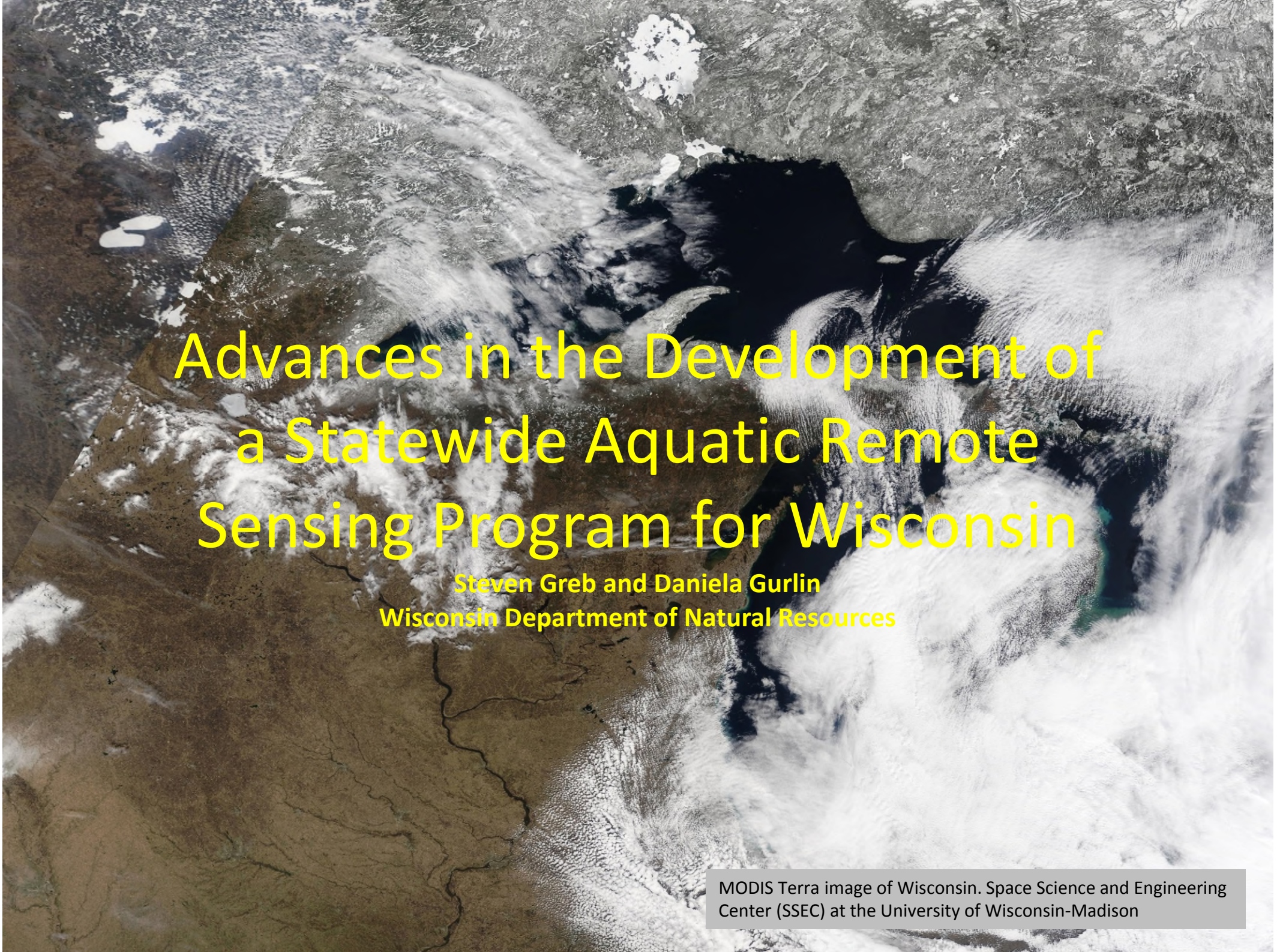
Advances in the Development of a Statewide Aquatic Remote Sensing Program for Wisconsin

Steven Greb and Daniela Gurlin
Wisconsin Department of Natural Resources

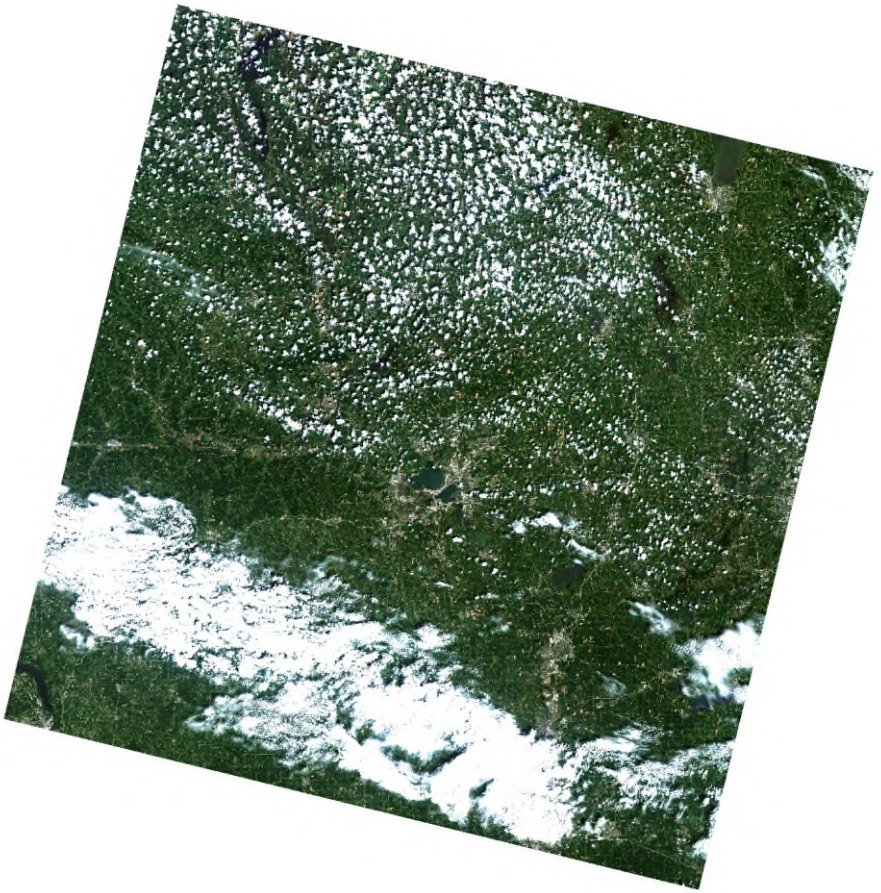


MODIS Terra image of Wisconsin. Space Science and Engineering Center (SSEC) at the University of Wisconsin-Madison

Remote sensing activities at the WDNR

Towards new monitoring capabilities

- Systematic processing of Landsat 7 ETM+ and Landsat 8 OLI imagery for water clarity
- Studies of the major drivers of lake water clarity, their interactions, and the potential impacts of land use and climate on water clarity
- Increase in earth observation monitoring capabilities through the optical and biogeochemical characterization of lakes in support of algorithm calibration, refinement, and validation



Landsat 8 image of southern Wisconsin from 08/13/2014. U.S. Geological Survey

Current and future sensors

New tools in the toolbox

Sentinel 3 - ESA Image

Key earth observation sensors suitable for water quality assessment with public access data policy

