**NASA DEVELOP National Program**

**2017 Spring Project Proposal**

**University of Georgia**

**Eastern India Ecological Forecasting II**

*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 and to use the tool 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 Chilika Development Authority (CDA) and the Department of Forest and Environment (DFE) will receive long-term spatio-temporal estimations of mangrove physiological status and model results that will identify ‘hotspots’ for early stages of mangrove degradation.

***Community Concern:*** In recent years, 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 (CDA) 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 to December 2016; Forecasting to 2030

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

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| Government of Odisha; DFE; Chilika Development Authority (CDA) | Dr. Gurdeep Rastogi, Senior Scientist, Wetland Research and Training Centre | End-User | No |
| Government of Odisha; Department of Forest and Environment (DFE) | 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 biophysical status of the mangrove habitats and fish production are deeply interlinked, research projects should focus beyond habitat delineation to monitoring and forecasting mangrove productivity trends.

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

Chilika Development Authority, Odisha – 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 basic 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 high temporal and spatial resolution data, availability of surface reflectance products (no need for atmospheric correction), and open source software (NASA’s SeaDAS) for processing the satellite images.

Department of Forest and Environment, Odisha – CDA works closely with DFE in information dissemination and has similar capabilities to utilize remote sensing and GIS products. They are familiar with NASA data and as previous project partners, they were exposed to Landsat, Terra, and Sentinel throughout the first term of this project.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The team will send a weekly project update to the partners and have video conferences 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 | Semi-empirical models using Hyperion based vegetation indices and field data will be developed and tuned. |
| **Terra MODIS** | Canopy Chlorophyll, Leaf Area Index, and Aboveground Biomass | Semi-empirical models using MODIS based vegetation indices and field data will be developed and tuned. |
| **Terra ASTER** | Canopy Chlorophyll, Leaf Area Index, Aboveground Biomass | Semi-empirical models using ASTER, MERIS and Sentinel-2 based vegetation indices and field data will be developed and tuned. |
| **Landsat 4, Landsat 5, Landsat 7, Landsat 8** | Canopy Chlorophyll, Leaf Area Index, Aboveground Biomass | Semi-empirical models using Landsat based vegetation indices and field data will be developed and tuned. |
| **Sentinel-2** | Canopy Chlorophyll, Leaf Area Index, Aboveground Biomass | Semi-empirical models using ASTER, MERIS and Sentinel-2 based vegetation indices and field data will be developed and tuned. |
| **Sentinel-1A (SAR)** | 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 Product:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **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 30-m, MODIS 250-m, ASTER 15-m, MERIS and Sentinel-2 data and mangroves biophysical variables data (i.e., Chl content, LAI, and biomass). | I |

***End-User Benefit*:** CDA and DFE 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:** Fall 2016 (UGA) – Eastern India Ecological Forecasting
  + Semi-empirical models will be developed, calibrated, validated, and tuned using Landsat, ASTER, and MODIS data to monitor mangrove biophysical parameters.
* **Term 2 (Proposed Term):** Spring 2017 (UGA) – Eastern India Ecological Forecasting II
  + Models will be applied to predict the biophysical characteristics of mangrove habitats from 2002-2016. When the biophysical models are complete, the team will explore the value of implementing them in Google Earth Engine to potentially make the project more transferable and offer a solution for dealing with challenges due to frequent cloud cover. Map products and phenology charts will be developed and disseminated to project partner.
* **Term 3:** Summer 2017 (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

***Related DEVELOP Work:***

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

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

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

2013 Summer (LaRC) – 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. Vol. 161: 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.