LINKING SATELLITE IMAGERY WITH WATER QUALITY TO DETECT ALGAL BLOOMS IN LAKE OKEECHOBEE

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Lake and River Ecosystems Section
Pelagic Zone – Deepest area, fluid mud sediments, turbid water, higher nutrients

Nearshore Zone – Clear or turbid water, submersed plants, bulrush, knot grass, cattail

Littoral (Marsh) – Shallow areas, dense vegetation, lower nutrients, clearer water
Monitoring Algae on Lake Okeechobee

In Lake Water Quality Monitoring

- 17 Monthly monitoring stations (surface water)
  - 8 nearshore stations
  - 9 pelagic stations
- Monitoring conducted monthly for nutrients and bloom conditions (chlorophyll $a$)
- Species ID and abundance, Microcystin-LR measured monthly at subset of 6 stations (surface water)

❖ Additional monitoring at FDEP request during blooms

- Additional samples from observed bloom areas for dominant species ID and Microcystin-LR
Investigating the Use of Satellite Imagery to Predict Algal Blooms on Lake Okeechobee
A NOAA, SFWMD and FDOH Partnership

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Figure 1. MERIS imagery of the 2010 Lake Okeechobee bloom. Corresponding Field chlorophyll a measurements collected by SFWMD.

The District is currently working with NOAA and FDOH on a partnership to collect instantaneous surface reflectance data. These readings are being taken using a Hand Held Hyperspectral Radiometer on loan to the District from NOAA. The readings are being gathered with concurrent grab collections of Chlorophyll a taken during the Lake Okeechobee ambient water quality monitoring trips.

The District’s current Lake Okeechobee algal bloom monitoring program is useful for providing general trends on localized bloom conditions, however, the extrapolation of these data are limited spatially. A more frequent, less time consuming determination of algal bloom conditions on Lake Okeechobee would allow for timelier management decisions.

Figure 2. Wavelength data collected from the Hyperspectral Radiometer (The HyperGun) by SFWMD staff. Field radiometry is being used to develop a correlation between satellite retrievals and in situ Chl a. The SFWMD is supplying NOAA staff with processed HyperGun readings and real time water quality data.

LOOKING FORWARD – POTENTIAL FUTURE USES

- Linking to current and future models (e.g. Lake Okeechobee Ecological Model) to allow predictions of bloom movements
- Providing algal bloom data for other major water bodies within the District’s purview
- Providing a readily available and affordable option for monitoring and forecasting potentially harmful blooms for public health protection and response (FDOH)

Figure 3. Most recent Algal Bloom Health Bulletin distributed by FDOH reporting bloom conditions in major water bodies in the St. John’s River Water Management District and in Lake Okeechobee. Data from Lake Okeechobee has not been validated.

There has been an increasing occurrence of Cyanobacterial blooms in Florida’s lakes, rivers, and estuaries. NOAA has verified that in open water, the MERIS satellite imagery is a better indicator of cyanobacteria blooms than chlorophyll a concentrations alone. The use of spectral shape algorithms removes the complications associated with atmospheric corrections and sediments. NOAA is applying the same algorithms developed to detect cyanobacteria blooms from the MERIS satellite images of large water bodies and seeing if it holds true in Lake Okeechobee.

The satellite images above are generated with a Medium Resolution Imaging Spectrometer (MERIS) Satellite. These remotely-sensed products are validated with in situ data. MERIS’s temporal resolution has advanced the ability to monitor high biomass blooms and track the development of individual bloom events. These modeling techniques can be incorporated into an operational forecasting system.
Lake Okeechobee Water Quality
*Provisional Data*

SFWMD considers an algal bloom to be >40 µg/L Chl a
BDL-Below detectable limit of 0.20 µg/L

### July 9 - 10, 2019

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<th>Site</th>
<th>Chlorophyll a (µg/L)</th>
<th>Microcystin (µg/L)</th>
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Gray = Cloud Cover

NOAA cyanobacteria product derived from
Copernicus Sentinel-3 OLCI data from EUETSAT

Lake Okeechobee July 11, 2019

Estimated Bloom Potential
Lake Okeechobee
Cyanobacteria FDEP Sampling

➢ 14 samples taken in apparent bloom (per satellite imagery)
➢ 4 samples in NE had low toxin
➢ no observable bloom
➢ no dominant taxa in 10 samples
➢ no toxin detected in 10 samples

Sample map from https://floridadep.gov/dear/algal-bloom/content/algal-bloom-sampling-results

- 1.10 µg/L (8/6) Microcystin
- 0.47 µg/L (7/24) Microcystin
- 2.10 µg/L (7/30) Microcystin
- 0.56 µg/L (7/24) Microcystin

No detect in apparent bloom
Detect in apparent bloom
Lake Okeechobee
July 2019 Cyanobacteria Bloom Potential

NOAA cyanobacteria product derived from Copernicus Sentinel-3 OLCI data from EUMETSAT

