**NASA DEVELOP National Program**

**2017 Summer Project Proposal**

**University of Georgia**

**Eastern India Ecological Forecasting III**

*A Multi-Sensor Approach to Enhance the Prediction of Mangrove Biophysical Characteristics in Chilika Lagoon and Bhitarkanika Wildlife Sanctuary, Odisha, India*

**Project Overview**

***Project Synopsis*:** The objective of this project is to develop a mangrove biophysical characteristic prediction tool for Bhitarkanika Wildlife Sanctuary and Chilika Lagoon by using moderate resolution remote sensing reflectance data (Landsat, Sentinel, and MODIS). This tool will be used to derive a long-term phenology in order to improve management and restoration efforts in Odisha, India. The biophysical characteristics of mangroves will be determined through the evaluation of chlorophyll content, leaf area index, and gross primary productivity. Project partners from the Government of Odisha’s Department of Forest and Environment of Forest and Environment (DFE) and the Chilika Development Authority (CDA) will receive long-term spatio-temporal estimations of mangrove physiological status and model results that will identify ‘hotspots’ for early stages of mangrove degradation. Additionally, this project will address Sustainable Development Goal Indicators including percentage of change in wetlands extent over time and trends in land degradation.

***Community Concern:*** Mangroves have been overexploited or converted to other forms of land use. Mangrove forests provide valuable services such as food, raw materials, and medicinal and ornamental resources. Several villages and animal species including olive ridley sea turtles, saltwater crocodiles, water monitor lizards, and eleven species of birds depend on these resources. Between 1975 and 1993, mangrove vegetation in Odisha has reduced from 234 km2 to 199.19 km2. There is growing concern for the effective management and conservation of these mangrove forests because they support families from 36 villages around the Odisha region.

***Source of Project Idea:*** Communication between Dr. Mishra and Dr. Rastogi of the Chilika Development Authority began in 2014 after the Category 5 hurricane, Phailin, devastated parts of Thailand, Myanmar, and India. Through their communication, the CDA has expressed interest in collaborating with United States partners to learn more about the ability of remote sensing and mapping to inform early detection of mangrove degradation.

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

***Study Location:*** Odisha, India

***Study Period:*** January 2000 – December 2016; Forecasting to 2030

***Advisor:*** Dr. Deepak Mishra (University of Georgia)

**Partner Overview**

***Partner Organization:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| Government of Odisha, Department of Forest and Environment, Chilika Development Authority (India) | Dr. Gurdeep Rastogi, Senior Scientist, Wetland Research and Training Centre | End-User | No |

***End-User Overview***

***End-User’s Current Decision-Making Process:***Current assessments of Odisha coast mangrove forests conducted by the CDA and DFE are limited to habitat delineation and documentation of change in areas using ground and aerial surveys. Most of the research funding from DFE and CDA are aimed at fisheries research which is the most important economic driver of the region. However, since mangrove habitats and fish production are deeply interlinked, project partners are interested in biophysical parameters that can inform early detection of mangrove stress to guide future restoration efforts.

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

*Government of Odisha, Department of Forest and Environment, Chilika Development Authority (Indi*a) – CDA uses moderate resolution satellite data on a regular basis to map coastal habitats, land use/ land cover, etc. They mostly use Indian Remote Sensing (IRS) satellites such as Ocean Colour Monitor (OCM) on Indian Remote Sensing Satellite (IRS-P4) and ResourceSat for application development. They have GIS specialists in the agency who are experienced in mapping. Although biophysical parameter estimation using advanced remote sensing models and algorithms is not a part of their expertise, they have the geospatial skills to utilize the biophysical maps developed through this project to inform decision making. Additionally, this project is using NASA Earth observations which would provide several advantages over IRS products such as higher temporal and spatial resolution, availability of surface reflectance products (no need for atmospheric correction), and open source software (NASA’s SeaDAS) for processing the satellite images.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The team will email a weekly project update to the partners and have videoconferences as needed to answer any questions the partner may have or address any requests the team has for the partner. Although, the end-users are well aware of the project’s goals and expected outcomes, the team will schedule a conference call with them before starting the work to discuss logistics and expectations. The primary point of contact for this communication will be the team lead and Dr. Rastogi.

