**NASA DEVELOP National Program**

**Georgia – Athens**

*Project Summary – Spring 2018*

**Miami Beach Urban Development II**

*Utilizing NASA Earth Observations to Assess Vegetation Resiliency and Water Quality Concerns to Enhance Green Infrastructure Plans in Light of Extreme Weather Events*

**VPS Title:** Sink or Swim: Adapting to Environmental Change in Miami Beach

**Project Team**

***Project Team*:**

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**Project Overview**

***Project Synopsis*:** This project aimed to provide the City of Miami Beach Public Works Department with a better understanding of how NASA satellite data can be used to identify resilient ecosystems after catastrophic events, such as Hurricane Irma, to improve decision making for future green infrastructure plans. The team worked to create a vegetation time series showing canopy loss and recovery after the hurricane, along with a water quality analysis to increase understanding of water pollutants and their origin. These end products will assist management in evaluating the changing conditions across the Biscayne Bay area and provide decision makers with additional information to enhance restoration plans.

***Abstract*:**

In response to projected sea level rise and extreme weather events, Miami Beach and other urban areas surrounding Biscayne Bay are developing adaptive strategies to mitigate the effects of changing environmental conditions. City officials are involved with ongoing efforts to reduce storm damage and monitor water quality with the goal of protecting coastal resources. Some important considerations for these adaptive strategies include identifying resilient plant species and gaining a better understanding of water quality patterns. This NASA DEVELOP project employed Earth observations to assess post-Hurricane Irma canopy loss and recovery, in addition to water quality changes of the surrounding bay. These analyses will assist the Miami Beach Public Works Department in enhancing restoration plans and undertaking proactive countermeasures by evaluating changing conditions across the Biscayne Bay area and providing additional predictive insights from deep learning models. The results of the vegetation damage and water quality analyses will aid the ecological management, hurricane preparedness, and land use planning efforts led by the city of Miami Beach to improve coastal resiliency.

**Keywords:**

Coastal wetlands, green infrastructure, Landsat, Biscayne Bay, Hurricane Irma

***National Application Areas Addressed:*** Urban Development, Water Quality

***Study Location:*** Miami Beach and Biscayne Bay, FL

***Study Period:*** January 2014 –March 2018

***Community Concern:***

* Extreme weather events, such as hurricanes, pose major ecological and economic threats to coastal communities surrounding Biscayne Bay.
* Predicted changes in the shoreline, such as projected sea level rise and hurricanes could significantly impact the economy, primarily the tourist industry sector, of Miami Beach.
* Declining water quality poses a risk to ecologically critical habitats and the coastal community of the bay area.
* Hurricane damage assessments utilizing Earth observations are of great importance when supporting resource allocation and adaptation strategies to enhance coastal resilience.

***Project Objectives:***

* Examine and assess the resiliency of coastal vegetation species in response to hurricane impacts
* Analyze the water quality patterns in the Biscayne Bay from 2014 to present
* Communicate the relevance of NASA Earth observation satellites to the city of Miami Beach, and identify how the project’s methods can be applied to geographically similar locations

***Previous Term:*** 2017 Fall (GA) - Miami Beach Urban Development

**Partner Overview**

***Partner Organization:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **City of Miami Beach, Public Works Department** | Francisco D’Elia, GIS Analyst | End User | Yes |

***Decision Making Practices & Policies***:

Currently, the City of Miami Beach’s Public Works Department is looking into several adaptive strategies to address vegetation loss and storm damage to assets, and gray infrastructures. These include raising roads, building seawalls, and upgrading stormwater drainage systems. Miami Beach has also implemented plastic filtration mechanisms into the new stormwater network, preventing plastic pollution from being released into the bay. However, periodic monitoring is necessary to enhance knowledge about dissipation patterns to assist future planning on improvements to next generation of stormwater system. Alongside coastal reinforcement proposals, the city monitors water quality through ground observations, monitoring runoff and stormwater discharge.

