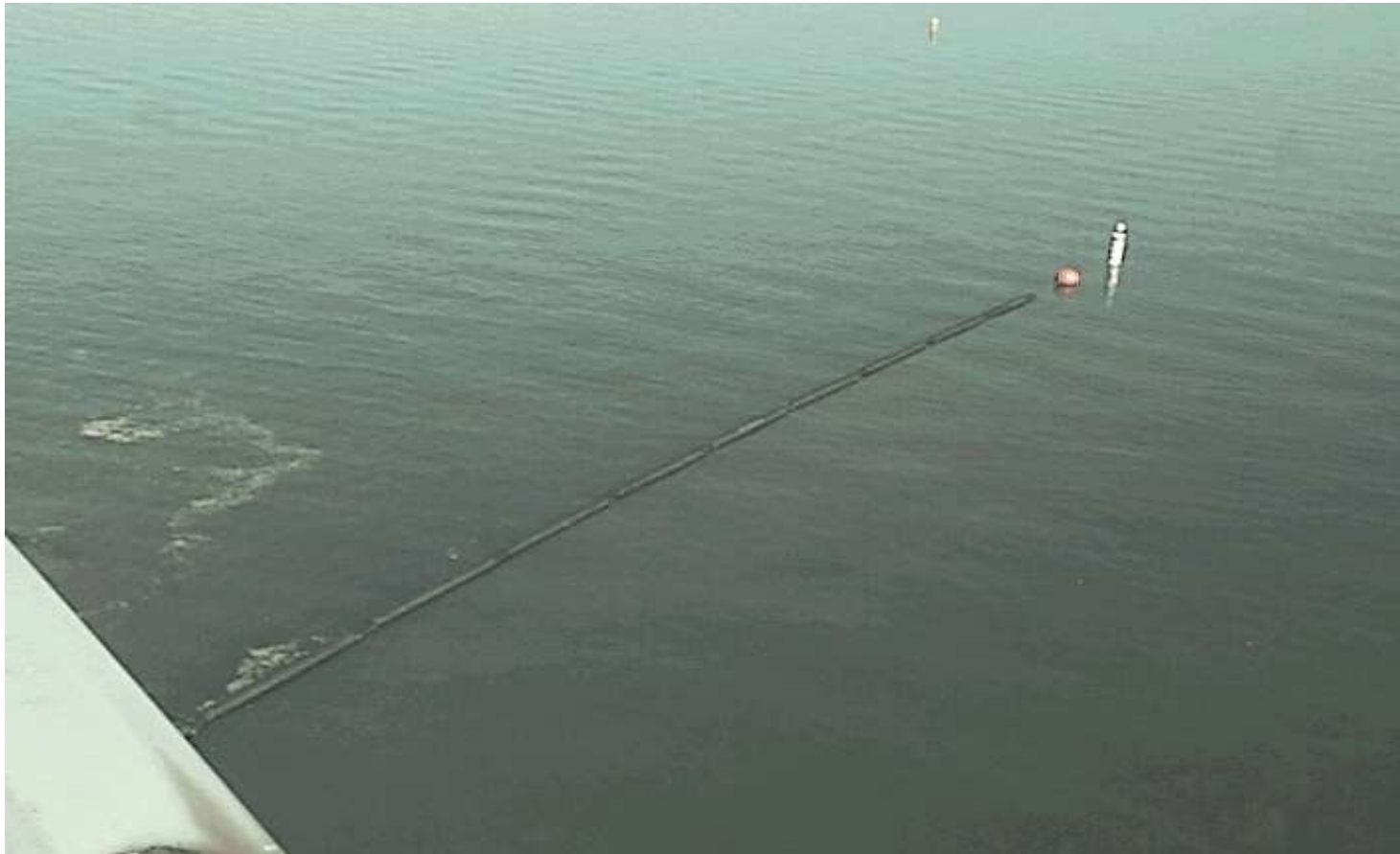


Real-Time Water Imaging System

A Ground-Based Water Quality Monitoring Tool



Adam Bechle and Chin Wu

University of Wisconsin-Madison



Algae blooms in Madison Lakes

JAMES MADISON BEACH

LAKE MENDOTA

Address: 614 E. Gorham Street, Madison

Directions: James Madison Park. See map below.

Description: Park/beach located downtown on Lake Mendota. On street parking. Restrooms available.

Water Quality Monitoring: PHMDC



CLOSED



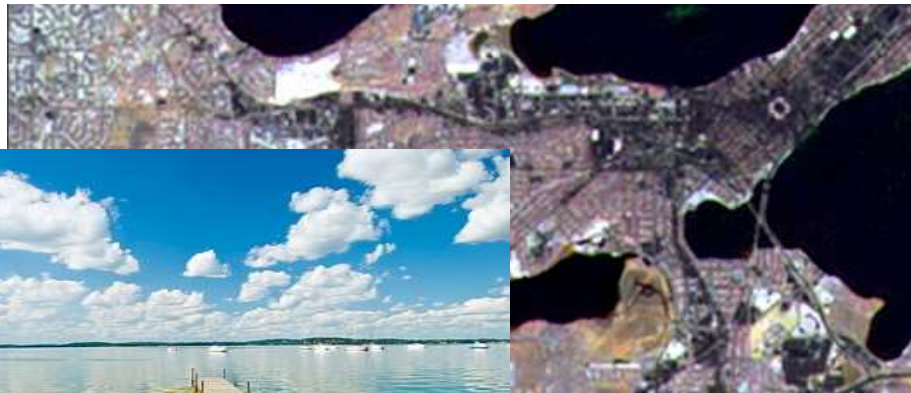
Madison.com

SAFETY INFORMATION

Swim Ropes	Lifeguard	Lifeguard Schedule
Yes	Yes (not on duty today)	06/12/2014 - 08/17/2014 12:30 PM - 4:30 PM
NOTICE: Lifeguard is off duty today due to off season		

