


# Statewide Aquatic Remote Sensing Program in Wisconsin

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Wisconsin Department of Natural Resources



**2016 Wisconsin Lakes Partnership Convention**  
Wednesday - Friday  
March 30 - April 1, 2016

Held in conjunction with the 7th Citizen-based Monitoring Conference and the Water Action Volunteers Annual Symposium  
April 1-2

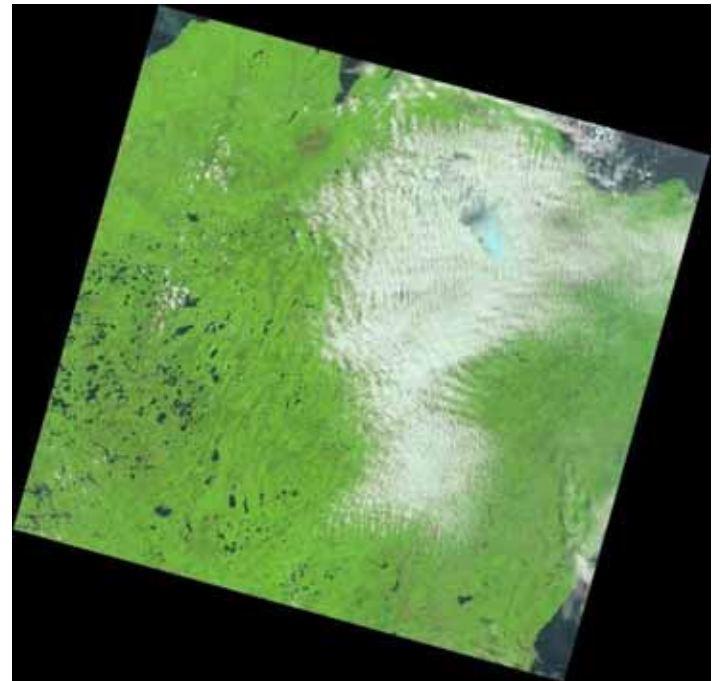
Holiday Inn and Convention Center  
Stevens Point

**CELEBRATING VOLUNTEERS 2016**

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

# Remote Sensing Activities at the Wisconsin DNR

- 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



LC80240282013174LGN00

# Remote Sensing Activities at the Wisconsin DNR

## EO sensors suitable for water quality assessment with public access data policy

	Pixel Size (m)	Bands (400-900 nm)	Revisit cycle	CHL	CYP	TSM	CDOM	SD	K <sub>d</sub>
<b>Low res.</b>									
MODIS	1000	9	Daily	●	●	●	●	●	●
MODIS	500	2	Daily	●	●	●	●	●	●
MODIS	250	2	Daily	●	●	●	●	●	●
MERIS & OC2	300	15	2-3 days	●	●	●	●	●	●
VIIRS	750	7	2x/day	●	●	●	●	●	●
<b>Med res.</b>									
Landsat	30	4	16	●	●	●	●	●	●
<b>Future</b>									
Sentinel-3	300	21	Daily	●	●	●	●	●	●
LDCM	30	5	16	●	●	●	●	●	●
Sentinel-2	10-60	10	3-5 days	●	●	●	●	●	●
HySpIRI	60	60	19 days	●	●	●	●	●	●

● Highly suited ● Suited ● Potential ● Not suited

CHL=Chlorophyll; CYP=Cyanophycocyanin; TSM=Total Suspended Matter; CDOM=Coloured Dissolved Organic Matter; SD= Secchi Disk Transparency; K<sub>d</sub>=Vertical Attenuation of Light

Table 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

## Landsat 8 OLI and TIRS (02/11/2013)



NASA photo

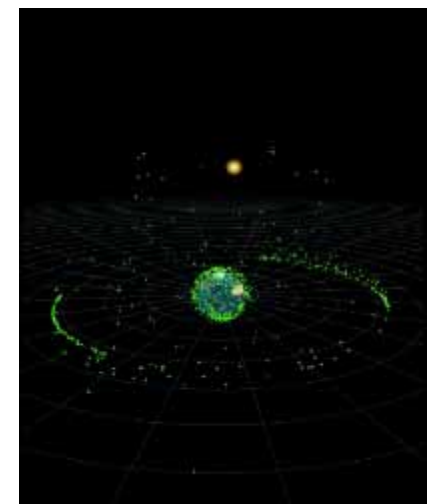
### OLI

- Eight multispectral bands and one panchromatic band
- Pixel size 30 m for multispectral bands and 15 m for panchromatic band

- Scene size 170 x 180 km
- Repeat cycle 16 days

### TIRS

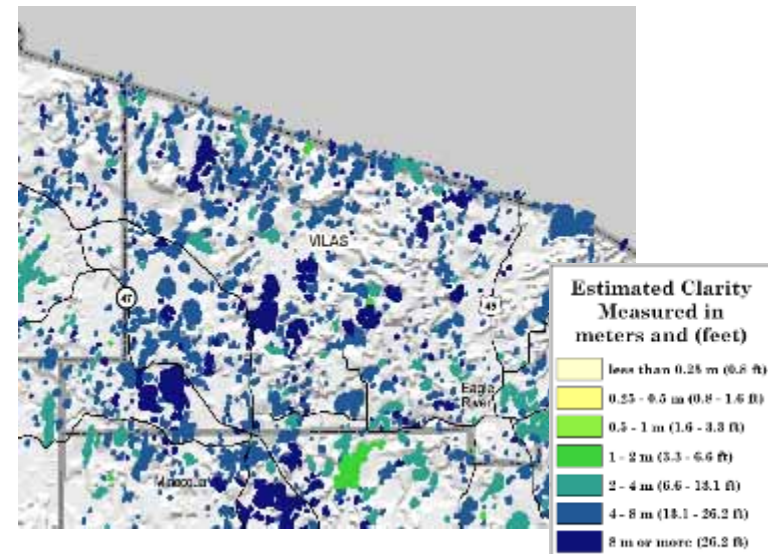
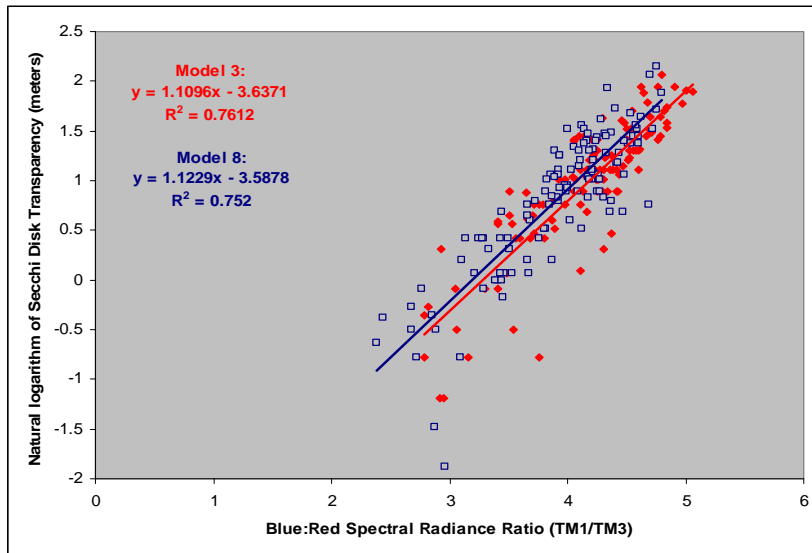
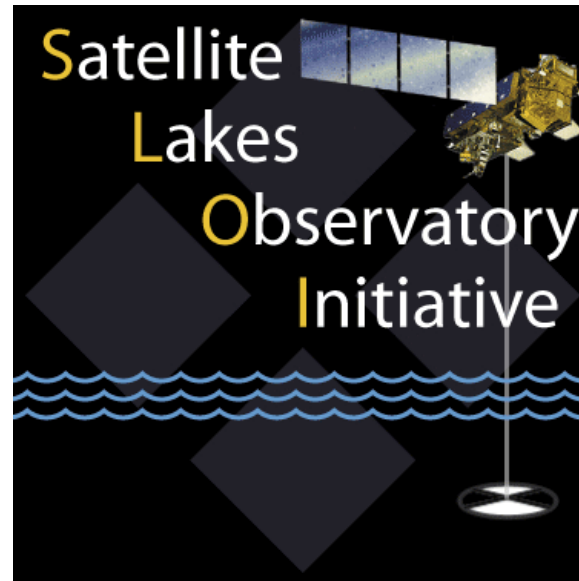
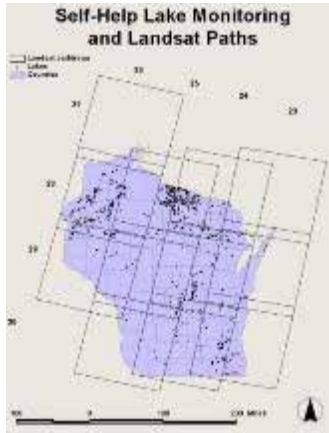
- Two thermal bands
- Pixel size 100 m



