**NASA DEVELOP National Program**

**2018 Summer Project Proposal**

**Massachusetts – Boston**

**Plum Island Water Resources II**

*Using NASA Earth Observations to Quantify Sediment Supply in Plum Island Sound and Evaluate Vulnerability of the Plum Island Salt Marshes*

**Project Overview**

***Project Synopsis*:** Vulnerability of coastal areas to sea level rise is directly related to sediment supply; net import of sediment indicates growth and resilience against sea level rise, while net export of sediment indicates coastal deterioration. However, determining the input of sediments from the ocean to the sediment budget is challenging. This project will use Earth observations coupled to model results to determine the spatial distribution and fluxes of suspended sediments between Plum Island Sound in Massachusetts and the Atlantic Ocean. The team will use Landsat 8 OLI and Sentinel-2 MSI imagery to derive the temporal variability of water turbidity and suspended sediment concentration (SSC) at the bay inlet and will validate the data using available *in situ* measurements of turbidity and SSC. These data will be used by USGS, the Plum Island Ecosystems LTER, and the Parker River National Wildlife Refuge to compute the sediment budget of the entire system.

***Community Concern:*** US Fish and Wildlife Region 5 refuges manage approximately 24,000 hectares of coastal wetland, a diverse ecosystem that is undergoing drastic change under accelerating sea-level rise and changing climatic forcing. The refuges have implemented hundreds of millions of dollars in restoration projects to enhance coastal resiliency in response to signs of marsh destabilization, such as widening channels, water logged platforms, accelerating erosion, and internal disintegration. However, more data on the long-term viability of salt marsh units are needed in order to ensure that limited resources are targeted to those sites most likely to persist with sea level rise.

***Source of Project Idea:***

Previous work by the USGS and Dr. Fagherazzi showed sediment flux is critical to wetland long-term viability. As sea level rises, wetlands must import sediment to maintain geomorphological structures. Most wetland assessments rely on point measurements of SSC, accretion, and/or elevation change, which can be misleading. Disintegrating wetlands release a large internal sediment supply that can lead to enhanced accretion and elevation, but an overall loss of vegetated area. The USGS and Dr. Fagherazzi concluded it is critical to use more spatially and temporally integrative measures, like remote sensing data, to guide management and restoration priorities. Fluxes of sediments in coastal areas are the most difficult to determine and, therefore, a high priority for the USGS.

***National Application Area Addressed:*** Water Resources

***Study Location:*** Plum Island Estuary, MA

***Study Period:*** April 2013 – May 2018

***Advisors:*** Sergio Fagherazzi (Boston University), Cédric Fichot (Boston University), Neil Ganju (USGS)

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **USGS, Woods Hole Coastal and Marine Science Center** | Dr. Neil Ganju, Research Oceanographer | End-User | Yes |
| **US Fish and Wildlife Service, Parker River National Wildlife Refuge** | Nancy Pau, Biologist | Collaborator | No |
| **Long Term Ecological Research Network, Plum Island Ecosystems LTER** | Anne Giblin, Interim Director, Ecosystems Center | Collaborator | No |

***End-User Overview***

***End-User’s Current Decision-Making Process:***The USGS, in collaboration with Dr. Fagherazzi (Boston University) and Nancy Pau (US Fish and Wildlife), is measuring fluxes of sediments in different marshes of Plum Island Sound, MA. These data are used by the Parker River National Wildlife Refuge to develop rapid assessment metrics that can be applied by US Fish and Wildlife Service (USFWS) and other conservation organizations to assess salt-marsh persistence on a regional-scale and allow USFWS to conduct region-wide vulnerability assessment and focus future research, management, restoration, and acquisition funds where needed.

***End-User’s Capacity to Use NASA Earth Observations:***

*USGS, Woods Hole Coastal and Marine Science Center* – The group of Dr. Neil Ganju at USGS has used Landsat imagery in the past to determine vegetation cover in coastal bays. The methodology developed in this NASA DEVELOP project will enable the USGS to use Landsat data to assess the availability and fluxes of marine sediments in a coastal bay. The methodology developed herein will also be tested in the near future for other bays along the US East Coast.

***Collaborator & Boundary Organization Overview***

***Collaborator Support:***

*US Fish and Wildlife Service, Parker River National Wildlife Refuge* – Sergio Fagherazzi, Neil Ganju, and Nancy Pau are currently funded by the Department of Interior to calculate the sediment budget of several marshes within Plum Island Sound. The partner will provide feedback on the results and products generated by the DEVELOP team.

*Long Term Ecological Research Network, Plum Island Ecosystem LTER* – PIE-LTER is highly interested in fluxes of sediments, water and nutrients within the Plum Island System. They are funded by NSF. LTER will provide *in situ* (e.g., turbidity) data to facilitate validation, as well as feedback on the results and products generated by the DEVELOP team.

***Dissemination by Boundary Organizations*:**

*USGS, Woods Hole Coastal and Marine Science Center* – The USGS will communicate results and products to the LTER network and the Parker River National Wildlife Refuge, likely in the form of short presentations. The project might potentially lead to a publication which will disseminate the project results to the greater community.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** Dr. Fagherazzi and the Center Lead at the Boston University node will serve as the POC between USGS, the NASA DEVELOP node, and the Parker River National Wildlife Refuge. The team will communicate with the partners once a month during the project.

***Transition Plan*:** At the end of the project, the DEVELOP team will provide USGS with the time series of suspended-sediment concentration in the water column of Plum Island Sound as well as the sediment concentration calibration.