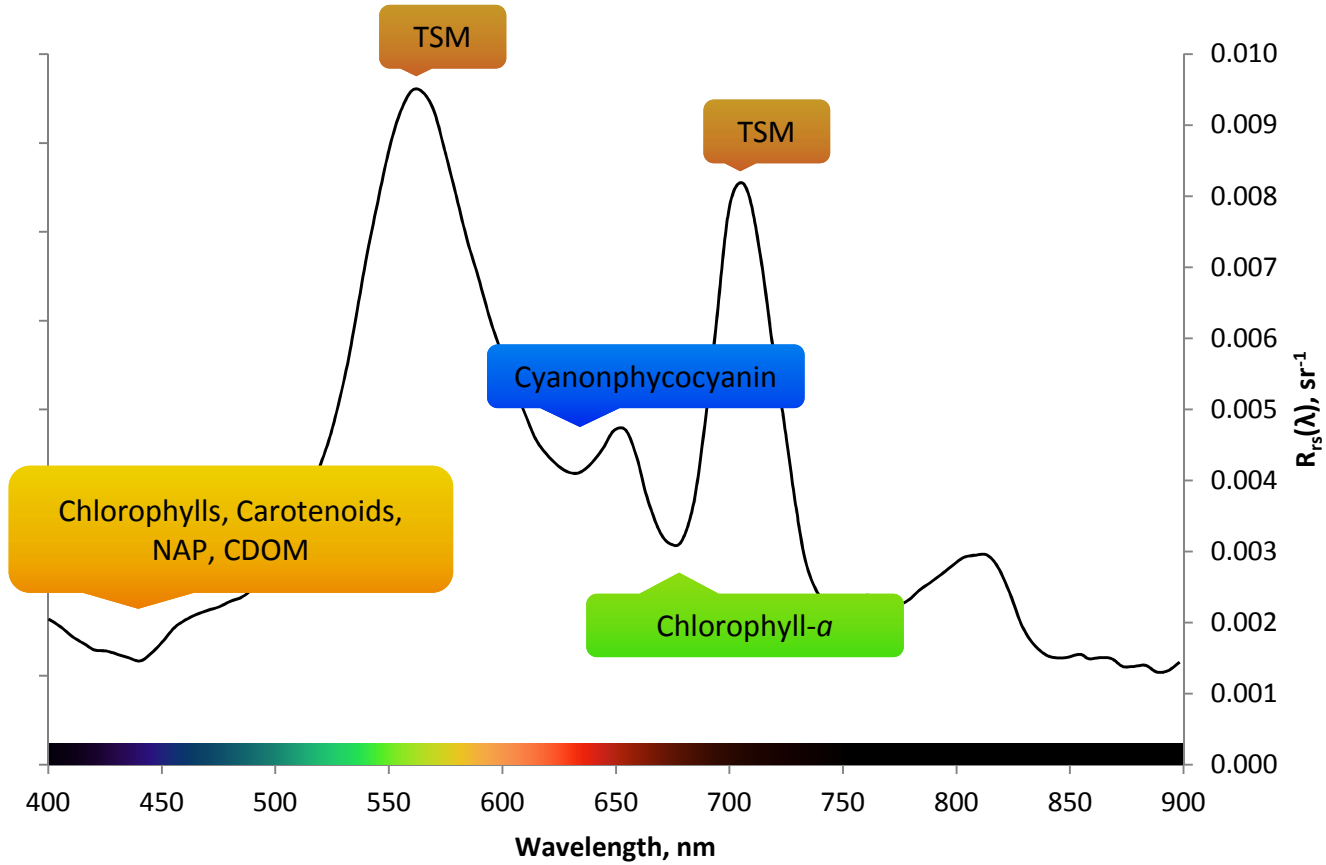
	Landsat-7	Landsat-8	Sentinel-2	Sentinel-3
Satellite and sensor details				
Satellite sensor system	ETM+	OLI/TIRS	MSI	OLCI
Spatial resolution (m)	15, 30, 60	15, 30, 100	10, 20, 60	300
Spectral Bands	8	11	12	21
Revisit cycle (days)	16	16	5	2
Swath width (km)	185	185	290	1270
Launch date	April 1999	February 2013	June 2015	Feb 2016
Years in orbit/minimum design life (years)	15/5	2/5	0/7	0/7
Suitability for water quality assessment	●-Highly Suited ; ●-Suitable ; ●-Potential			
CHL	●	●	●	●
CYP	●	●	●	●
TSM	●	●	●	●
CDOM	●	●	●	●
SD	●	●	●	●
K_d	●	●	●	●

CHL – Chlorophyll, **CYP** – Cyanophycocyanin, **TSM** – Total Suspended Matter, **CDOM** – Colored Dissolved Organic Matter, **SD** – Secchi Disk Transparency, **K_d** – Vertical Attenuation of Light

Suitability for water quality assessment from Dekker, A.G. & Hestir, E. L. (2012) *Evaluating the Feasibility of Systematic Inland Water Quality Monitoring with Satellite Remote Sensing*. CSIRO: Water for a Healthy Country National Research Flagship