AMENITIES

- Drinking Water
- Picnic Tables
- Playground
- Restrooms
- Volleyball



Rapid estimates of algae are needed to improve response time

com

Monitoring Algae

Satellite Remote Sensing

Landsat



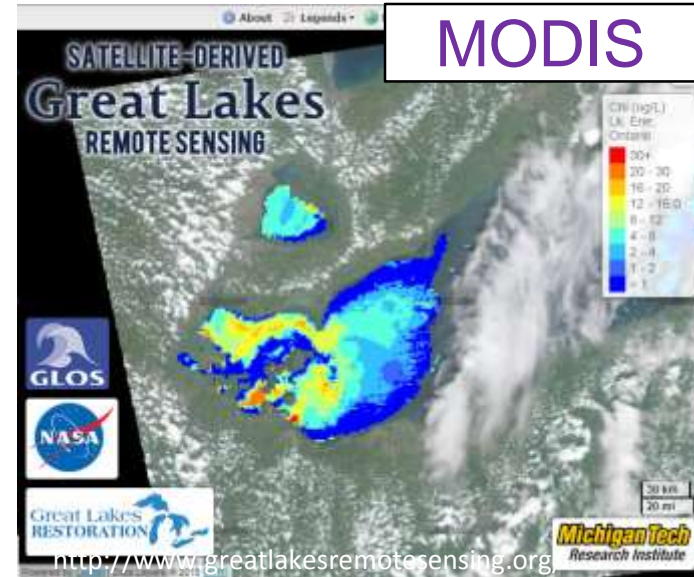
Spatial
Resolution

30 m 1 km

Temporal
Resolution

16 days 1-2 days

MODIS



Fluorometer



In Situ Sensors

Limited to point samples

Biofouling requires maintenance

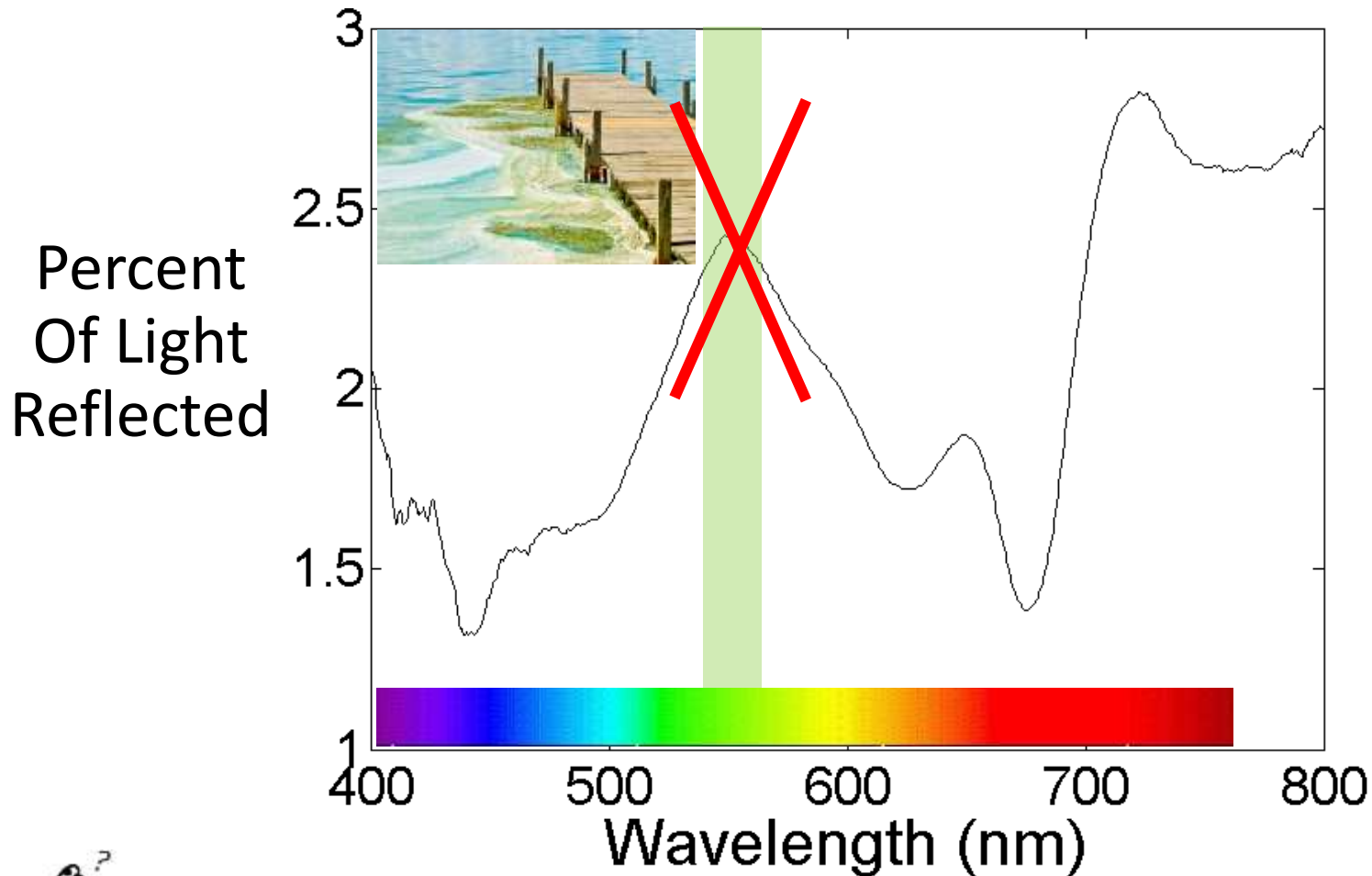
Research Objective

Develop an *image-based system* to measure **algae concentration** with high **spatial** resolution and **real-time** capabilities



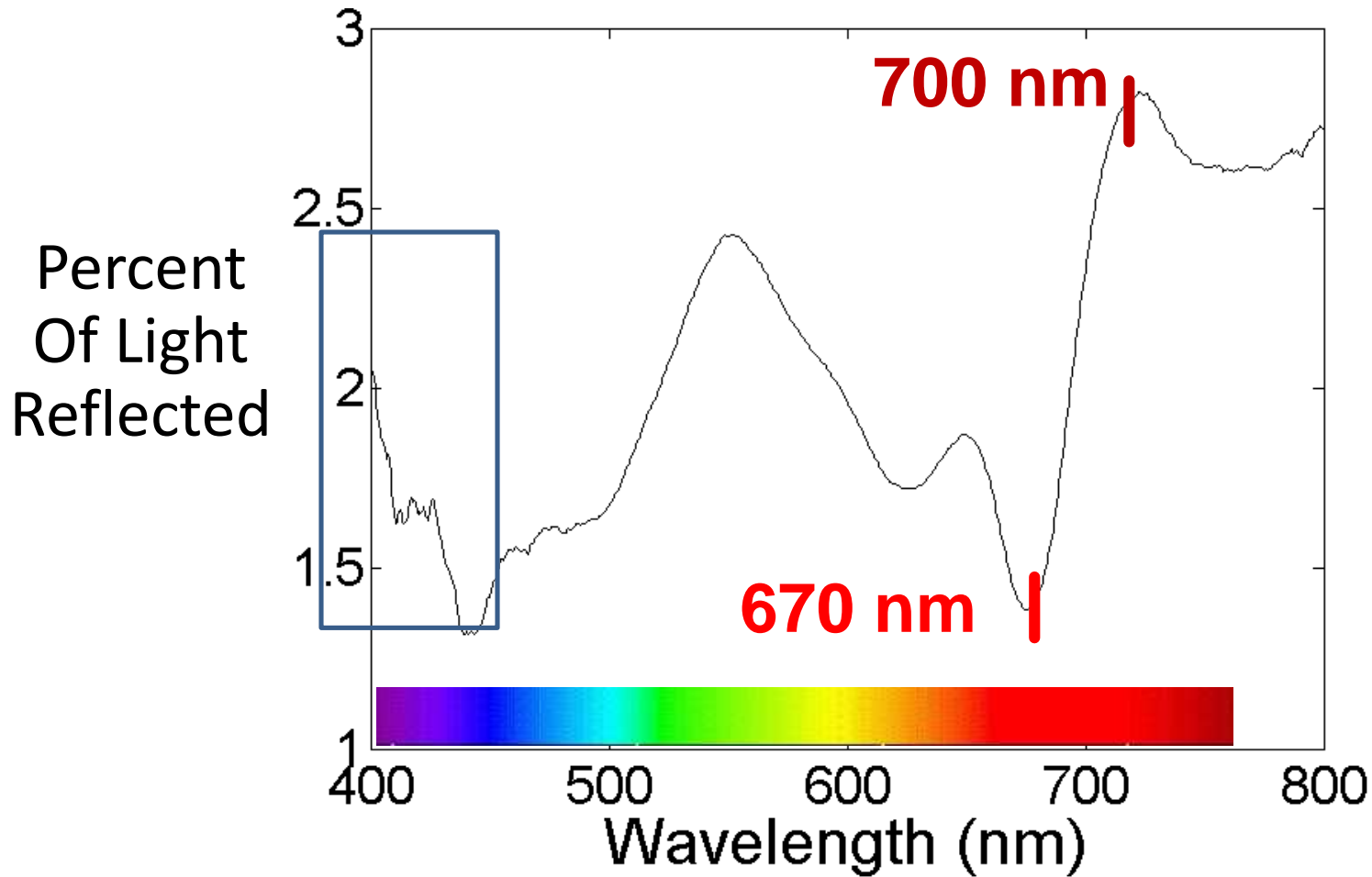
Algae Spectral Properties

Use **chlorophyll-a** concentration as proxy for algae

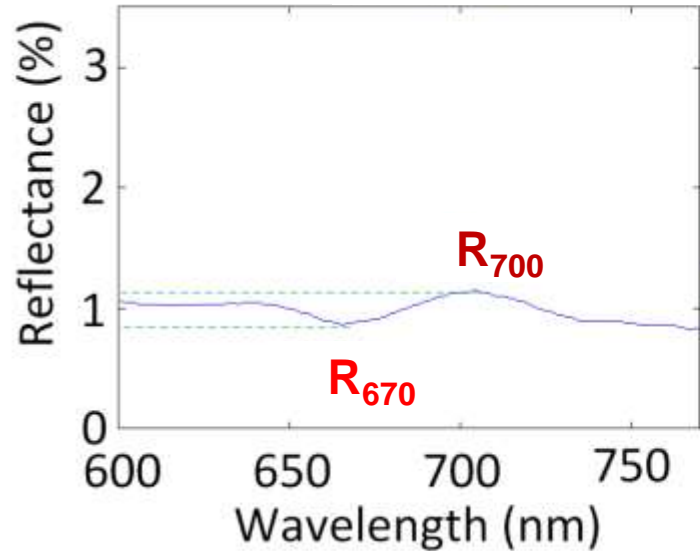


Sediment also strongly reflects green light

Algae Spectral Properties



Algae Spectral Properties



$\frac{R_{700}}{R_{670}}$ ratio increases with **Chl-a Concentration**

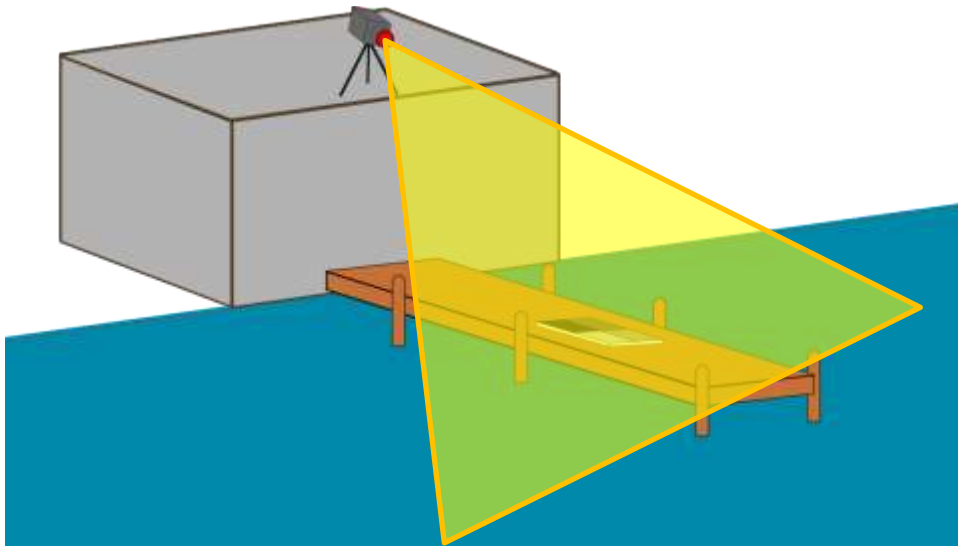


Measure Reflectance



Estimate Algae

Real-time Water Imaging System (RT-WIS)