Space.com image



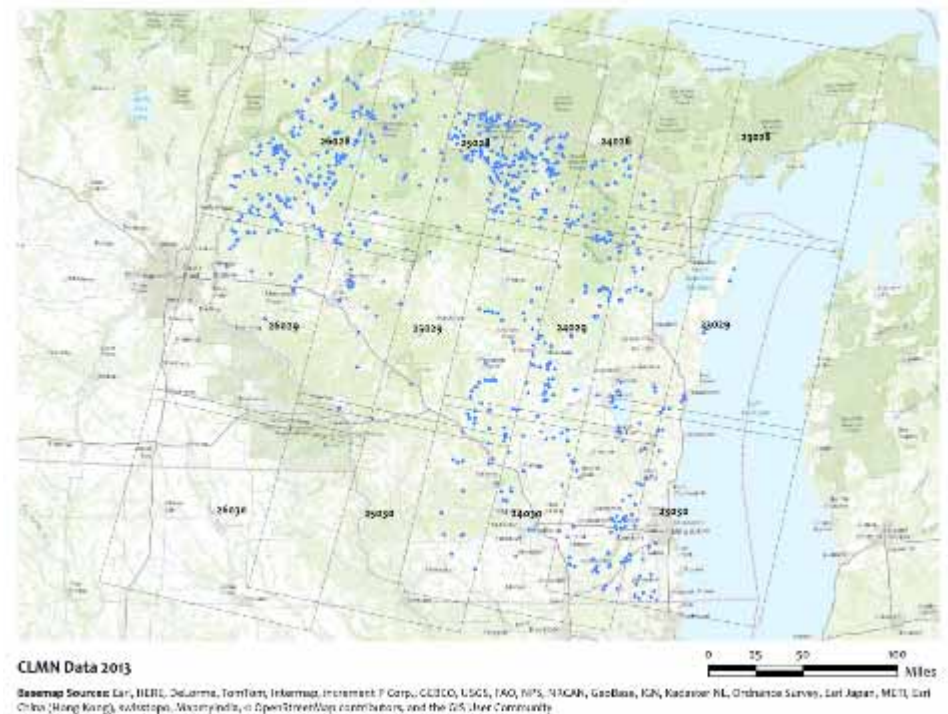
# Water Clarity Estimates from Landsat imagery



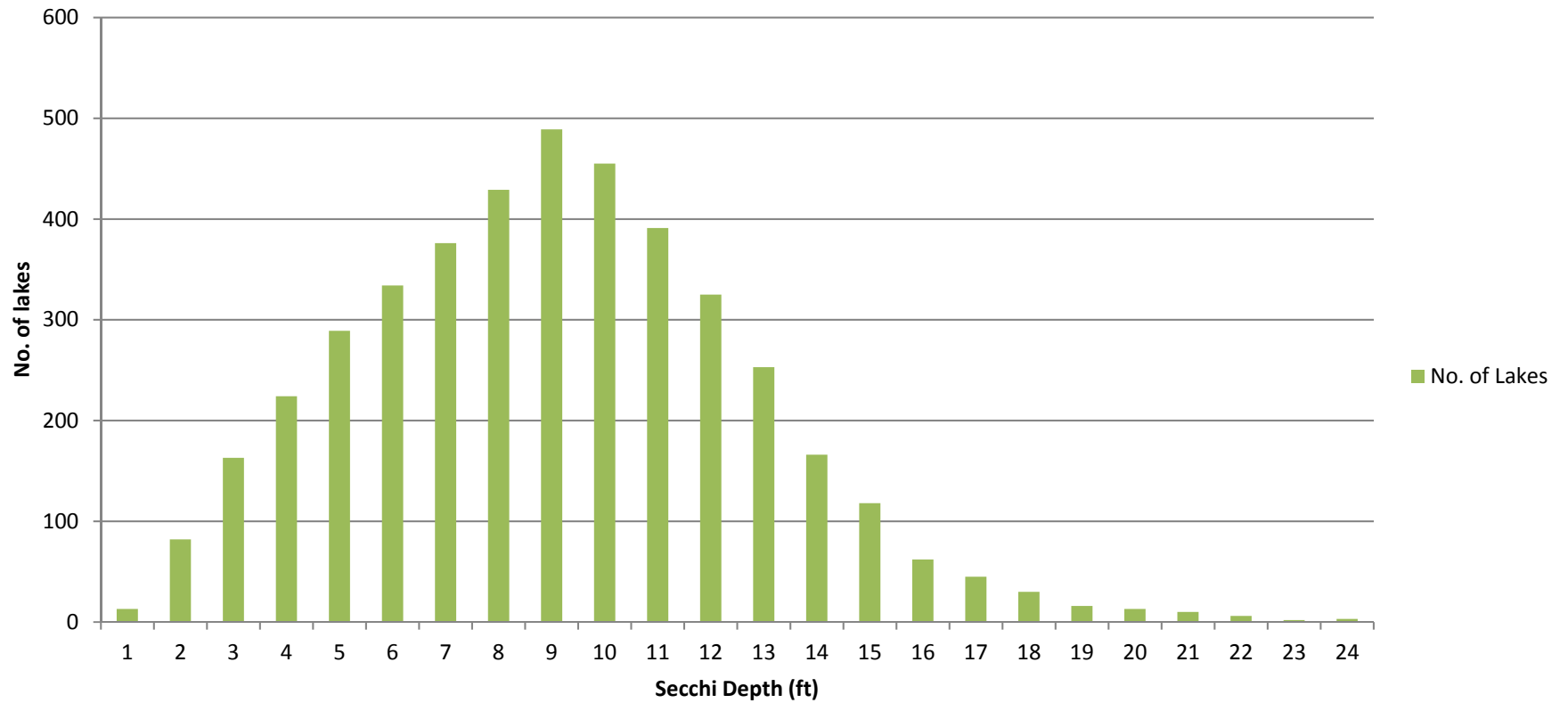
# Systematic processing of satellite imagery for water clarity