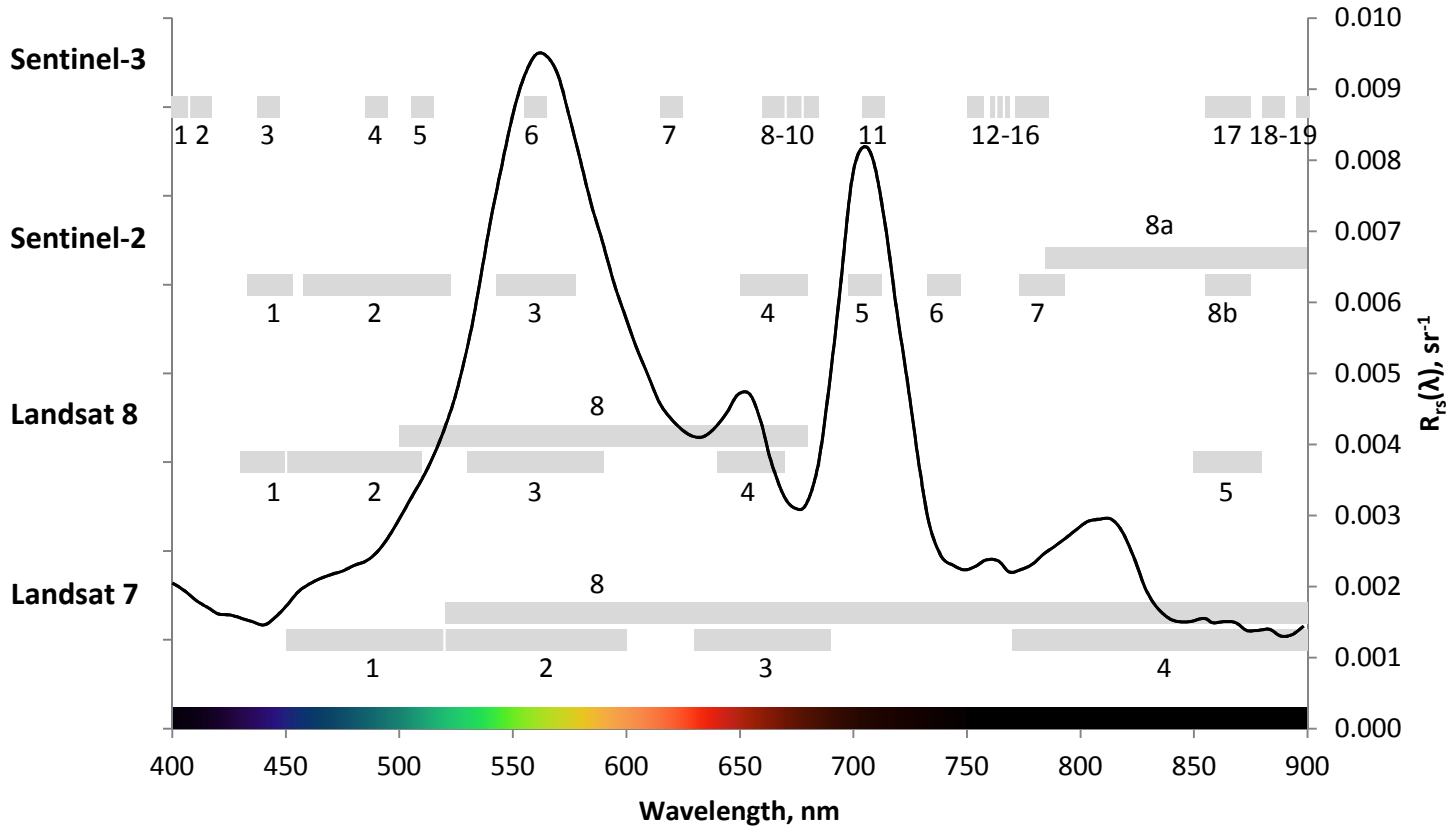
Current and future sensors

New tools in the toolbox



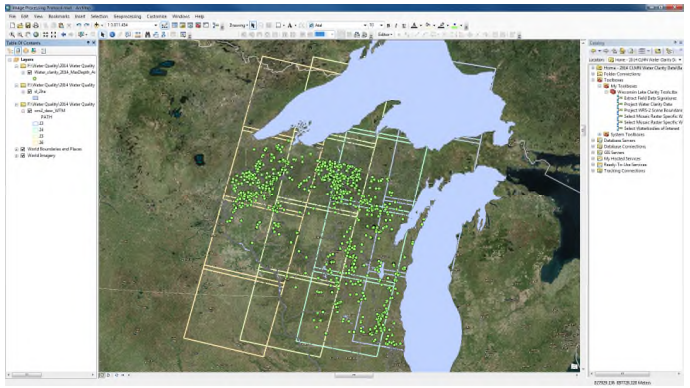
Current and future sensors

New tools in the toolbox

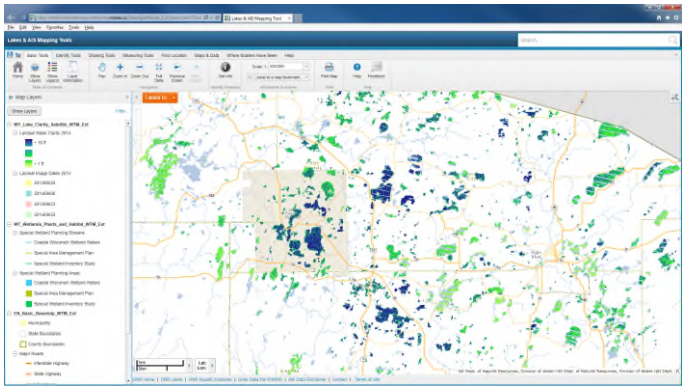


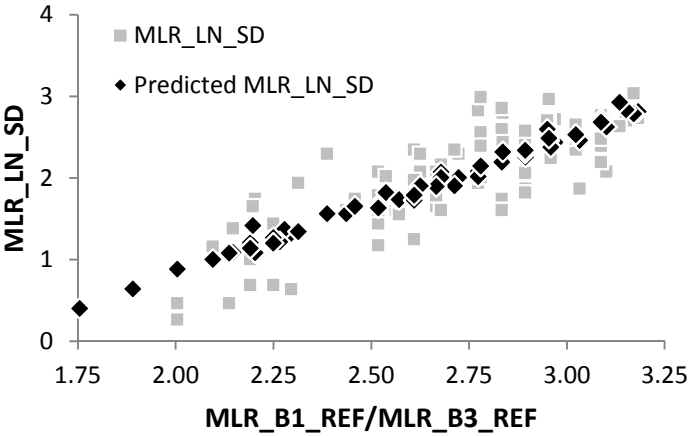
Satellite retrieval of water clarity

Overview



Satellite
Lakes
Observatory
Initiative





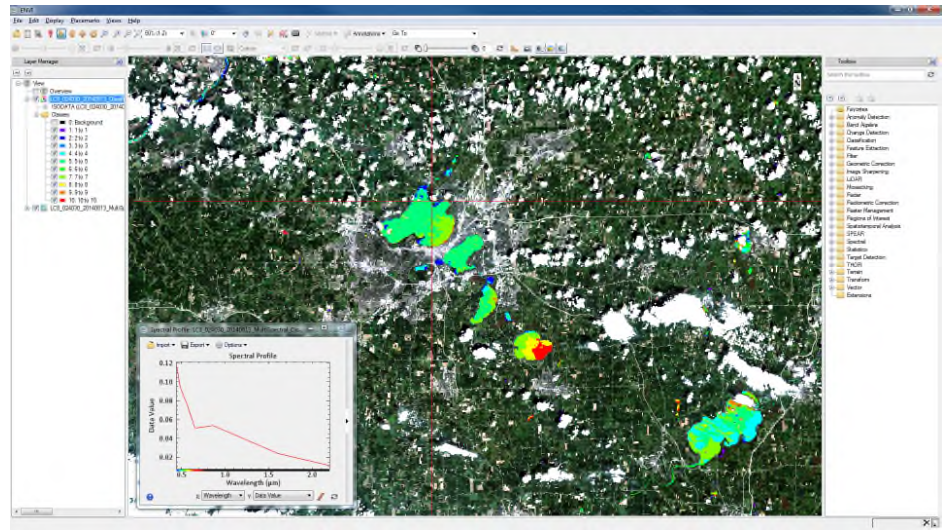
Satellite retrieval of water clarity

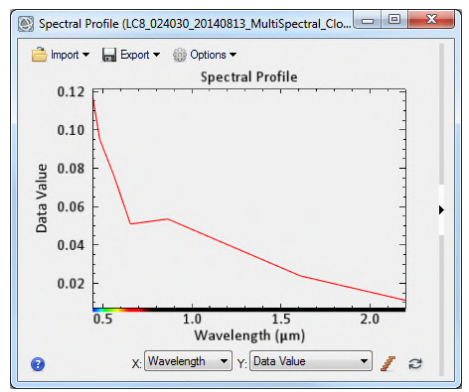
The latest results

2014 water clarity estimation

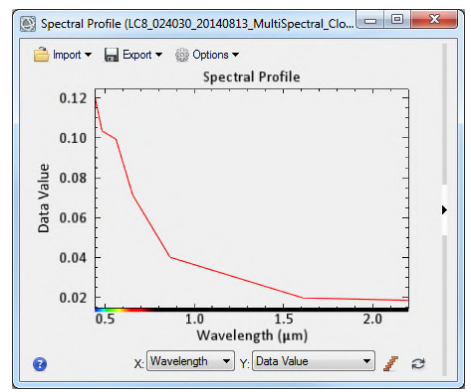
- Preprocessing and mosaicking of Landsat images
- QA/QC of ground-truth measurements
- Extraction of field data signatures from Landsat images
- Multiple linear regression of field and satellite data
- Retrieval of water clarity from satellite data
- QA/QC of satellite measurements

$$\ln(SD) = a + b \times \frac{OLI_{B2}}{OLI_{B4}} + c \times OLI_{B2}$$





Lake edge at the shoreline of Lake Mendota



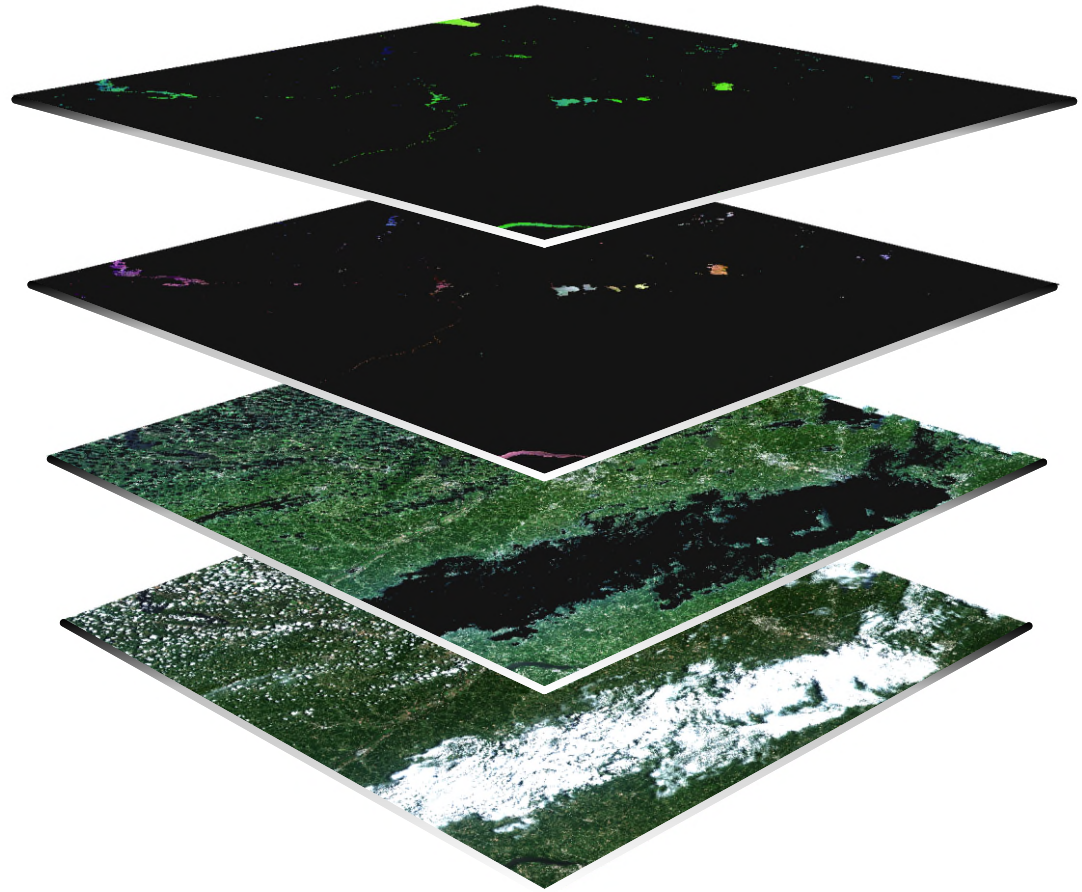
Shallow water at the public swimming beach at Devil's Lake