Near-Infrared Camera



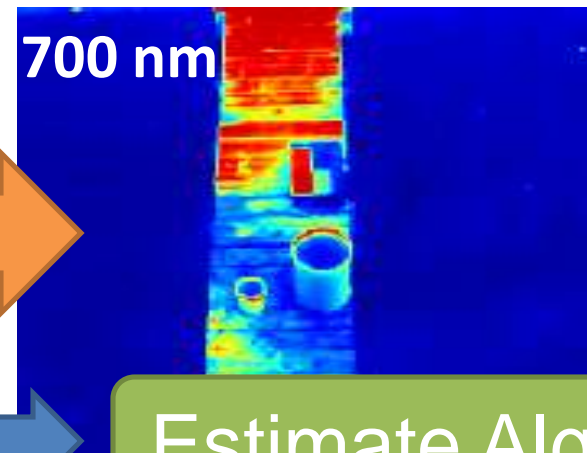
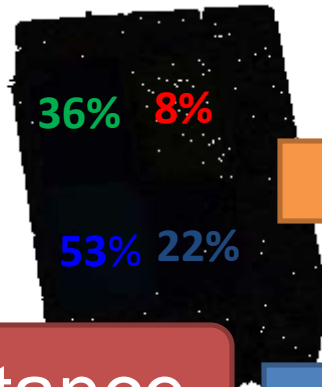
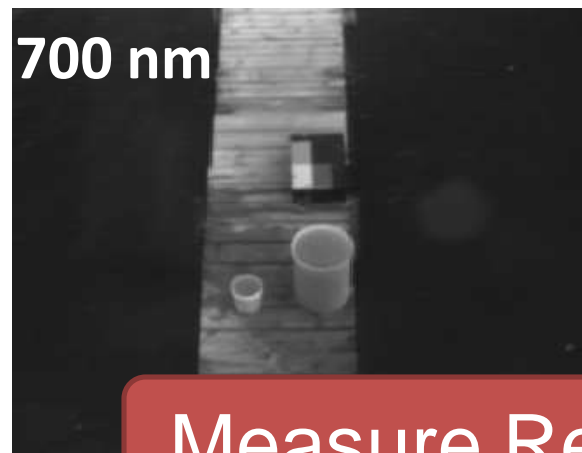
Optical Filters

Isolate 670 and 700 nm light

Filtered Image

Reflectance Reference

Reflectance Image

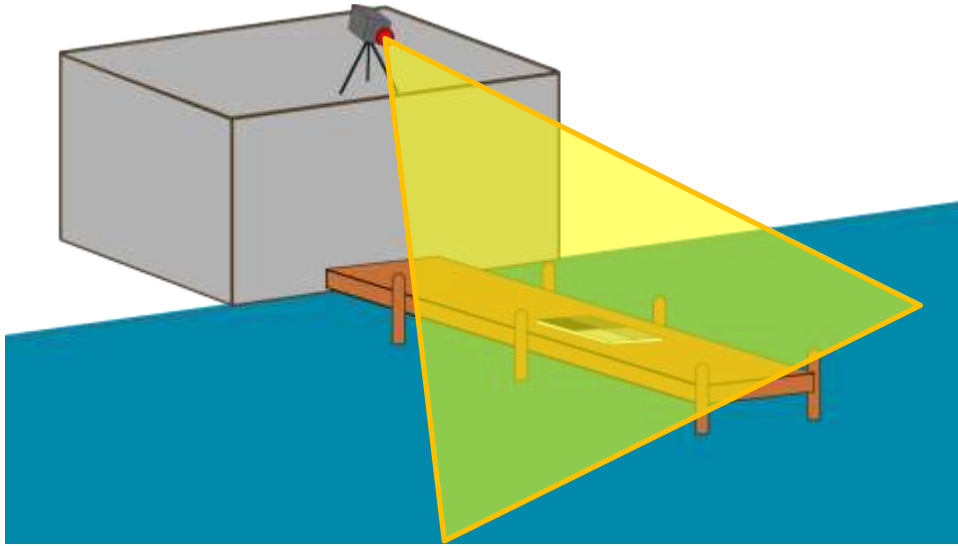


Reflectance (%)

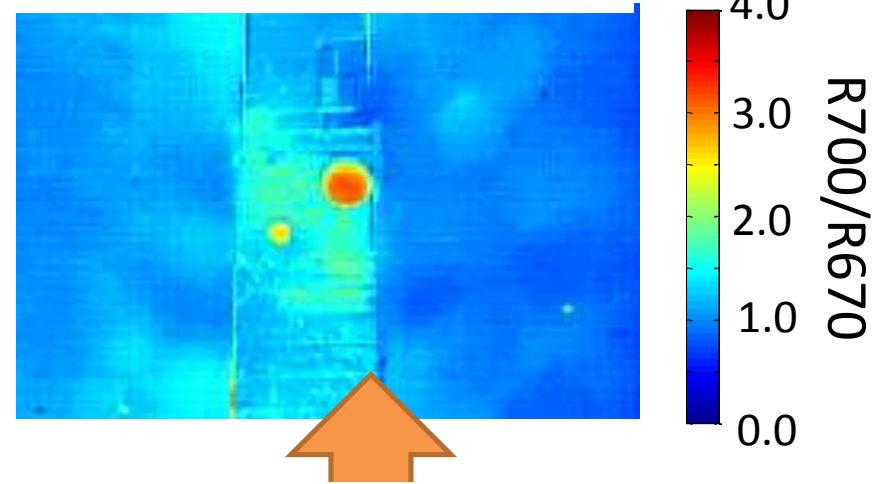
Measure Reflectance

Estimate Algae

Real-time Water Imaging System (RT-WIS)