## 2014 water clarity estimation

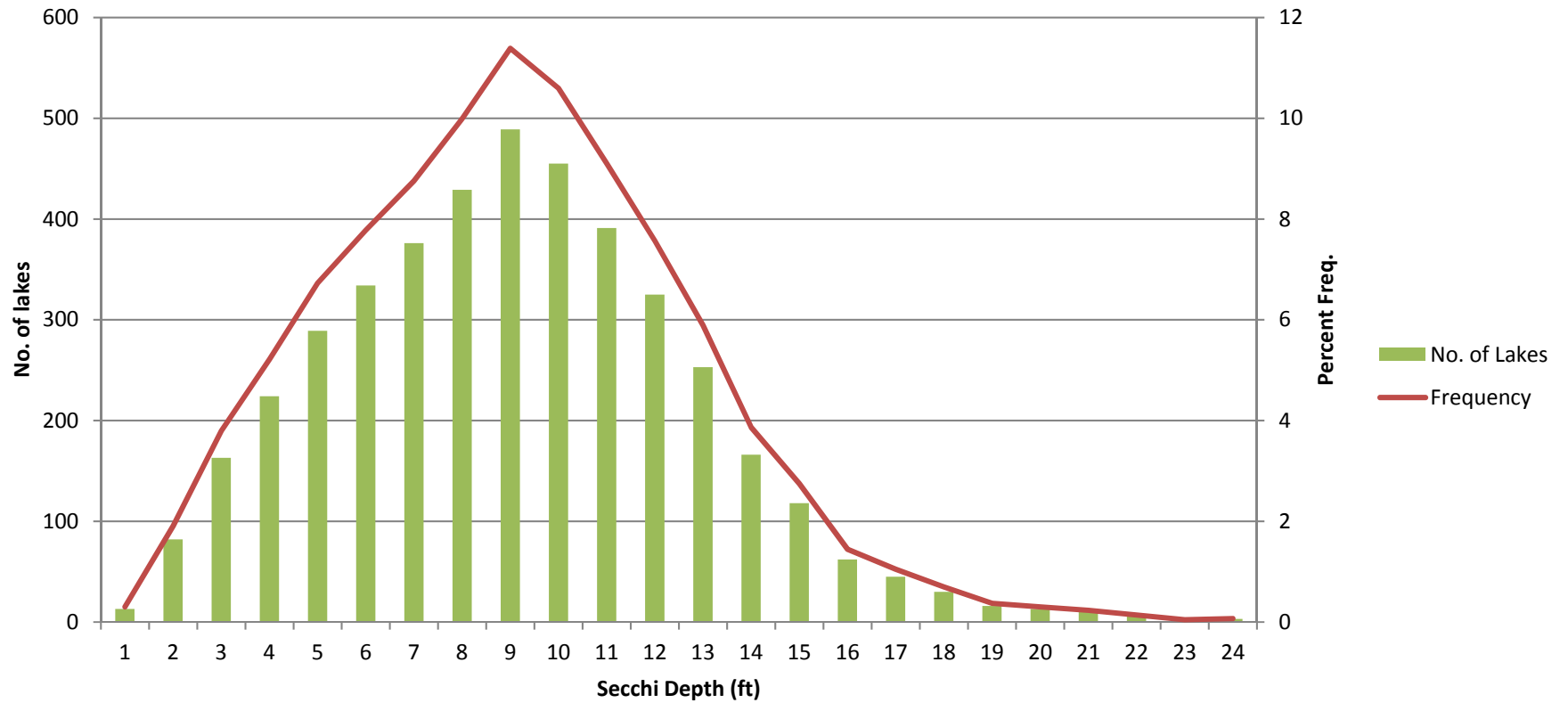
- 86 satellite images
- 32 data processing steps
- 12 image mosaics for algorithm development
- 760 ground truth measurements for algorithm development
- 10703 water clarity estimates
- 4294 Water Bodies



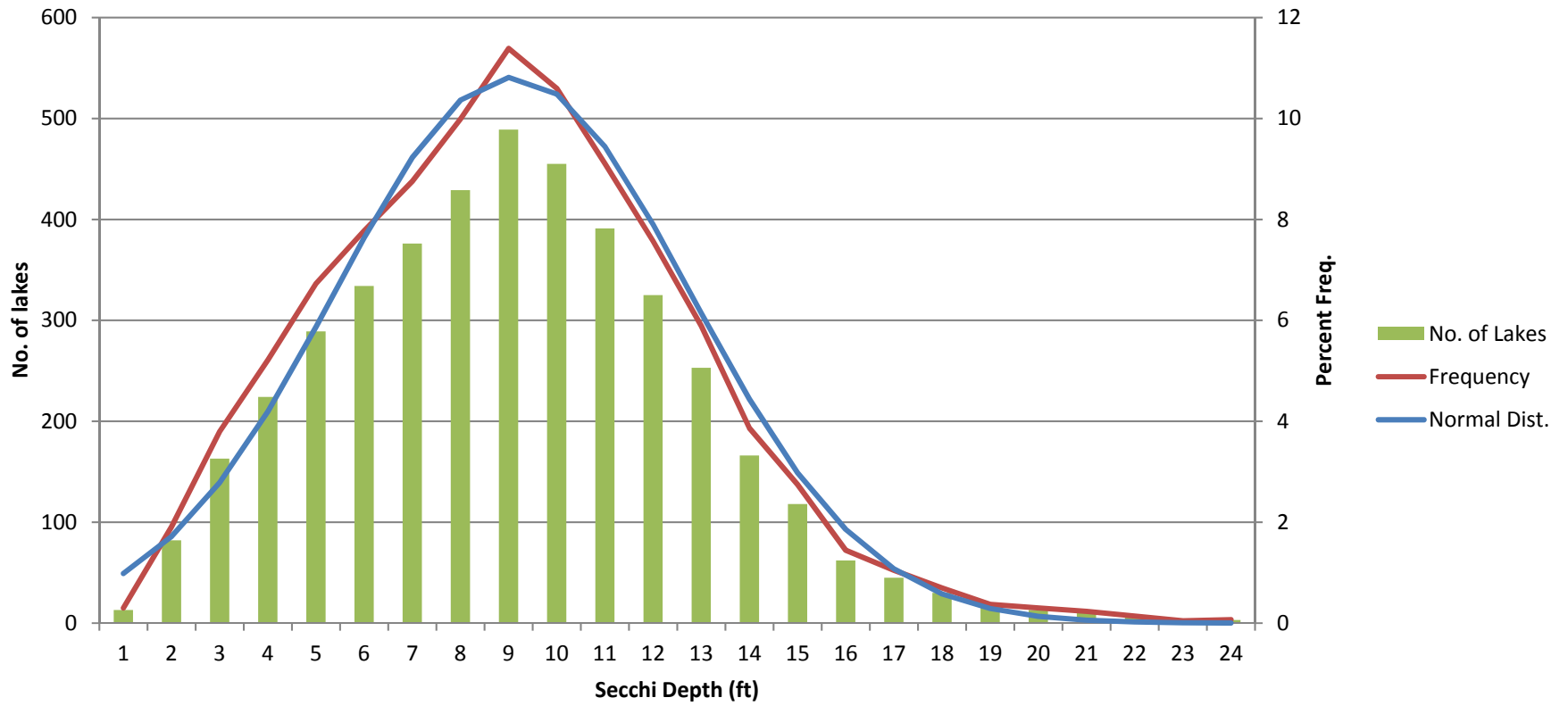
## Number of Lakes by Secchi Depth (1 ft. Intervals) Year 2014