Satellite retrieval of water clarity

The latest results

2014 water clarity estimation

- 86 Landsat 7 and 8 images
- 3 main software packages
- 42 data processing steps
- 12 image mosaics for algorithm development
- 760 ground-truth measurements for algorithm development
- 10702 water clarity estimates
- 4294 water bodies
- Average mean normalized absolute error of 2.5 ft

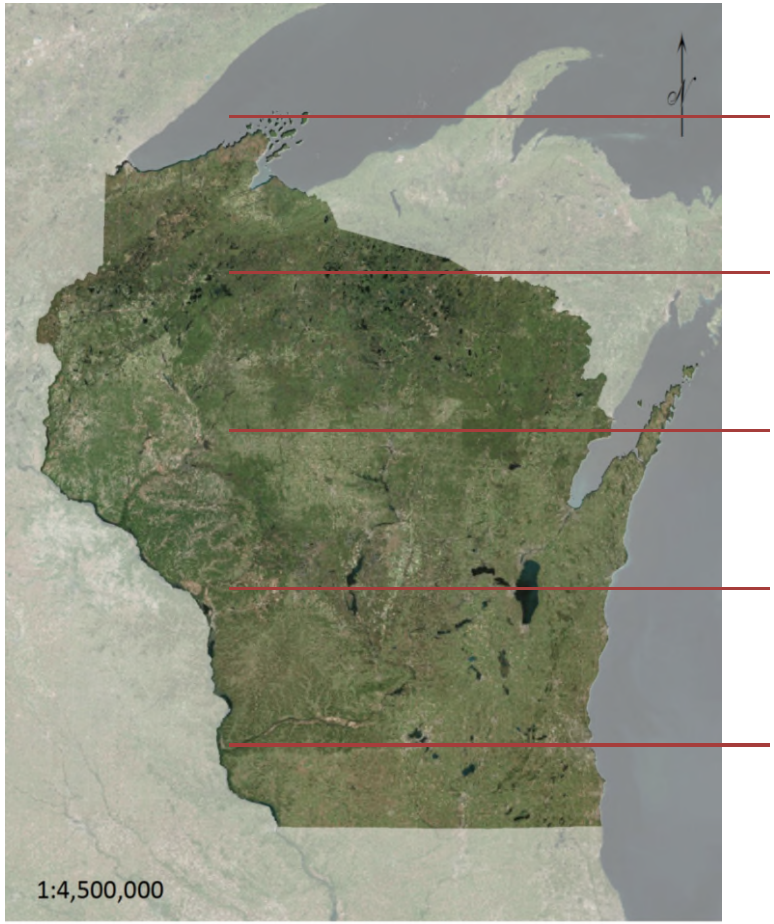


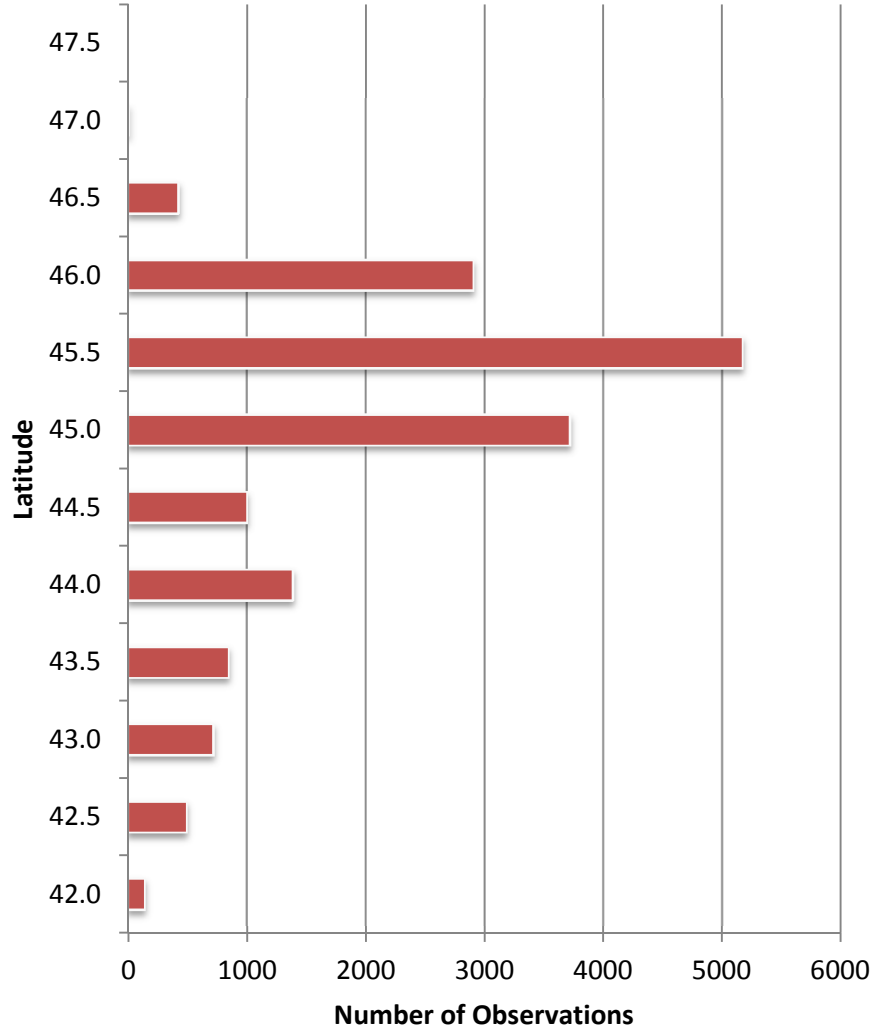
Source of Landsat 8 image: U.S. Geological Survey

