NWP model forecasts in the first few hours; NWP models tend to have higher skill at longer lead times.

By accounting for the relative strengths and skill of these two forecast methods a seamless 0-12 hour forecast of precipitation rate and cloud top heights was generated that has increased skill over the individual components, particularly in the 3-6 lead hours. Over the past few years, the National Center for Atmospheric Research (NCAR) Research Applications Laboratory (RAL) collaborated with the MIT Lincoln Laboratory (MIT LL) and NOAA Global System Division (GSD) to develop a 0-8 hour storm forecasting system over the continental United States (CONUS) for the Federal Aviation Agency (FAA)'s Aviation Weather Research Program (AWRP). This forecasting system, called the Consolidated Storm Prediction for Aviation (CoSPA) is expected to provide high resolution rapidly updating storm forecasts to the FAA's Next Generation Air Traffic System (NextGen) four-dimensional data cube.

Blending techniques developed at NCAR as part of CoSPA including phase correction and calibration methods were considered in the development of this new oceanic weather nowcasting system that could be applied anywhere on the globe. The methodology was to blend satellite-derived & Global Forecast System (GFS) model-derived rain rate and cloud top height.

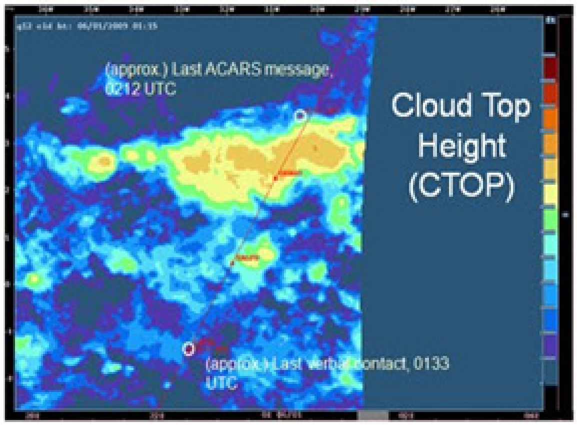


Figure 2 - Cloud Top Height (CTOP) imaging product.

Results

As a result of this research, an effective 0-12 hour storm forecasting system has now been implemented. This blended forecasting system of satellite-derived rain rate and cloud top height, (see Figure 2), with the corresponding fields derived from the NOAA GFS numerical model over the GOM was developed.

This is the first attempt to produce short-term storm forecast by blending satellite-derived and GFS model-derived rain rate and cloud top height. The forecasting skill is shown in Figure 3, where forecast skill score is plotted against forecast lead time. Blended forecasts shows improved scores over either the NWP or extrapolation method alone. The resulting blended forecast model is shown in Figure 4. Also, algorithms developed for rain rate blending are now applied to cloud top height blending and preliminary results are promising.

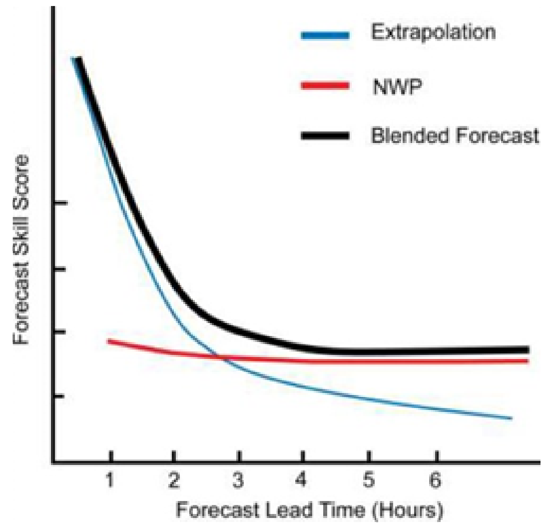


Figure 3 - Schematics of forecast skill score (prediction capability) compared to forecast lead time.

