Optical characterization of several lakes in upstate New York

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Introduction:

The geometry of the underwater light field is directly impacted by the constituents found within the waterbody. By measuring inherent optical properties like spectral absorption ($a(\lambda)$) and scattering ($b(\lambda)$), and those optically active constituents within the water, it is possible to create representative relationships between optical measurements and concentrations. These measurements can then be related to satellite data for use with remote sensing. Remote sensing is capable of providing measurements on a spatial scale unobtainable using conventional monitoring.

$$a_t(\lambda) = a_P(\lambda) + a_{CDOM}(\lambda) + a_w(\lambda)$$

Where a_t total absorption and a_P, a_{CDOM} and a_w are the absorption of particles, dissolved material and water, respectively. Scattering consists of two components, forward scattering $b_f(\lambda)$ and backscattering $b_b(\lambda)$.

$$R_{rs}(\lambda) = 0.45\frac{b_b(\lambda)}{a_t(\lambda) + b_b(\lambda)}$$

The remote sensing reflectance R_{rs} is the signal seen by a satellite sensor. b_b is that scattering which is reflected towards the point of emission.

Objective:

Demonstrate the optical variation and similarities of the systems we encountered.

Lakes:

Adapted from Google Earth Graphic

Lake	Type	Trophic State	Area (10^6 m^2)	Volume (10^9 m^3)
Wolf	Scour	Mesotrophic	0.599	0.0039
Song	Kettle	Mesotrophic	1.736	0.0061
Onondaga	Moraine	Meso/Eutrophic	12.7	0.14
Skaneateles	Moraine	Oligotrophic	36	16.1
Green	Plunge Pool	Oligotrophic	0.026	0.0074

Methods:

IOP Frame: ac-s and bb9

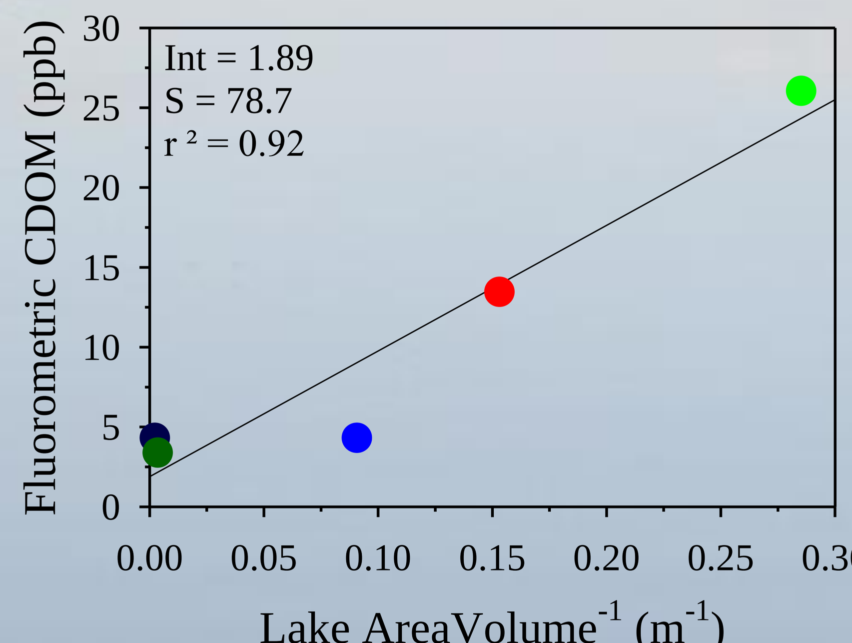
ac-s:

- Measures profiles of spectral beam attenuation ($c(\lambda)$) and absorption ($a(\lambda)$).
- 2 flow cells: *a* measured in cell which funnels all scattered light to collector, *c* cell absorbs all scattered light.
- Estimates of spectral scattering ($b(\lambda)$) are done by difference ($c(\lambda)$)) - ($a(\lambda)$).
- Spectral range of 400 – 715 nm at 4 nm resolution; sampling rate 4 Hz.
- Lowered through the water column at a rate of ~ 0.2 m/s.
- A 0.2μm filter was employed on *a* cell to measure CDOM.