Satellite retrieval of water clarity

The latest results

Distribution of lakes across the state for the 2014 water clarity dataset



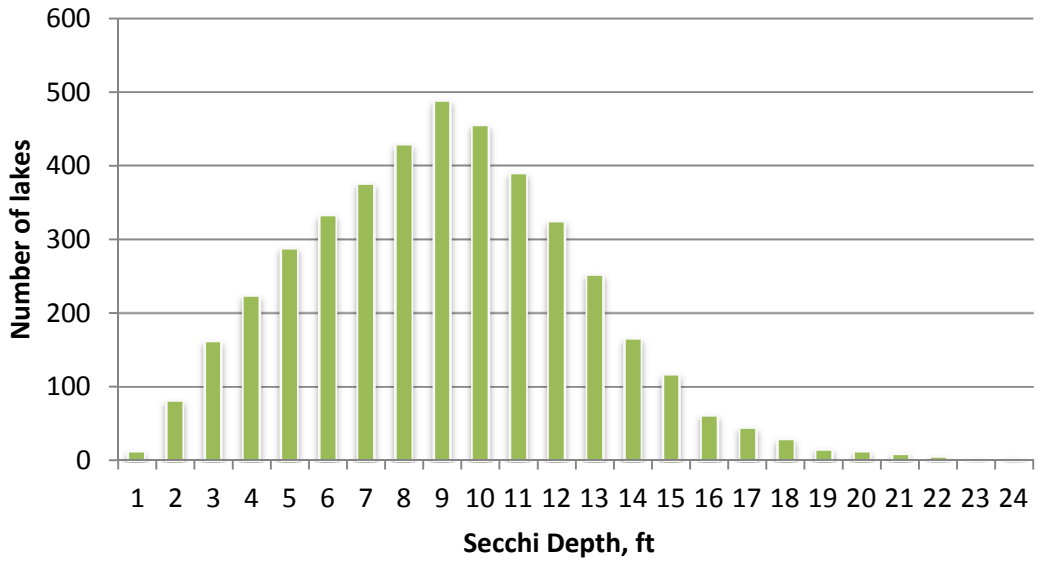


Source of basemap: ESRI, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Satellite retrieval of water clarity

The latest results

Number of lakes by Secchi depth intervals (2014 water clarity dataset)



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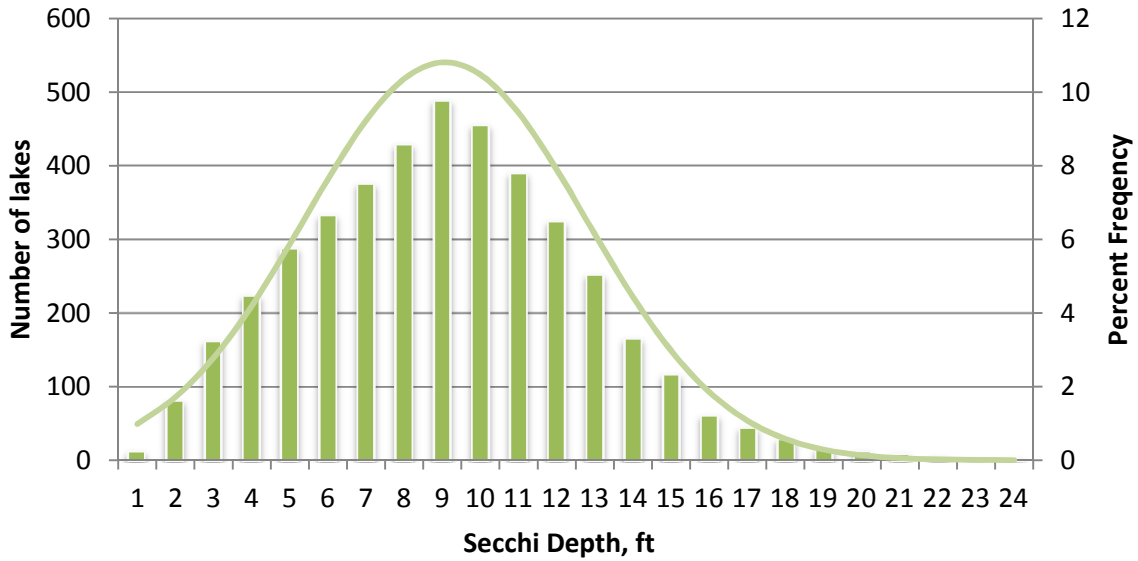

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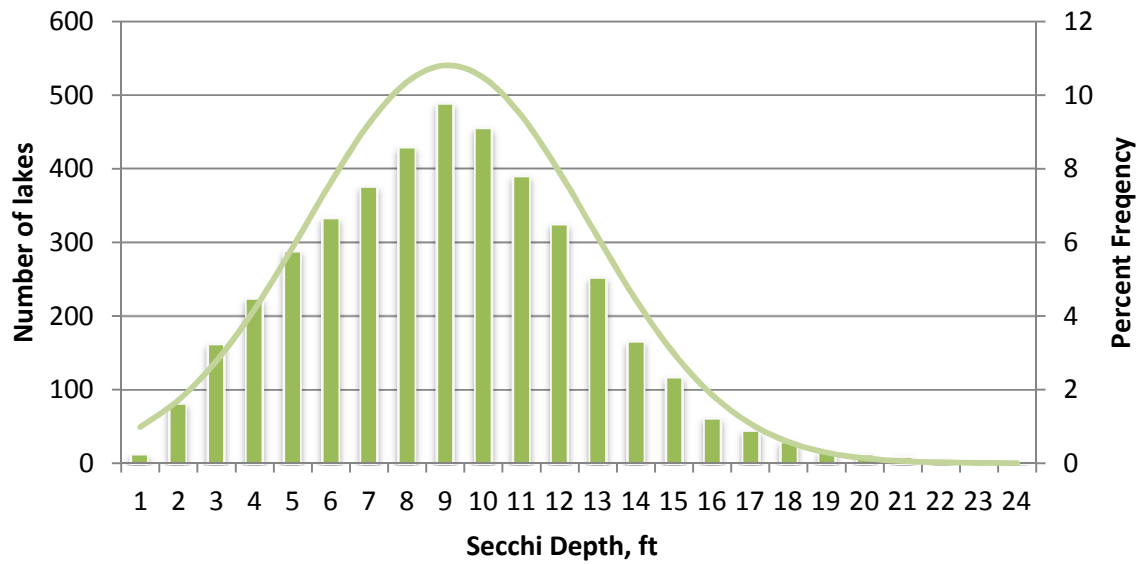
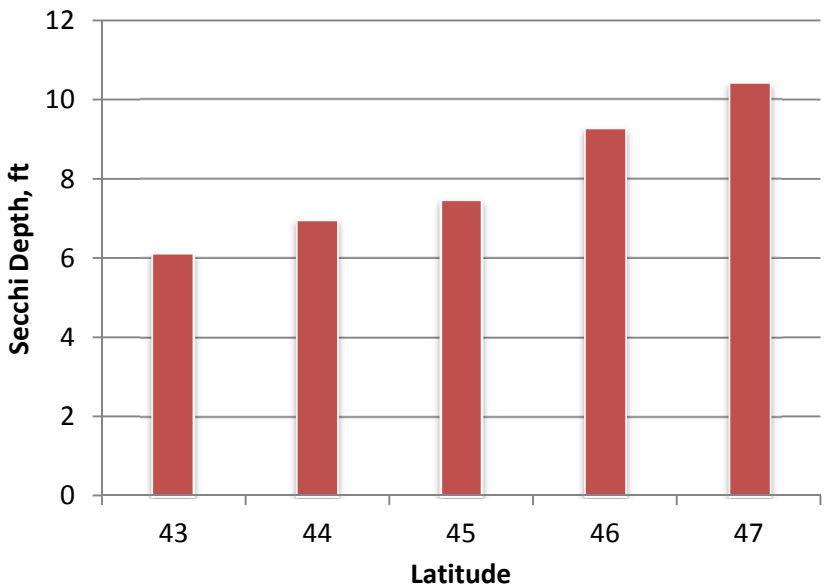