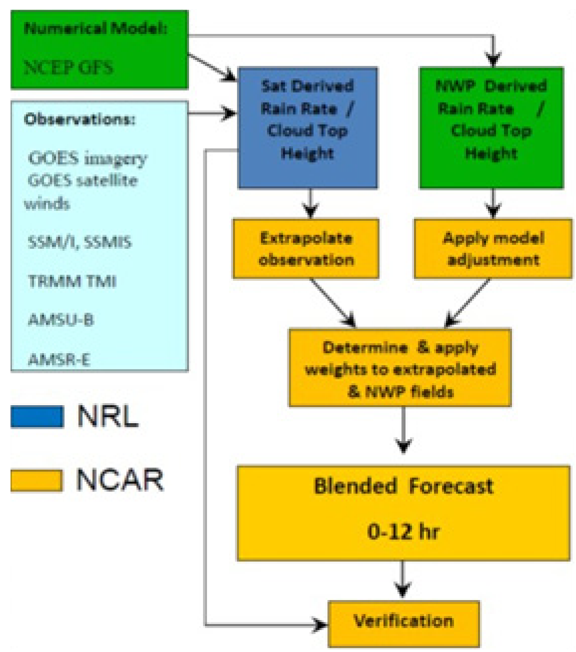


Figure 4 - Methodology for Blended Forecasting System.

General aviation safety is a concern for all, and this research effort provided a means by which weather forecasting becomes more exact and more effective in ensuring the safety of air travelers throughout the GOM region.

PI: John Mecikalski, University of Alabama-Huntsville;			
Partners: National Center for Atmospheric Research; National Weather Service Forecast Office; Conrad Blucher Institute; Texas A&M University at Corpus Christi			
Users: National Weather Service, Ocean Prediction Center; Corpus Christi Weather Forecast Office (WFO)			
RFP: ROSES 2009 A.40			
ARL Start	**2**	**ARL End**	**4**
Societal Benefit Area Mapping			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Introduction

Short-term forecasts of convective initiation (CI) and early storm development (Figure 1) are essential for providing adequate warning of lightning, flash flood, and other storm-related hazards. Such hazards frequently impact the Gulf of Mexico region at large (Figure 2), where convection is prevalent year-round, and workers are exposed on ships, oil platforms and helicopters. Operational weather prediction models are unreliable at pinpointing locations and timing of CI.

Figure 1 - Field view of convective storm (Source: NOAA)

Goals for this project included: 1) Enhanced methods of using NASA and NOAA satellite data, along with non-satellite fields, to forecast CI over oceanic and coastal regions; 2) Improved SATellite Convection AnalySis and Tracking (SATCAST) algorithm resulting in higher probability of detection and reduced false alerts; 3) Enhanced thunderstorm forecasts produced by the Thunderstorm Artificial Neural Network (TANN) algorithm, resulting in improved weather information for coastal residents and Gulf of Mexico transportation interests; 4) Enhanced CI nowcasts within the operational Convective Nowcast Oceanic (CNO) and Global Turbulence decision support systems, developed with NASA funding in support of the Washington World Area Forecast Center; and 5) Improved understanding on how AI techniques can be applied to convective weather forecasting.

Figure 2 - Study area location. (Source: Google Maps).

Methods

The study used Tropical Rainfall Measuring Mission (TRMM) (Figure 3) and CloudSat data to characterize storms, defining "truth" for tuning and verification of convective nowcasts. Moderate Resolution Imaging Spectroradiometer (MODIS) land temperatures (Figure 4) and Advanced Microwave Scanning Radiometer - Earth Observing System (AMSR-E) sea surface temperatures were assessed as potential CI predictor fields. The Rapid Update Cycle numerical weather prediction model was used in SATCAST. This model assimilates NASA satellite cloud products. AI techniques were used to identify new data for incorporation into the SATCAST algorithm, to optimize SATCAST and to create a probabilistic predictive model of early storm development. The project components were: enhancement to the SATCAST satellite–based 0-1 hour CI nowcasting algorithm; using NASA

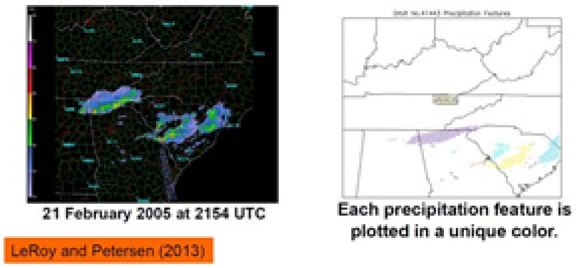


Figure 3 - Example TRMM storm cell detection product for areas not covered by Doppler radar products.

