**NASA DEVELOP National Program**

**2017 Spring Project Proposal**

**NASA Ames Research Center**

**Lake Erie Water Resources**

*Utilizing Satellite and Hyperspectral Airborne Imagery to Identify Annual and Seasonal Trends of Harmful Algal Blooms and Resulting Water Quality in Lake Erie’s Western Basin*

**Project Overview**

***Project Synopsis*:** Harmful algal blooms (HABS), have increased in Lake Erie over the past decade, and are negatively impacting ecosystem services (drinking water supplies, fisheries), and property values in the region. To address these concerns this project will involve partnering with the Ohio Environmental Protection Agency (EPA) and NASA Glenn Research Center to analyze trends associated with the formation of HAB events and cyanobacteria blooms. Researchers at NASA GRC will provide hyperspectral airborne data of Lake Erie, as well as *in situ* water quality datasets. These partners are interested in several objectives: determining dominant cyanobacterial groups in Lake Erie, applying FAI and NDTI to airborne imagery, and comparing Landsat satellite multispectral medium resolution imagery (30m pixel size) to hyperspectral high spatial resolution (1.2-2.4m pixel size depending on flying altitude) airborne imagery. Results of this research will be shared with the Division of Drinking and Ground Waters of the Ohio Environmental Protection Agency to enhance their decision making processes and continued monitoring of freshwater systems.

***Community Concern:*** Since the 1940’s, the health of Lake Erie has been threatened by eutrophication and HABs effecting hundreds of thousands of people in their daily utilization of cooking, drinking, and bathing water. Cyanobacteria, also known as blue-green algae, naturally occur in waterbodies and can become harmful when they proliferate in warm and shallow areas. *Microcystis*, the algae most commonly found in the Great Lakes, produces toxins that affect the brain, liver, and skin, and poses a significant risk to those who depend on the Great Lakes as a water source. In 2013, the Carroll township, along Lake Erie, experienced an emergency shutdown of its water supply due to abnormally high levels of toxic microcystisn, highlighting HABs as one of the greatest current threats to freshwater resources. Furthermore, half a million residents of the Maumee Bay Area were impacted in 2014 when a HAB event in Lake Erie forced the city of Toledo, Ohio to shut off its municipal drinking water system for several days.

***Source of Project Idea:*** This project originated from Carol Tolbert, a project manager within the Science Mission Directorate at NASA Glenn Research Center. She was made aware of the DEVELOP program at Ames Research Center through Dr. Sherry Palacios, and began to formulate a collaboration for a DEVELOP project between ARC and GRC.

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

***Study Location:*** Lake Erie, OH

***Study Period:*** June 2015 – September 2016

***Advisors:*** Dr. Juan Torres-Perez (Bay Area Environmental Research Institute), Dr. Sherry Palacios (Bay Area Environmental Research Institute)

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| Ohio Environmental Protection Agency (EPA) - Division of Drinking and Ground Waters | Heather Raymond, HAB Coordinator and Lead Hydrogeologist | End-User | No |
| NASA Glenn Research Center | Carol Tolbert, Program Manager | Collaborator | Yes |

***End-User Overview***

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

The Division of Drinking and Ground Waters of the Ohio EPA ensures compliance with the federal Safe Drinking Water Act and evaluates potential threats to source waters that supply the more than 4,800 public drinking water systems throughout the state. The division has a lead role for statewide ground water protection in cooperation with other state and federal agencies, implements a ground water quality monitoring program, and provides technical assistance to the Agency's waste management divisions.

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

*National Center of Water Quality Research (NCWQR)* – The NCWQR is interested in collaborating with DEVELOP due to similar water quality research and policy efforts, as they are working with agricultural communities, and find hyperspectral imagery valuable in this field. The Ohio EPA does not directly incorporate NASA Earth Observations into their monitoring, hence the importance of this partnership for this study.

***Collaborator & Boundary Organization Overview***

***Collaborator Support:***

 *NASA Glenn Research Center* (GRC) – NASA GRC will provide a syllabus for Lake Erie Harmful Algal Blooms, access to 2015 and 2016 aerial hyperspectral and *in situ* data generated by GRC for validation, and connection to advisors (regional experts in hyperspectral data analysis and freshwater algal activity) who may provide student guidance and research input during the project.