Gray = Cloud Cover
Lake Okeechobee Cyanobacteria Bloom Potential - Day to Day

Lake Okeechobee
July 13, 2018
NOAA cyanobacteria product derived from Copernicus Sentinel-3 OLCI data from EUMETSAT
Estimated Bloom Potential

Lake Okeechobee
July 14, 2018
NOAA cyanobacteria product derived from Copernicus Sentinel-3 OLCI data from EUMETSAT
Estimated Bloom Potential

Lake Okeechobee
July 17, 2018
NOAA cyanobacteria product derived from Copernicus Sentinel-3 OLCI data from EUMETSAT
Estimated Bloom Potential

Lake Okeechobee
July 18, 2018
NOAA cyanobacteria product derived from Copernicus Sentinel-3 OLCI data from EUMETSAT
Estimated Bloom Potential

sfwmd.gov
Lake Okeechobee Cyanobacteria Bloom Potential - Yearly

Early July

Lake Okeechobee July 7, 2016
Lake Okeechobee July 6, 2017
Lake Okeechobee July 2, 2018
Lake Okeechobee July 7, 2019

Mid July

Lake Okeechobee July 22, 2016
Lake Okeechobee July 16, 2017
Lake Okeechobee July 18, 2018
Lake Okeechobee July 19, 2019

Gray = Cloud Cover
Lake Okeechobee Phytoplankton Divisions and Bloom Potential

**June 2016**
- Chl a = 39 µg/L
- Micro = 0.5 µg/L
- Chl a = 278 µg/L
- Micro = 18.0 µg/L
- Chl a = 22 µg/L
- Micro = 8.8 µg/L

**July 2016**
- Chl a = 62 µg/L
- Micro = 0.4 µg/L
- Chl a = 22 µg/L
- Micro = 6.6 µg/L
- Chl a = 17 µg/L
- Micro = 1.1 µg/L

**August 2016**
- Chl a = 60 µg/L
- Micro = 0.6 µg/L
- Chl a = 56 µg/L
- Micro = 0.2 µg/L
- Chl a = 51 µg/L
- Micro = 0.5 µg/L
- Chl a = 9 µg/L
- Micro = BDL
Lake Okeechobee Cyanobacteria Species and Bloom Potential

**June 2016**
- Chl $\alpha = 39 \, \mu g/L$
- Micro $= 0.5 \, \mu g/L$
- Chl $\alpha = 278 \, \mu g/L$
- Micro $= 18.0 \, \mu g/L$

**July 2016**
- Chl $\alpha = 62 \, \mu g/L$
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- Chl $\alpha = 22 \, \mu g/L$
- Micro $= 6.6 \, \mu g/L$
- Chl $\alpha = 9 \, \mu g/L$
- Micro $= BDL$
- Chl $\alpha = 51 \, \mu g/L$
- Micro $= 0.5 \, \mu g/L$
Chla at L006 on June 15, 2016 = 48.3 µg/L
Chla at LZ30 on June 15, 2016 = 278 µg/L
New growth of *Vallisnaria*, nearshore Indian Prairie

Secchi Depth at LZ40

20 cm

*Chara* lawn in Bay Bottom
Interpreting algal bloom product from NOAA is challenging with lower lake levels, clearer water in nearshore. Only in pelagic areas, where clarity is lower and algae are accumulated on surface, is there more of a “scum” visible (right product). NOAA working on issue right now.
SeaPRISM on LZ40 Weather Platform

Installed and Maintained by HBOI

LZ40 Weather Platform (photo by Malcolm McFarland, HBOI)

LZ40
SITE: LZ40
ACTIVITY_TYPE: Hydrometeorologic
ACTIVITY_SUBTYPE: Weather
STATUS: Active
START_DATE: 04/25/1990
END_DATE: 06/12/2018
STATION_DESC: LZ40 WEATHER STATION ON LAKE OKEECHOBEE
POINT_X: 724932.19285525
POINT_Y: 933536.31144524
LAT: 26.901815
LON: -80.7890025
The SeaPRISM is an autonomous, robotic light sensor that continuously measures incident sunlight and light reflected from the water.

Part of NASA's Aerosol Robotic Network (Aeronet)

Data transmitted over cell network to NASA servers for processing and archiving

All data publicly available at: https://aeronet.gsfc.nasa.gov/new_web/index.html
Reflectance decreases during summer and fall with higher algal biomass (Greens and Yellows)

Reflectance is highest during winter and early spring with less algal biomass (Orange and Reds)
Limitations / Issues

- Complex System
- Scale
  - Spatial
  - Temporal
- Water Clarity
  - Lake Levels
  - Turbidity/CDOM
- Cloud Cover
- Public perception

Cyanobacteria Bloom Potential

Lake Okeechobee
June 25, 2016

NOAA cyanobacteria product derived from Copernicus Sentinel-3 OLCI data from EUMETSAT

Estimated Bloom Potential
Questions?