TRMM observations to verify over–ocean CI; enhancement of the TANN algorithm for cloud-to-ground lightning forecasting; and demonstrating improved convective storm forecasts over land and water (Figure 5).

Results

An operational prediction model of timing and location of thunderstorms with a 3-12 hour lead time was one result of this project. This was done by combining North American Mesoscale (NAM) atmospheric model initialization and predictions with sub grid scale land moisture or SST gradients as input to an Artificial Neural Network or Random Forest model. The newly enhanced TANN algorithm provided fast and consistent predictions with similar accuracy to forecasters and was tested at the Corpus Christi Weather Forecast Office (WFO) Cloud Profiling Radar for >2 years, outperforming TAFF forecasts. Results were immediately available to the WFO, and this effort opened the possibility of leading to improvements in Convective Nowcast Oceanic (CNO) and Global Turbulence decision support systems, currently under development under NASA funding for use in the World Area Forecast System (WAFS).

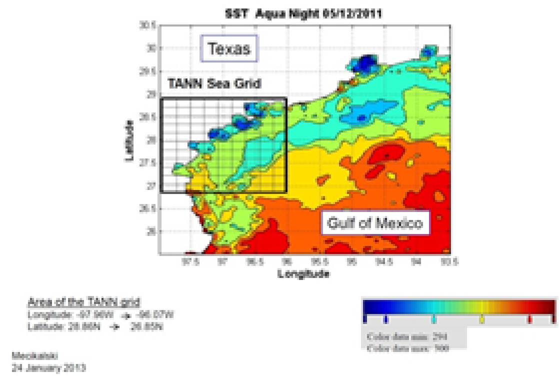


Figure 4 - Example of MODIS AQUA SST product used in TANN.

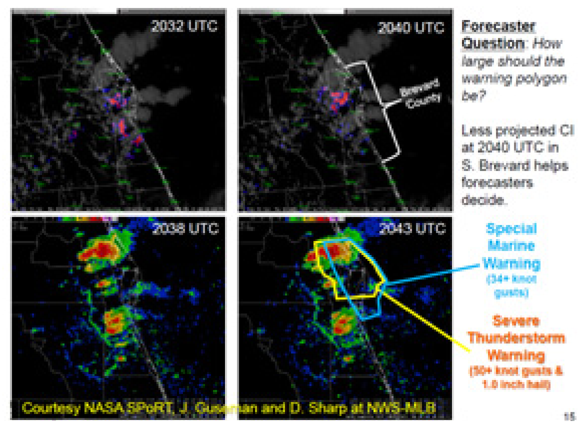


Figure 5 – Example product from project with projected Convective Initiation in south Brevard County.

Project accomplishments included: 1) Increased use of NASA data within two convective initiation forecasting algorithms; 2) Developed applied AI/machine learning approaches for optimizing satellite and NWP datasets; 3) Improved over-ocean convective storm nowcasting, using TRMM for validation; and 4) transitioned SATCAST and TANN algorithms to the NWS, Central Weather Service Units, and the Ocean Prediction Center.

Demonstration of Satellite-Based Lightning Initiation Nowcasts Toward Enhancing FAA Tactical Forecasts for Improving Ground-based Airport Operations

PI: Haig Iskenderian, MIT Lincoln Laboratory			
Partners: University of Alabama at Huntsville			
Users: Emergency Operations Centers at John C. Stennis Space Center and Michoud Assembly Facility			
RFP: 2009 ROSES A.40			
ARL Start	1	**ARL End**	3
Applicable Societal Benefit Areas			
Disasters	**Ecological Forecasting**	**Health & Air Quality**	**Water Resources**
Agriculture	**Climate**	**Oceans**	**Weather**

Figure 1 - Study area location. (Source: Google Maps).

