**NASA DEVELOP National Program**

**2017 Summer Project Proposal**

**NASA Ames Research Center**

**US Virgin Islands Ecological Forecasting**

*Using NASA Earth Observations to Monitor Land-use Change and Map At-risk Coastal Habitats in the US Virgin Islands*

**Project Overview**

***Project Synopsis*:** The Caribbean islands of St. Thomas, St. John, and St. Croix comprise the US Virgin Islands (USVI). Spanning a total land area of 344 km2, the islands are surrounded by coastal marine habitats including mangroves, seagrasses, and coral reefs. The total population of the US Virgin Islands has more than tripled in the past 50 years to approximately 105,000 people. This DEVELOP project aims to understand how humans have altered the islands’ coastal environments by performing an analysis of land-use change using the Landsat series (5, 7 and 8) and EO-1 Hyperion, complemented with Sentinel-2 data. Ultimately, this project will contribute to the determination of which coastal areas are most vulnerable to human development in the USVI.

***Community Concern:*** The economy of the US Virgin Islands depends heavily upon beach tourism. The condition of the islands’ coastal environments is therefore critical to the economic success of the territory, yet many of these environments, like coral reefs, have seen extreme declines in health and cover of major reef-building coral species and biodiversity correlated to the increase in local human population. These habitats are also threatened regionally by the impacts of a changing climate-related factors such as increased sea surface temperatures. Rapid land use change has impacted the quality of both terrestrial and nearshore marine environments. However, land use varies across the span of each island and among the islands themselves and has not been comprehensively quantified. Knowledge of land-use change and its environmental impacts will inform local management actions and spatial planning by identifying coastal habitats that are most at risk.

***Source of Project Idea:*** This project was generated by researchers at the University of the Virgin Islands in collaboration with the Virgin Islands Division of Coastal Zone Management, and researchers at the College of Charleston and Kent State University.

***National Application Area Addressed:*** Ecological Forecasting

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

***Study Period:*** 1998 – 2025 (January – April)

***Advisors:*** Dr. Juan Luis Torres-Pérez (Bay Area Environmental Research Institute), Dr. Sherry Palacios (Bay Area Environmental Research Institute), Dr. Liane S. Guild (NASA Ames Research Center)

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| US Virgin Islands, Department of Planning and Natural Resources, Coastal Zone Management | Jean-Pierre Oriol, Director;  Leslie Henderson, Coral Reef Initiative 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 |

***End-User Overview***

***End-User’s Current Decision-Making Process:***The Virgin Islands Division of Coastal Zone Management (CZM) is primarily concerned with issuing development permits for areas defined within the coastal zone. CZM has a set of goals that guide them in the issuance of permits which are determined on a case-by-case basis. In some instances, CZM uses the National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center land use maps, land cover maps, and data to inspect specific areas for permit decisions. Although they do take into account the intensity of recent development in an area, the inclusion of this information on the ultimate permit decision many times relies on the memory of the CZM permit review team. Inspections are performed during developments, but surveys on overall development activity in the watershed are not completed and record keeping is spotty. There is no database for tracking land-use, and there is no long-term development plan that might track changes or limit a specific area once it has reached a theoretical carrying capacity. This project will provide insight into how much development projects have modified the lands of the USVI.

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

*US Virgin Islands, Department of Planning and Natural Resources, Division of Coastal Zone Management* – Spatial data, such as GPS points for moorings, project sites, etc. are used often but no remote sensing data has been used in decision-making. One CZM employee has experience with NASA Earth observations, but it is minimal and has not been applied in a management capacity. This project will provide an example for how NASA Earth observations can be used in an applied management scenario for understanding how land use changes impact the coastal zone.

***Collaborator & Boundary Organization Overview***

***Collaborator Support:***

*University of the Virgin Islands* – Dr. Marilyn Brandt and Dr. Tyler Smith are Research Associate Professors at the UVI Center for Marine and Environmental Studies, which is currently involved in NASA-funded research on the relationship between water quality and coral reef health. Drs. Brandt and Smith also have extensive experience monitoring marine habitats in the US Virgin Islands, and Dr. Smith serves as the Coordinator for the Territorial Coral Reef Monitoring Program. Drs. Brandt and Smith have agreed to provide *in situ* data on the distribution and health of coastal marine ecosystems to be used as validation.

*College of Charleston* – Dr. Adem Ali is an Assistant Professor and expert in aquatic remote sensing and is currently working with UVI researchers on NASA-funded research to use remote sensing to understand water quality and its impacts on coral reef environments of the US Virgin Islands. Dr. Ali will provide guidance for the project, particularly in the area of water quality assessment.

*Kent State University* – Dr. Joseph Ortiz is a Professor in the Department of Geology with expertise in characterizing spectral reflectance data in freshwater and marine environments. He is currently working with UVI researchers on NASA-funded research to use remote sensing to understand water quality and its impacts on coral reef environments of the US Virgin Islands. Dr. Ortiz will provide guidance for the project, particularly in the area of water quality assessment.

***Dissemination by Boundary Organizations*:**Project results will be disseminated at US Virgin Islands community events and local scientific symposia by UVI researchers and students. Events include the annual community-oriented festivals Reef Fest and the St. Thomas Agricultural Fair. Scientific-oriented events include the annual UVI Research Day and the UVI Fall Research Symposium.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** Researchersat UVI, CofC, and KSU will communicate bi-weekly throughout the summer term via Skype.

