**NASA DEVELOP National Program**

**2020 Summer Project Proposal**

**Virginia – Langley**

**South Carolina Water Resources**

*Implementing the Unvegetated-Vegetated Ratio to Assess Salt Marsh Vulnerability in South Carolina Using Airborne and Space-Based Remote Sensing Imagery*

**Project Overview**

***Project Synopsis*:** Marsh sediment budgets are a spatially integrated metric of marsh vulnerability to erosion, but calculating these budgets can be cumbersome and costly. The South Carolina Department of Health and Environmental Control (DHEC) and the South Carolina Department of Natural Resources (DNR) hope to quantify marsh vulnerability around Charleston to help policymakers at the DHEC understand how to best prioritize resources for restoration and preservation efforts. With support from USGS Woods Hole Coastal and Marine Science Center, this project seeks to analyze marsh vulnerability using Unvegetated-Vegetated Ratio (UVVR) derived from Landsat 8 OLI, Landsat 7 ETM+, Landsat 5 TM, Sentinel-1 C-SAR, and Sentinel-2 MSI in conjunction with high-resolution aerial imagery provided by the DNR. Maps of UVVR will not only provide indicators of current marsh vulnerability to sea level rise but will also allow for analysis of changes in marsh vulnerability over time, which will provide researchers with a deeper understanding of changing sediment dynamics.

***Community Concern:*** Estuaries are unique ecosystems that serve as a habitat for diverse species, support recreational and commercial fisheries, and provide numerous ecosystem services such as carbon sequestration, protection from storm surge, and water filtration. Along South Carolina’s coast, rising seas and land use changes upstream could result in an altered sediment budget for estuarine ecosystems, threatening their stability and long-term health. Estimates from NOAA and the US Army Corps of Engineers suggest that South Carolina may experience sea level rise between 7 and 21 inches in the next decade, which could result in increased seaward erosion in these estuaries.

***Source of Project Idea:*** This project originated through a discussion between the LaRC Fellow and Tanner Arrington, GIS Specialist at the South Carolina DNR. The DNR’s interest in estuarine health prompted us to build off of work conducted during the Plum Island Estuary Water Resources project completed at DEVELOP MA during 2018, and further discussions involved USGS and the DHEC.

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

***Study Location:*** Charleston, SC

***Study Period:*** January2000 – June 2020

***Advisors:*** Dr. Kenton Ross (NASA Langley Research Center), Dr. Venkataraman Lakshmi (University of Virginia)

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **South Carolina Department of Health and Environmental Control** | Adam Bode, Coastal Services Project Manager, Planning; Jessica Boynton, Coastal Services Project Manager, Shoreline Management | End User | Yes |
| **South Carolina Department of Natural Resources** | Tanner Arrington, GIS Specialist; Katie Luciano, Coastal Geologist; Evan Cook, Marine Resources GIS Manager | Collaborator | Yes |
| **USGS, Woods Hole Coastal and Marine Science Center** | Dr. Neil Ganju, Research Oceanographer | Collaborator | No |

***End User Overview***

***End User’s Current Decision-Making Process:***The DHEC is responsible for managing development, alterations, and shoreline stabilization activities in coastal and estuarine tidelands. DHEC carries out these responsibilities through various research and policy development initiatives, planning, regulation and enforcement, restoration, and extension and education activities. GIS experts and coastal services managers at the DHEC work directly with other local decision-makers to implement scientifically informed policies.

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

*South Carolina Department of Health and Environmental Control* – The DHEC is well versed in GIS applications and principles, but they do not currently utilize any remote sensing or NASA Earth observations in their regular workflows. The DHEC hosts several interactive map applications on their website, including a coastal hazard vulnerability assessment, which incorporates inundation vulnerability and shoreline change vulnerability, and land cover maps from the National Land Cover Database.

***Collaborator & Boundary Organization Overview***

***Collaborator Support:***

*South Carolina Department of Natural Resources* – The South Carolina DNR conducts research and monitoring programs to assess the condition of South Carolina’s coastal resources, including estuarine environments. The DNR uses GIS as an integral tool in their work to understand the spatial component of this work, and they maintain maps and other spatial data relating to the state’s natural resources.