R700/R670 Image

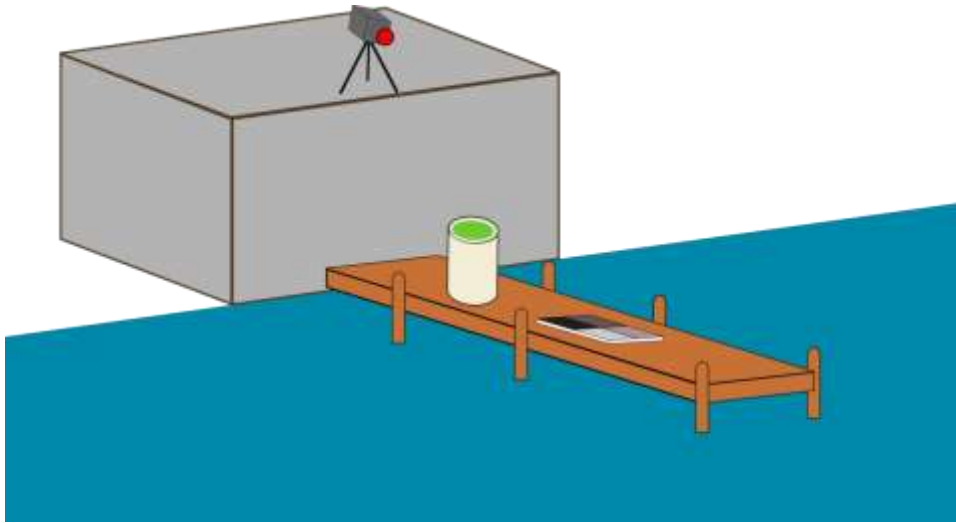


Measure Reflectance



Estimate Algae

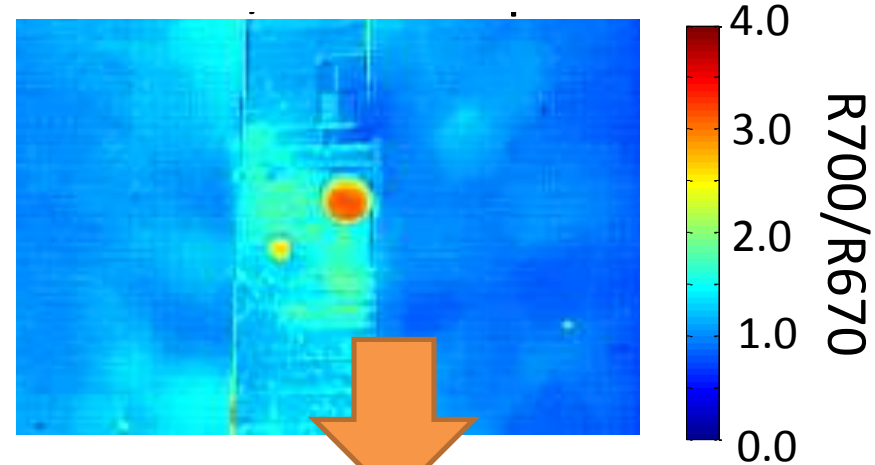
Relating Reflectance to Chl-a



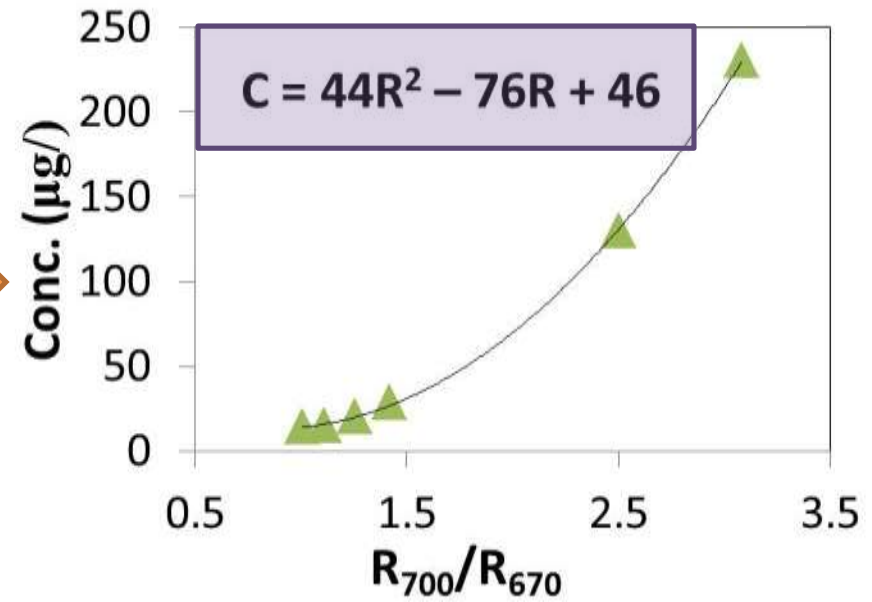
Dilute Algae in Bucket



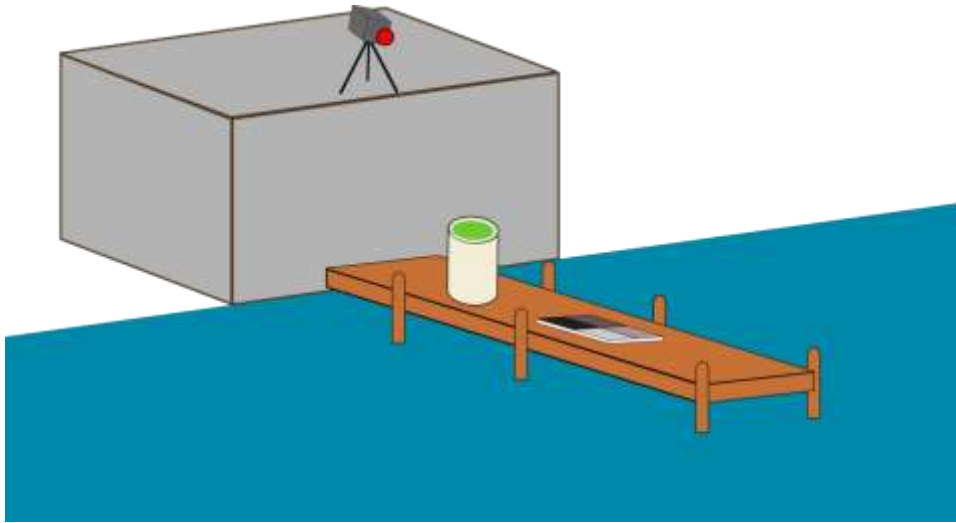
R700/R670 Image



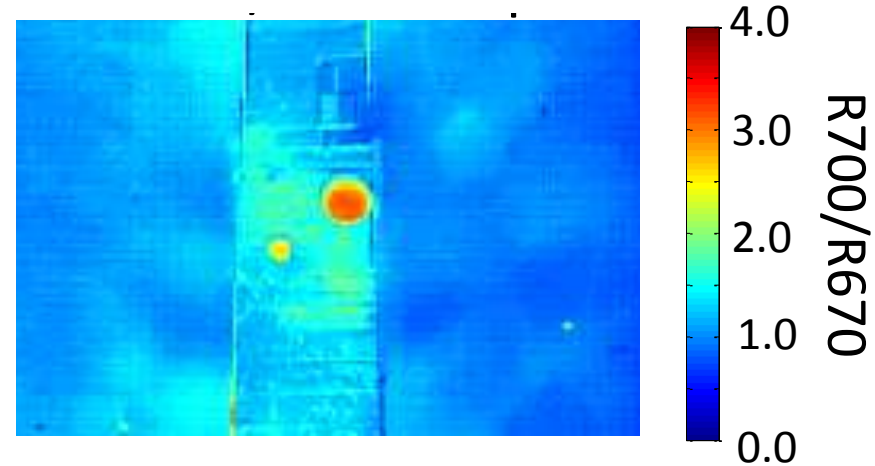
Calibration Curve



Relating Reflectance to Chl-a



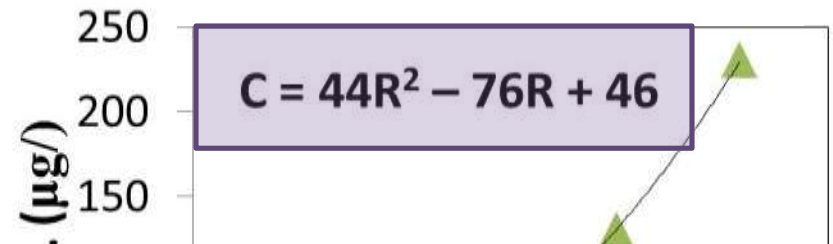
R700/R670 Image



Dilute Algae in Bucket



Calibration Curve



Measure Reflectance

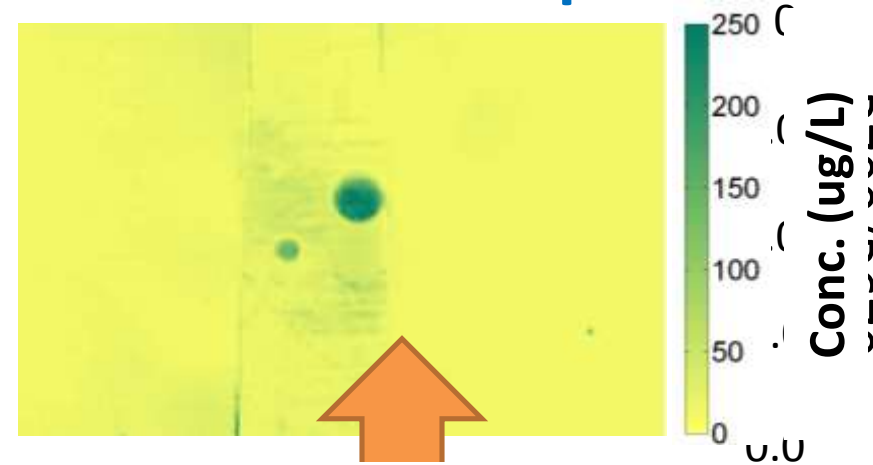


Estimate Algae

Relating Reflectance to Chl-a



Chl-a Conc. Map