## Frequency of Occurrence of Secchi Depth

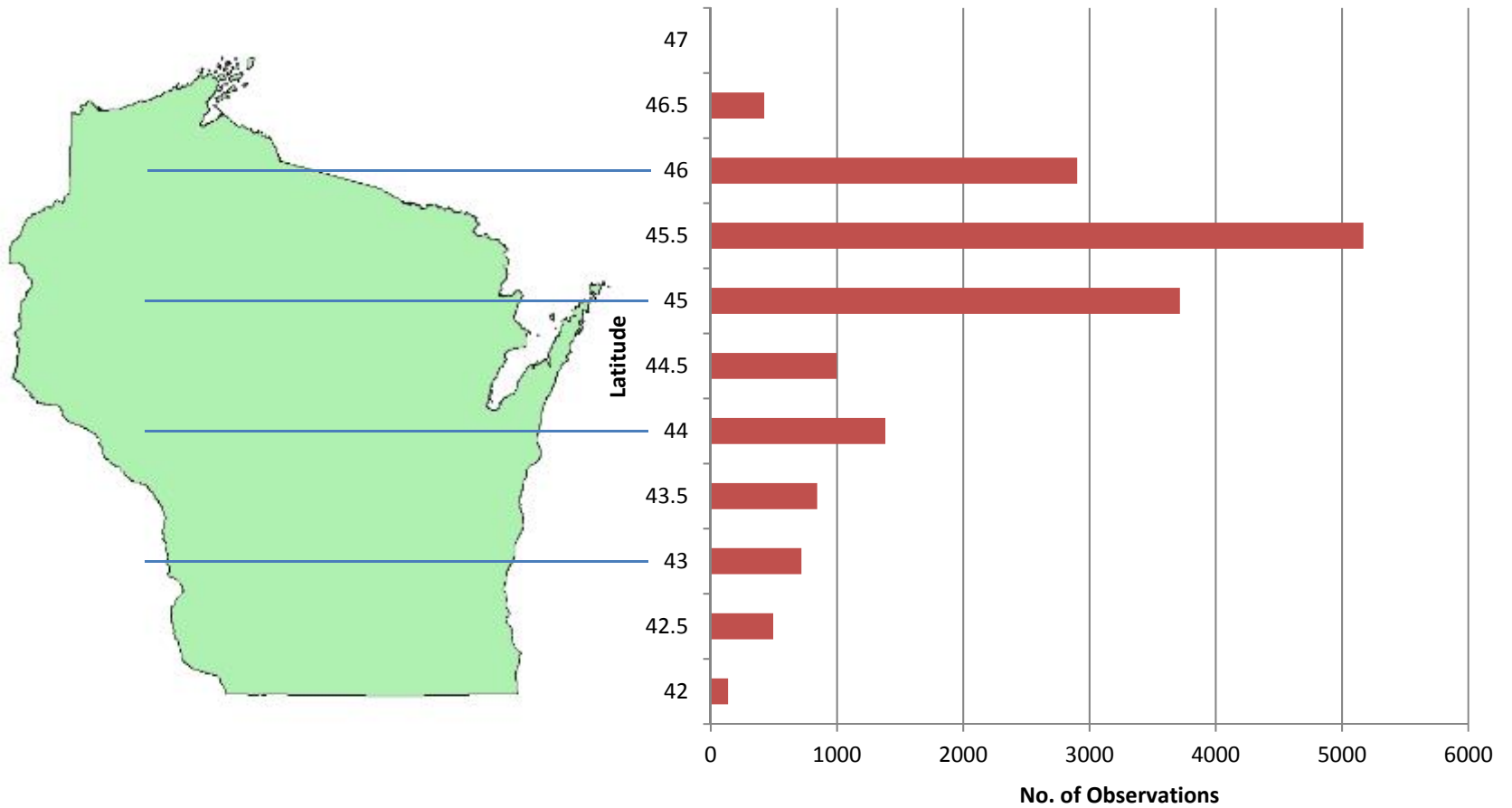


Frequency of Occurrence of Secchi Depth  
w/ fitted Normal Distribution

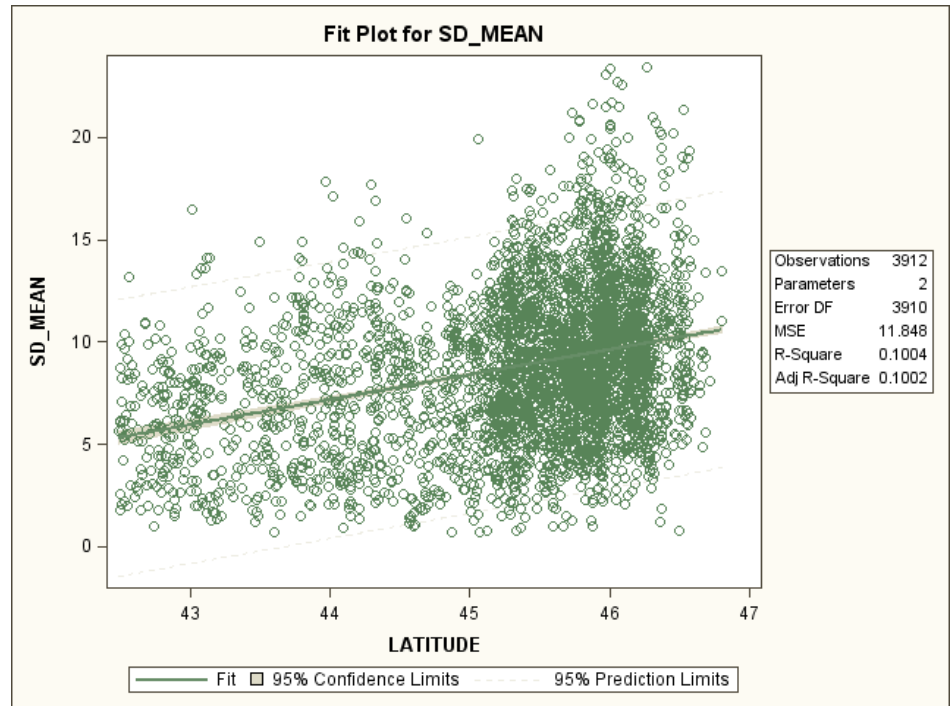
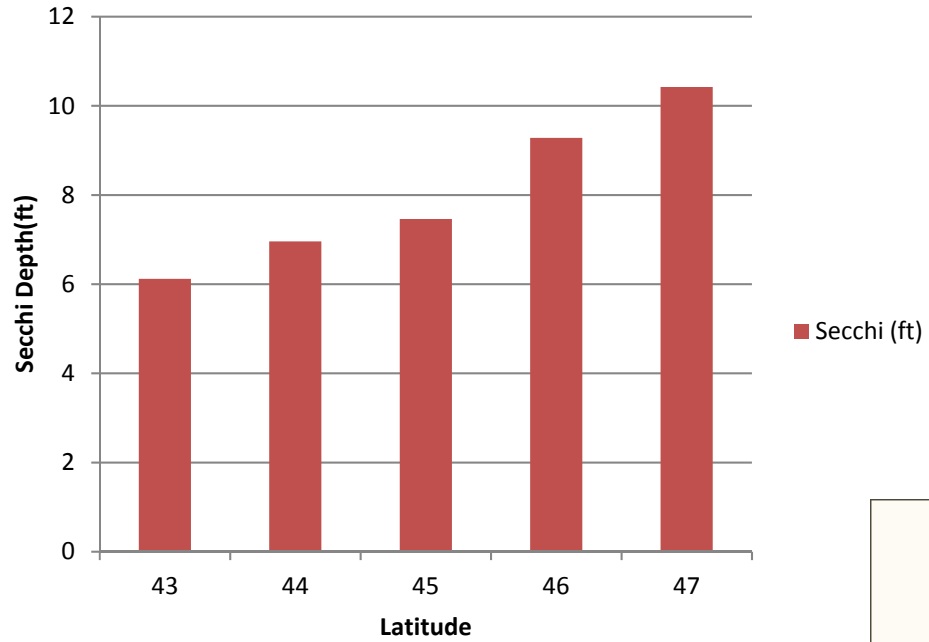




