**NASA DEVELOP National Program**

**Spring 2016 Project Proposal**

**NASA Jet Propulsion Laboratory**

**Louisiana Ecological Forecasting II**

Using UAVSAR, AVIRIS and AirSWOT to Model Coupled Water Flow and Sediment Transport in Delta Building within the Wax Lake Delta, Louisiana to Inform Coastal Restoration Efforts

**Project Overview**

***Objective:*** To use advanced hydrological modeling combined with remote sensing data to model coupled water and sediment flow through the Wax Lake Delta.  The objective this term is to determine the model flow conditions through the delta during the Spring 2015 combined AirSWOT/UAVSAR/AVIRIS-NG campaign, and to extrapolate from the calibrated conditions to determine long-term sediment deposition rates and patterns, in order to better model and understand the conditions necessary for land building in shallow deltas that evolve under the influence of both riverine sediment influx and tidal influx.

***Community Concern:*** Land loss due to erosion, land subsidence and sea level rise along the Louisiana coast has amounted to a staggering 4900 km2  since the 1930’s, threatening one of the most economically important port systems in the United States as well as the tapestry of unique cultures that contributes to the region’s rich history. The State of Louisiana’s Comprehensive Master Plan for a Sustainable Coast (2012) confirmed that Louisiana has the potential to lose up to an additional 4500 km2 over the next 50 years unless immediate efforts are taken to combat this trend. Yet, while most of the rest of the coast is degrading, the Wax Lake Delta has been growing at a rapid rate. Much work has been done to understand what natural processes contribute to this growth, but these studies are limited by a lack of tested models and key observations. Measurements that do exist are largely boat-based and inherently spatially and temporally limited. A synoptic view of the accretion process at Wax Lake will help guide coastal managers’ efforts in land loss reduction and preserve the future of the Louisiana coastline.

***National Application Area(s) Addressed:*** Ecological Forecasting

***Study Location:*** Wax Lake Delta, Louisiana

***Study Period:*** May 2009 – May 2015

***Advisor(s):*** Dr. Cathleen Jones (JPL), Dr. Marc Simard (JPL)

***Source of Project Idea:*** DEVELOP JPL representatives heard about the AirSWOT campaign, and through past DEVELOP projects we learned about the decreasing coastal elevation within Louisiana. By combining AirSWOT data, modeled outputs, and UAVSAR data, DEVELOPERs would be able to better inform restoration efforts within Louisiana, to promote coastal aggradation. After the successful progress of the first term, a second term was proposed to finalize model outputs and validate these outputs using NASA Earth Observations.

**Partner Overview**

***Partner Organization(s):***

Naval Research Laboratory (End-User, POC: Richard Crout, Supervisory Oceanographer)

Louisiana Universities Marine Consortium (Collaborator/Boundary Organization, POC: Alexander Kolker, Assistant Professor)

***End-User Current Decision Making Process:***

Currently, restoration decisions are based on findings from roughly 400 projects identified by experts, citizens and government studies. Restoration efforts can take the form of structural protection, bank stabilization, oyster barrier reefs, ridge restoration, shoreline protection, barrier island restoration, marsh creation, sediment diversion, and hydrological restoration. Nearly all of these projects rely on moving or trapping sediment, yet Louisiana has limited supplies of, or access to, renewable sediment. It is thus imperative to understand the dynamics of delta building to maximize the use of the limited sediment available. These dynamics are currently studied using spot field measurements and labor-intensive boat-based surveys.

***NASA Earth Observations Capacity:***

Naval Research Laboratory – Dr. Crout is an oceanographer at the Naval Research Laboratory at Stennis Space Center, MS, where they are investigating buoyancy plume modulation of coastal processes in the area impacted by the Mississippi and Atchafalaya River discharge. Their project utilizes an ocean circulation model complement *in-situ* observations that requires water level and discharge rates from the Atchafalaya Bay and Wax Lake outlet region. The products of the proposed project will be delivered to Dr. Crout to help initiate the model.

***Collaborator & Boundary Organization Support:***

Louisiana Universities Marine Consortium – Dr. Kolker is an academic liaison to Louisiana’s Comprehensive Master Plan for a Sustainable Coast that is being developed for 2017. The products of this project will provide Dr. Kolker with a broad-scale picture of the accretion process to inform the development of an improved sediment distribution algorithm that will help these managers understand how to direct land restoration efforts along the Louisiana coast. Dr. Kolker will help the team gather the model parameters needed for this particular study region.

***Communication Plan & Transition Approach:***

The main POC for communication between the partners and team will be the team lead. During the first term, the team met with the partners biweekly, and this will continue for the proposed second term to ensure end products that are beneficial to each partner. The results of this project will be presented will be delivered to the partners virtually, and a copy of the tech paper will be made available.