Real-time Water Imaging System RT-WIS



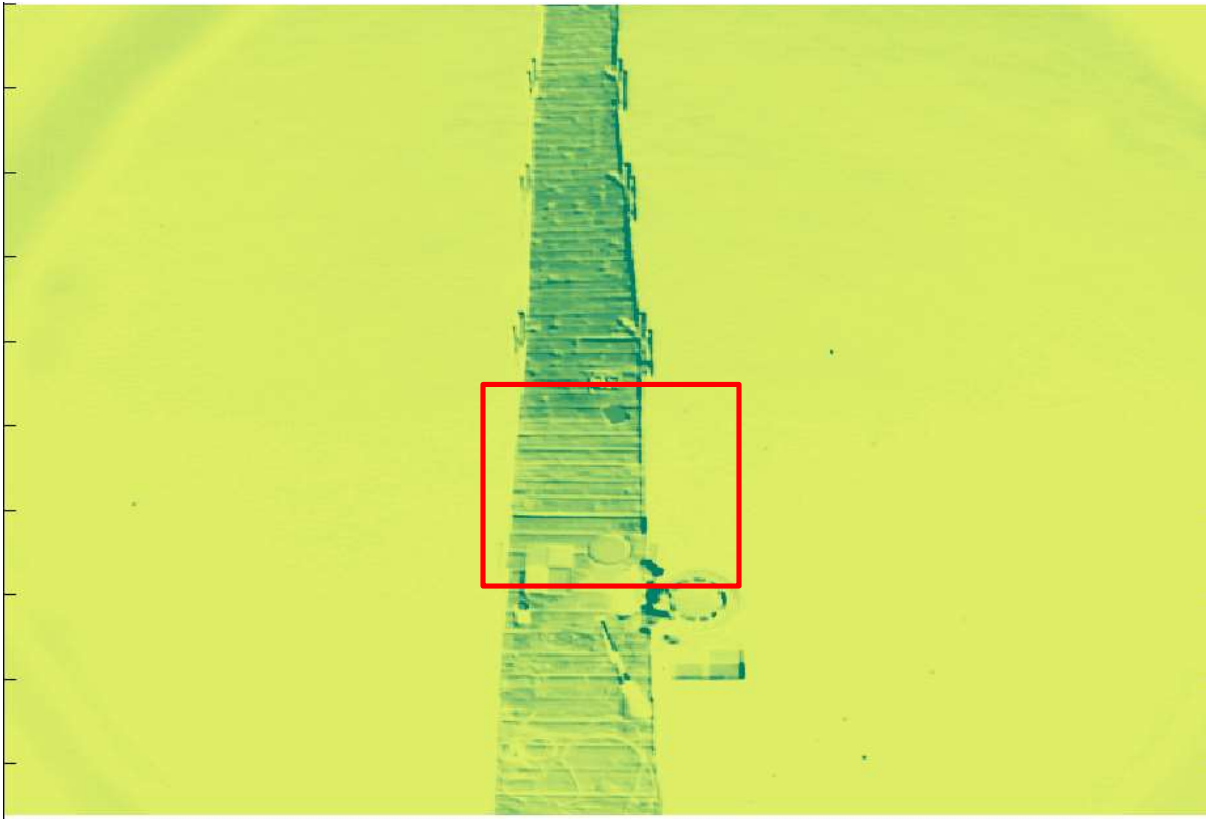
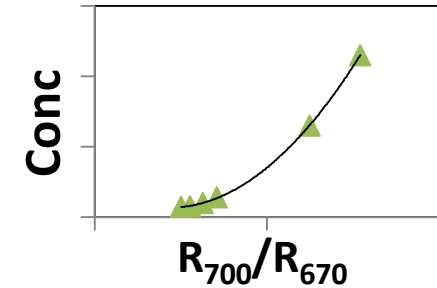
Measure Reflectance



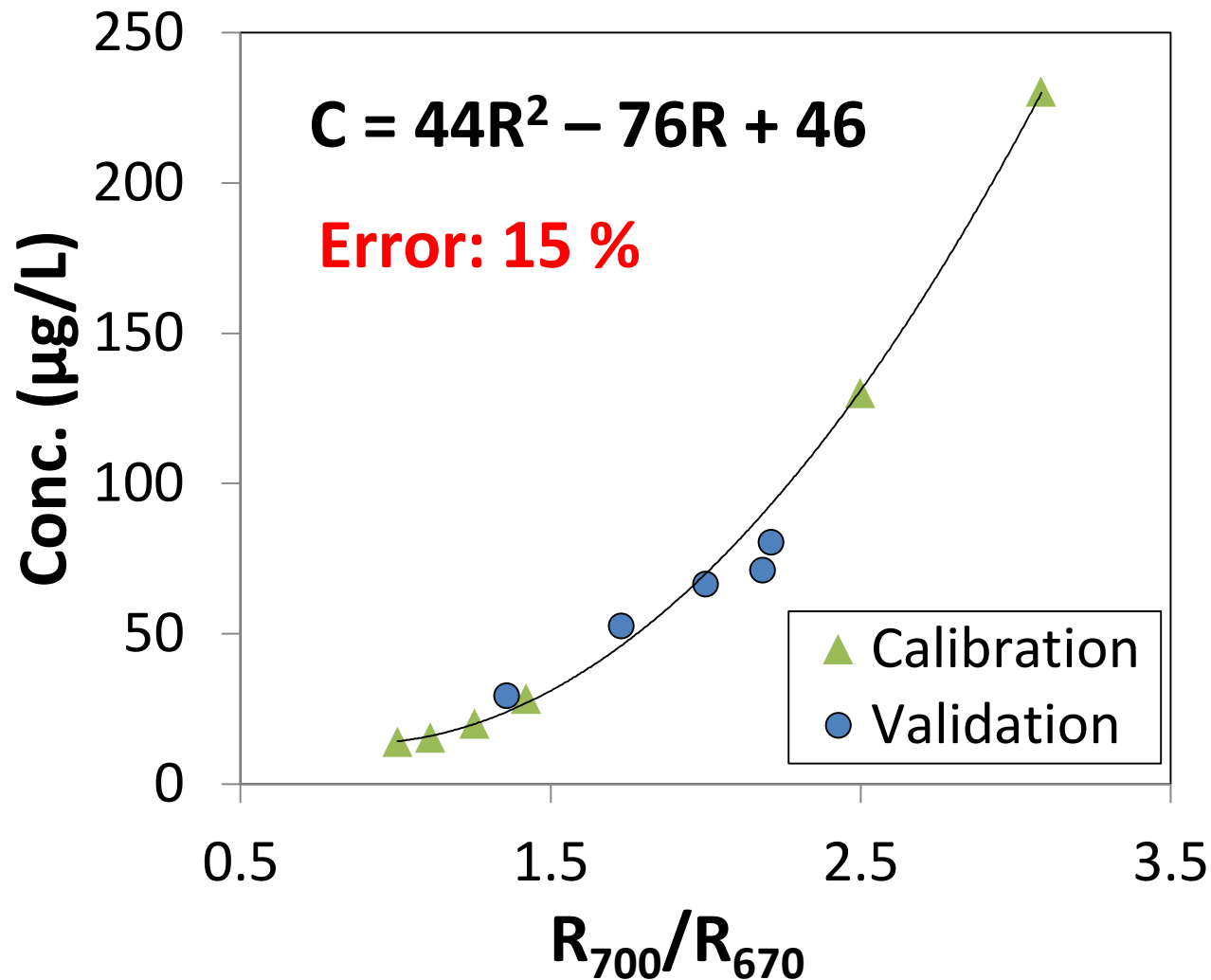
Estimate Algae

Validation Case

Compare Calibration with Repeated Algae Dilutions

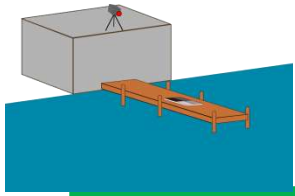


Validation Case



Measurement time: ~5 minutes

Real-time Speed

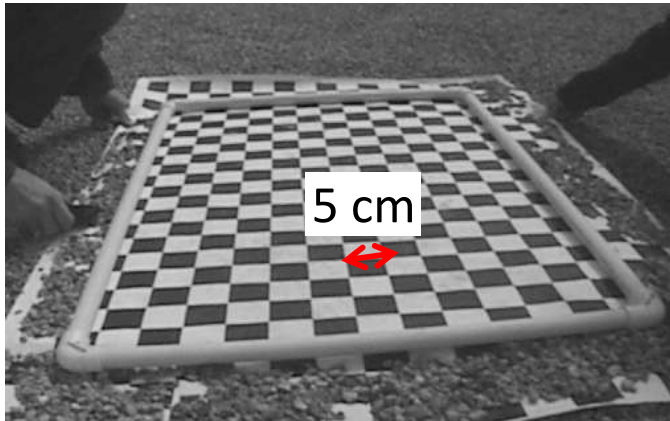


Spatial Measurement

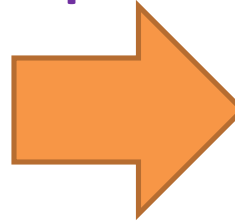


Geometric Rectification

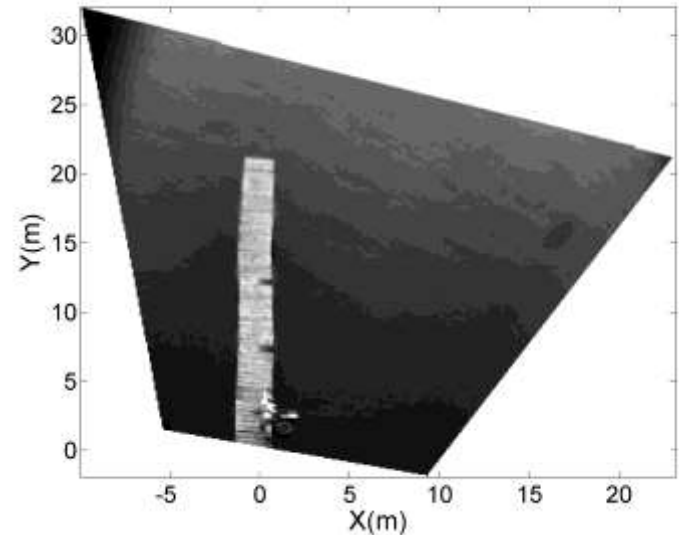
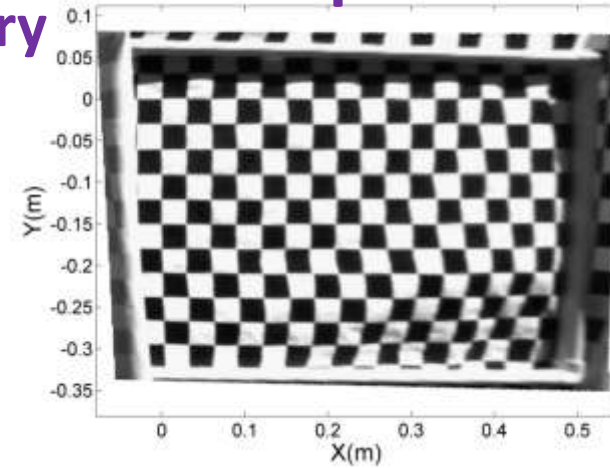
Image of known points



