**NASA DEVELOP National Program**

Mobile County Health Department & University of Georgia

*Summer 2017*

**Short Title: Costa Rica Oceans**

**Subtitle:** Assessing Changes in Vegetation and Marine Environments at the Isla del Coco Marine Reserve with Satellite Imagery

**VPS Title:** An Ocean Between Us: Monitoring Marine and Vegetation Health on Cocos Island

**Project Team**

**Project Team:**

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**Project Overview**

**80-100 Word Objectives Overview:**

Corals of the Isla del Coco Marine Reserve located off the coast of Costa Rica are at risk of bleaching brought on by changes in total suspended sediments (TSS), biophysical parameters, and sea surface temperature (SST). To help Área de Conservación Marina Isla del Coco (ACMIC) better understand the current conditions of the ecosystem and prepare accordingly for future changes, spatio-temporal analysis maps will be developed for each variable affecting coral health as well as changes in coastline. Vegetation change maps were created to determine key management areas for controlling local input of TSS using remote sensing and GIS technology.

**Abstract:**

The Isla del Coco Marine Reserve, located off the coast of Costa Rica, is experiencing several environmental challenges including rising sea surface temperature (SST), coral reef bleaching, coastal erosion, and loss of cloud coverage above its cloud forest. These challenges not only threaten the well-being of vegetation and marine ecosystem, but also the national park’s infrastructure. Therefore, this project aimed to provide a better understanding of the problem by conducting time series analysis on changes in vegetation on the island, SST, total suspended sediments (TSS), and biophysical parameters in the surrounding ocean. Satellite data from Landsat 7 Enhanced Thematic Mapper Plus (ETM+), Landsat 8 Operational Land Imager (OLI), Moderate Resolution Imaging Spectroradiometer (MODIS), and Medium Resolution Imaging Spectrometer (MERIS) were collected for the period March 2002 to October 2016 to analyze vegetation health and cloud forest coverage and its impact on vegetation. NetCDF data products of SST, remote sensing reflectance, and inherent optical properties were converted to raster and windows representing the study area were applied to extract data for trend analysis. MERIS level 2 products were used in combination with products derived from Sentinel-2 level 1 data to create a time series analysis ranging from 2002 to 2016 for TSS. Results of this project are important for Sistema Nacional de Áreas de Conservación de Costa Rica, Embassy of Costa Rica to the United States, and the Ministry of Environment and Energy-Water Directorate to make informed decisions to protect the marine reserve.

**Keywords:**

Landsat, remote sensing, NDVI, MODIS, coral reef bleaching, sea surface temperature, biophysical parameters, total suspended sediments

**Partner Organizations:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| Sistema Nacional de Áreas de Conservación de Costa Rica, Área de Conservación Marina Isla del Coco (ACMIC) (Costa Rica) | Esteban Herrera Herrera, Director Areas Silvestres Protegidas, Coordinacion Investigaciones, Area de Conservacion Marina Cocos; Ing. Marco Vinicio Araya Barrantes, Conservation Director of the Isla del Coco | End User | No |
| Embassy of Costa Rica to the United States | Ms. Alejandra Solano Cabalceta, External Affairs Officer | Collaborator | Yes |
| Ministry of Environment and Energy, Water Directorate (DA-MINAE) (Costa Rica) | Vivian Gonzalez Jimenez, Project Engineer | Collaborator | Yes |

**Community Concerns:**

* The island was declared a National Park by the Costa Rican government in 1978 and a World Heritage site by UNESCO in 1997 due to its natural richness in biodiversity, but over the last decade local researchers have discovered several environmental concerns.
* Increased coral bleaching due to increasing sea surface temperature, deeper cold water temperatures, and changes in exposure to solar radiation.
* Coastal erosion that threatens the national parks’ infrastructure and decrease in coral habitat quality brought on by increased suspended sediment load.
* Environmental changes threaten local reefs ecological services i.e. coastal protection, recruitment, economically important fish and invertebrate species, and recreational activities.