Introduction

Nowcasting of lightning initiation (LI) from Geostationary Operational Environmental Satellites (GOES) is a novel, new concept. This project leveraged NASA assets to demonstrate the capabilities of a GOES-based algorithm for producing 0-1 hour lightning initiation (LI) nowcasts along the coast of the Gulf of Mexico (Figure 1).

Satellite-based nowcasting leverages a mature convective initiation (CI) algorithm, the SATellite Convection AnalySis and Tracking (SATCAST) system, as tested and transitioned to the Consolidated Storm Prediction for Aviation (CoSPA) from 2008-09, to enhance 0-1 hour CI nowcasts offshore beyond the range of next generation radars (NEXRAD). CoSPA is part of the NextGen Initial Operational Capability whose goal is to improve Air Traffic Management planning via automated, real-time nowcasts of aviation weather hazards to FAA decision makers.

The goal was to enhance predictability of new cumulonimbus clouds, and the timing and location of first-time LI from thunderstorms. The hypothesis was that enhanced predictability of lightning via LI nowcasts led to more efficient terminal operations. The project team anticipated uses for accurate LI nowcasts include terminal operations at airports (ramp closure and re-opening for safety), utilities (resource management and crew safety) and recreation (safety of public and employees). In short, NASA assets are required to improve the LI methodology.

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Methods

The project sought to explore the potential of satellite-based cloud-to-ground LI forecasts. Expanding LI validation to multiple LMA networks across the Southeastern U.S. (Dallas, North Alabama, and Kennedy Space Center) allowed us to optimize these LI nowcasts.

NASA's CloudSat earth observation satellite provided detailed Cloud Profiling Radar (CPR) data, which increased our knowledge of cloud-base altitude, cloud-top height, cloud-top temperature, and cloud-top glaciation. The Glaciation verification with CloudSat and the Moderate Resolution Imaging Spectroradiometer (MODIS), in comparison to GOES indicators (e.g., 3.9 micron reflectivity), is very important for enhancing that key component of SATCAST's LI methodology.

In this study, weighted lightning flash densities were compared to actual densities to derive a scalar for adjusting Weather Research Forecast (WRF) models to observed values. This adjusted WRF forecast cannot provide an expected flash density for SATCAST LI nowcasts.

NASA's CloudSat, MODIS, Lightning Mapping Array (LMA) total lightning data, and National Lightning Detection Network (NLDN) fields, were used to validate and refine the LI nowcasting algorithm as it is fielded within a

Federal Aviation Administration (FAA) system for several major airports. It also developed an automated technique that uses machine learning framework for combining satellite, environmental, and model information (Figure 2). In doing so, it leverages the FAA Corridor Integrated Weather System (CIWS) and UAH SATCAST systems.

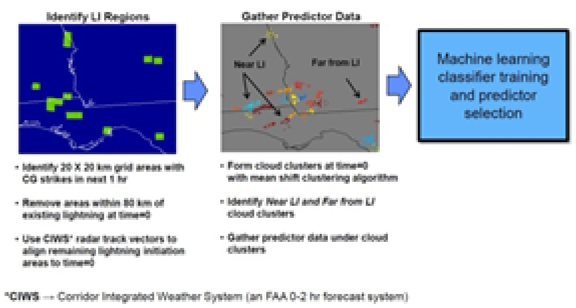

Figure 2 - Work flow for machine learning algorithm used for CI prediction.

The project team used satellite data to explore various LI forecasting capabilities (Figure 3).

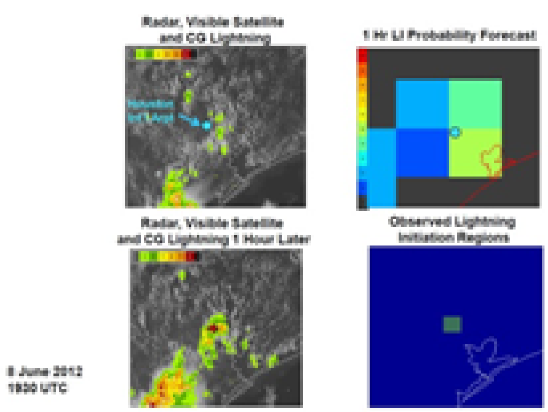

Figure 3 – LI forecast example using satellite data.

