**NASA DEVELOP National Program**

**Fall 2016 Project Proposal**

**NASA Marshall Space Flight Center**

**Lake Victoria Water Resources III**

Utilizing NASA Earth Observations to Identify Water Hyacinth Dynamics and Other Water Quality Parameters in Lake Victoria

**Project Overview**

***Objective:***  To implement surface reflectance processing for Landsat imagery in the Surface Aquatic Vegetation Detection Toolbox (SAVDT), implement a water extraction algorithm in the SAVDT, conduct an accuracy assessment on the SAVDT outputs, and create algorithms for deriving water surface temperature in Lake Victoria.

***Community Concern:*** The water hyacinth is an invasive species that has established itself in Africa and has spread prolifically due to the favorable growing conditions due to poor water quality throughout Lake Victoria. The hyacinth can have adverse impacts on the lake: outcompeting native plant species for space and nutrients, restricting boating access, and creating hypoxic zones that killing aquatic life.

***National Application Area Addressed:*** Water Resources

***Study Location:*** Lake Victoria in Kenya, Uganda, and Tanzania

***Study Period:*** August 2000 to August 2016

***Advisors:*** Dr. Jeffrey Luvall (NASA at NSSTC), Dr. Robert Griffin (University of Alabama in Huntsville), Africa Flores (NASA SERVIR)

***Source of Project Idea:*** This project resulted from discussions with Eric Anderson and Africa Flores from NASA SERVIR about collaborating efforts between DEVELOP and SERVIR to monitor Lake Victoria in Kenya, Uganda, and Tanzania. While discussing the project, it was indicated that SERVIR Eastern & Southern Africa Hub and Regional Centre for Mapping of Resources for Development (RCMRD) could benefit from having a historical analysis of the lake that highlights potential areas of hyacinth occurrences so as to have a better understanding of it and its changes over time.

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| NASA SERVIR Coordination Office at MSFC | Africa Flores, Eastern & Southern Africa Science Coordination Lead | Collaborator | No |
| NASA SERVIR-Eastern and Southern Africa Hub | Robinson Mugo, Earth Observations Lead  James Nyaga, Graduate Research Assistant | End-User | Yes |
| Makerere University Department of Geomatics and Land Management | Dr. Anthony Gidudu, Senior Lecturer | End-User | No |

***End-User Overview***

***End-User’s Current Decision Making Process:***

Currently RCMRD, along with other organizations, and Makerere University Department of Geomatics and Land Management are measuring the water quality of Lake Victoria using standard methods (i.e., *in situ* measurements, observations, etc.). These methods are expensive, time consuming, and only collect data from a single location across Lake Victoria.

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

SERVIR Eastern & Southern Africa Hub – The SERVIR Eastern & Southern Africa Hub currently uses NASA Earth observations. However, their current capacity in detecting water quality parameters and the water hyacinth are limited. This project will create methodologies, products, and scripts that will serve as a stepping-stone to support ground data and future studies on the water hyacinth using NASA Earth Observations.

Makerere University Department of Geomatics and Land Management – The Makerere University Department of Geomatics and Land Management currently uses NASA Earth observations. However, their current capacity in detecting water quality parameters and the water hyacinth are also limited. This project will create methodologies, products, and scripts that will serve as a stepping-stone to support ground data and future studies on the water hyacinth using NASA Earth Observations.

***Collaborator & Boundary Organization Overview***

***Collaborator Support:***

NASA SERVIR Coordination Office – NASA SERVIR will assist the project by giving knowledge and advice on water quality, GIS, and remote sensing.

SERVIR Eastern & Southern Africa Hub– The SERVIR Eastern & Southern Africa Hub will assist the project by giving knowledge and advice on monitoring water quality and water hyacinth in Lake Victoria from their recent research.

***Boundary Organization Dissemination:***

SERVIR Eastern & Southern Africa Hub– SERVIR Eastern & Southern Africa Hub will use the tools and methodologies created to detect water hyacinth and the water quality parameters that make the plant thrive in Lake Victoria. The data created will then be disseminated to a broader user-base within the Lake Victoria area in order to broaden the community’s knowledge on how the water quality can be managed to prevent the growth of the water hyacinth.

***Project Communication & Transition Overview***

***In-Term Communication Plan:***

The team lead will open communication during the first week of the term through email and set a time for a meeting or telecon. During this scheduled meeting or telecon, the team will discuss the proposed end-products to ensure there have not been any changes. In addition, the team will also ask how often the partners would like to be updated with the progress throughout the term.

***Transition Approach:***

The 1st term of this project aimed to create an algorithm for the detection of surface aquatic vegetation in Lake Victoria. From there, the 2nd term focused on automating this process in the near real-time aspect. This series of python scripts called the Surface Vegetation Detection Toolbox (SAVDT) are currently undergoing NASA software release process. The 3rd and final term of the project will aim to perfect the script and conduct accuracy assessment on the SAVDT outputs. During the term, the team will reach out to the project partners and virtually present the functionality of the SAVDT and how to set it up properly.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 5 TM** | Surface Reflectance | Landsat 5 TM is a 30m dataset that will aid in creating the methodologies for deriving water quality parameters. |
| **Landsat 8 OLI** | Surface Reflectance | Landsat 8 OLI is a 30m dataset that will be used in the improved Surface Aquatic Vegetation Detection Toolbox. In addition, the data will be used to derive water quality parameters. |
| **EO-1 Hyperion** | Surface Reflectance | EO-1 Hyperion is a 30m dataset with 220 bands and will be used to aid in the methodologies created for water quality parameters. |
| **Suomi NPP VIIRS** | Surface Reflectance | Suomi NPP VIIRS will be used to derive water quality parameters at a coarser resolution but for the entire Lake Victoria. |
| **Sentinel-2 MSI** | Surface Reflectance | Sentinel-2 MSI data will be used in collaboration with Landsat 5 TM and Landsat 8 OLI for increased temporal resolution. |
| **World View 2 & 3** | Surface Reflectance | Higher resolution data from World View 2 & 3  will be used to conduct an accuracy  assessment on the Surface Aquatic  Vegetation Detection Toolbox outputs. |