**Current Decision-Making Practices & Policies**

Main threats to the island’s vegetation include climate change, and invasive flora and fauna species. Thus, ACMIC limits access and human presence on the Cocos Island to preserve the natural landscape and vegetation. The island is strictly protected by law and is state-owned and managed by Costa Rica’s National Park Service with the Ministry of Environment and Energy partnered with several government and non-government institutions. The Ministry has the authority to create policies and programs in order to obtain a sustainable environment for the island and its natural resources. Due to the protection of the island’s ecosystem, the vegetation is able to grow and reproduce naturally. Tourists and visiting scientists work to prevent new invasion, however, sufficient funding is needed as travel to this island is costly due to its remote location. The island has a team of researchers, rangers, biologist and marine operators, who support the well-being of the island. The current practice is to allow the island to grow in its natural vegetation state with the least amount of human interaction possible.

**Decision Support Tools & Benefits:**

|  |  |  |  |
| --- | --- | --- | --- |
| **End-Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software**  **Release** |
| Isla del Coco Vegetation Time Series Analysis | Landsat 7 ETM+ and Landsat 8 OLI | This analysis will help the end users identifying potential patterns of vegetation loss or changes in forest structure. | I |
| Time Series Analysis of Environmental Variables (TSS, SST, biophysical parameters) Affecting the Health of the Island’s Coral Reefs and Vegetation | Envisat MERIS  Sentinel-2 MSI  POES AVHRR  Aqua MODIS  Terra MODIS | This aims to aid decision-making officials on assessing potential climate change related factors that may be affecting the island’s shallow-water marine ecosystems and vegetation. | I |

**Project Benefit to End User**:

The project methodologies and end products will help Isla de Coco Marine Reserve managers to enhance remote monitoring capabilities, providing a new means for measuring change. Improved understanding of the island’s vegetation health, coastal erosion, and water quality variables will support the Isla del Coco Marine Reserve in environmental decision making.

**Project Details**

**Applied Sciences National Application Addressed:** Oceans

**Study Area:** Costa Rica, Isla del Coco Marine Reserve

**Study Period:** March 2000 – October 2016

**Earth Observations & Parameters:**

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| Landsat 7 ETM+ | Normalized Difference Vegetation Index (NDVI), Near-Infrared/Red Band Ratio (Near-IR/R) | Imagery will be used to evaluate historical and current changes in vegetation health over time and create land cover mapping. |
| Landsat 8 OLI | Normalized Difference Vegetation Index (NDVI), Near-Infrared/Red Band Ratio (Near-IR/R) | Imagery will be used to evaluate historical and current changes in vegetation health over time and create land cover mapping. |
| Envisat MERIS | Surface Reflectance | MERIS ocean and land color instrument (OLCI) will be used to estimate TSS. TSS data will be compiled into time series plots. |
| Sentinel-2 MSI | Surface Reflectance | Sentinel-2 MSI will be used to estimate TSS. TSS data will be compiled into time series plots. |
| Aqua MODIS | Remote Sensing Reflectance, Inherent Optical Properties | Level 3 products of Aqua MODIS will be used in detecting changes in biophysical parameters (2002-2016). |
| Terra MODIS | Remote Sensing Reflectance, Inherent Optical Properties | Level 3 products of Terra MODIS will be used in detecting changes in biophysical parameters (2000-2016). |
| POES AVHRR | Optimum Interpolation 1/4 Degree Daily sea surface temperature (OISST) Analysis | NetCDF data products of AVHRR will be used to study sea surface temperature (SST) variation. |

**Software Utilized:**

* ERDAS Imagine – land classification of Landsat imagery
* Esri ArcGIS – raster manipulation and analysis, image enhancement & map creation of Landsat data
* SNAP – time series analysis of MERIS and Sentinel-2 OLCI TSS data
* MATLAB – statistical analysis and time series plotting

**Project Handoff Package**

**Transition Plan:**

Results from the environmental variables and shoreline assessment will be provided to the end users through Google Drive and all reports and documents will be shared via email. The project results will be presented to the interested parties through a webinar at the end of the summer term. Software release will not be necessary as the team will be providing model outputs and results (graphs and maps), as opposed to Python scripts.

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**Handoff Package:**

* Final draft deliverables
* Graphs showing variations in SST and biophysical parameters over the analysis period
* A series of maps showing changes in TSS
* Map of the coral reef system
* Time series mapping of vegetation health and cloud forest
* Map displaying historical changes and current land cover
* Project video