It also explored satellite-based cloud-to-ground LI forecasts. The current LI method produced improved results over the Localized Aviation Model Output Statistics Program (LAMP) (see Figure 4).

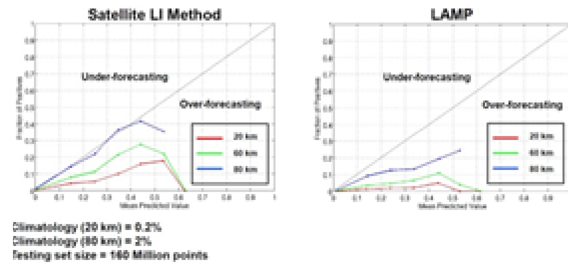

Figure 4 - Forecast reliability comparison for satellite LI method versus LAMP.

Results

Lightning ramp warnings are largely issued by individual airlines since there is no “official source” of lightning warning information. This reality opens the door to inconsistencies in applying lightning information in decision-making. The project team deduced that existing LI forecast probabilities are not high enough or spatially concentrated enough to spur user action.

Project results demonstrated that nowcasts could provide benefits over publicly available lightning forecasts via LAMP, particularly as larger forecast regions are considered. This project produced useful results and demonstrated great potential. Based on the results obtained during this research, it is believed that satellite-based LI.

Appendix A - NASA Application Readiness Levels

The NASA Applied Sciences Program instituted a nine-step Application Readiness Level (ARL) index to track and manage the progression of funded projects. This index reflects the three main tiers of project research, development, and deployment. In general, ARLs 1-3 encompass discovery and feasibility; ARLs 4-6 address development, testing, and validation; and, ARLs 7-9 focus on integration of the "application" into an end-user's decision-making activity. Using this scale, the "maturity" of the Applied Sciences project can be assessed throughout its life cycle.

Definitions for each level and its associated milestones follow.

ARL	Description	Explanation
1	Basic Research	Basic principles and phenomenology observed and reported. Scientific research produces results that could begin to be translated into applied research and development.
2	Application Concept	Application invention and formulation begins. Once basic principles are observed and products produced and validated, practical applications.
3	Proof of Application Concept	Feasibility studies to assess the potential viability of the application. More complete characterization of the decision-making process, including baseline performance and mechanisms. Analytical and experimental studies to set the Earth science products into the decision-support context.
4	Initial Integration and Verification in Laboratory Environment	Basic components of Earth science products and decision-making activity (decision support system, tool, etc.) are integrated together to establish that they will work together
5	Validation in Relevant Environment	Basic components are integrated with reasonably realistic supporting elements so application can be tested in a simulated decision making environment.
6	Demonstration in Relevant Environment	Major increase in the application's demonstrated readiness. Prototype system demonstration in a relevant environment or simulated operational decision making environment.
7	Application Prototype in Partner's Decision-Making	Prototype near or at planned operational system. A major advance from TRL 6, requiring prototype system demonstration of an actual system prototype in an operational environment, such as partners' decision-making activity.
8	Application Completed and Qualified	Actual system completed and 'qualified' through test and demonstration for partners' decision-making activity. Application has been proven to work in its final form and under expected conditions.
9	Approved, Operational Deployment and Use in Decision-Making	Actual operational, successful use of application by users in decision-making activities.