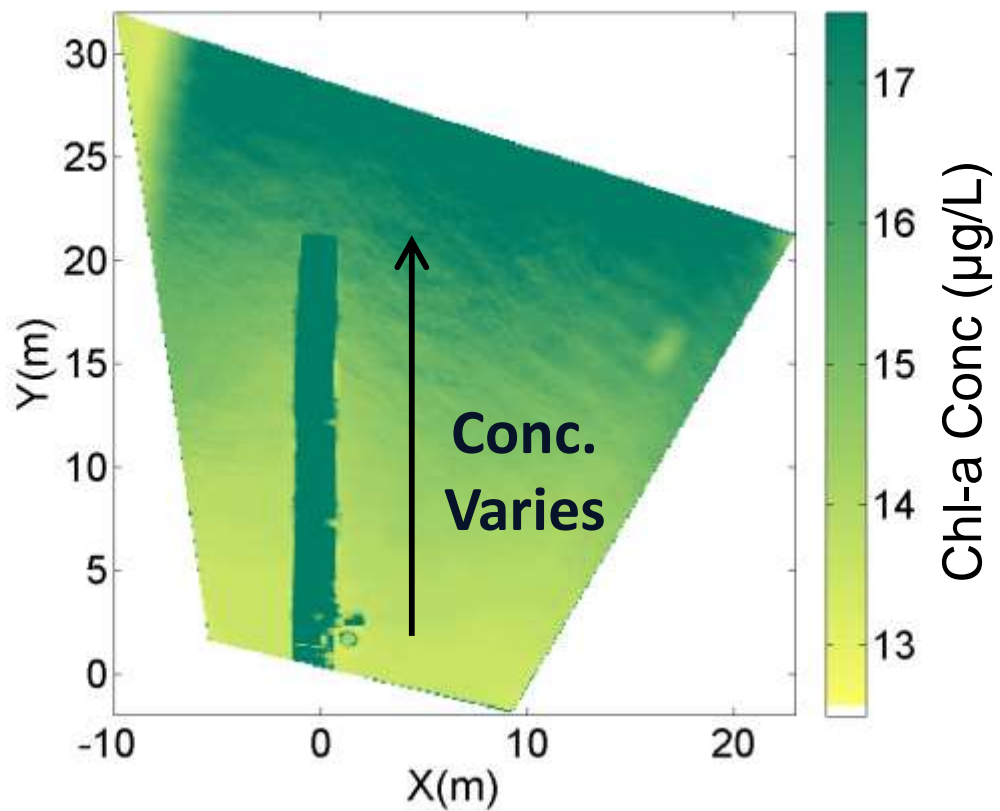
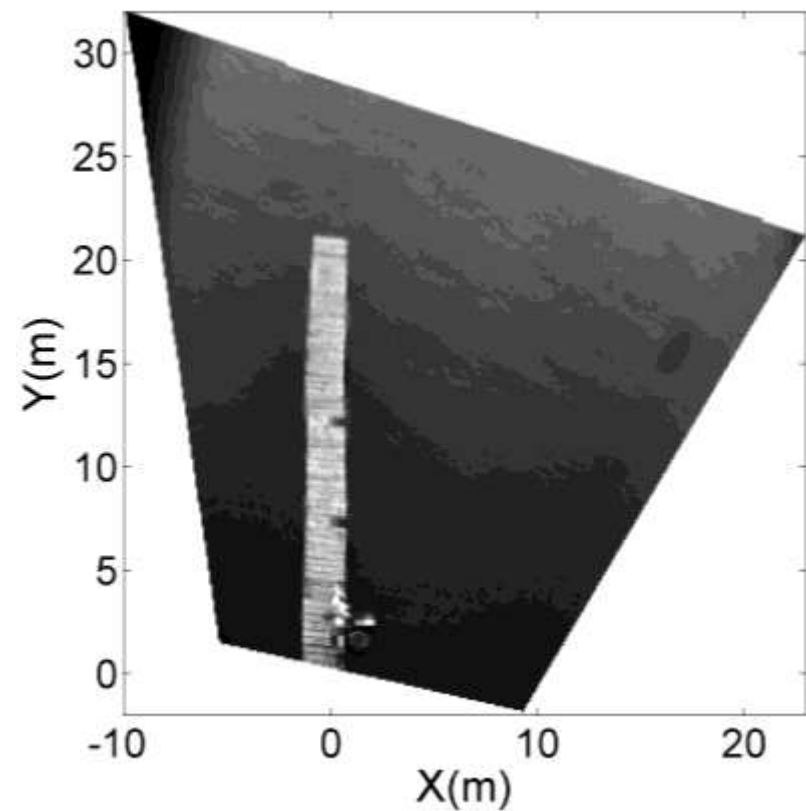
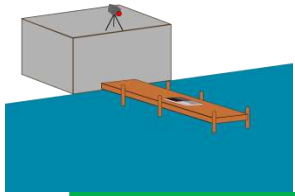
Camera Geometry Equations



Orthophoto



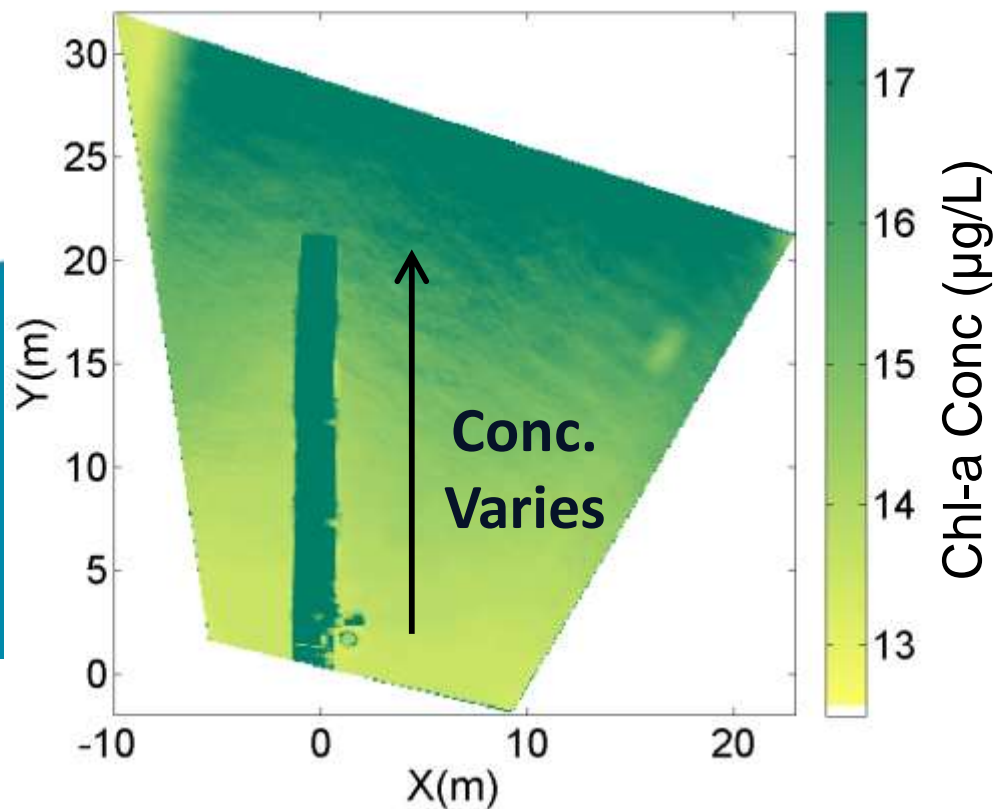
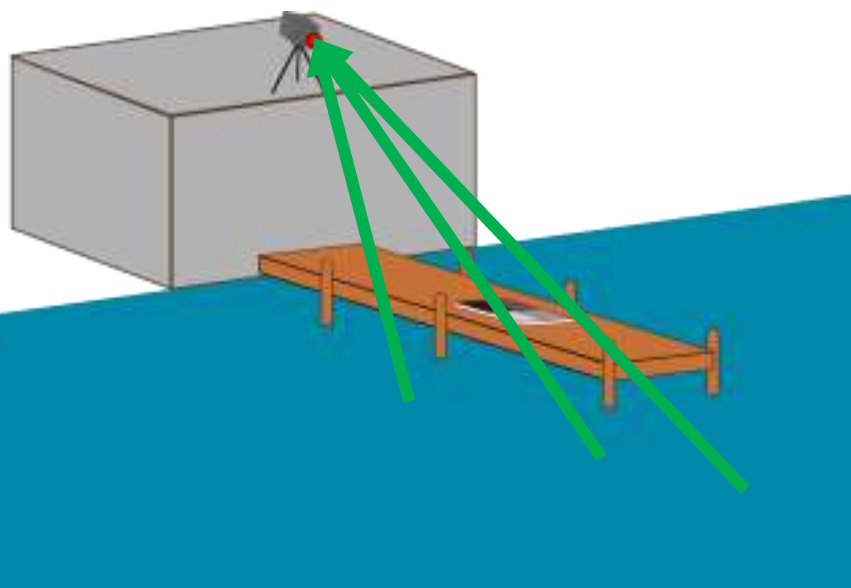
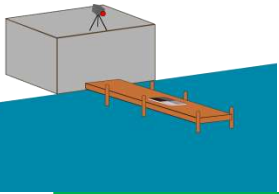
Spatial Measurement



