**NASA DEVELOP National Program**

****Ames Research Center

**Spring 2015**

**Lake Erie Water Resources**

*Utilizing NASA Satellite Data to Detect Harmful Algal Blooms in the Western Basin of Lake Erie*

**Project Team:**

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**Partner Organizations**

Bay Area Environmental Research Institute (BAERI) - National Geospatial-Intelligence Agency (NGA), End-user, POC: Dr. Cindy Schmidt, Dr. Sherry Palacios, and Chase Mueller M.S.

National Center of Water Quality Research (NCWQR), End-User, POC: Dr. Laura Johnson and Dr. Rem Confesor

University of Toledo (UT), Collaborator, POC: Dr. Ricky Becker, Dr. Kevin Czajkowski

Great Lakes and St. Lawrence Cities Initiative, Boundary organization, POC: Dave Ullrich

**Applied Sciences National Applications Addressed:**

Water Resources

**Study Area:**

This study was conducted for Lake Erie, which is the smallest of the five Great Lakes in North America. The lake is centered at approximately 42°07'35.7"N 81°20'43.2"W located at the southern border of Canada and the northern border of the United States.

For the purposes of DEVELOP impact maps and metrics (as initially requested): States that border Lake Erie include: Michigan, Ohio, Pennsylvania, New York, and the Canadian province of Ontario.

**Study Period:**

Spring and summer months (March through September) for years 2005, 2011, 2013 and 2014

**Earth Observations & Parameters**

Landsat 7, Enhanced Thematic Mapper Plus (ETM+) - Visual & Near Infrared Bands used within the FAI, NDTI and PII indices

Landsat 8, Operational Land Imager (OLI) - Visual & Near Infrared Bands used within the FAI, NDTI and PII indices

Terra, MODIS - Visual & Near Infrared Bands (Ocean Color) used within the FAI, NDTI and PII indices

**80-100 Word Objectives Overview**

This project’s objectives involved validating indices (floating algal index, normalized difference turbidity index, phycocyanin intensity index) derived from Landsat and MODIS products by comparing these outputs to Lake Erie *in-situ* data. Other objectives included representing the final statistics of this validation technique, and documenting the workflow of this project to assist NGA partners in understanding the accuracy of applying these remotely-sensed indices in other regions of the world.

**Abstract**

Harmful algal bloom events, or HABs, have increased in Lake Erie and are negatively impacting drinking water supplies as well as fisheries and property values. HAB events also pose a risk to water resources around the world, drawing various stakeholders to take steps towards mitigation efforts and to better understand its effects on nearby communities.  Remote sensing is proving to be a useful tool for HAB detection, and can be applied in areas of the world where *in-situ* data is either inaccessible or extremely costly. To validate the precision of remote sensing in detecting HAB events, we applied two indices to satellite imagery obtained over Lake Erie. The indices were compared against *in-situ* data to assess satellite accuracy statistics.  These indices included Floating Algal Index (FAI) and Normalized Difference Turbidity Index (NDTI). Both indices were applied to visual and near-infrared products from NASA Earth Observing System’s Landsat 5 Thematic Mapper(TM), Landsat 8 Operational Land Imager (OLI), and Terra Moderate-Resolution Imaging Spectrometer (MODIS), as well as data from the Hyperspectral Imager for the Coastal Ocean (HICO) aboard the International Space Station (ISS).  The National Geospatial-Intelligence Agency (NGA), National Center of Water Quality Research (NCWQR), the University of Toledo, and the Great Lakes and St. Lawrence Cities Initiative utilizes these methods and end-results to evaluate the potential of applying these indices within Lake Erie and other regions of the world.

**Community Concerns**

* HAB events can be toxic, and lead to problems such as impaired water quality, damaged ecosystem health, and negatively impacting drinking water supplies, fisheries, recreational areas and property values.
* In 2011, Lake Erie experienced its largest HAB event in history, totaling to about 5,000 square kilometers of algal mass. This further publicized Lake Erie’s HAB event problem, and its consequential environmental and community issues.
* In 2013, the Carroll township drinking water supply along Lake Erie experienced an emergency shutdown due to abnormally high levels of toxic microcystin, highlighting HABs as one of the greatest current threats to freshwater resources.

**Current Management Practices & Policies**

Current management practices involving Lake Erie algal blooms include a stream gauge sensor network along major tributaries to collect data on nutrient loading into Lake Erie. Field campaigns are also conducted to collect *in-situ* data through multiple agencies and various remote sensing investigations, including overflight of airborne sensors. The NGA are specifically using the same project indices to test for HABs in other areas of the world to improve water systems monitoring. However, increased confidence in these satellite data products are needed.

**Decision Support Tools**

* Provide a methodology for calculating total algae, turbidity, and cyanobacteria through scripts created to interpret remotely sensed imagery.
* Calculate the statistics of the accuracy and reliability results that validate the use of satellite imagery to determine water quality remotely.
* Create datasets of each index from all three satellite sensors.

**Benefit to End-User:**

* The ability to use remotely sensed data to conduct research for HABs in Lake Erie and from remote or inaccessible regions of the world.

**Models Utilized**

NGA reflectance to Index script, to run:

* Floating Algal Index (FAI)
* Normalized Difference Turbidity Index (NDTI)
* Phycocyanin intensity index

**Ancillary Datasets Utilized**

* University of Toledo Maumee River GIS Dataset – Watershed boundary shapefiles
* International Field Years on Lake Erie (IFYLE) Field Sampling Data – Chlorophyll-a, Total Suspended Matter, phycocyanin measurements
* NOAA GLERL Master Stations - Chlorophyll-a, Total Suspended Matter, phycocyanin measurements buoy data

**Software Utilized**

ArcGIS - Raster Manipulation/Analysis, Image Enhancement & Map Creation of Landsat series data, Aqua/Terra MODIS, and HICO

ENVI – Manual band algorithm calculations to quality check script calculations