***Project Benefit to End User***:

The end products of this project will allow the Public Works Department to utilize Landsat 8 Operational Land Imager (OLI) data to address issues such as vegetation resiliency and water quality. The data presented will inform the city’s plans for green infrastructure by pinpointing species that withstand damage from storms and protect valuable beachfront area. Alongside vegetation indices, satellite imagery will supplement the need for field tests analyzing water quality along the Biscayne Bay, allowing for a time series analysis of changes in the water quality of the bay. The results of this project will enhance decisions on prioritizing areas of interest in relation to water quality and coastal resiliency.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Aqua MODIS** | Chlorophyll-A | Aqua MODIS imagery was used to measure water quality change over time and to visualize *in situ* water quality data from 2014-2018. The *in situ* data was then compared to measurements from Aqua MODIS for validation purposes. |
| **Landsat 8 OLI** | Spectral vegetation indices | Landsat 8 OLI imagery captured at various time intervals before and after Hurricane Irma was processed using NDVI (Normalized difference vegetation index) to compare the resiliency of vegetation species during storm surges. |
| **PlanetScope** | Spectral vegetation indices | Data from PlanetScope was used to validate the results of the Landsat 8 OLI canopy loss analysis. |

***Ancillary Datasets:***

Department of Environmental Resources Management (DERM) Water Quality Data – validate results of satellite-based water quality analysis

***Modeling:***

Recurrent Neural Networks (POC: Charles Lu, NASA DEVELOP) – predict patterns in water quality

***Software & Scripting:***

Esri ArcGIS 10.5 – image processing and mosaicking, map creation, and hotspot analysis

Sentinel Application Platform (SNAP) – image processing and visualization

Python 3.6 – scripting and data analysis

Google’s TensorFlow – Deep Learning framework used for modeling

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Vegetation Resiliency Map** | Landsat 8 OLI, PlanetScope | The maps will be used by the partners to determine which species of vegetation withstood storm damages and showed the highest recovery rates. The project partner will then use the resulting information to aid in green infrastructure planning. | N/A |
| **Water Quality Trend Map** | Aqua MODIS | Maps of the Biscayne Bay region will display Chlorophyll-A patterns over time. | N/A |
| **Deep Learning Predictive Water Quality Model Code** | Aqua MODIS | The predictive modeling software will be used to forecast water quality measurements across the bay to inform proactive counter-measures to prevent future degradation. | IV |

**Project Handoff Package**

**Transition Plan:**

The team conducted a virtual hand-off to share end products and results, including vegetation resiliency and water quality trend maps, with the City of Miami Beach Public Works Department. Additionally, the team shared the results of a trained model code. After the software release process is complete, this predictive modeling software will be given to the partners to inform their planning efforts.

*Software Release Plan*: The partner is familiar with deep learning and has provided large amounts of *in situ* water quality data, approximately 840,000 measurements, including salinity, pH, and turbidity, which can be used to train recurrent neural network models to forecast future trends and patterns. We are prepared to assist our partner in the utilization of such trained models, which includes proper documentation and communication of the model’s limited predictive capabilities in certain scenarios. We will also include a list of software dependencies that must be installed and detailed directions for how to do so.

*Project Continuation Plan*: There is potential for the Miami Beach Urban Development project to continue in a future term at the Georgia – Athens node. The additional products our partners could benefit from include a more in-depth water quality analysis using higher resolution imagery such as Sentinel. During the Spring 2018 term, the team explored the possibility of including Sentinel and successfully analyzed one Sentinel-3 image and extracted chlorophyll values, which were validated with *in situ* measurements. Additionally, if extended for a third term, the team would be able to analyze historic water quality data to examine longer term trends in total suspended sediment and chlorophyll. Finally, a third term would allow for the inclusion of more recent imagery to update the vegetation recovery results and gain a better understanding of coastal resiliency.

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**Partner POC**: Francisco D’Elia, franciscodelia@miamibeachfl.gov

**Handoff Package:**

* Vegetation resiliency analysis and map
* Water quality trend analysis and map
* Trained water quality model and associated code (after approval process is complete)
* Final draft deliverables
* Project video

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