**NASA DEVELOP National Program**

**Fall 2015 Project Proposal**

NASA Marshall Space Flight Center

**Lake Victoria Water Resources**

Spatio-Temporal Analysis of Lake Victoria Pollution and Algal Blooms using NASA Earth Observations for Improved Water Management

**Objective:**

To explore the capabilities of the Landsat series and Hyperion hyperspectral data to create a historical inventory of the lake’s characteristics, changes over time, pollution levels, and algal blooms.

**Community Concern:**

The water hyacinth is an invasive species to Africa and has spread prolifically due to the lake having favorable growing conditions. The hyacinth can have adverse impacts on the lake, outcompeting native plant species for space and nutrients, blocking boat access to the lake, and deoxygenating the water which kills aquatic life.

**Partner Organizations:**

SERVIR Coordination Office (Collaborator/Boundary Organization, POC: Africa Flores, Hub Science and Technical Lead)

SERVIR – Africa Team: Regional Centre for Mapping of Resources for Development (RCMRD) (Collaborator/Boundary Organization, POC: Dr. Robinson Mugo, Earth Observations Lead)

Regional Centre for Mapping of Resources for Development (RCMRD) (Collaborator/Boundary Organization, POC: James Nyaga Wanjohi, Graduate Research Assistant)

A meeting was held between the MSFC DEVELOP center leads and Eric Anderson of SERVIR during the fall of 2014 to discuss potential collaborative projects, and this project was identified to complement SERVIR efforts in the Lake Victoria region. RCMRD, SERVIR Eastern and Southern Africa (E&SA) Hub is developing an application to monitor water quality parameters in Lake Victoria. They are using MODIS satellite data to monitor water quality parameters such as chlorophyll concentration, temperature, and turbidity. SERVIR and RCMRD can utilize this project’s end-products as the foundation for future work to calibrate and validate models for the lake. The project partners will use similar techniques that are currently being used with MODIS and apply it to VIIRS. These end-products will help the project partners towards having a baseline of the lake so they can validate these new methodologies. Contact with RCMRD was initiated through Africa Flores. The main POC for RCMRD on this project is Dr. Robinson Mugo, who is the Earth Observations Lead at the SERVIR-Africa hub. James Nyaga Wanjohi will also be collaborating on the project.

**Letters of Support:** NASA SERVIR, Africa Flores, NASA SERVIR Hub Science and Technical Lead (copy of letter attached the email).

**Decision Making Process:**

Currently, water quality of Lake Victoria is measured using standard methods, such as taking water samples in the field to estimate water quality parameters. These methods are time consuming, expensive and only collect data from single point locations. Some key institutions already collecting data in the lake, using standards methods, are the Kenya Marine and Fisheries Research Institute (KMFRI), Tanzania Fisheries Research Institute (TaFIRI), and Lake Victoria Fisheries Organization (LVFO). RCMRD’s operational system and the work performed during this DEVELOP project will provide temporal and spatial water quality information over the lake. The information will be used by institutions such KMFRI, TaFIRI and LVFO to complement the current data they collect.

**Earth Observations:**

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| --- | --- | --- |
| **Platform** | **Sensor** | **Geophysical Parameter** |
| **EO-1** | Hyperion | Surface reflectance, water quality parameters such as suspended sediment and chlorophyll-a |
| **Landsat 5, 7, 8** | TM, ETM+, OLI and TIRS | Surface reflectance, land surface temperature, water quality parameters such as suspended sediment, chlorophyll-a |
| **Aqua/Terra** | MODIS | Suspended sediment, chlorophyll-a, land surface temperature |

**NASA Earth Observations Highlighted:**

The use of other satellite data, such as EO-1 Hyperion, with higher spatial and spectral resolution will provide valuable information to identify water hyacinth along the shores and hotspot areas within the Lake. This DEVELOP project will support RCMRD’s efforts to monitor water quality in Lake Victoria. Overall, the use of this suite of satellite resources will provide additional information to the application and products being developed by RCMRD for Lake Victoria.

EO-1 Hyperion data has 242 bands at 30m spatial resolution. This will offer more band combinations to enhance the detection of chlorophyll-a, suspended sediment, and the presence of hyacinth.

Landsat 5 TM, Landsat 7 ETM+, and Landsat 8 OLI and TIRS will be used to assess the water quality of Lake Victoria and how it has changed over time. Due to the spectral characteristics of chlorophyll-a, which strongly reflects green light (0.7-1.3µm) and absorbs light between 0.45-0.67µm, data from EO-1 Hyperion, Landsat, Aqua and/ Terra will be able to detect its presence in the water.

Aqua and Terra MODIS imagery offers daily coverage of the study area. The data will provide information about the water quality of the lake, as well as land surface temperature, which can be used to assess how quickly these characteristics change.

