**NASA DEVELOP National Program**

NASA Ames Research Center

*Spring 2017*

**Short Title: Lake Erie Water Resources**

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

**VPS Title:** Wildfires of the Water: Remote Sensing of Harmful Algal Blooms in Lake Erie

**Project Team & Partners**

**Project Team:**

Rachel Green (Point of Contact), rachel.k.green@nasa.gov

John Dilger

Rachel Johnson

**Advisors & Mentors:**

Dr. Juan Torres-Perez (Bay Area Environmental Research Institute, NASA Ames Research Center)

Dr. Sherry Palacios (Bay Area Environmental Research Institute, NASA Ames Research Center)

**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 (GRC) | Dr. Carol Tolbert, Program Manager  Dr. John Lekki, Optical Systems Research Engineer | Collaborator | Yes |
| NOAA Great Lakes Environmental Research Laboratory (GLERL) | Dr. Andrea VanderWoude, Remote Sensing Specialist | Collaborator | No |

**Project Details**

**Applied Sciences National Applications Addressed:** Water Resources

**Study Area:** Lake Erie, OH

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

**Earth Observations & Parameters:**

Glenn Hyperspectral Imager II - Spectral signatures at 1 meter spatial resolution

Aqua, Moderate Resolution Imaging Spectroradiometer (MODIS) – Spectral signatures at 1 kilometer spatial resolution

Landsat 8, Operational Land Imager (OLI) – Spectral signatures at 30 meter spatial resolution

**Ancillary Datasets Utilized:**

* NOAA GLERL – Chlorophyll-a, turbidity, and phycocyanin *in situ* measurements
* Ohio EPA and Ohio State University’s Stone Lab – Phycocyanin, microcystin, and chlorophyll-a *in situ* measurements

**Software Utilized:**

* Exelis ENVI – land classification of Landsat 8 imagery, hyperspectral imagery, and Aqua MODIS. Preprocessing of hyperspectral imagery.
* Interactive Data Language (IDL) - statistics and data analysis

**Project Overview**

Our objective was to determine the comparative advantages of utilizing hyperspectral sensor imagery (HSI), Landsat 8, or Aqua MODIS to detect and predict microcystin levels in Lake Erie’s Western Basin. We implemented a suite of algorithms to remotely sensed imagery in order to detect the presence of cyanobacterial harmful algal blooms. The analysis of hyperspectral imagery, multispectral imagery, and corresponding *in situ* water quality datasets for Lake Erie contributes to further understanding bloom formation and growth. Our results were shared with our project partners to improve their water quality monitoring process, risk assessment and bloom event preparedness.

**Abstract:**

Harmful algal blooms (HABs) in the Western Basin of Lake Erie have been increasing in frequency and severity over the past decade. Cyanobacteria is the dominant phylum in the blooms that occur in Lake Erie. *Microcystis*, a species of cyanobacteria, is of particular concern due to its ability to produce microcystin, a toxin that can adversely affect human health in high enough concentrations. So far, abnormally high concentrations of microcystin have incited the temporary shutdown of two water treatment facilities causing the communities dependent on those facilities to be without drinking water. Additionally, the blooms harm ecological, economic, and recreational services in the region. This study utilized Landsat 8 - Operational Land Imager (OLI), Aqua - Moderate Resolution Imaging Spectroradiometer (MODIS), NASA Glenn Research Center’s aircraft hyperspectral imaging (HSI) sensor, Glenn Hyperspectral Imager II, and corresponding *in situ* data to aid in monitoring and predicting HAB events. The Cyanobacteria Index (CI), Floating Algae Index (FAI), Normalized Difference Turbidity Index (NDTI), and PHYDOTax algorithms were correlated with *in situ* data to determine the most effective method of cyanobacteria detection and prediction. The comparative analysis can be used to better inform managers of the most efficient and effective observational platforms so to optimize the response time for HAB events.

**Keywords:**

Aqua MODIS, Landsat 8 - OLI, aircraft HSI, remote sensing, cyanobacteria, phycocyanin, *Microcystis*, risk assessment

**Current Management Practices & Policies**:

In compliance with the federal Safe Drinking Water Act, the Ohio Environmental Protection Agency Division of Drinking and Ground Waters evaluates potential threats to source waters that supply potable water to 4,800 public drinking water systems within the state. The division, in cooperation with other state and federal agencies, is responsible for protecting Ohio’s ground water through the implementation of a groundwater monitoring program and provision of technical assistance to the Ohio EPA’s waste management divisions.

**Community Concerns:**

* Cyanobacterial blooms in Lake Erie produce a toxin, microcystin, which poses a threat to public health through the contamination of water resources used every day by millions of people for drinking, cooking and agriculture. Exposure has been linked to various health issues including skin irritation, liver failure or cancer, and even death.
* Rising lake temperatures and increased eutrophication have produced more frequent HAB events in Lake Erie.
* In 2013, Carroll Township, Ohio along Lake Erie had an emergency shutdown of its drinking water supply due to abnormally high levels of toxic microcystin. The event lasted nearly two days and affected 2,000 Ohio residents.
* In 2014, a harmful algal bloom event led to the shutdown of municipal drinking water in Toledo, Ohio for several days. This event impacted half a million residents of the Maumee Bay Area.

**Decision Support Tools & Benefits:**

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| --- | --- | --- | --- |
| **End-Product** | **Earth Observations Used** | **Benefit & Impact** | **Software**  **Release** |
| Time Series of Harmful Algal Blooms in Lake Erie | Landsat 8 - OLI, Aqua MODIS, and Glenn Hyperspectral Imager II. | Historical understanding of HAB events with help predict future events. | N/A |
| Results and Comparative Analysis of Airborne, Satellite and *In Situ* Data | Landsat 8 - OLI, Aqua MODIS, and Glenn Hyperspectral Imager II. | 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. | N/A |
| HAB Watches | Landsat 8 - OLI, Aqua MODIS, Glenn Hyperspectral Imager II. | Alert the public of HAB events through monthly newsletters outlining current water quality trends | N/A |