***Transition Plan*:** Results from the project will be provided to the VI Division of Coastal Zone Management through a shared data portal (such as Google Drive) and all reports, tutorials, and documents will be shared via email. Any students participating in the research will also be encouraged to present the results at USVI forums including UVI Research Day and the UVI Fall Student Research Symposium. The UVI collaborators will also share results at two major USVI community events: Reef Fest and The St. Thomas Agricultural Fair (Ag Fair).

***Letters of Support*:** Jean-Pierre Oriol, Director, Virgin Islands Department of Planning and Natural Resources – Coastal Zone Management

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **EO-1 Hyperion** | Spectral vegetation indices | Mapping of the vegetation on the island to determine current land-use and land cover changes |
| **Landsat 5 TM** | Landcover | Time series analysis of land-use and land cover changes in the USVI |
| **Landsat 7 ETM+** | Landcover | Time series analysis of land-use and land cover changes in the USVI |
| **Landsat 8 OLI/TIRS** | Landcover, Suspended Sediments | Time series analysis of land-use and land cover changes in the USVI, and to map at risk surrounding marine environments |
| **Sentinel-2 MSI** | Landcover | Time series analysis of land-use and land cover changes in the USVI |

***Ancillary Datasets:***

Socioeconomic Data and Applications Center (SEDAC) – Gridded Population of the World (GPW) population density data for the USVI – trends in population density in the USVI to relate to land use changes through time.

US Census Bureau – Population Data (1990, 2000, 2010) – Population density data by districts.

NOAA Coastal Services Center Coastal (CSC) Change Analysis Program (C-CAP) – NOAA’s land use/land cover (LULCC) maps for 2002, 2003, 2005, 2007, and 2012 (depending on which island) – LULCC maps to compare to more recent LULCC map to be produced by the project.

***Modeling:***

TerrSet’s Earth Trends Modeler and/or Land Change Modeler (POC: James Toledano, Clark Labs/ Clark University)

***Software & Scripting:***

Exelis ENVI – image processing

Esri ArcGIS – map creation

Python – SeaDAS – processing imagery

TerrSet – land-use change maps and time series analysis

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product(s)** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Land-use Map** | Identification of changes in land-use and land cover and intensity of human impacts on both terrestrial and nearshore marine habitats. This can be used for decision-making processes pertaining the evaluation of development permits at or near coastal areas. | Land cover classification performed using Landsat and Sentinel-2. | I |
| **Analysis of Land-use Change** | Understanding of areas where largest and most rapid rates of change have occurred. This can be used for decision-making processes pertaining the evaluation of development permits at or near coastal areas. | Change detection analyzed using the Earth Trends module in TerrSet with Earth observations Landsat and Sentinel-2 | I |
| **Coastal Zone Risk Map** | Identification of nearshore habitats with high risk. This complements current NASA-funded efforts dedicated to study the present condition of coastal and marine ecosystems in the USVI. | Analysis of EO-1, MODIS, Landsat, and Sentinel-2 will model coastal zones at high risk of impact due to land-use change on the islands. | I |

***End-User Benefit*:** The end-user will be provided with a better understanding of the risks to coastal habitats associated with land-use changes and their impacts on coastal water quality and adjacent marine ecosystems. The products may further be used by our partners and end-users to complement efforts to address watershed issues on each island.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 2 Terms: 2017 Summer (Start) to 2018 Summer (Completion)

***Multi-Term Objectives:***

* **Term 1 (Proposed Term):** 2017 Summer (ARC) – US Virgin Islands Ecological Forecasting I
  + This first term will focus on assessing the current land-use patterns and distribution of human impacts on both the terrestrial and nearshore marine environments. We will work closely with our partners from the UVI, CofC and KSU. They will provide in situ data to complement our efforts. We will use TerrSet’s Land Change Modeler to analyze land change trends in the USVI for the past three decades (1998-present) and to predict future changes in land use.
* **Term 2:** 2018 Summer (ARC) – US Virgin Islands Oceans II
  + This term will focus on expanding the analysis of land-use back through time to examine land-use change and its impacts. We will incorporate a watershed hydrological analysis for main watershed in the three main islands that comprise the USVI. The results of these analyzes can further be incorporated in the current efforts being led by our partners from the UVI, CofC, and KSU to address human impacts to the coastal and marine ecosystems in the USVI.

***Related DEVELOP Work:***

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

2017 Spring (NASA Langley Research Center) Chesapeake Bay Water Resources LaRC Spring 2017

**Notes & References:**

***Notes*:** Additional funds will be provided from a NASA EPSCoR project (Brandt, PI; Ali, Co-I; Ortiz, Co-I) to allow for two students from the UVI to participate at ARC during each term of the project. This innovative approach will provide for minority students from the US Virgin Islands to be directly exposed to the use and analysis of NASA Earth observations at a NASA center. Further, Dr. Torres-Pérez has been funded to participate in a field campaign related to the EPSCoR project in May 2017. Dr. Torres-Pérez will use this opportunity to meet with the partners (and potentially with some end-users as well), to facilitate for data transfer and explore additional ideas for future DEVELOP projects.