***Dissemination by Boundary Organizations*:**NASA Glenn Research Center has a list of users to whom they disseminate their weekly algal intensity maps, including the Ohio Environmental Protection Agency (EPA). They also send routine updates and newsletters to these organizations, and will incorporate results from the DEVELOP project in said newsletters.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** During the research term, the team will have weekly teleconferences with NASA Glenn Research Center and the Ohio EPA. The main POC for this communication will be Brittany Zajic, current Center Lead at NASA Ames Research Center.

***Transition Plan*:** A formal end-user handoff will take place at the end of the research term in the form of a WebEx teleconference. Results will be sent via NASA’s Large File Transfer (LFT). This project is not likely to require software release.

***Letters of Support*:** Carol Tolbert,Program Manager, NASA Glenn Research Center

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Landsat 8 – Operational Land Imager (OLI)** | Sediment deposition, water color, true color images, surface water temperature, Floating Algal Index (FAI) | This sensor can detect spectral radiance of Lake Erie, surface water temperature, near shore sediment, chlorophyll concentration, and true color images that are indicators of algal growth. |
| **Aqua - MODIS** | Chlorophyll-a, water color, surface water temperature, turbidity | This sensor can detect spectral radiance of Lake Erie, surface water temperature, near shore sediment, chlorophyll concentration, and true color images that are indicators of algal growth. |
| **Aircraft HSI – Hyperspectral Imaging (GRC)** | Spectral signature, sediment deposition | This sensor will provide enhanced detection of HABs to identify and analyze trends.  |

***Ancillary Datasets:***

NOAA GLERL – Weather, wind speed / temperature, precipitation, modeled water temperature, chlorophyll-a, turbidity, and air temperature – *in situ* validation data for hyperspectral imagery

Ohio EPA and Ohio State University’s Stone Lab – Water quality data and cyanobacteria levels from water buoys and sampling cruises - *in situ* validation data for hyperspectral imagery

***Software & Scripting:***

Exelis ENVI – Processing imagery from Earth Observations

Python – Create scripts to enhance data processing

TerrSet – Earth Trends Modeler for time series analysis

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product(s)** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| Time Series of Harmful Algal Blooms in Lake Erie  | Historical understanding of HAB events will help predict future events | Time series of Landsat and hyperspectral imagery of historical HAB occurrences will help drive agricultural policy decisions within the Great Lakes Region. Data will be processed and analyzed using ENVI and Python. | N/A |
| Results and Analysis of Hyperspectral Data | Modeled outputs of HABs within Lake Erie will improve response to water quality issues in Lake Erie, organize restoration projects, and address water contamination issues in the community. | The hyperspectral imagery will be analyzed in TerrSet using the Earth Trends Modeler | N/A |
| HAB Watches | Alert the public of HAB events though monthly newsletters outlining current water quality trends.  | Imagery and analysis | N/A |

***End-User Benefit*:**

The Division of Drinking and Ground Waters mission is to protect human health and the environment by characterizing and protecting ground water quality and ensuring that Ohio's public water systems provide adequate supplies of safe drinking water. The objective of this project is to enhance the division’s knowledge of HABs in regards to early detection, causes, and continued monitoring as a result of high spatial resolution hyperspectral imagery provided by the GRC. Results and end products of this project will directly align with the division’s mission to increase their overall knowledge of HABs and thus increase the community’s knowledge as well.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 1 Term: 2017 Spring

***Related DEVELOP Work:***

2016 Fall (FC) – Rocky Mountain National Park Climate: Assessing the Feasibility of Monitoring Algal Productivity Using Landsat 8, Sentinel-2, and WorldView-2 to Inform Spatiotemporal Alpine Lake Dynamics in Rocky Mountain National Park

2016 Summer (UGA) – Southeast Ecological Forecasting III: Utilizing NASA Earth Observations and Proximal Remote Sensing for Mapping the Spatio-Temporal Distribution of Hydrilla verticillata

2015 Summer (ARC) – Lake Erie Water Resources II: Methodology Validation for Quantitative Analysis to Model Indicators of Harmful Algal Blooms in the Maumee River Watershed of Lake Erie

2015 Spring (ARC) – Lake Erie Water Resources I: Utilizing NASA Satellite Data to Model Indicators of Harmful Algal Blooms in the Maumee River Watershed of Lake Erie

2012 Fall (LaRC) - Monitoring Nearshore Stormwater Runoff with the Great Lakes: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