***End-User Benefit:***

The Wax Lake Delta was formed during an observable time-period and not altered by humans, and has thus been the focus of many deltaic formation studies. Many of these deltaic formation studies have also used Delft3D modeling software, however very few are able to incorporate remotely sensed data into the model. End products from this project will provide the end-user with modeled results calibrated by remotely sensed data, specifically AirSWOT, one of NASA’s newest Earth Observations. Modeled results from this project are expected to improve coastline change prediction accuracy. These models can serve as decision support to control or reduce the impacts from modifications to infrastructure such as addition or removal of levees, dredging of channels or from natural phenomena such as storm surges, hurricanes, and land cover and land use change within watersheds.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform** | **Sensor** | **Geophysical Parameter** |
| **NASA King Air B200** | AirSWOT | Sea Surface Extent |
| **NASA Gulfstream III** | UAVSAR | Sea Surface Roughness |
| **NASA ER-2 Jet** | AVIRIS-NG | Vegetation |

***NASA Earth Observations Use:***

AirSWOT is a new airborne sensor, in the testing stage at JPL, designed for centimeter-level detection of water surfaces and flood plains. Water-surface gradients measured by this instrument will be used to constrain deposition rates on deltas, yielding new insight into how delta tops keep pace with sea-level rise. AirSWOT is the calibration/validation and science support instrument for the upcoming NASA SWOT mission, and is designed for centimeter-level detection of water surfaces and flood plains and will be used to constrain the hydrological model.

UAVSAR provides high-resolution (<10 m) radar data collected regularly over the study area. Actively growing fronts of deltas are not at the shoreline, but rather offshore in the form of submarine channels and islands that extend offshore at hundreds of meters per year. SAR shows great promise in detecting shallow bathymetry because the radar detects changes in water-surface roughness (e.g., waves), which are influenced by water depth and can be observed under a range of wind and current conditions.

AVIRIS-NG provides high-spectral resolution to identify vegetation type within the study region. The second term will develop a python-based code to process AVIRIS-NG images and ultimately create a vegetation classification that will result in vegetation bathymetry that will be used as a parameter in the hydrological model.

***Ancillary Datasets:***

DNR Strategic Online Natural Resources Information System (SONRIS) – Bathymetric data;

DNR (SONRIS) – Infrastructure (levees, etc);

CPRA Coastal Information Management System (CIMS) - Accretion estimates;

CPRA Coastwide Reference Monitoring System (CRMS) – Vegetation species;

USGS National Land Cover Dataset (NLCD) – Land cover use;

***Models:***

Deltares Delft3D (POC: Douglas Edmonds, Indiana University)

**Decision Support Tool & End-Product Overview**

|  |  |  |
| --- | --- | --- |
| **Proposed End Products** | **Decision to be Impacted** | **Current Partner Tool/Method** |
| Modeled Water Flow and Sediment Transport of Wax Lake Delta | Inform coastal restoration efforts of how and why the Wax Lake Delta is aggregating while the surrounding wetlands suffering from land loss | Tidal gauges, field measurements |

*End Product 1* - UAVSAR, AirSWOT, AVIRIS-NG, and *in situ* data will be used as parameters and calibration in Delft3D modeling software and provide remotely sensed data modeled outputs/end products that will play a vital role in coastal restoration efforts.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 2 Terms: 2015 Fall to 2016 Spring

***Multi-Term Objectives:***

* **Term 1:** Fall 2015 (JPL) – Louisiana Ecological Forecasting
  + To use remotely sensed data to obtain a better understanding of why the Wax Lake Delta is experiencing aggregation and model sediment transport within the Delta to help predict future extent of the Delta to provide crucial data to coastal scientists and managers for insight into how to direct coastal restoration projects.
* **Term 2 (Proposed Term):** Spring 2016 (JPL) – Louisiana Ecological Forecasting II
  + To highlight remotely sensed data as parameters for the Delft3D modeling software that will help obtain a better understanding of why the Wax Lake Delta is growing while other deltaic formations are losing land. Modeled outputs of water flow and sediment transport within the Delta will provide coastal scientists a new method to predict future extent of the Wax Lake Delta and insight for coastal restoration efforts. Dr. Alex Kolker will continue to collaborate with the team via teleconference pertaining to model parameters and overall progress. Richard Crout will continue as an end-user who looks forward to the new remotely sensed data parameters that are being used in Delft3D.

***Previous Related DEVELOP Work:***

Fall 2014 (JPL) - Gulf Coast Ecological Forecasting: Utilizing Spaceborne and Airborne SAR Sensors to Monitor the Health of Louisiana’s Coastal Wetlands

Fall 2015 (JPL) – Louisiana Ecological Forecasting: *Using UAVSAR, AVIRIS and AirSWOT to Examine Historic Trends and Model Sediment Transport within the Wax Lake Delta, Louisiana to Inform Coastal Restoration Efforts*

**Project Needs/Requests**

***Participants Requested:*** 3

***Software & Scripting:***

* ArcGIS - Raster Manipulation/Analysis, Image Enhancement & Map Creation of UAVSAR and AirSWOT Data
* Exelis ENVI – Image Enhancement and Vegetation Bathymetry creation of AVIRIS-NG data
* Deltares Delft3D – Model Water Flow and Sediment Transport of Wax Lake Delta
* QGIS – Radiometric Correction of UAVSAR Data
* Python – To process AVIRIS-NG images

**Notes & References:**

***References:***

Bathymetric data - <http://sonris-www.dnr.state.la.us/gis/dnld/download.html>

Land cover and land use maps - <http://map.louisiana.gov/losco_2007_Zip.html>

Infrastructure (levees, etc) - <http://sonris-www.dnr.state.la.us/gis/dnld/download.html>

Accretion estimates - <http://cims.coastal.la.gov/monitoring-data/>

Olea, R. a., & Coleman, J. L. (2014). A Synoptic Examination of Causes of Land Loss in Southern Louisiana as Related to the Exploitation of Subsurface Geologic Resources. *Journal of Coastal Research*, *297*(5), 1025–1044. http://doi.org/10.2112/JCOASTRES-D-13-00046.1