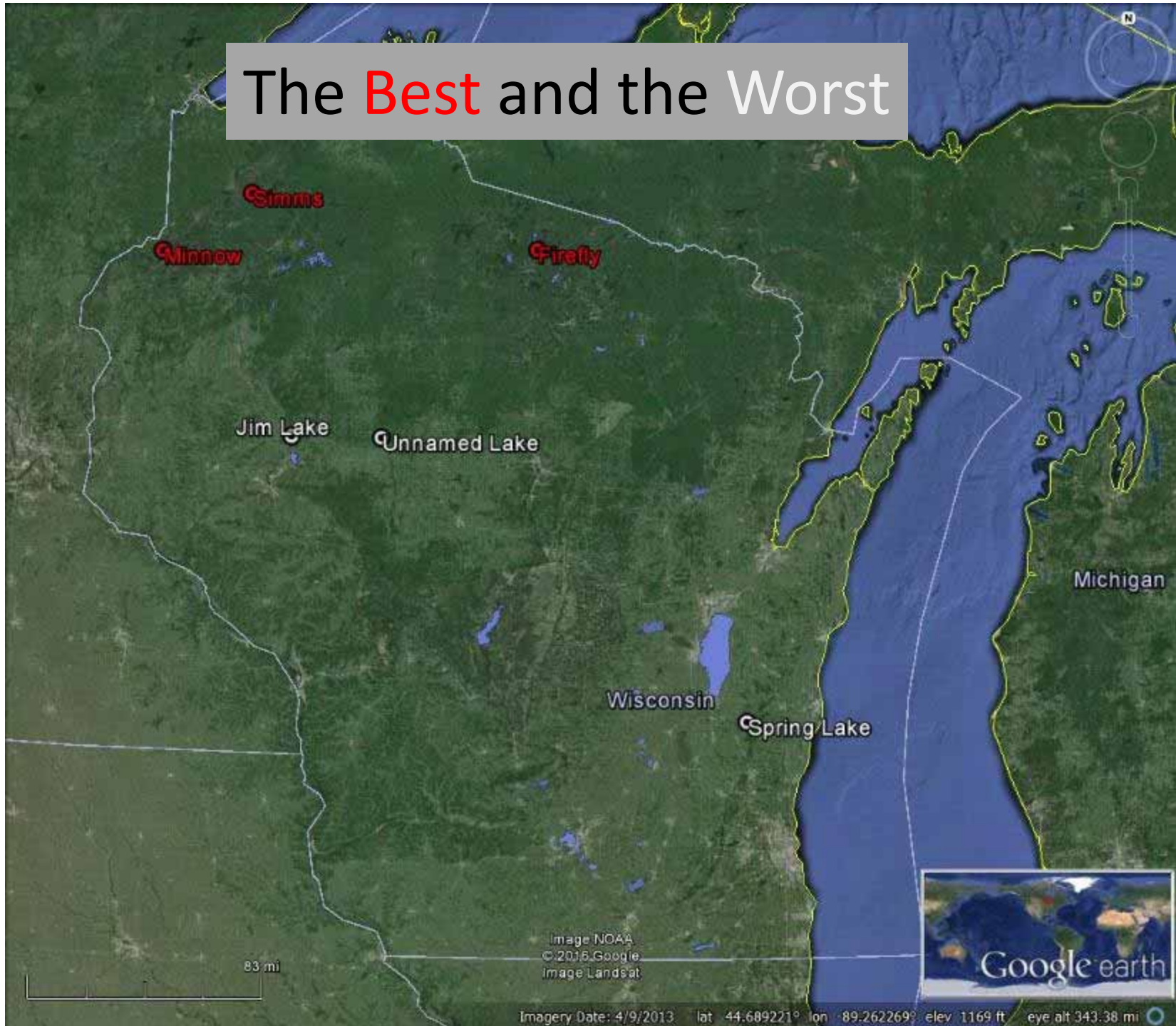
Distribution of Lakes across the state  
(from 2014 data set)