*USGS, Woods Hole Coastal and Marine Science Center* – Researchers at Woods Hole Coastal and Marine Science Center have created and piloted a methodology to calculate UVVR, a measure of open water in a marsh versus vegetated land area. Previous research shows that this metric scales with the sediment budget, making this a strong indicator of marsh vulnerability. Prior studies have implemented the metric to assess salt marsh vulnerability across the Atlantic East Coast, including the Plum Island Estuary in northern Massachusetts, Cape Cod National Seashore, and Assateague Island in Maryland. Dr. Neil Ganju is a principal researcher using UVVR, and he will be assisting the team through advising and expert knowledge of UVVR.

***Dissemination by Boundary Organizations*:**

*South Carolina Department of Health and Environmental Control* – The DHEC sees this project as an opportunity for outreach and engagement, such as a webinar or in-person meeting, to share the final products with the wider end user organization. They will share the results and a summary of the methodologies of this work with the scientific community through fact-sheets and with the public through other communicative resources.

*South Carolina Department of Natural Resources* – The DNR works closely with other organizations that are interested in the health of nearby estuarine ecosystems and intend to share the results of this project with relevant organizations, such as the Charleston District of the US Army Corps of Engineers who are interested in how a recent harbor-deepening project influenced nearby marshes. The DNR will also share results with resilience managers at the City of Charleston, who are currently planning for the effects of sea level rise on the city. Project results will also help DNR better evaluate future placement of Surface Elevation Table locations in the Charleston Harbor area. They will also share this information with the public through their webpage or an ArcGIS StoryMap.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The team will have biweekly teleconferences with end users to provide updates on project methodologies and analyses throughout the term and will communicate with collaborators through phone calls and emails on an as-needed basis. The Project Lead will be the primary POC for in-term communication with the partners following an introduction by the Fellow during the first week of the term.

***Transition Plan*:** A handoff will be conducted at the end of the term using WebEx. End users will receive a package with access to the final products through NASA Large File Transfer (LFT). The team will present their results and conclusions and answer any questions the end users or collaborators have during this handoff event. End users and collaborators will be invited to attend the Virtual Annual Earth Science Applications Showcase at the beginning of August.

**Earth Observations Overview**

***Earth Observations:***

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| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| **Landsat 8 OLI** | Surface reflectance | Surface reflectance from Landsat 8 OLI will be used to calculate the UVVR from 2013 – 2020 that will be used to assess salt marsh vulnerability. |
| **Landsat 7 ETM+** | Surface reflectance | Surface reflectance from Landsat 7 ETM+ will be used to calculate the UVVR from 2000 – 2013 that will be used to assess salt marsh vulnerability. |
| **Landsat 5 TM** | Surface reflectance | Surface reflectance from Landsat 5 TM will be used to calculate the UVVR from 2000 – 2012 that will be used to assess salt marsh vulnerability. |
| **Sentinel-2 MSI** | Surface reflectance | Surface reflectance from Sentinel-2 MSI will be used to calculate the UVVR from 2017 – 2020 that will be used to assess salt marsh vulnerability and will be compared to Landsat imagery. |
| **Sentinel-1 C-SAR** | Land Cover | Sentinel-1 C-SAR data will be evaluated for use in the classifications used to calculate UVVR. |

***Ancillary Datasets:***

* USDA Farm Service Agency National Agriculture Imagery Program (NAIP) aerial imagery (2005, 2006, 2009, 2011, 2013, 2015, 2017, and 2019) – high-resolution surface reflectance from NAIP will be used to evaluate UVVR in conjunction with Landsat and Sentinel-2 imagery
* South Carolina Department of Natural Resources 6-inch aerial imagery (2020) – surface reflectance from airborne missions conducted in the early months of 2020 will be used to evaluate UVVR in conjunction with Landsat and Sentinel-2 imagery
* South Carolina Department of Natural Resources 1-meter NIR imagery (2006) – surface reflectance from airborne missions conducted in the early months of 2020 will be used to evaluate UVVR in conjunction with Landsat and Sentinel-2 imagery
* US Fish and Wildlife Service National Wetlands Inventory – wetland classification maps from the 1970s to present were used to clip tidal marsh boundaries