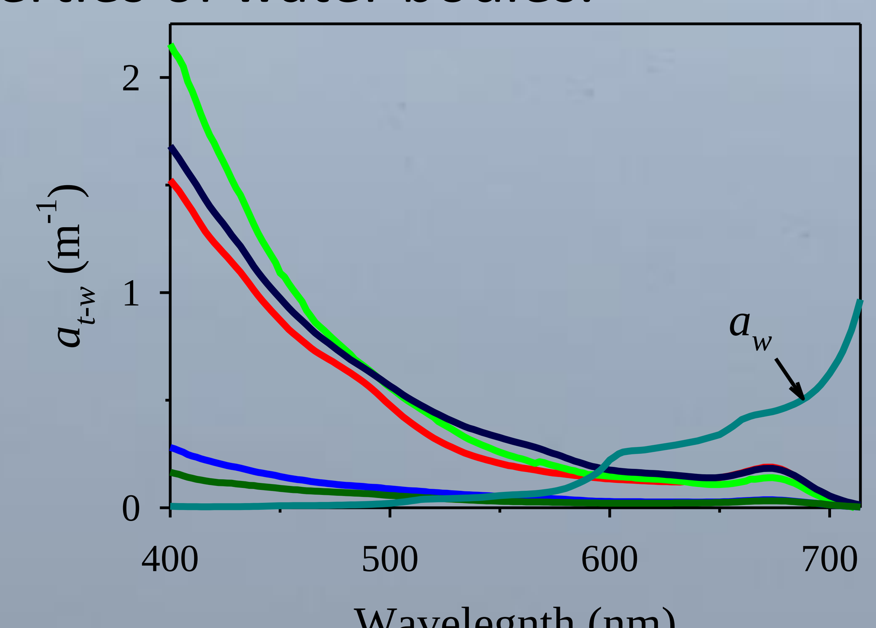
Bb9:

- A WETLabs bb9 measured backscattering at 9 wavelengths

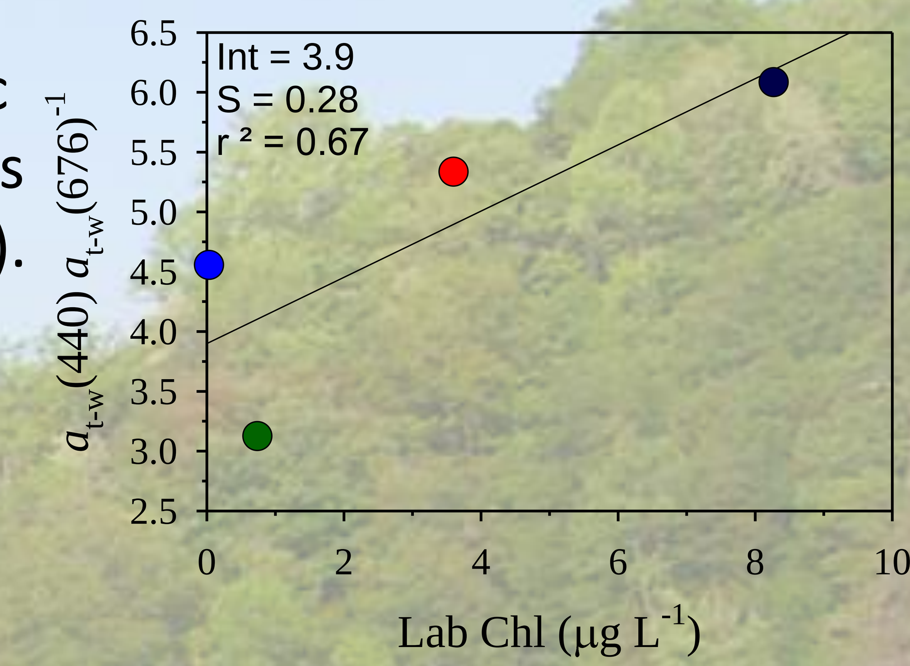
Results:



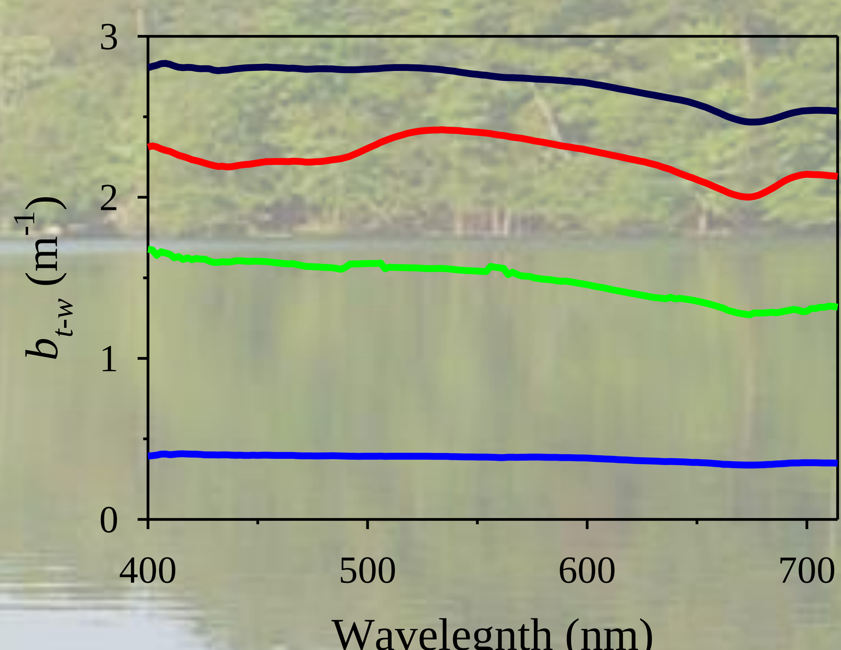
- Lake morphology influences the optical properties of water bodies.



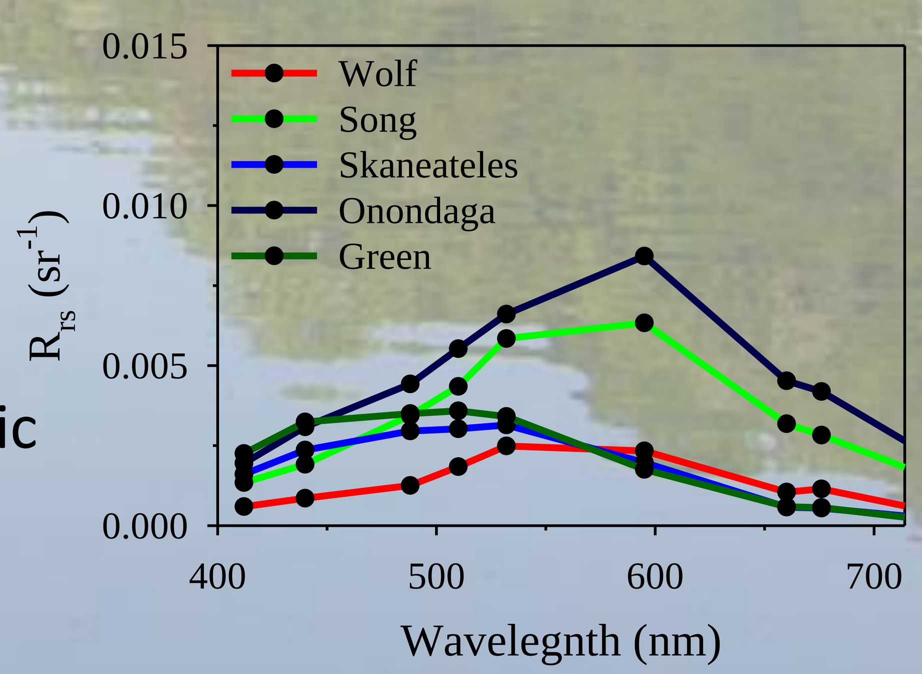
- Absorption at 440 and 676 exhibit peaks from chlorophyll a.
- Chlorophyll peaks more pronounced in lakes of higher trophic state.



- 440 nm and 676 nm ratio is a good metric for nature of particles (organic vs inorganic).
- Oligotrophic lakes exhibit smaller 440/676.



- Scattering higher in Song, Wolf and Onondaga lakes.
- Scattering is regulated by inorganic particles.



- R_{rs} more sensitive to backscattering than absorption.
- R_{rs} not necessarily lower for lower tropic state lakes.

Conclusion:

- Increases in optically active constituents in more eutrophic lakes manifests as higher optical signals for that lake.
- Remote sensing is more sensitive to backscattering and will vary based on inorganic particles.
- Lakes will need to be assessed separately when using remote sensing. Differences in optically active constituents between systems must be determined.
- Skaneateles and Green lakes (with the exception of R_{rs}) had the lowest optical signals while Onondaga typically had the largest.