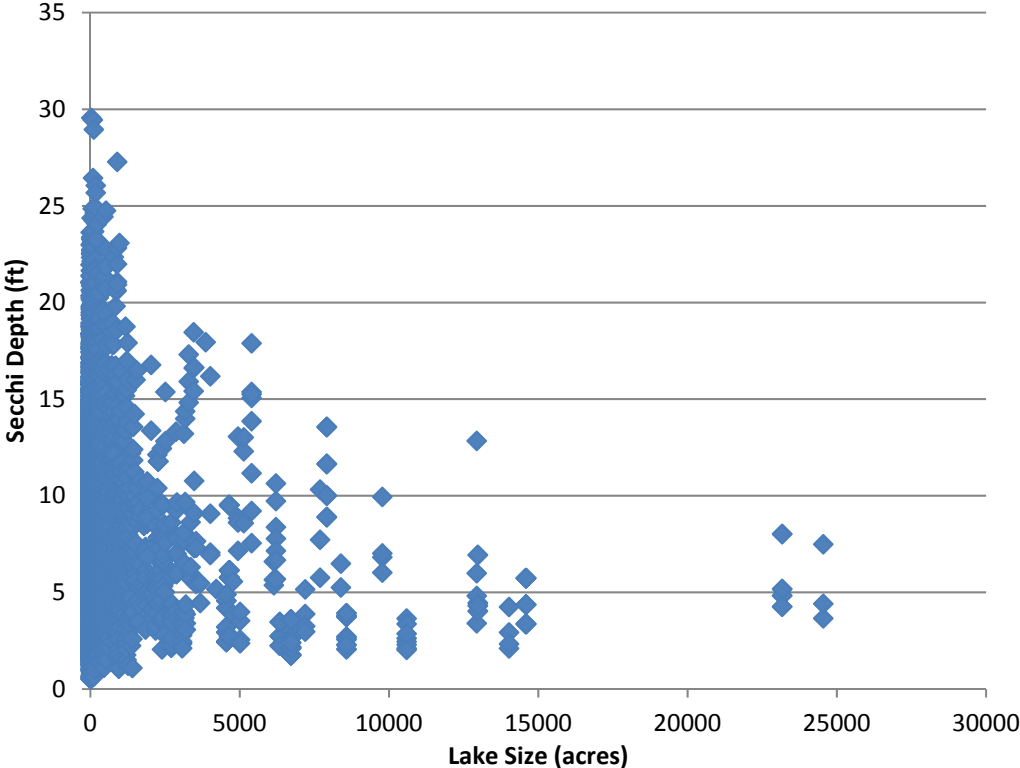
# Secchi Depth South to North



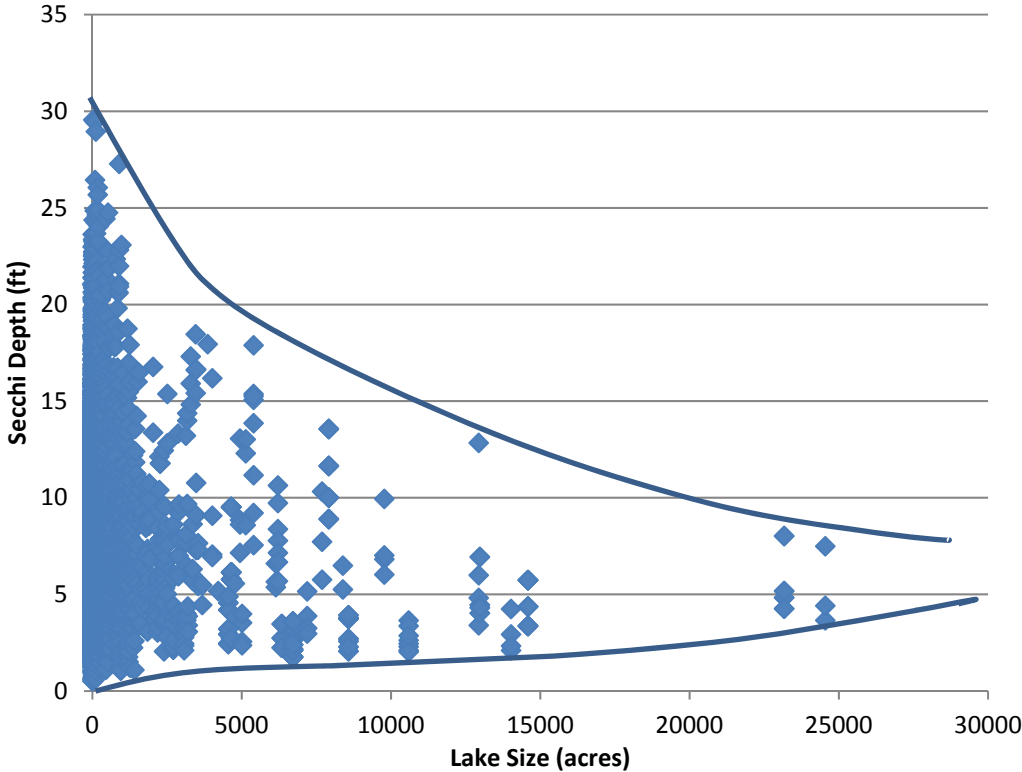
# The **Best** and the Worst



Relationship of Secchi to Lake Depth



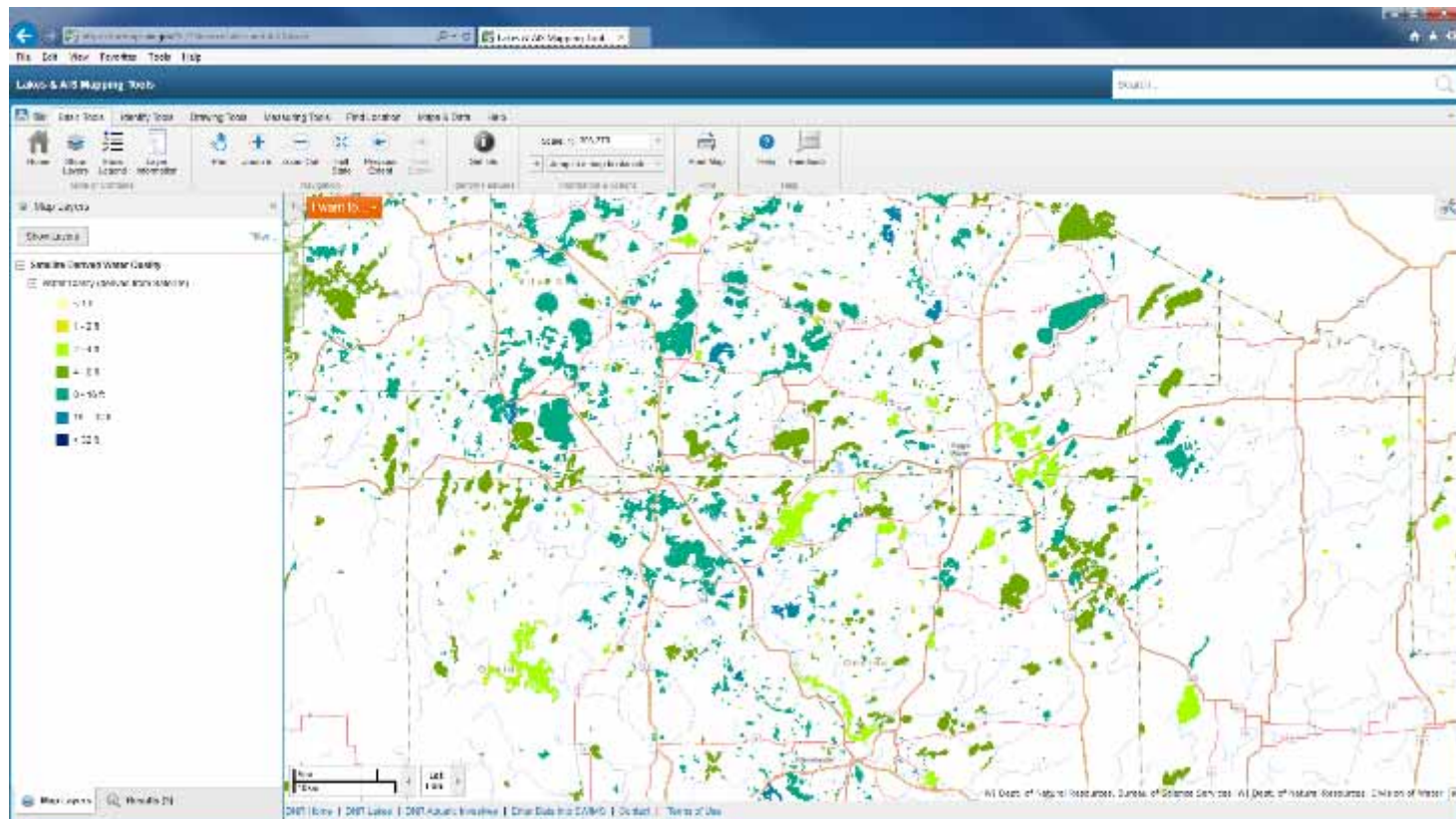
Relationship of Secchi to Lake Depth





# Lakes and Aquatic Invasive Species (AIS) Mapping Tool

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



# Optical and Biogeochemical Characterization of Lakes

## Field data collection

- Field data collection in summer and fall 2014-15 for algorithm development
- 24 lakes in Wisconsin
- Color samples collected by CBM volunteers

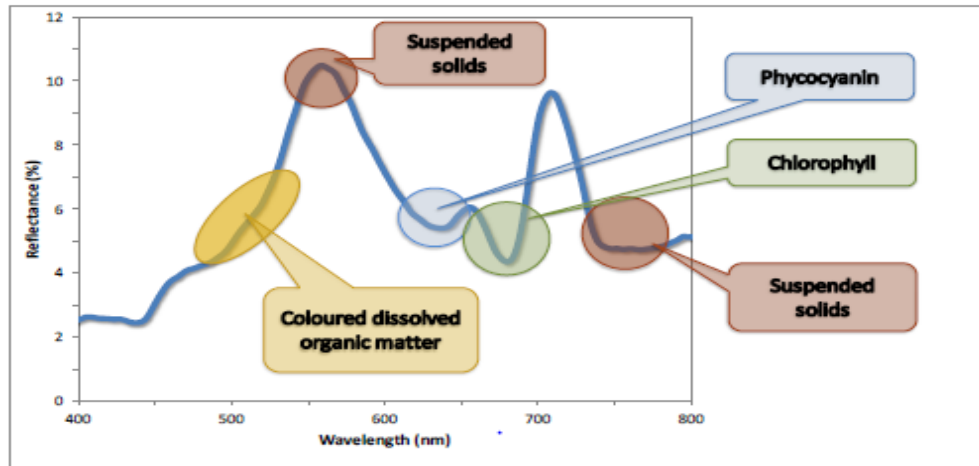
## Field and laboratory measurements

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



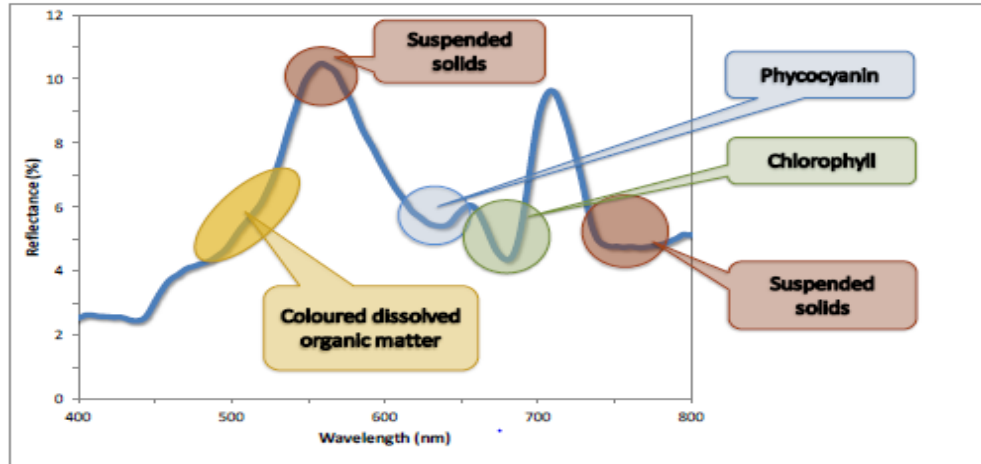
Collection of reflectance spectra with CDAP-2

# Remote sensing of water quality

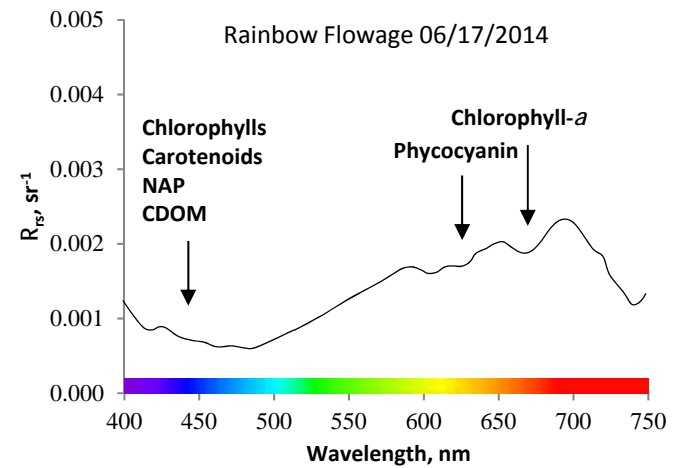
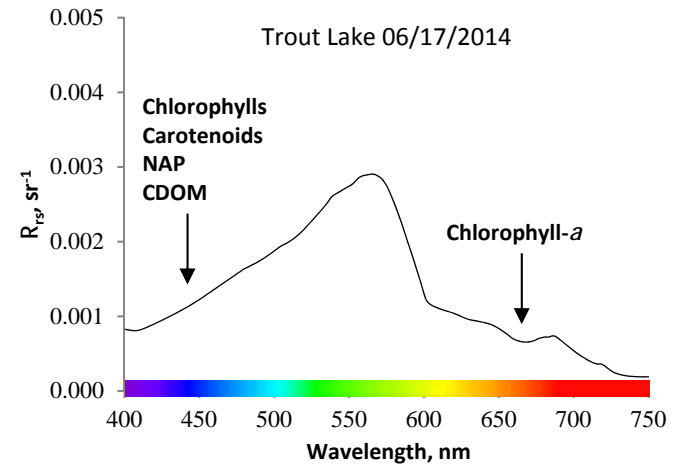


