**NASA DEVELOP National Program**

**California – Ames**

*Project Summary – Summer 2018*

**US Virgin Islands Water Resources**

*Analyzing Historical Hurricane Influences on Coastal Water Quality and their Impact to Marine Ecosystems*

**VPS Title:** Is the Coast Clear? Hurricane-Caused Perturbations on Near-Coastal Water Quality in the US Virgin Islands

**Project Team**

***Project Team*:**

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***Advisors & Mentors*:**

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Dr. Marilyn Brandt (University of the Virgin Islands)

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***Past or Other Contributors*:**

Jenna Williams

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**Project Overview**

***Project Synopsis*:** The US Virgin Islands (USVI) near-coastal marine ecosystems are integral to the US Virgin Island communities. These marine ecosystems are subject to many stressors, including poor water quality and storm damage. The DEVELOP USVI Water Resources Team investigated the interaction between hurricanes, land development, and water quality. We used Landsat 5 Thematic Mapper (TM), Landsat 8 Operational Land Imager (OLI), and Sentinel-2 Multispectral Instrument (MSI) to quantify water turbidity, suspended sediment, and chlorophyll-a following Hurricanes Hugo (1989), Irma (2017), and Maria (2017) and during 2016, a relatively storm-free year. The data, in addition to land classification data created by the 2017 DEVELOP USVI Ecological Forecasting team will aid the U.S. Virgin Islands Department of Planning and Natural Resources, Coastal Zone Management mitigate future storm impacts on USVI near-coastal ecosystems.

***Abstract*:**

**Keywords:**

US Virgin Islands, hurricane, marine ecosystem, turbidity, chlorophyll-a, sediment, Landsat 8, Sentinel-2

***National Application Areas Addressed:*** Water Resources

***Study Location:*** US Virgin Islands

***Study Period:*** 1989 – 2017

***Community Concern:***

* With over 2,300,000 visitors annually, tourism accounts for approximately 80% of the US Virgin Island gross domestic product. Tourism to the US Virgin Islands can be directly attributed to its ocean resources.
* Coral reefs provide vital ecosystem services including, but not limited to, flood control, storm buffers, fish habitat, tourist attraction, and biodiversity maintenance. Hurricane disturbances can benefit coral reefs, but the dual impact of hurricanes and degraded water quality due to anthropogenic activities can reduce coral reef biomass.
* Fishing provides cultural and commercial values to the US Virgin Islands.
* The U.S. Virgin Islands are home to both endangered and threatened marine species whose health and fitness, in part, depends on water quality.
* Increasing island visitation and the changing climate will expand developed areas and increase hurricane intensity, respectively.

***Project Objectives:***

* Create a database of water quality parameters to compare major (Category 4/5) hurricanes (1989, 2017) and non-active hurricanes seasons (2016) in the US Virgin Islands nearshore habitat
* Characterize the temporal and spatial influence of hurricanes on suspended sediment, turbidity, and chlorophyll-a concentration
* Identify coral reef communities at risk of poor water quality and assess the influence of development on hurricane impacts to nearshore marine water quality parameters

***Previous Term:*** 2017 Summer (ARC) – US Virgin Islands Ecological Forecasting

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **US Virgin Islands Department of Planning and National Resources, Coastal Zone Management** | Jean-Pierre Oriol, Director;  Leslie Henderson, Coral Reef Initiative Coordinator;  Pedro Nieves, Program Coordinator | End User | Yes |
| **University of the Virgin Islands** | Dr. Marilyn Brandt, Research Associate Professor;  Dr. Tyler Smith, Research Associate Professor | Collaborator | No |
| **College of Charleston** | Dr. Adem Ali, Assistant Professor | Collaborator | No |
| **Kent State University** | Dr. Joseph D. Ortiz, Professor | Collaborator | No |

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

The US Virgin Islands Department of Planning and National Resources, Coastal Zone Management (CZM) investigates and mitigates the impact of anthropogenic and natural disturbances on the territory’s 100,000+ residents and its 175 miles of coastline. Currently, the CZM monitors the effects of development and hurricanes on nearshore water quality using *in situ* data. The oversight of water parameters is vital to protect marine biodiversity and tourism—a major factor in the US Virgin Islands economy. The CZM currently does not use remote sensing to determine water quality.