***Transition Plan*:** The decision support tools will be handed-off to the partner via a Skype call with all of the partners and team members. In this meeting, the team will discuss with the partners at CDA and DFE what the results are and explain any tutorials or additional resources to them.

***Letters of Support*:** Dr. Gurdeep Rastogi, Senior Scientist, Wetland Research and Training Centre, Chilika Development Authority

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **EO-1 Hyperion** | Spectral vegetation indices | Biophyical models using Hyperion based vegetation indices and field data will be developed and tuned. |
| **Terra MODIS** | Canopy chlorophyll, leaf area index, and aboveground biomass | Biophyical models using MODIS based vegetation indices and field data will be developed and tuned. |
| **Terra ASTER** | Canopy chlorophyll, leaf area index, aboveground biomass | Biophyical models using ASTER, MERIS and Sentinel-2 based vegetation indices and field data will be developed and tuned. |
| **Landsat 4 TM, Landsat 5 TM, Landsat 7 ETM+, Landsat 8 OLI** | Canopy chlorophyll, leaf area index, aboveground biomass | Biophyical models using Landsat based vegetation indices and field data will be developed and tuned. |
| **Sentinel-2** | Canopy chlorophyll, leaf area index, aboveground biomass | Biophyical models using ASTER, MERIS and Sentinel-2 based vegetation indices and field data will be developed and tuned. |
| **Sentinel-1A** | Energy, entropy | SAR images that provide texture, energy, entropy will be used to correlate with biophysical parameters and improve the accuracy and detail of classification. |

***Ancillary Datasets:***

CDA – Top of Canopy (TOC) Reflectance – calibrate and validate products

CDA – Canopy-Level Chlorophyll Content – calibrate and validate products

CDA – LAI Readings – calibrate and validate products

CDA – Biomass Measurements – calibrate and validate products

CDA – GPS Locations– calibrate and validate products

***Modeling:***

Three-band model (POC: Dr. Anatoly Gitelson, University of Nebraska-Lincoln)

Visible Atmospheric Resistance Index (VARI) (POC: Dr. Anatoly Gitelson, University of Nebraska Lincoln)

Wide Dynamic Range Vegetation Index (WDRVI) (POC: Dr. Anatoly Gitelson, University of Nebraska-Lincoln)

Weighted Difference Biophysical Model (WDBI) (POC: Dr. Deepak Mishra, University of Georgia)

***Software & Scripting:***

Exelis ENVI – Developing vegetation indices (WDBI, VARI, WDRVI, Three-band) and atmospheric correction

R – Developing semi-empirical models and statistical analysis

Esri ArcGIS – Map production

Sentinel Application Platform (SNAP) software – image processing

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Mangrove Biophysical Characteristics Forecast Model** | Determination of the regions that are most degraded or stressed; determining whether past restoration efforts have produced effective result; prediction of the overall health of Odisha coast mangroves ecosystem. | Models will be calibrated and validated to establish relationship between Landsat 30m, MODIS 250m, ASTER 15m, MERIS and Sentinel-2 data and mangroves biophysical variables data (i.e., Chl content, LAI, and biomass). | I |
| **Mangrove Extent Maps** | Extent maps will provide partners with information about areas transforming from mangrove to other land cover types, directly related to the Sustainable Development Goal indicators. | Landsat 5 & 8 and Sentinel 1A will be used to analyze trends in changing wetland and mangrove extent within the study area. | N/A |

***End-User Benefit*:** CDA will benefit from receiving an archive of a long-term spatio-temporal estimation of mangrove physiological status. The results of this project will allow them to identify ‘hotspots’ for early stages of mangrove degradation which can only be delineated by evaluating mangrove biophysical characteristics including distribution of chlorophyll content, leaf area index (a ratio of green foliage area vs. ground area), and aboveground biomass. The project partners will be able to continually monitor the effectiveness of a prior or ongoing restoration project using the models created by the DEVELOP team.