Acronyms

ACW: Arroyo, Colorado Watershed
ADCIRC: Advanced Circulation
AFC: Alabama Forestry Commission
AgMIP: Agricultural Model Inter-comparison and Improvement
ALDHS: Alabama Department of Homeland Security
ALI: Advanced Land Imager
AMPR: Advanced Microwave Precipitation Radiometer
AMSR(-E): Advanced Microwave Scanning Radiometer (-Earth Observing System)
ANN: Artificial Neural Network
AOD: Aerosol Optical Depth
AOI: Area of Interest
AOM: Atmospheric Ocean Model
ARCGIS: Arc Geographic Information System
ASAR: Advanced Synthetic Aperture Radar
ASP: Applied Science Program
ASTER: Advanced Spaceborne Thermal Emission and Reflection Radiometer
AVHRR: Advanced Very High Resolution Radiometer
AWIPS: Advanced Weather Interactive Processing System
AWRP: (FAA) Aviation Weather Research Program
BCO-DMO: Biological and Chemical Oceanography Data Management Office
BMP: Best Management Practices
CALIOP: Cloud-Aerosol Light Detection and Ranging with Orthogonal Polarization
CAMA: Coastal and Aquatic Managed Areas
CAMx: Comprehensive Air Quality Model with Extension
CAMx-HDDM: CAMx-High Order Decoupled Direct Method
C-CAP: Coastal Change Analysis Program Regional Land Cover
CDC: Centers for Disease Control and Prevention
CDOM: Colored (or Chromophoric) Dissolved Organic Matter
CFCI: Coastal Forest Conservation Initiative
CGDSS: Collaborative Geospatial Decision Support System
CHL: Chlorophyll
CI: Convective Initiation
CIT: Convectively Induced Turbulence
CIWS: (FAA) Corridor Integrated Weather System
CLEAR: Coastal Louisiana Ecosystem Assessment and Restoration
CMAQ: Community Multi-scale Air Quality
CMECS: Coastal and Marine Ecological Classification Standard
CNO: Convective Nowcast Oceanic
COAST: Coastal Online Analysis and Synthesis Tool
CONUS: Continental United States
CoSPA: Consolidated Storm Prediction for Aviation
CPR: Cloud Profiling Radar
CRMS: (Louisiana) Coast-wide Reference Monitoring System
CTD: Conductivity, seawater Temperature, and Depth

Acronyms (continued)

dBz: Decibel relative to Z
DEM: Digital Elevation Model
DHS: Department of Homeland Security
DIN: Dissolved Inorganic Nitrogen
DOC: Dissolved Organic Carbon
DON: Dissolved Organic Nitrogen
DOP: Dissolved Organic Phosphorus
DOTD: (Louisiana) Department of Transportation and Development
DSS: Decision Support System
DST: Decision Support Tool
DWH: Deepwater Horizon (oil spill)
EDAC: Ecosystems Data Assembly Center
EFPM: Eastern Fire Potential Model
E-MAPS: Emergency & Planning Support
ENKF: Ensemble Kalman Filter
ENVISAT: Environmental Satellite
EOC: (NASA) Emergency Operations Center
EOS: (NASA) Earth Observing System
EPA: Environmental Protection Agency
EPAAQS: Environmental Protection Agency's Air Quality System
EPHT: (CDC) Environmental Public Health Tracking Network
ERDC: (USACE) Engineer Research and Development Center
ESA: European Space Agency
ESRR: (NASA) Earth Science Research Results
ETM+: Enhanced Thematic Mapper Plus
EVCM: Envirocast Vision Collaboration Module
EVTTS: Envirocast® VisionTM TouchTables
FAA: Federal Aviation Administration
FDA: (United States) Food and Drug Administration
FDACS: Florida Department of Agriculture and Consumer Services
FDEP: Florida Department of Environmental Protection
FDOH: Florida Department of Health
Fe: Iron
FEMA: Federal Emergency Management Administration
FEPHT: Florida's Environmental Public Health Tracking
FGBMS: Flower Garden Banks Marine Sanctuary
FVCOM: Finite Volume Coastal Ocean Model
GBM: Green Biomass
GBNERR: Grand Bay National Estuarine Research Reserve
GCIS: Gulf Coast Information System
GeoRSS: Geographically Encoded Objects for RSS feeds
GFS: Global Forecast System
GHz: Gigahertz
GIS: Geographic Information System

Acronyms (continued)