***Ancillary Datasets:***

Makerere University Department of Geomatics and Land Management *–* *in situ* measurements – *The* *in* situmeasurements will be provided by the project partner for use in determining water quality measurements using remote sensing techniques

***Modeling:***

Water Quality Parameters Model (POC: Leigh Sinclair, NASA DEVELOP Program)

Hyacinth-Vegetation Detection Algorithm (POC: Jeanné le Roux, University of Alabama Earth System Science Center)

Surface Aquatic Vegetation Detection Toolbox (SAVDT) (POC: Daryl Ann Winstead, NASA DEVELOP Program)

***Software & Scripting:***

Python 2.7 – Python scripting is used in the SAVDT

ArcMap 10.3 – Raster manipulation/analysis, image enhancement and map creation of Landsat 5 TM, Landsat 8 OLI, Suomi NPP VIIRS, and EO-1 Hyperion

ENVI Classic – Georeferencing Suomi NPP VIIRS

DEVELOP National Program Python Package (Dnppy) – Dnppy will be used for processing Landsat 5 TM and Landsat 8 OLI data to surface reflectance

**Decision Support Tool & End-Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| SAVDT Accuracy Assessment | The project partner will know the accuracy among the sensors used in the SAVDT. | The SAVDT uses Landsat and Sentinel-2 imagery as inputs. An accuracy assessment will be conducted on the SAVDT outputs. | N/A |
| Water Extraction Algorithm Script | The coastline will be updated every time the SAVDT is executed allowing for the script to keep up with the constantly changing water levels. The project partner will have a more accurate thematic layer from the SAVDT. | The SAVDT currently uses a designated coastline shapefile. The created script will extract the coastline from the imagery and will be implemented into the SAVDT | 3 |
| Surface Reflectance Python Script | The project partner will have Landsat outputs from SAVDT that are preprocessed so data can be used at the surface. | The SAVDT does not implement any scripting for surface reflectance on Landsat imagery. The created script will process the Landsat imagery inputs to surface reflectance. | 3 |

***End-User Benefit:***

The algorithms and products created will benefit the end-users at SERVIR Eastern & Southern Africa Hub, RCMRD, and Makerere University Department of Geomatics and Land Management by complementing their research on the water hyacinth and gaining a better understanding on what makes the plant thrive in Lake Victoria. Having a better understanding in this will result in future eradication efforts and water quality management in the lake.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 3 Terms: 2015 Fall (Start) to 2016 Fall (Completion)

***Multi-Term Objectives:***

* **Term 1:** 2015 Fall (MSFC) – Lake Victoria Water Resources I
  + The goal of this term was to gather historic satellite imagery to determine how the aquatic vegetation in the Winam Gulf area of the lake has changed over time. This was achieved by deriving model outputs using NDWI and MNDWI. After conducting an accuracy assessment, the MNDWI methodology proved to be more sufficient than the NDWI methodology.
* **Term 2:** 2016 Spring (MSFC) – Lake Victoria Water Resources II
  + The goal of this term was to implement the MNDWI methodology created during the Lake Victoria Water Resources I project into a near real time automated python script in order to complement the project partners’ research. The project also focused on the inclusion of Sentinel-2 MSI data for an increased temporal resolution over the course of the study period.
* **Term 3 (Proposed Term):** 2016 Fall (MSFC) – Lake Victoria Water Resources III
  + The objectives of this term will be to implement atmospheric correction for Landsat imagery into the SAVDT python script, implement a water extraction algorithm for an improved coastline shapefile into the SAVDT python script, conduct an accuracy assessment on the SAVDT outputs, and create an algorithm to derive water surface temperature while water hyacinth is present in Lake Victoria using remote sensing techniques.

***Related DEVELOP Work:***

2012 Fall (Great Lakes - GLSLCI) Great Lakes and St. Lawrence Basin Water Resources: Using NASA EOS to Monitor Nearshore Stormwater Runoff and its Effects on Water Quality within the Great Lakes to Enhance the Decision Support Tools Used by Policy Makers from Great Lakes and St. Lawrence Cities Initiative

2013 Summer (Langley Research Center) New England Water Resources: Monitoring of New England Freshwater Resources to Assess Turbidity, Algal Blooms, and Water Quality for Enhanced Natural Resource Management

2014 Spring (Langley Research Center) Lake Champlain Water Resources II: Utilizing NASA Earth Observations to Forecast Algal Blooms in Lake Champlain for Enhanced Water Resource Management

2014 Fall (University of Georgia) Georgia Inland Water Resources II: Developing a Cyanobacteria Tool for Georgia Inland Waters Using NASA Landsat OLI Data for Water Quality Protection and Restoration

**Notes & References:**

***References:***

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