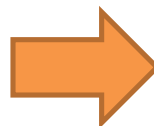
Fluorometer indicates
homogeneous Chl-a conc.

Spatial Measurement

Spatial Reflectance Correction



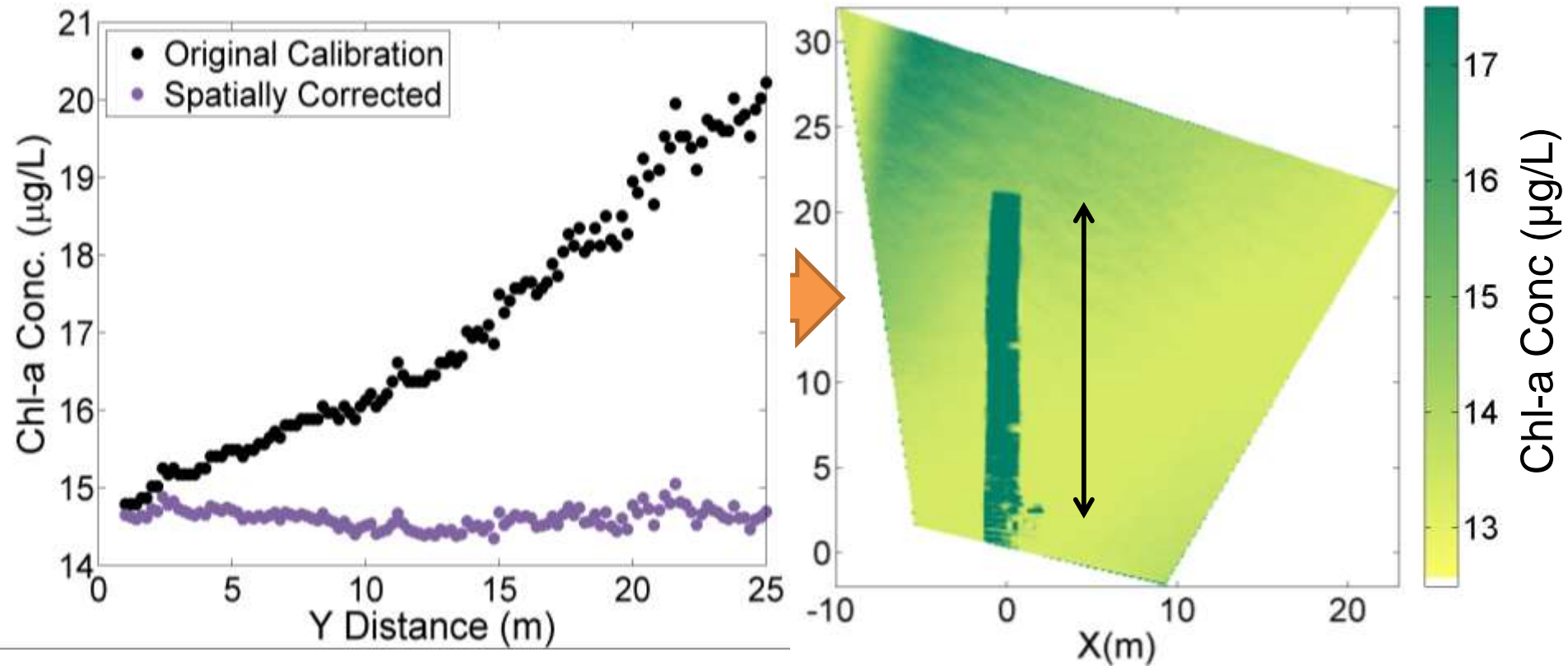
Reflectance changes
with angle



Need a spatially variable
reflectance correction

Spatial Measurement

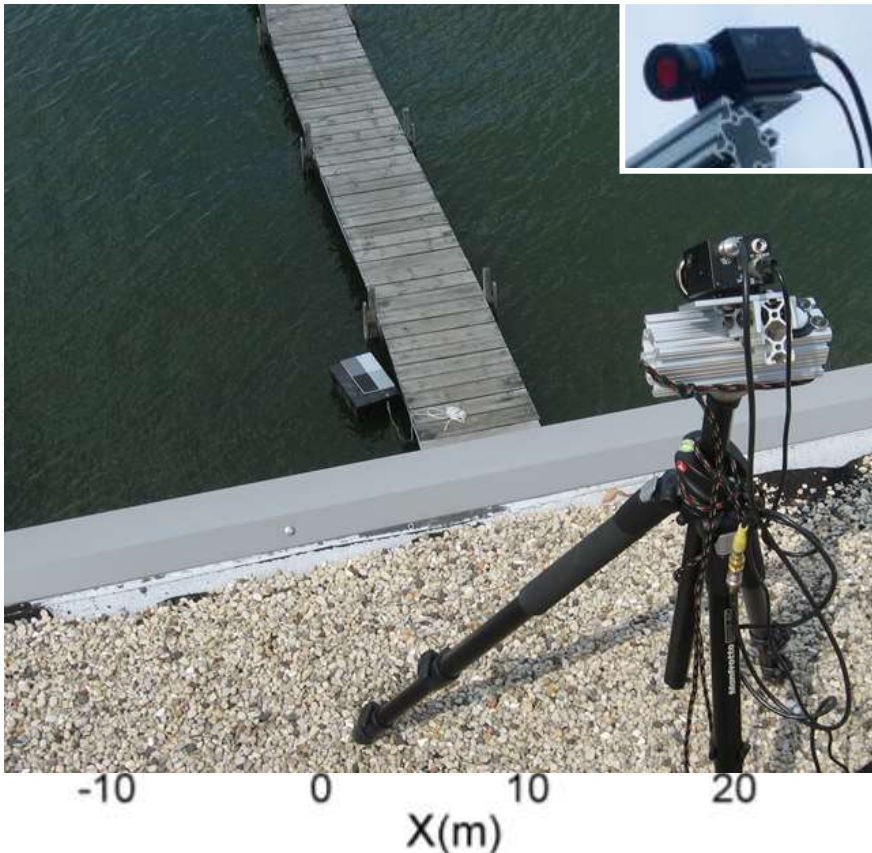
Spatial Reflectance Correction



Spatial Reflectance Correction \rightarrow Homogeneous Chl-a Conc

Summary

A **Real Time WIS** is developed to measure **algae concentration** with high *spatial* resolution and *real-time* capabilities.