GISS: Goddard Institute for Space Studies
GLC: Gray Level Co-Occurrence
GOES: Geostationary Operational Environmental Satellite
GOM: Gulf of Mexico
GOMA: Gulf of Mexico Alliance
GOM-HYCOM: Gulf of Mexico Hybrid Coordinate Ocean Model
GOMI: Gulf of Mexico Initiative
GOMMS: Gulf of Mexico Modeling System
GoMRC: Gulf of Mexico Regional Collaborative
GPS: Global Positioning System
GSA: Geological Survey of Alabama
GSD: (NOAA) Global System Division
GUI: Graphical User Interface
HAB: Harmful Algal Blooms
HABSIM: HAB Simulation
HAPC: Habitat Areas of Particular Concern
HKM: Half-Kilometer
HPP: Habitat Priority Planner
HWRF: Hurricane Weather Research and Forecasting
HYP: Hyperion Imaging Tool
IASNFS: Intra-American Seas Nowcast Forecast System
ICS: Incident Command System
IDV: Integrated Data Viewer
INSAR: interferometric SAR
IPCC AR4: Intergovernmental Panel on Climate Change Fourth Assessment Report
JPL: Jet Propulsion Laboratory
K.Brevis: Karenia Brevis
KBDI: Keetch-Byram Drought Index
kM: Kilometer
kM2: Square Kilometer
KML: Keyhole Markup Language
KSC: (John F.) Kennedy Space Center
LAI: Leaf Area Index
LAMP: Localized Aviation Model Output Statistics Program
LCA: Louisiana Coastal Area
LDAF: Louisiana Department of Agriculture and Forestry
LDEQ: Louisiana Department of Environmental Quality
LDNR: Louisiana Department of Natural Resources
LIDAR: Light Detection and Ranging
LI: Lightening Initiation
LIS: Land Information System
LMA: Lightning Mapping Array
LULC: Land-Use and Land-Cover
MAF: Michoud Assembly Facility
MARPOL: International Convention for Prevention of Pollution from Ships

Acronyms (continued)

MBNEP: Mobile Bay National Estuary Program
MERIS: Medium Resolution Imaging Spectrometer
MERRA: Modern Era Retrospective analysis for Research and Application
MIFI: Mississippi Institute for Forest Inventory
MIT LL: MIT Lincoln Laboratory
MODIS: Moderate Resolution Imaging Spectroradiometer
MORT: Mixing Over Rough Topography
MSCI: Marsh Surface Condition Index
MSS: Multispectral Scanner
MSU: Mississippi State University
N: Nitrogen
NADP: National Atmospheric Deposition Program
NAIP: National Agriculture Imagery Program
NAM: North American Mesoscale (Atmospheric Model)
NARCCAP: North American Regional Climate Change Assessment Program
NASA: National Aeronautics and Space Administration
NASS: (USDA) National Agricultural Statistics Service
NAVOCEANO: Naval Oceanographic Office
NCAR: National Center for Atmospheric Research
NCDDC: (NOAA) National Coastal Data Development Center
NCOM: Navy Coastal Ocean Model
NDBC: National Data Buoy Center
NDMC: National Drought Mitigation Center
NDMI: Normalized Difference Moisture Index
NDVI: Normalized Difference Vegetation Index
NDWI: Normalized Difference Water Index
NEP: National Estuary Program
NEXRAD: Next Generation Radars
NextGen: Next Generation Air Transportation System
NGA: National Geospatial-Intelligence Agency
NGO: Non-governmental organizations
NGOM: Northern Gulf of Mexico
NIR: Near Infrared
NLDN: National Lightning Detection Network
NOAA: National Oceanic and Atmospheric Administration
NO2: Nitrogen Dioxide
NOx: Nitrogen Oxide
N:P: Relative Availability of Nitrogen (N) and Phosphorus (P)
NRCS: (USDA) National Resources Conservation Service
NRL: Naval Research Laboratory
NTR: (Organic) Nitrate
NWP: Numerical Weather Prediction
NWRC: National Wetlands Research Center
NWS: National Weather Service