Guerschman, et al., 2015

# Remote sensing of water quality



Guerschman, et al., 2015



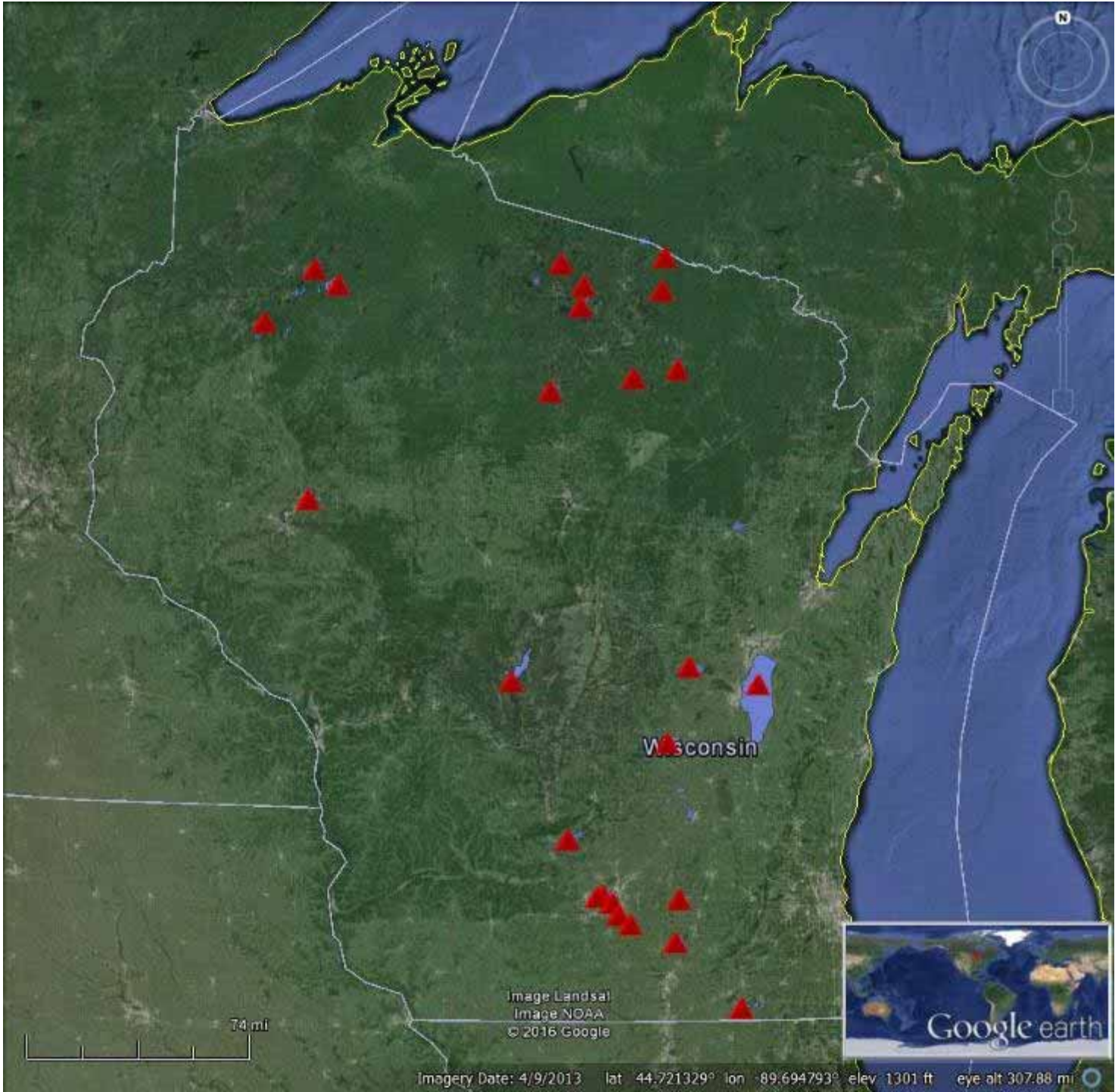
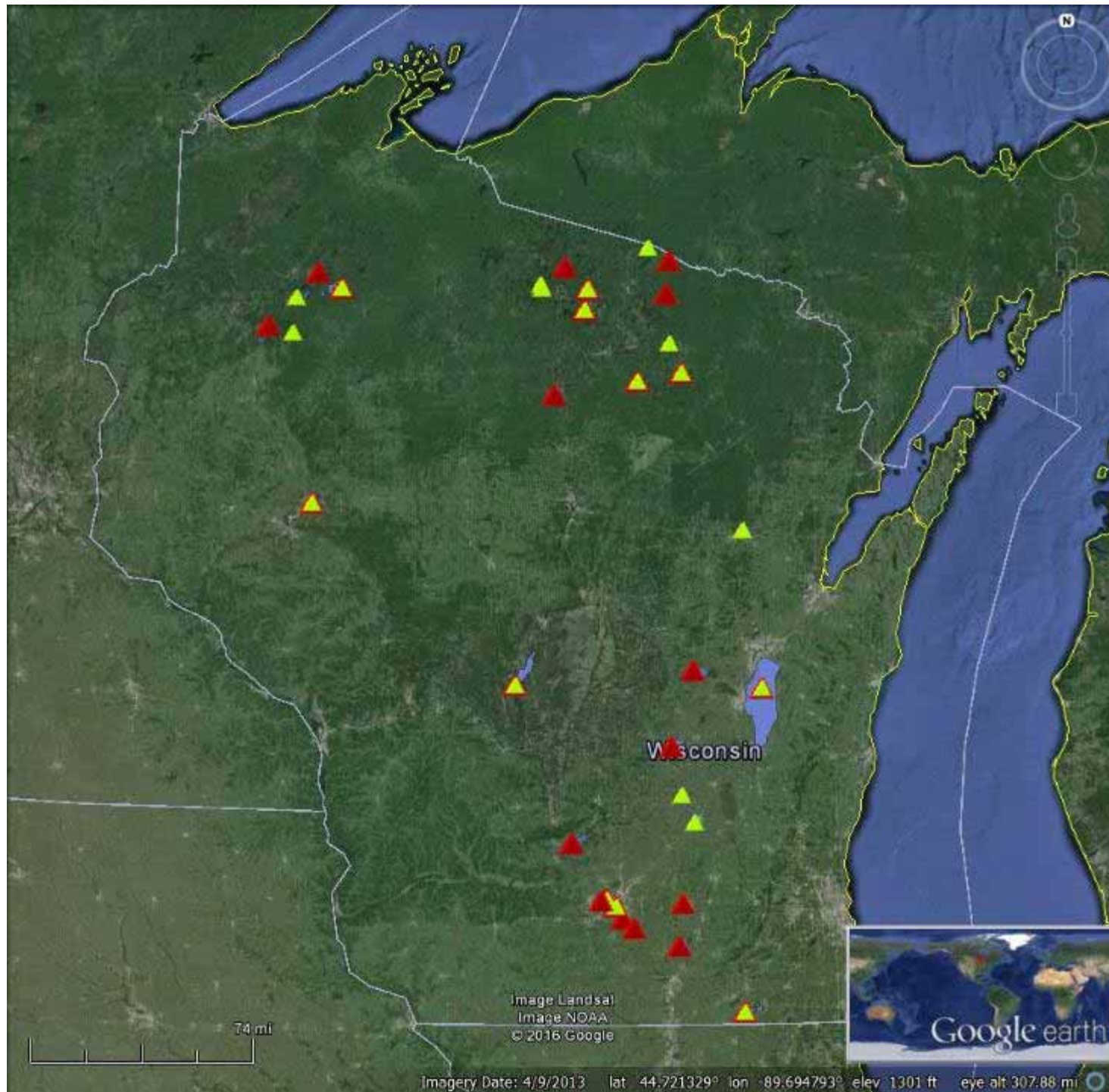