**Earth Observations Overview**

***Earth Observations:***

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| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 8 OLI** | Remote-sensing reflectance (Rrs), turbidity, suspended-sediment concentration (SSC) | High-resolution maps (30 m) of turbidity and suspended sediment concentration will be used with the outputs of a hydrodynamic model to derive sediment fluxes in and out of the Sound. |
| **Sentinel-2 MSI** | Remote-sensing reflectance (Rrs), turbidity, suspended-sediment concentration (SSC) | High-resolution maps (10-20 m) of turbidity and suspended sediment concentration will be used with the outputs of a hydrodynamic model to derive sediment fluxes in and out of the Sound. |

***Ancillary Datasets:***

Boston University (C. Fichot, *in situ* measurements of remote-sensing reflectance (Rrs) – algorithm development and product validation

Boston University (S. Fagherazzi and C. Fichot), *in situ* measurements of turbidity and SSC – algorithm development and product validation

Boston University (S. Fagherazzi), *in situ* measurements of surface-water currents – model product validation

***Modeling:***

Delft3D model (POC: Sergio Fagherazzi, Boston University)

***Software & Scripting:***

SeaDAS – remote sensing data atmospheric correction and re-projection for Landsat-8 OLI

ACOLITE - remote sensing data atmospheric correction for Landsat-8 OLI and Sentinel-2 MSI

Exelis ENVI – remote Sensing data visualization

Esri ArcGIS – production of maps

MATLAB – data processing

R – statistical analyses

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Surface-water Turbidity and SSC Maps** | This information will provide the partners with valuable information about the spatio-temporal variability of surface-water turbidity and SSC in the Plum Island Estuary. These products will directly inform about the sensitivity of these variables to environmental forcing. These products will also be used to derive the sediment-flux products described below. | A local algorithm will be applied to Landsat-8 OLI and Sentinel-2 MSI remote-sensing reflectances to produce maps of turbidity and SSC over Plum Island Sound. | N/A |
| **Maps of Suspended–sediment Exchange (Fluxes In and Out of the Plum Island Sound)** | These data will help constrain sediment budgets for the estuary. These budgets, in turn, will provide valuable information about the vulnerability of the Plum Island salt marsh and inform future management strategies to increase the resilience of this environment to climate change. | High-resolution maps of SSC will be combined with water-flux outputs from the model to generate maps of sediment fluxes in and out of Plum Island Sound. | N/A |

***End-User Benefit*:** Coupling Earth observations to the model outputs will greatly facilitate the estimation of surface sediment distributions and sediment flux in and out of the inlet, compared to the use of field measurements. The results will allow the end-user to better quantify sediment budgets for the Plum Island Estuary and help guide preservation or restoration practices.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 2 Terms: 2018 Spring and 2018 Summer

***Multi-Term Objectives:***

* **Term 1:** 2018 Spring (Massachusetts – Boston) – Plum Island Water Resources
  + During the first term, the team gathered all usable Landsat-8 OLI and Sentinel-2 MSI data collected over the Plum Island Estuary and developed and applied algorithms to generate surface maps of turbidity and SSC. However, the products generated during the term need to be validated in order to ensure they are representative and reliable estimates, which will require high quality *in situ* measurements.
* **Term 2 (Proposed Term):** 2018 Summer (Massachusetts – Boston) – Plum Island Water Resources II
  + The second term will combine remote-sensing products with the outputs of a hydrodynamic model to generate mapped products quantifying the fluxes of sediment in and out of the Plum Island Estuary. Further focus will be directed to the validation of the new products using ground data: surface-water maps of turbidity/SSC and of suspended sediment exchange. Field measurements of current velocity, turbidity, and suspended sediment concentration in the Plum Island Estuary will be collected by the scientific advisors’ teams (Fagherazzi, Fichot) between April and August 2018, specifically during Landsat-8 and Sentinel-2 overpasses. These *in situ* measurements will provide high-quality measurements to ground-truth remote sensing products generated for that period. This validation will allow to assess the uncertainty associated with the remote-sensing products generated throughout this multi-term project.

***Related DEVELOP Work:***

Summer 2014 (ARC) – American Samoa Oceans: Evaluating a Watershed Modeling Approach for Water Quality on Near-Shore Coral Reef Ecosystems in American Samoa Using NASA Earth Observations

Spring 2017(LaRC) – Chesapeake Bay Water Resources: Assessing Water Clarity to Identify Potential Areas of Submerged Aquatic Vegetation (SAV) in the Chesapeake Bay

Summer 2017(LaRC) – Chesapeake Bay Water Resources II: Assessing and Assisting Monitoring Efforts of Water Clarity to Identify Potential Areas of Submerged Aquatic Vegetation (SAV) in the Chesapeake Bay

Summer 2017 (MCHD & MSFC) – Coastal Alabama Oceans: Using NASA Earth Observations to Evaluate Water Quality in Coastal Alabama to Enhance Marine Wildlife Management.

Summer 2017 (LaRC) – Miami Beach Water Resources: Assessing the Feasibility of Using NASA Earth Observations to Monitor Trends in Runoff and Storm Water Discharge of the Biscayne Bay Summer 2017 (JPL) – San Francisco Bay-Delta Water Resources: Utilizing NASA and ESA Earth Observations to Monitor Turbidity Conditions in the San Francisco-Bay Delta

Spring 2018 (MA) – Plum Island Estuary Water Resources: Utilizing NASA Earth Observations to Assess Marine Sediment Fluxes and Determine Marsh Vulnerability in the Plum Island Estuary

**Notes & References:**

***References:***

Kirwan, M. L., Temmerman, S., Skeehan, E. E., Guntenspergen, G. R. & Fagherazzi, S. (2016). Overestimation of marsh vulnerability to sea level rise. *Nature Climate Change, 6*, 253–260.