OASIM: Ocean Atmosphere Spectral Irradiance Model
OAWP: FDACS Office of Agricultural Water Policy
OI SST: Optimal Interpolated Sea Surface Temperature
OMI: Ozone Monitoring Instrument
ONFS: (NRL) Ocean Nowcast/Forecast System
P: Phosphorus
PALSAR: L-band SAR products
PAR: Photosynthetically Available Radiation
PM: Particulate Matter
POC: Particulate Organic Carbon
PRISM: Parameter-elevation Regressions on Independent Slopes
PS: Persistent Scatterers
PSU: Practical Salinity Units
QA: Quality Assurance
QKM: Quarter-Kilometer
RAL: (NCAR) Research Applications Laboratory
RAMS: Regional Atmospheric Modeling System
REDM: (NCDDC) Regional Ecosystem Data Management
RISA: (NOAA) Regional Integrated Sciences and Assessments
RMSE: Root Mean Square Error
ROF: Runoff Fingerprinting
ROMS: Regional Oceanic Modeling System
ROSES: (NASA) Research Opportunities for Space and Earth Sciences
ROV: Remote Operated Vehicle
RS: Remotely Sensed
RSM: Response Surface Model
RSOWQ: Remotely Sensed Optical Water Quality
S: Sulfur
SAB: (NOAA) Satellite Analyses Branch
SABGOM: South Atlantic Bight and Gulf of Mexico
SAFE: Sensor-Assisted Forecasting Environment
SANDS: Sediment Analysis Network for Decision Support
SANE: Sensor-Assisted Nowcasting Environment
SAR: Synthetic Aperture Radar
SATCAST: SATellite Convection AnalySis and Tracking
SAV: Synthetic Aquatic Vegetation
SBA: Societal Benefit Area
SC: State Climatologist
SDD: Sechi Disk Depth
SeaDAS: SeaWiFS Data Analysis System
SEAMAP: Southeast Area Monitoring and Assessment Program
SeaWiFS: Sea-Viewing Wide Field-of-View Sensor
SECC: Southeast Climate Consortium
SIGMET: Significant Meteorological information

SLOSH: Sea, Lake, and Overland Surges from Hurricanes
SPoRT: (NASA) Short-term Prediction Research and Transition Center
SPOT-XS: Satellite Pour l'Observation de la Terre
SRP: Soluble Reactive Phosphorous
SRTM: Space Shuttle RADAR Topography Mission
SSC: (John C.) Stennis Space Center
SST: Sea Surface Temperature
STAR: Center for Satellite Applications and Research
SWAT: Soil and Water Assessment Tool
SWET: Soil and Water Engineering Technology, Inc.
TANN: Thunderstorm Artificial Neural Network
TBEP: Tampa Bay Estuary Program
TCNNA: Texture Classifying Neural Network Algorithm
TCEQ: Texas Commission on Environmental Quality
TDEM: Texas (Department of Public Safety) Division of Emergency Management
TDN: Total Dissolved Nitrogen
TDP: Total Dissolved Phosphorus
TexAQS-II: Texas Air Quality Study (2006)
THREDDS: Thematic Real-Time Environmental Distributed Data Services
TM: Thematic Mapper
TMDL: Total Maximum Daily Load
TRMM: Tropical Rainfall Measuring Mission
TSPT: Time Series Product Tool
TSM: Total Suspended Matter
TSS: Total Suspended Solids OR Total Sediment Suspended
UAH: University of Alabama at Huntsville
UAVSAR: Unmanned Airborne Vehicle Synthetic Aperture Radar
USACE: United States Army Corps of Engineers
USDA: United States Department of Agriculture
USFS: United States Forest Service
USGS: United States Geological Survey
VA: "Virtual Alabama" Decision Support System
VBS: Virtual Buoy System
VF: Vegetation Fraction
VI: Vegetation Indices
VIIRS: Visible Infrared Imaging Radiometer Suite
VP: V. Parahaemolyticus
WAFS: (NOAA) World Area Forecast System
WAM: Watershed Assessment Model
WFAS: Wildland Fire Assessment System
WFLNFS: ONFS for West Florida
WFO: Weather Forecast Office
WQDM: Water Quality Decision Matrix
WRF: Weather Research Forecast

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