Image Landsat  
Image NOAA  
© 2016 Google

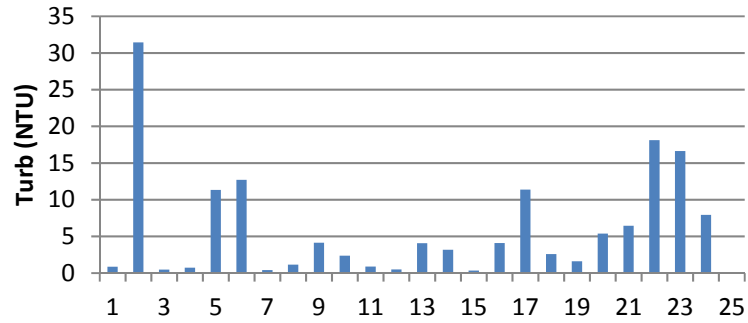
Imagery Date: 4/9/2013 lat 44.721329° lon -89.694793° elev 1301 ft eye alt 307.88 mi



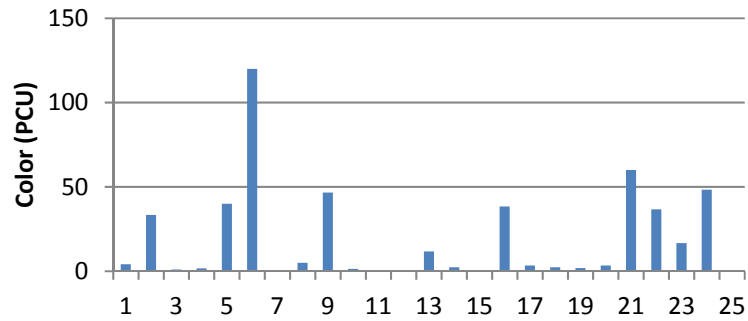


# 2015 Field Data

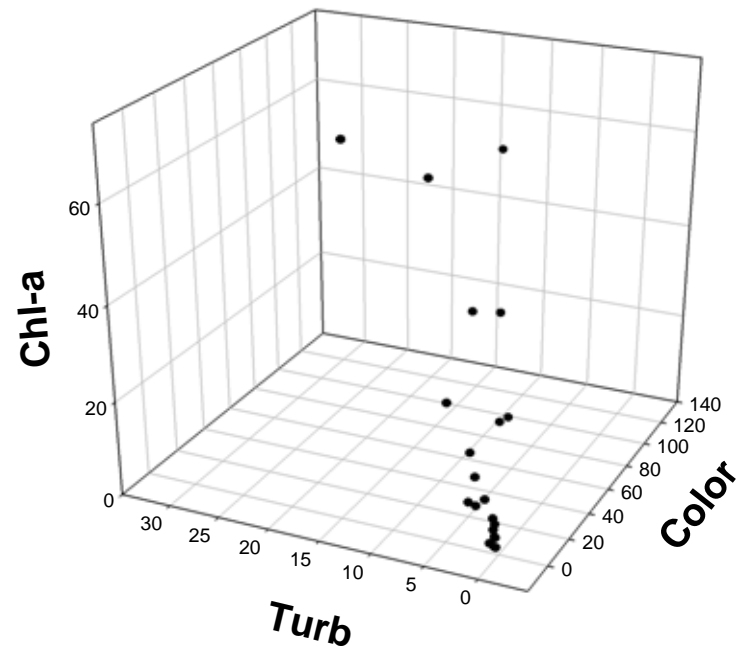
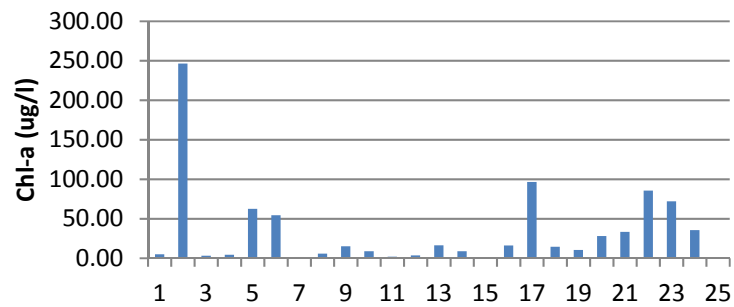
## Turbidity

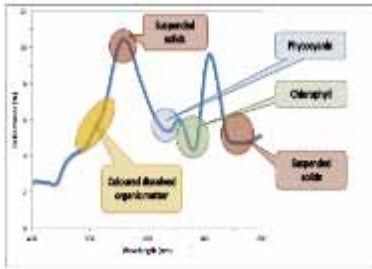


## Water Color



## Chl-a

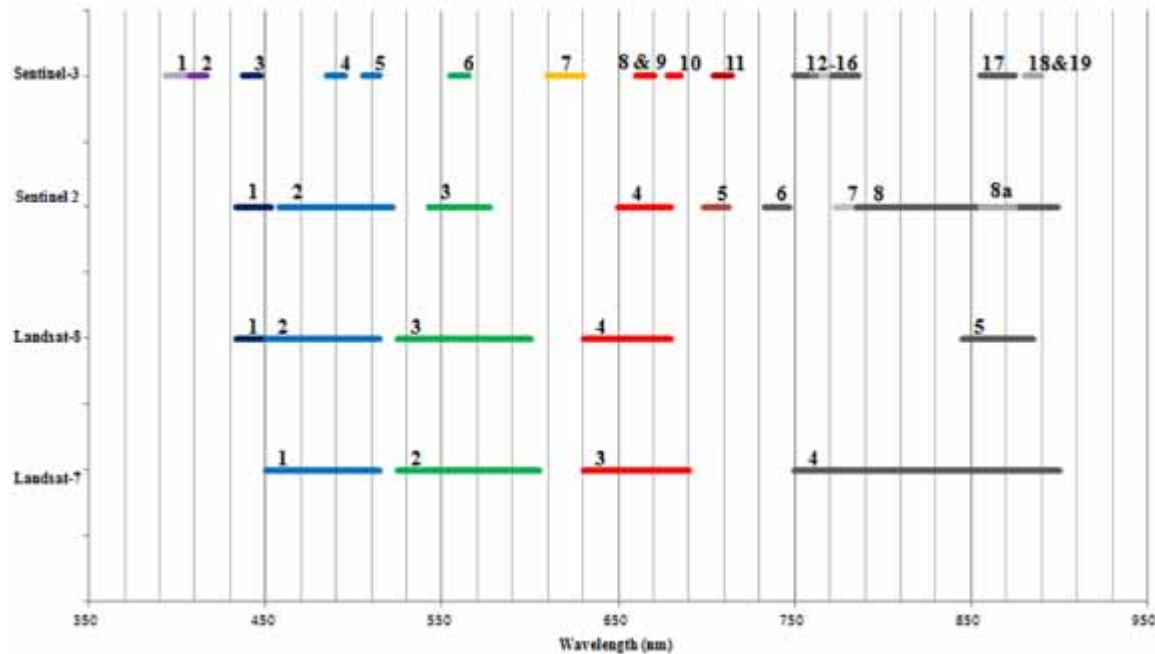




# Current and future sensors

*New tools in the toolbox*

Satellite	Landsat-7	Landsat-8	Sentinel-2	Sentinel-3
Satellite sensor systems	ETM+	OLI/TIRS	MSI	OLCI
Spatial resolution (m)	30	30	10, 20, 60	300
No of 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 (yr)	15/5	2/5	0/7	0/7



# Thank you



Sentinel 3 -ESA Image 2015