***Software & Scripting:***

* Python – batch image processing and analysis
* R Statistical Software – statistical analysis
* ENVI – image processing and corrections

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **UVVR Maps**  **2000 – 2020** | End users will use these biannual UVVR maps to assess vulnerability of salt marsh ecosystems and prioritize areas for future restoration efforts or develop policy regarding future development near the estuary. | UVVR will be calculated using surface reflectance from Landsat 7 ETM+, Landsat 8 OLI, Sentinel-2 MSI, NAIP imagery, and high-resolution aerial imagery provided by the DNR. | N/A |
| **UVVR Time Rate-of-Change Maps**  **2000-2020** | 5-year interval maps of UVVR time rate-of-change will allow partners to understand how quickly the estuary’s vulnerability is changing throughout the 20-year study period to anticipate future changes in vulnerability and recognize factors influencing the observed change in vulnerability. | UVVR time rate-of-change will be calculated using surface reflectance from Landsat 8 OLI, Landsat 7 ETM+, and validated with Sentinel-2 MSI, NAIP imagery, and high-resolution aerial imagery provided by the DNR. | N/A |
| **Tutorial of Methods** | End users and collaborators will be able to use this thorough tutorial of the methodologies conducted in this project to replicate the work for future marsh vulnerability assessments and to implement this work in other study areas throughout the region. | N/A | N/A |

***End User Benefit*:** These assessments of marsh vulnerability and change in marsh vulnerability over time will provide local and state managers with tools to estimate the vulnerability of estuarine ecosystems throughout the state and evaluate the associated ecosystem service potential. Understanding the response and resilience of coastal wetlands to physical factors such as changing sediment loads and shifting shorelines can help managers assess ensuing changes in vulnerability and prioritize areas for conservation or restoration. This metric will provide a meaningful measure of vulnerability that is less costly and less labor-intensive to measure than a complete sediment budget evaluation, which will help our partners complete more comprehensive and frequent estuary evaluations.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 1 Term: 2020 Spring

***Related DEVELOP Work:***

2018 Summer (MA) – Plum Island Estuary Water Resources II: Employing Remote Sensing Techniques to Quantify Sediment Supply and Evaluate Marsh Vulnerability in the Plum Island Estuary

2018 Spring (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:**

***Notes*:** The DHEC has expressed the possibility of involving officials from the City of Charleston or the Charleston District of the US Army Corps of Engineers in the project as well.

Examples of UVVR can be found at the following sources:

* https://catalog.data.gov/dataset/unvegetated-to-vegetated-marsh-ratio-in-plum-island-estuary-and-parker-river-salt-marsh-complex
* https://www.sciencebase.gov/catalog/item/5c62f414e4b0fe48cb34c8b9
* https://www.sciencebase.gov/catalog/item/5ba3ccc4e4b08583a5c81bd1

National Wetlands Inventory: https://www.fws.gov/wetlands/nwi/Overview.html

DHEC GIS resources: https://www.scdhec.gov/environment/environmental-data-maps-reports/gis-apps-data

***References:***

Ganju, N. K. (2019). Marshes are the new beaches: Integrating sediment transport into restoration planning. *Estuaries and Coast, 42,* 917-926. doi: 10.1007/s12237-019-00531-3

Ganju, N. K. et al. (2017). Spatially integrative metrics reveal hidden vulnerability of microtidal salt marshes. *Nature Communications,* *8*, 14156. doi: 10.1038/ncomms14156

Wasson, K. et al. (2019). Understanding tidal marsh trajectories: Evaluation of multiple indicators of marsh persistence. *Environmental Research Letters, 14,* 12. doi: 10.1088/1748-9326/ab5a94