“The science and objectives behind this NASA DEVELOP project will significantly contribute to the management of Odisha’s mangrove ecosystem. The forecasting model and map products will be very useful for monitoring and to guide future restoration projects.”

-Gurdeep Rastogi, PhD

**Project Timeline & Previous Related Work**

***Project Timeline:*** 3 Terms: 2016 Fall (Start) to 2017 Summer (Completion)

***Multi-Term Objectives:***

* **Term 1:** 2016 Fall (UGA) – Eastern India Ecological Forecasting
  + Biophysical models were developed, calibrated, validated, and tuned using Landsat, ASTER, and MODIS data to monitor mangrove health. Project partners were given Seasonal and Annual Time-series
  + Mangrove Biophysical Characteristics Maps which enabled them to observe the phenological pattern change over a given period of time and gain an understanding of the status of the restored region relative to non-restored region.
* **Term 2:** 2017 Spring (UGA) – Eastern India Ecological Forecasting II
  + The models developed in term 1 were applied to predict the biophysical characteristics of mangrove habitats from 1995-2016. When the biophysical models were completed, the team explored the use of radar data to offer a solution for dealing with challenges due to frequent cloud cover. Long-term Seasonal and Annual Time-series Mangrove Biophysical Characteristics Maps and Historical Mangrove Cover Change Maps were created and disseminated to project partner.
* **Term 3 (Proposed Term):** 2017 Summer (UGA) – Eastern India Ecological Forecasting III
  + Model will be applied to other study areas facing similar mangrove, wetland, and forest degradation issues. The team will focus on Sustainable Development Goal Indicators including: percentage of change in wetlands extent over time and trends in land degradation. A comprehensive Skype hand-off will occur with project partners in India.

***Previous Terms:***

2016 Fall (UGA) – Eastern India Ecological Forecasting

2017 Spring (UGA) – Eastern India Ecological Forecasting II

***Related DEVELOP Work:***

2016 Summer (NASA Langley Research Center) – Everglades Ecological Forecasting: Improving the Capacity of the Everglades National Park to Monitor Mangrove Extent using NASA Earth Observations

2015 Summer (NASA Langley Research Center) – North Carolina Ecological Forecasting: Evaluating the Application of NASA Earth Observations to Monitor Wetland Health in the Albemarle-Pamlico Watershed

2014 Summer (NASA Jet Propulsion Laboratory) – Coastal Colombia Ecological Forecasting: Mapping Mangrove Deforestation and Assessing Ecosystem Productivity in Colombia’s Coastal Wetlands

2013 Summer (NASA Langley Research Center) – Myanmar Ecological Forecasting: Utilizing NASA Earth Observations to Monitor, Map, and Forecast Mangrove Extent and Deforestation in Myanmar for Enhanced Conservation

**Notes & References:**

***Notes*:** The proposed work is significant because it will allow us for the first time to use NASA satellite data to study the biophysical characteristics of mangrove forest in Odisha, India which in turn, has the potential of increasing our predictive capability with respect to carbon sequestration in these ecosystems. The result will be an efficient and non-destructive biophysical mapping protocol for emergent wetlands to be used in restoration decision making.

***References:***

Gitelson AA. (2004). Wide dynamic range vegetation index for remote quantification of crop biophysical characteristics*. Journal of Plant Physiology, 1*6*1*, 165-173.

Gitelson A.A., Gritz, U. and Merzlyak M.N. (2003). Relationships between leaf chlorophyll content and spectral reflectance and algorithms for non-destructive chlorophyll assessment in higher plant leaves. *Journal of Plant Physiology, 160*, 271- 282.

Gitelson AA, Kaufman Y, and Merzlyak MN. (1996). Use of green channel in remote sensing of global vegetation from EOS-MODIS. *Remote Sensing of Environment,* *58*, 289-298.