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

The data provided by this project will inform the CZM on the combined impact of development and hurricanes on marine water quality. CZM will additionally use these water quality data as parameters in the NOAA openNSPECT model, which assesses the effect of development and natural disturbances on marine ecosystem health. Additionally, this project will inform project partners how acute events, like hurricanes, impact water quality in the US Virgin Islands for coral reef replanting programs and development regulations.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Landsat 8 OLI** | Turbidity Index (t\_dogliotti),  Suspended Particulate  Matter, Chlorophyll-a  concentrations, Dissolved Organic Matter (CDOM), Kd-490 Diffuse attenuation coefficient | This dataset was used to study the extent and patterns of sediment plumes after the impact of 2017’s Hurricanes Irma and Maria in the USVI, as well as 2016, a non-hurricane year. All plumes have been analyzed to understand the effects of sedimentation along coral reefs. |
| **Landsat 5 TM** | Turbidity Index (t\_dogliotti) ,  Suspended Particulate  Matter, Chlorophyll-a  concentrations, CDOM, Kd490  (Diffuse  attenuation coefficient) | This dataset was used to study the extent and patterns of sediment plumes following Hurricane Hugo in 1989. |
| **Sentinel-2 MSI** | Turbidity Index (t\_dogliotti),  Suspended Particulate  Matter, Chlorophyll-a  concentrations,  CDOM, Kd490 | This dataset was used to study the extent and patterns of sediment plumes in 2016 and following the impact of 2017’s Hurricanes Irma and Maria in the USVI. |

***Ancillary Datasets:***

NOAA IBTrACS – identify hurricanes that impacted the US Virgin Islands

***Software & Scripting:***

ACOLITE – Processing Sentinel-2 and Landsat data to quantify water quality

Esri ArcGIS – Compositing data, hurricane impacts

SeaDAS – Visualizing data

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Near Shore Marine Water Quality Raster Images** | Landsat 8 OLI  Landsat 5 TM  Sentinel-2 MSI | Post-hurricane water quality data for the US Virgin Islands marine environments can help address concerns the effect of hurricanes and development on coral health, which can inform zoning regulations and marine protection plans. | N/A |
| **Water Quality Areas of Concern for Near Shore Habitats** | Landsat 8 OLI  Landsat 5 TM  Sentinel-2 MSI | The Water Quality Areas of Concern Map identified areas with large coral communities and poor water quality post hurricanes in which the Coastal Zone Management can mitigate the impact of future hurricanes. | N/A |
| **Hurricane Impact Analysis on Water Quality** | Landsat 8 OLI  Landsat 5 TM  Sentinel-2 MSI | This Hurricane Impact Analysis will provide quantitative data on the influence of major hurricanes on water quality compared to years without hurricanes.  Moreover, the DEVELOP 2017 USVI Ecological Forecasting land classifications created in works with Christopher McDonald, in combination with the water quality data, will provide insight on how development modifies the impact of hurricanes on marine water quality. | N/A |

**Project Handoff Package**

**Transition Plan:**

All end products and deliverables created by the team will be disseminated to the project partners during the final week of the term via NASA LFT. The project presentation will then be live-streamed via WebEx teleconference for the project partners.

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**Handoff Package:**

* Visual Poster
* Presentation
* Project Video
* Technical Paper
* Map Package of .tiff and .png files with water quality data (turbidity, chlorophyll-a, and suspended sediment for 1989, 2016, and 2017 from September to January the following year). Additional data analysis such as Development and Coral Risk assessments are included.

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