Secchi depth from South to North



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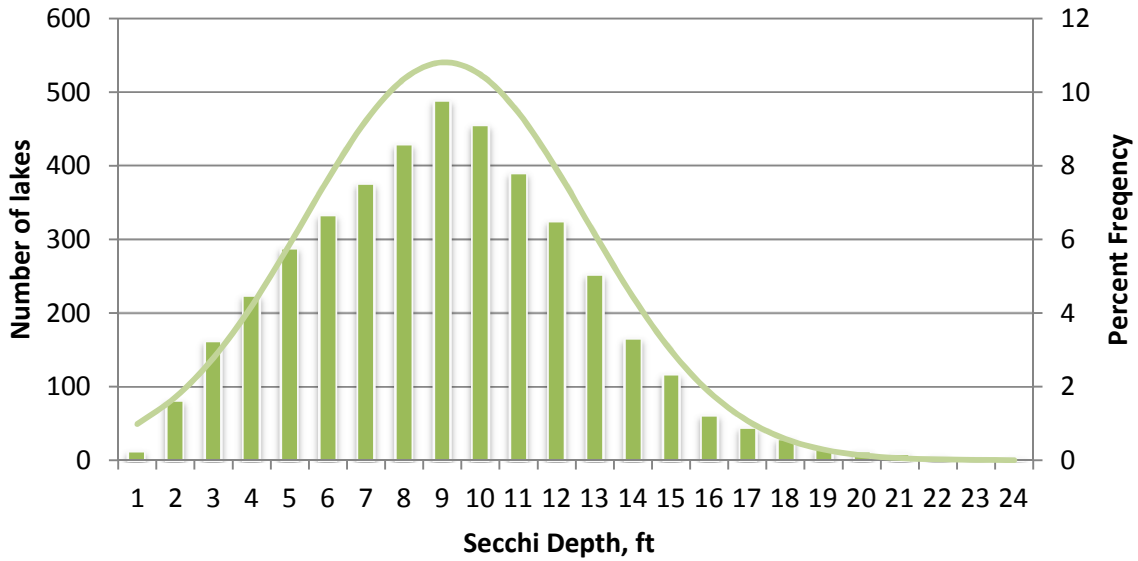

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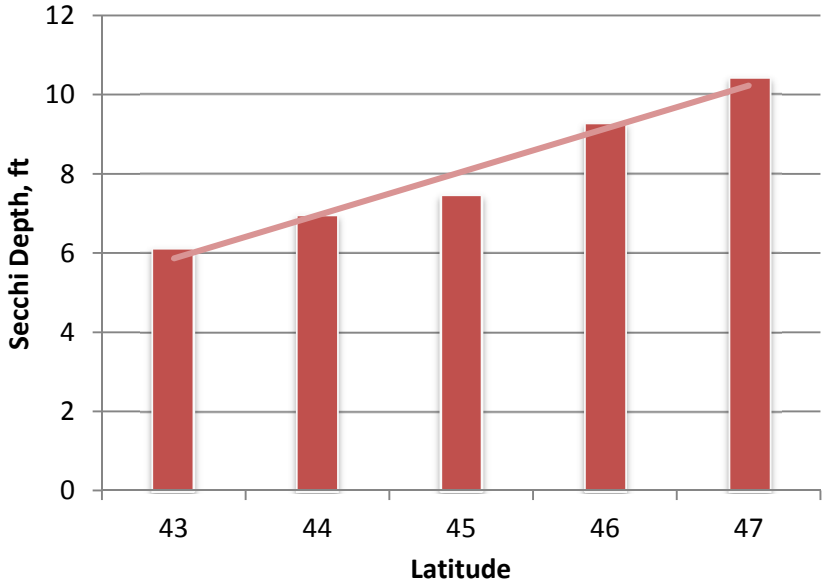

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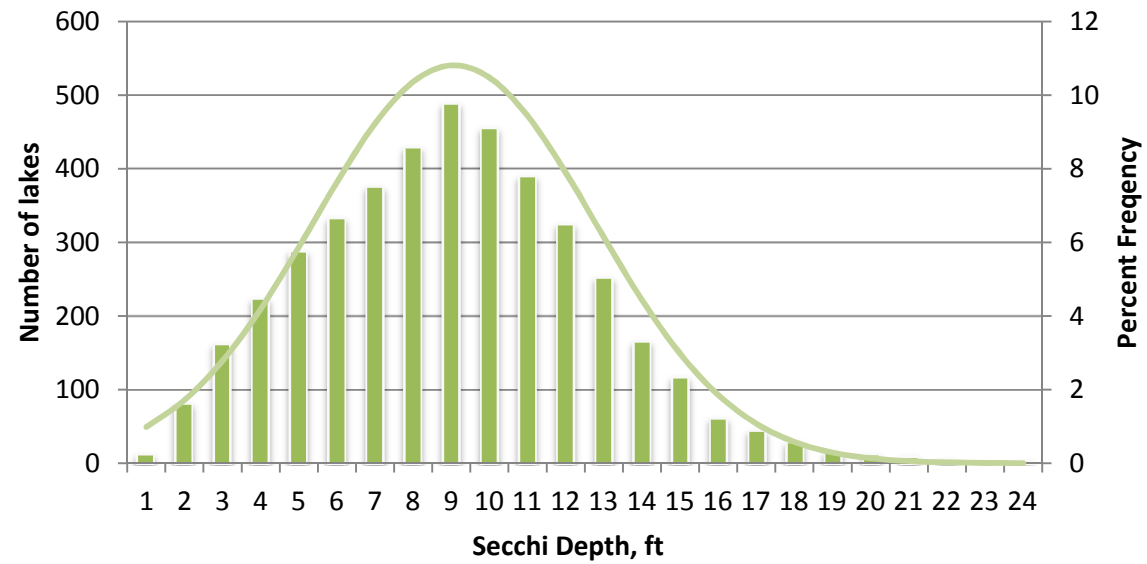

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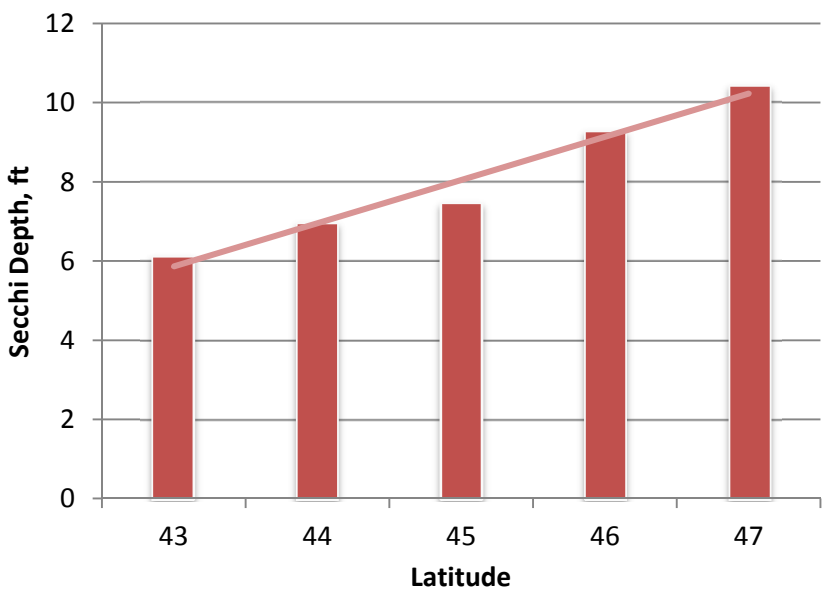
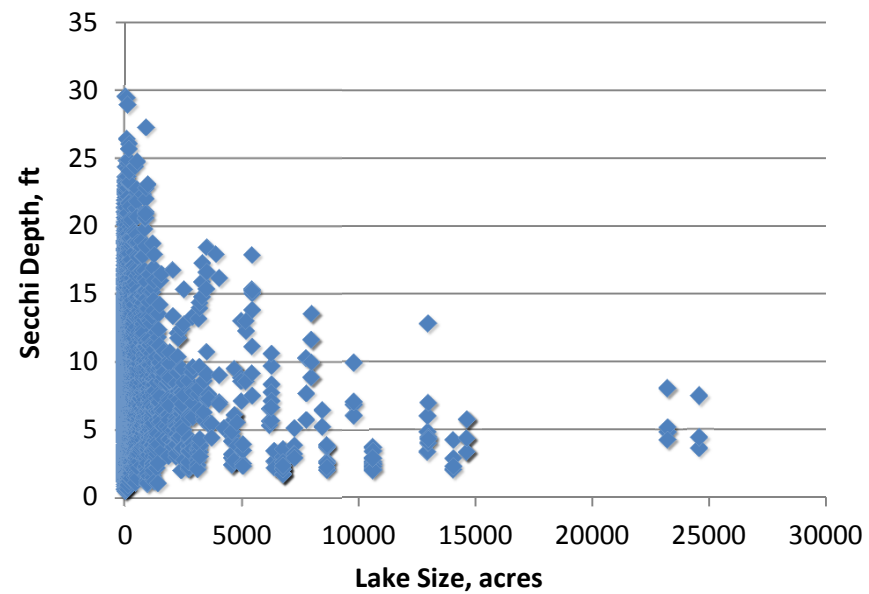


