Monitoring Harmful Algae Blooms (HABs) in the Great Lakes Using MODIS Satellite Data

Robert Shuchman, Ph.D.
MTRI
shuchman@mtu.edu
(734) 913-6860

Mike Sayers
MTRI
mjsayers@mtu.edu
(734) 913-6852

Zach Raymer
MTRI
zbraymer@mtu.edu
(734) 913-6865

Michigan Tech Research Institute (MTRI) + Michigan Technological University
3600 Green Court, Suite 100 + Ann Arbor, MI 48105
(734) 913-6840 + Phone + (734) 913-6880 + Fax + www.mtri.org

Gary Fahnenstiel, Ph.D.
MTRI/GLRC
gfahnen@mtu.edu
(231) 759-7824

Colin Brooks
MTRI
cbrooks@mtu.edu
(734) 913-6859

George Leshtevich
NOAA/GLERL
george.leshtevich@noaa.org
(734) 741-2265

Harmful algal blooms pose a serious risk to public health. MTRI is developing a multi-faceted approach towards monitoring such blooms with satellite data. Only satellite system (MERIS) designed to directly detect cyanobacteria went dark in 2012. Needed a new approach to work on existing satellite assets as well as new sensors as they become available.

Harmful algal blooms pose a serious risk to public health. MTRI is developing a multi-faceted approach towards monitoring such blooms with satellite data. Only satellite system (MERIS) designed to directly detect cyanobacteria went dark in 2012. Needed a new approach to work on existing satellite assets as well as new sensors as they become available.

Visualizing Time Series Data

The figure to the left shows the cumulative HAB occurrence Heat Map for the Western Basin of Lake Erie. This map was generated by summing the individual Heat Maps (to the far left). The southern shore of the Western Basin experiences the most frequent HAB occurrence over the decadal observational period. As distance increases from the mouth of the Maumee River, HAB occurrence decreases.

MODIS-Based Multi-Faceted Harmful Algal Bloom Mapping Algorithm

Atmospherically Corrected MODIS Satellite Data (250/1000m)
- Surface Algae Maps
- Plume Mapping (Sediment, Algae, and Clear Water)
- CPA (Chlorophyll a, CZOM, Suspended Mineral)
- In-situ Chlorophyll
- HAB Extent Maps
- Phytoplankton (NIR – Red / NIR + Red)
- NIR from open water
- Sediment Plume Extent
- Sub-surface Algal Mat Extent
- Water Quality and Public Health
- Public Health Advisory Extent
- Microcystin > 20µg/L (Surface Algal Mat)
- Water Quality / Public Health
- Harmful Algae Bloom Maps
- NDVI (NIR – Red / NIR + Red)
- NIT (NIR – Red / NIR + Red)
- NIR threshold from open water
- Phytoplankton (NIR – Red / NIR + Red)
- Microcystin > 20µg/L (Surface Algal Mat)
- Water Quality / Public Health

Detection of Surface Algae Mats

- Identify locations where algae filaments are at the air/water interface
- Utilize the Near-Infrared component of the EM spectrum
  - NDVI (NIR – Red / NIR + Red)
  - NIR threshold from open water
  - Phytoplankton (NIR – Red / NIR + Red)
  - Microcystin > 20µg/L (Surface Algal Mat)
- Concentrations greater than 300 µg/L are not discernible (Kuster et al., 2006)

Detection of Sub-surface Cyanobacteria

- Floating surface scum mats represent the highest concentrations of toxin (Kuster et al., 2004)
- Concentrations greater than 300 µg/L are not discernible (Kuster et al., 2006)

Long Term Data Trends

The top left graph shows no observed phycocyanin when chlorophyll a is < 18 µg/L; however there is a linear relationship between chlorophyll-a and phycocyanin when chlorophyll-a > 18 µg/L (top right graph). This data is invaluable for sensors lacking the spectral channels to optically determine phycocyanin concentrations directly. Therefore chlorophyll-a concentration can be used to make a reasonable assumption as to the presence of the HAB photopigment phycocyanin, which is related to microcystin toxin concentration.

Detection of Sub-surface Cyanobacteria

The right hand picture is the deployment of Satlantic instrument cluster used to measure in-situ radiance/irradiance. The left hand picture is of a HAB Scum found in the Western Basin of Lake Erie.

NOAA GLERL 2011 + MTRI 2013

MTRI

Colin Brooks
MTRI
cbrooks@mtu.edu
(734) 913-6859

George Leshtevich
NOAA/GLERL
george.leshtevich@noaa.org
(734) 741-2265

Harmful Algal Blooms pose a serious risk to public health when toxin concentrations become high enough (>20 µg/L microcystin, WHO). Harmful algae also pose a risk to lake water quality as drinking water becomes unsuitable at 1 µg/L of microcystin (Water Quality Advisory). Cyanobacteria can be identified from satellite imagery. Monitoring Cyanobacteria blooms with satellites can provide information about water quality and provide alerts when public health is at risk.

Visualizing Time Series Data

The graphic below is the Annual Occurrence Hot Spot map for the Western Basin in Lake Erie. This figure was generated by summing the number of HAB occurrences at each pixel within the given year. Note on the figure hot colors (yellow, orange, red) represent areas with more HABs occurrences. Black areas indicated no HAB occurrences in a given year.

Visualizing Time Series Data

The figure to the left shows the Average Total Extent of Harmful Algal Blooms in the Western Basin of Lake Erie from 2002 through 2013. The blue line on the figure is the least squares best fit and indicates the HABs extent has increased over the decadal observational period. The average area was relatively consistent through 2007, after which the area generally increases through the present (2013).

Visualizing Time Series Data

The figure to the left shows the cumulatively Harmful Algae Bloom Maps for the years 2002-2013 for the Western Basin of Lake Erie. This map was generated by summing the individual Heat Maps (to the far left). The southern shore of the Western Basin experiences the most frequent HAB occurrence over the decadal observational period. As distance increases from the mouth of the Maumee River, HAB occurrence decreases.

Visualizing Time Series Data

The left hand picture is the deployment of Satlantic instrument cluster used to measure in-situ radiance/irradiance. The right hand picture is of a HAB Scum found in the Western Basin of Lake Erie.

Visualizing Time Series Data

The top left graph shows no observed phycocyanin when chlorophyll a is < 18 µg/L; however there is a linear relationship between chlorophyll-a and phycocyanin when chlorophyll-a > 18 µg/L (top right graph). This data is invaluable for sensors lacking the spectral channels to optically determine phycocyanin concentrations directly. Therefore chlorophyll-a concentration can be used to make a reasonable assumption as to the presence of the HAB photopigment phycocyanin, which is related to microcystin toxin concentration.

Visualizing Time Series Data

The left hand picture is the deployment of Satlantic instrument cluster used to measure in-situ radiance/irradiance. The right hand picture is of a HAB Scum found in the Western Basin of Lake Erie.