**Ancillary Datasets:**

*In-situ* measurements and observations of the presence of hyacinth from RCMRD

**Models:**

Cyanobacteria concentration algorithms (POC: Antonio Ruiz-Verdú, University of Valencia)

Normalized Difference Chlorophyll Index (NDCI) (POC: Dr. Sachi Mishra, Dow AgroSciences)

2-band Cyanobacteria Model (POC: Dr. Sachi Mishra, Dow AgroSciences)

Quasi-analytical Model (QAA) (POC: Dr. Sachi Mishra, DOW AgroSciences)

Phycocyanin Detection Model (POC: Dr. Robert Vincent, Bowling Green State University)

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

**Decision Support Tools & Analyses:**

|  |  |  |
| --- | --- | --- |
| **Proposed End Products** | **Decision to be Impacted** | **Current Partner Tool/Method** |
| Seasonal Chlorophyll Concentration Map | Determine areas in need of mitigation and prioritize study efforts | Product developed by RCMRD and/or Ocean Color group |
| Water Quality Parameters Hotspot Map | Determine areas in need of mitigation and prioritize study efforts | None |
| Hyacinth Extent Map | Determine areas in need of mitigation and prioritize study efforts | None |

*Seasonal Chlorophyll Concentration Map* – This map will be derived from MODIS chlorophyll measurements to identify high concentrations of chlorophyll. Hotspots of chlorophyll can be depicted by using the visible bands form the satellite.

*Water Quality Parameters Hotspot Map* - This map will combine poor water quality indicators (water surface temperature, chlorophyll, turbidity, phosphorous, colored dissolved organic matter (CDOM), organic carbon, and nitrogen) to identify hotspots of low water quality within Lake Victoria. Landsat and Hyperion data will be used to derive these water quality parameters.

**Project Details:**

**National Application Area Addressed:** Water Resources

**Source of Project Idea:** This project resulted from discussions with Eric Anderson and Africa Flores from NASA SERVIR about collaborating efforts from DEVELOP and SERVIR to monitor Lake Victoria in Kenya, Uganda, and Tanzania. During discussions of the project, it was indicated that SERVIR and 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.

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

**Period being Studied:** August 2000 to Present

**Advisor:** Dr. Jeffrey Luvall (NASA at NSSTC)

**Participants Requested:** 3-4

**Project Timeline:** 2 Terms: 2015 Fall – 2016 Spring

**Multi-Term Objectives:**

* **Term 1 (Proposed Term)** – The goal of this term is to gather historic satellite imagery to determine how the water quality of the lake has changed over time. The water quality parameters to be studied are water surface temperature, turbidity, chlorophyll, colored dissolved organic matter (CDOM), organic carbon, nitrogen, and phosphorus.
* **Term 2** – The goal of this term is to create a time series of the water quality changing in the lake, as well as determining where hotspots of water hyacinth are located throughout the lake. A methodology and Hyacinth Hotspot map will be handed off to Africa Flores, SERVIR.

**Previous Related DEVELOP Work:**

Fall 2012 (Mobile County Health Department/Langley Research Center) - Mobile Water Resources and Urban Development: Characterization of Urban Growth after Highway Reconstruction in the J.B. Converse Reservoir and Big Creek Lake Watershed

Fall 2012 (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

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

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

Summer 2014 (Langley Research Center) - New England Water Resources III: Historical Tracking of Harmful Algal Blooms Utilizing Landsat Missions from 1999-2013

Summer 2014 (University of Georgia) - Georgia Water Resources: Developing a Cyanobacteria Detection Tool for Georgia Inland Waters Using NASA Landsat 8 OLI Data for Water Quality Protection and Restoration

Fall 2014 (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

Spring 2015 (Marshall Space Flight Center) - Alabama Water Resources: Incorporating NASA Earth Observations in Spatial and Temporal Water Quality Monitoring of Alabama’s Inland Waters

**Software & Scripting Requested:**

* ArcGIS - Raster manipulation/analysis, image enhancement & map creation of Landsat TM, ETM+, OLI, and EO-1 Hyperion
  + ModelBuilder to mosaic, clip, and run analysis of the data
* ENVI Classic/5.0 - Raster manipulation/analysis of EO-1 Hyperion
* Dnppy model - Landsat data pre-processing to TOA reflectance

**Notes:** This project supports the efforts that both NASA SERVIR and RCMRD are doing at Lake Victoria. The results of this project will help KMFRI, TaFIRI, and LVFO with the research they are currently doing which will go into providing better decision-making policies. This project will also lay some ground work for KMFRI, TaFIRI, and LVFO in using VIIRS for water quality products when transitioning from MODIS, and will give them information about the lake which will help validate and calibrate their methodologies.

Hernandez, B. et al., Satellite Monitoring of Lake Atitlan in Guatemala: http://www.researchgate.net/profile/Shahbaz\_Khan8/publication/271770533\_Building\_KnowledKn\_Bridges\_and\_not\_Walls\_for\_a\_Sustainable\_Water\_Future/links/54d19bcc0cf28370d0e0da6d.ppd#page=244

Flores, A., 2013, Hyperspectral Remote Sensing of Water Quality in Lake Atitlan, Guatemala