Relationship of Secchi to lake depth



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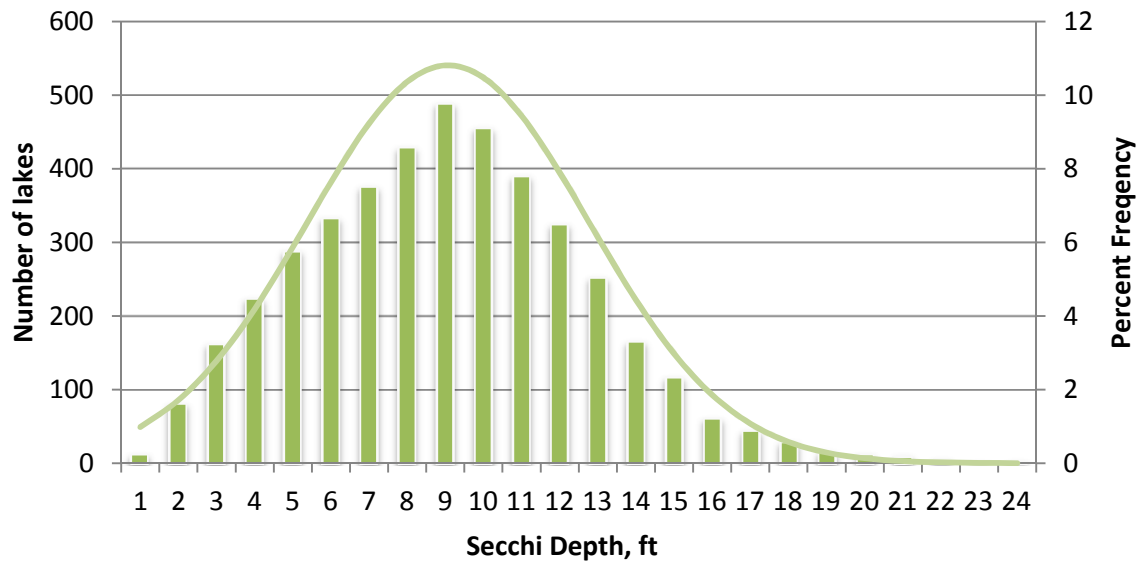

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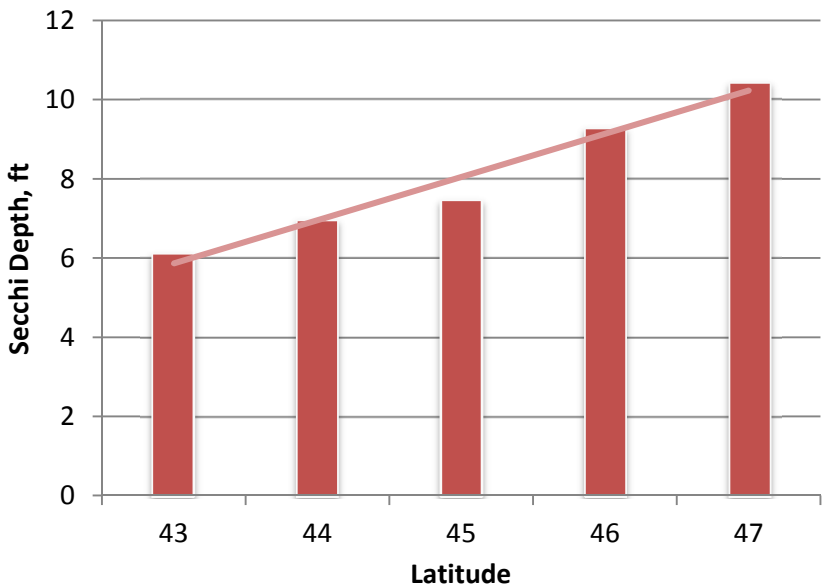

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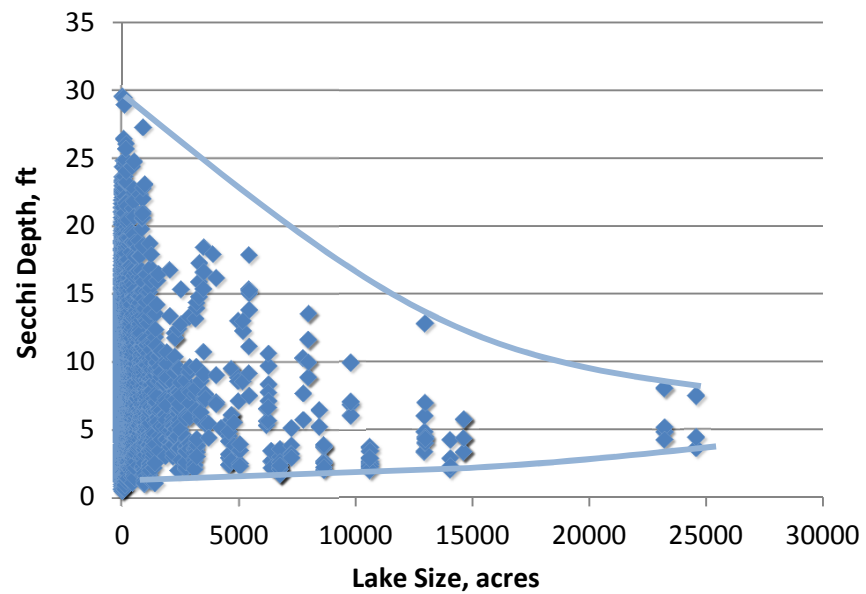
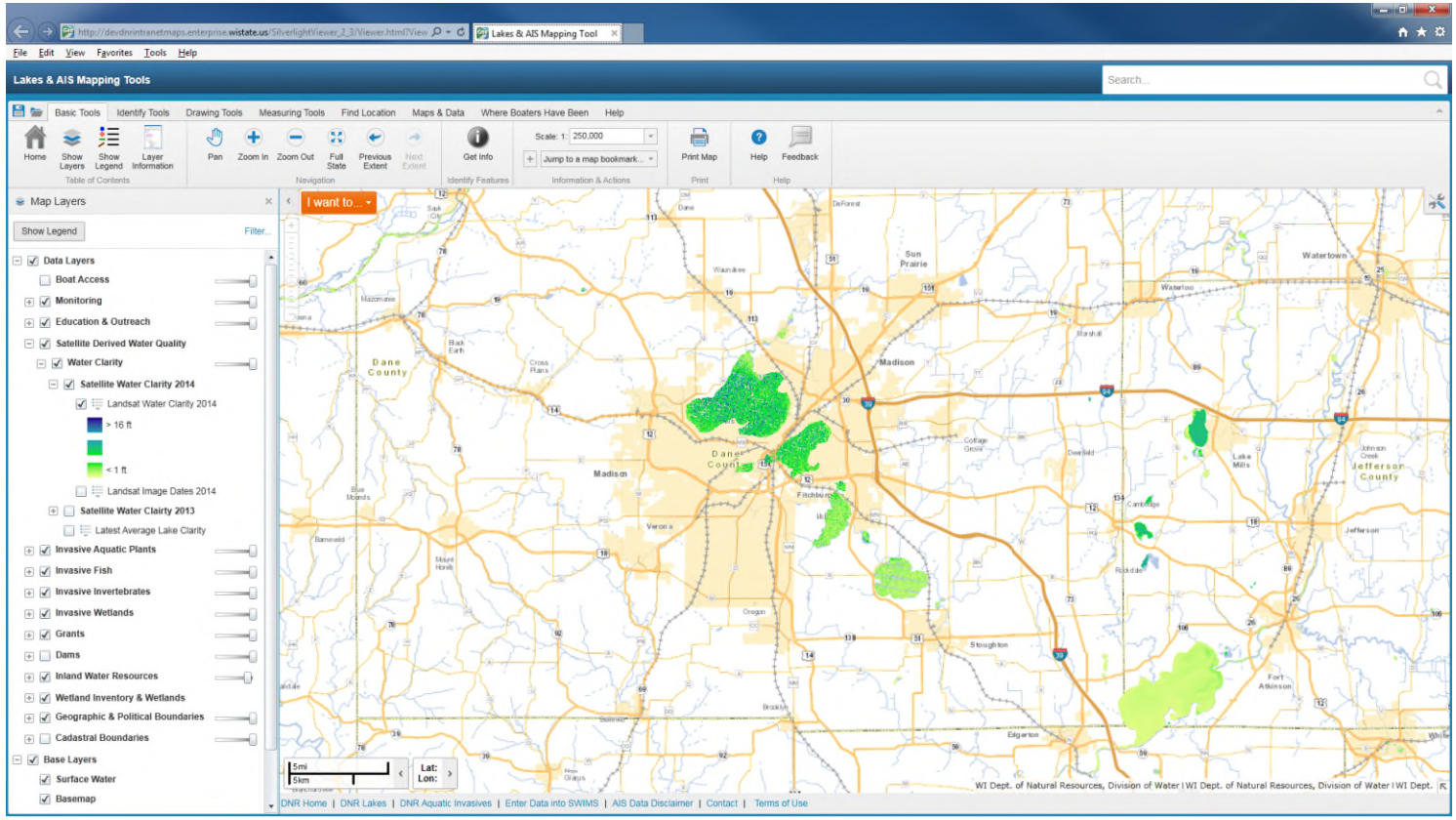


Data dissemination

The Lakes and Aquatic Invasive Species (AIS) Mapping Tool

http://dnr.wi.gov/lakes/viewer/



Current and future work

Towards new monitoring capabilities

Field data collection

- Water samples collected in summer and fall 2014 and 2015 for algorithm development
- 32 lakes in Wisconsin
- Color samples collected by CLMN volunteers

Field and laboratory measurements

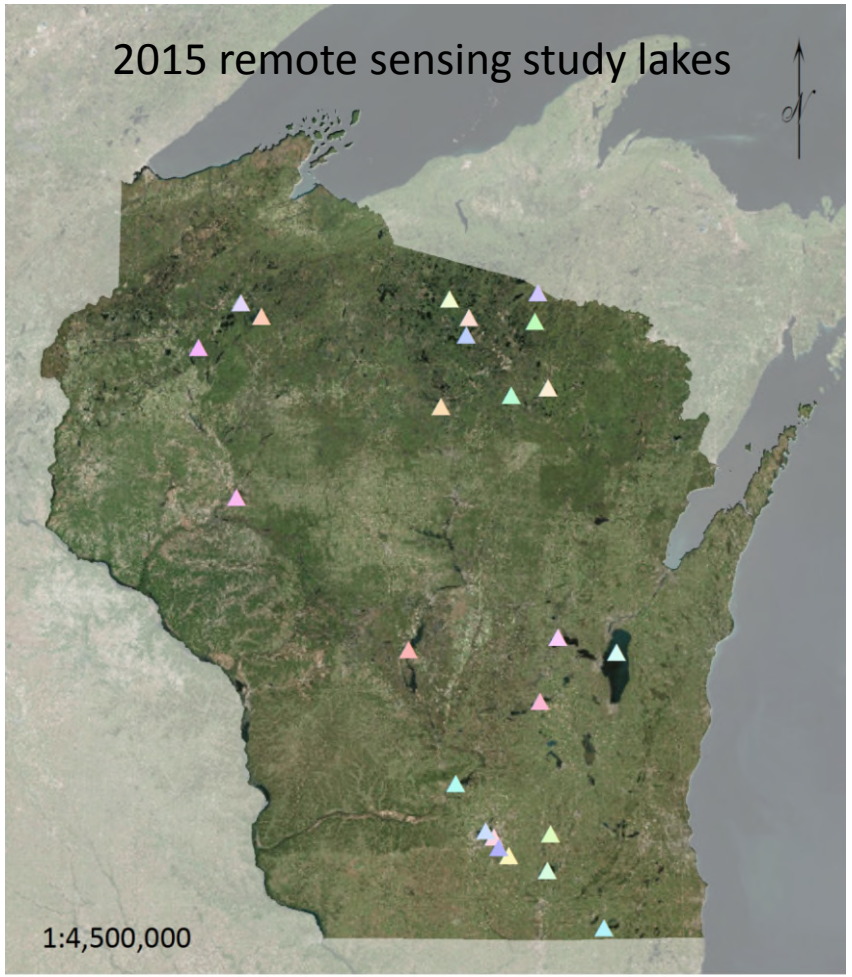
- Water temperature, dissolved oxygen, conductivity, and Secchi depth
- Reflectance
- Water color and turbidity
- TSS, ISS, and OSS
- Absorption and backscattering coefficients

Regretting the decision to collect field data…

Field data collection completed…

Current and future work

2015 field data collection



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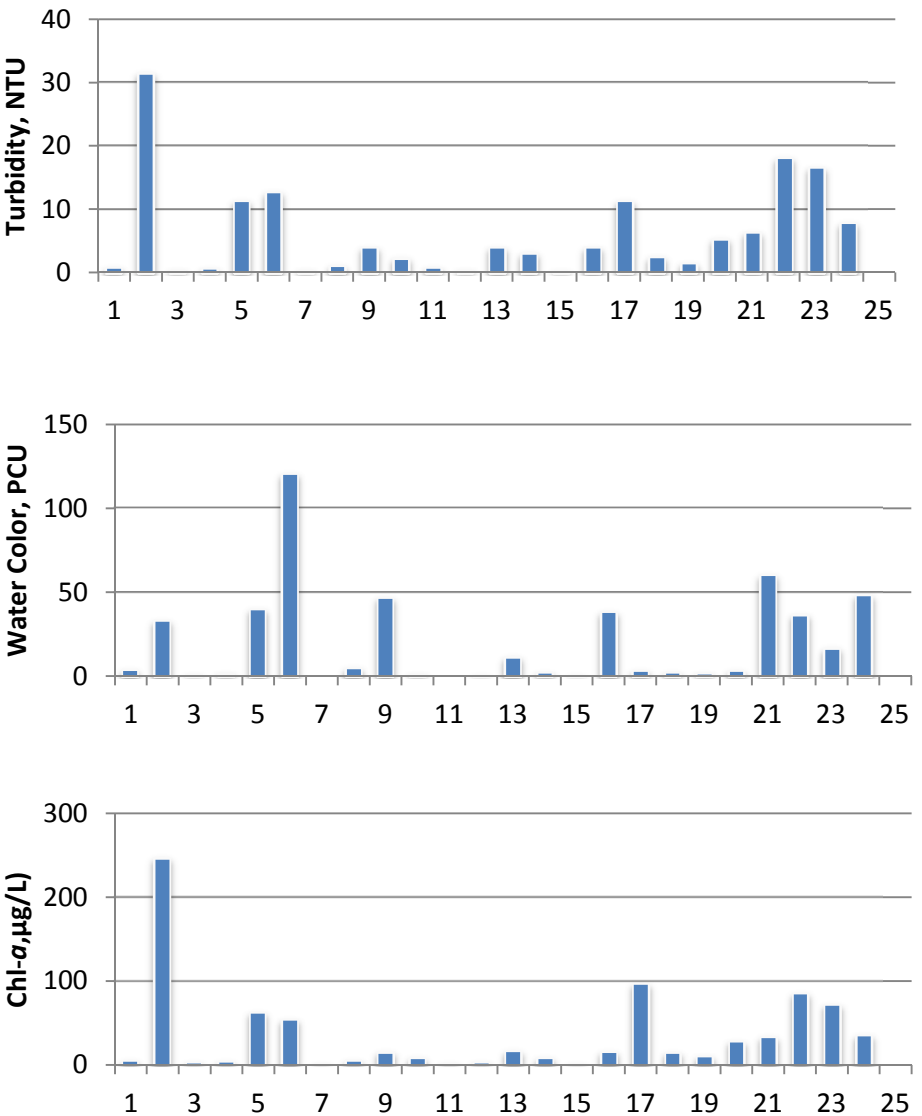

Thank you!

For more information see http://dnr.wi.gov/lakes/clmn/remotesensing/