Measure Reflectance



Reflectance to Chl-a



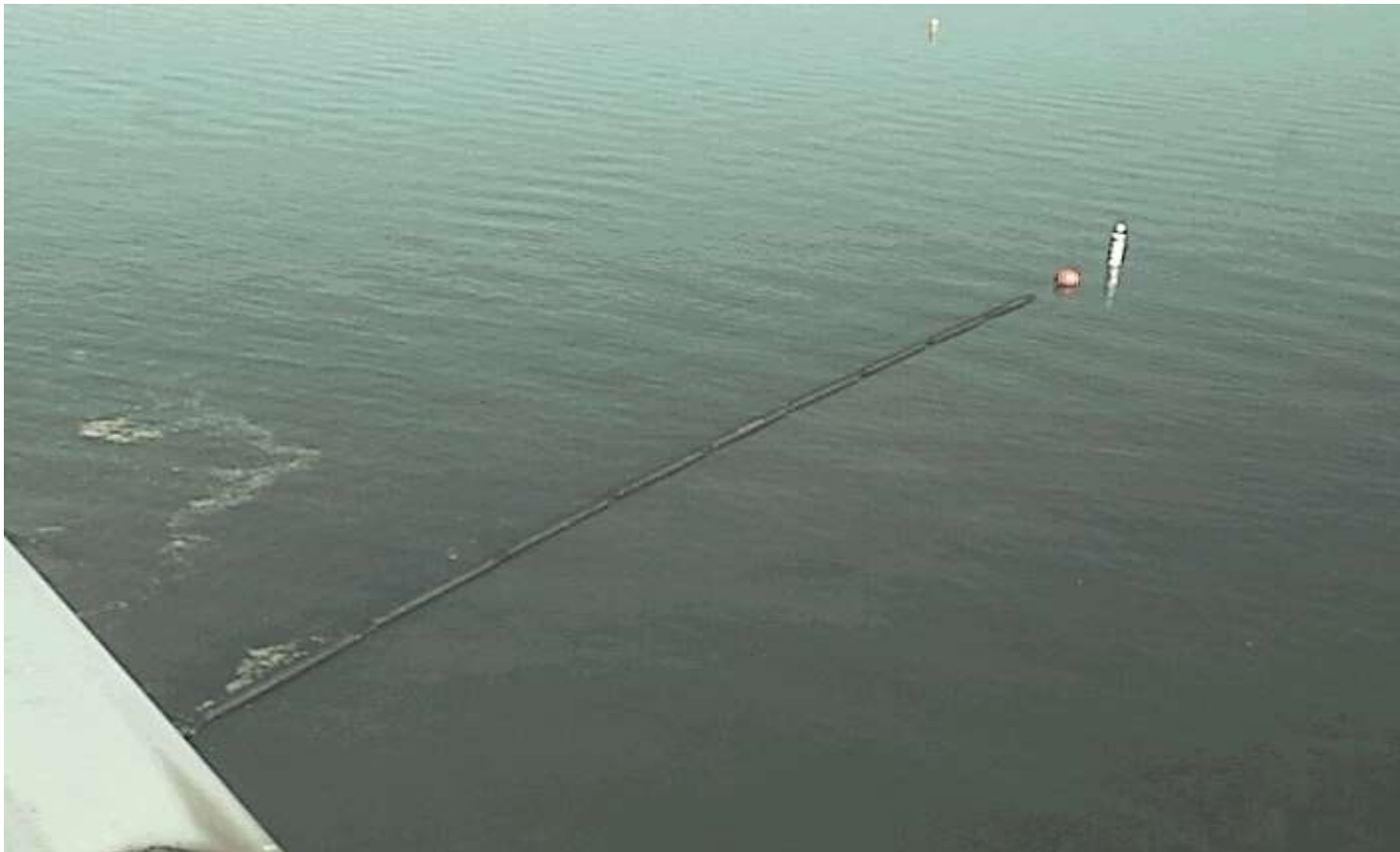
Geometric Rectification



Spatial Correction

Summary

A **Real Time WIS** is developed to measure **algae concentration** with high *spatial* resolution and *real-time* capabilities.



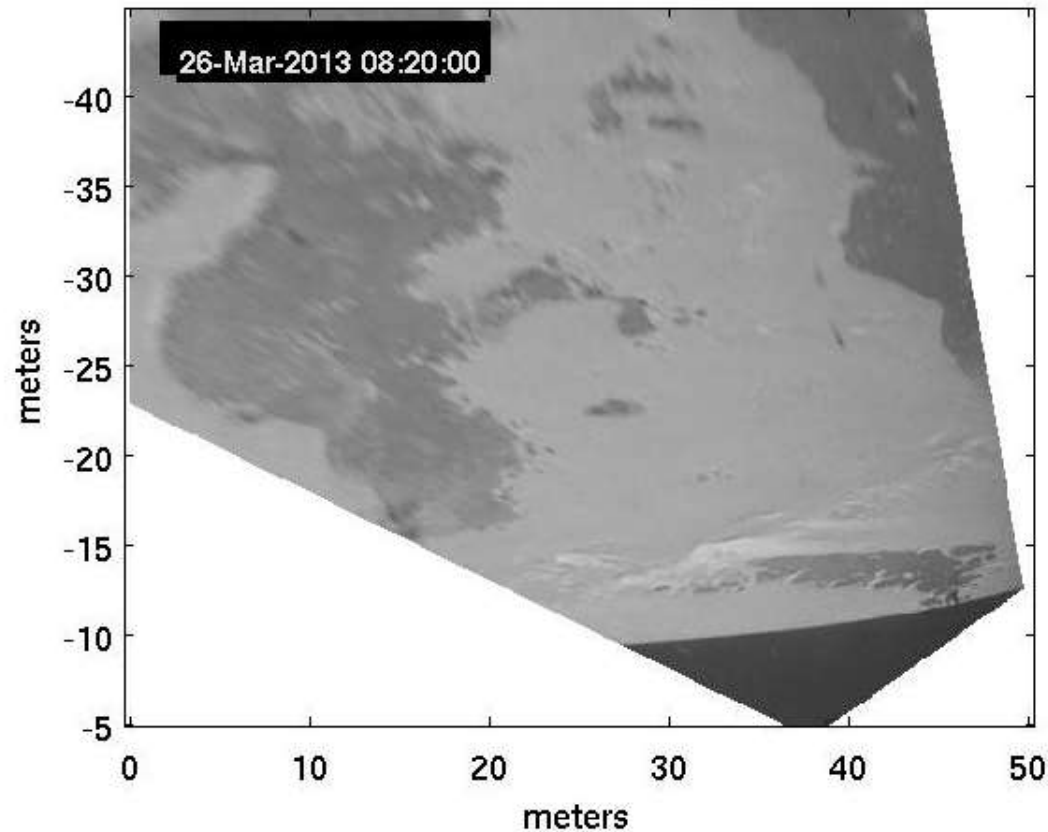
Summary

Union Terrace

MORE
INFORMATION

Links

Orthophoto



The above webcam image has been geometrically corrected to create an orthophoto or often referred as an aerial image. The orthophoto can be used to measure true distances. For more information please see the [Real Time Water Imaging System \(RTWIS\)](#) developed by the University of Wisconsin Madison.

<http://www.infosyahara.org/>

Acknowledgements

Field Work

- Alex Campbell
- Nikki Mohap

Field Resources and Sample Testing

- UW-Center for Limnology
- Dave Harring
- Paul Hanson
- Luke Winslow
- John Reimer

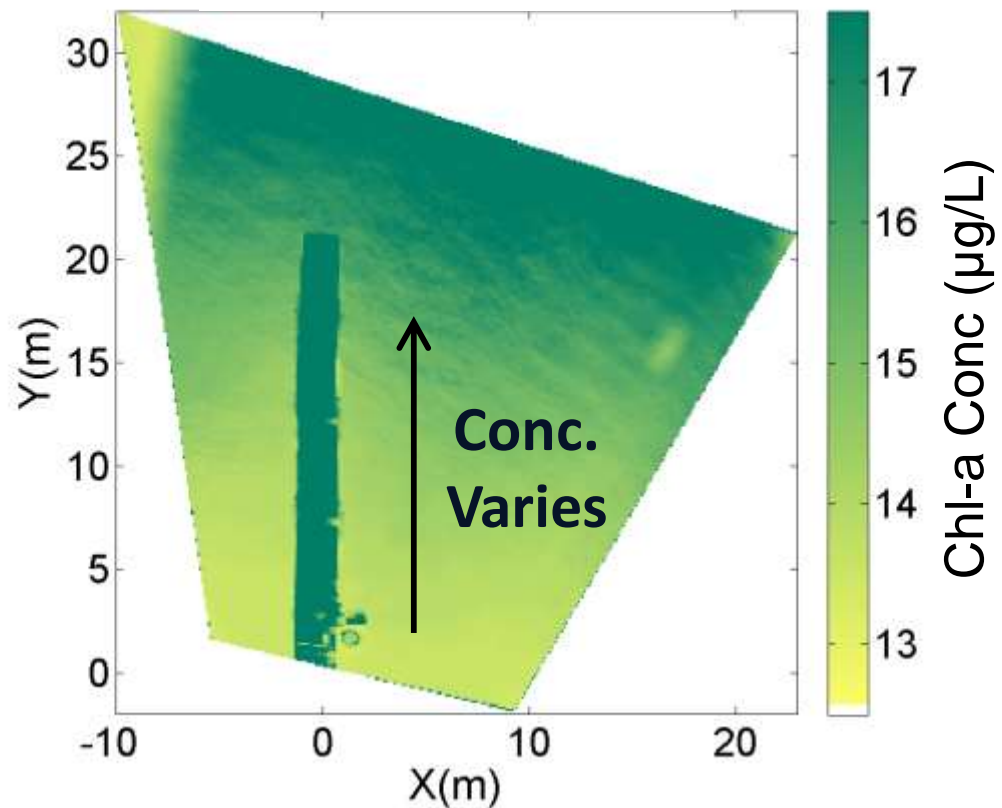
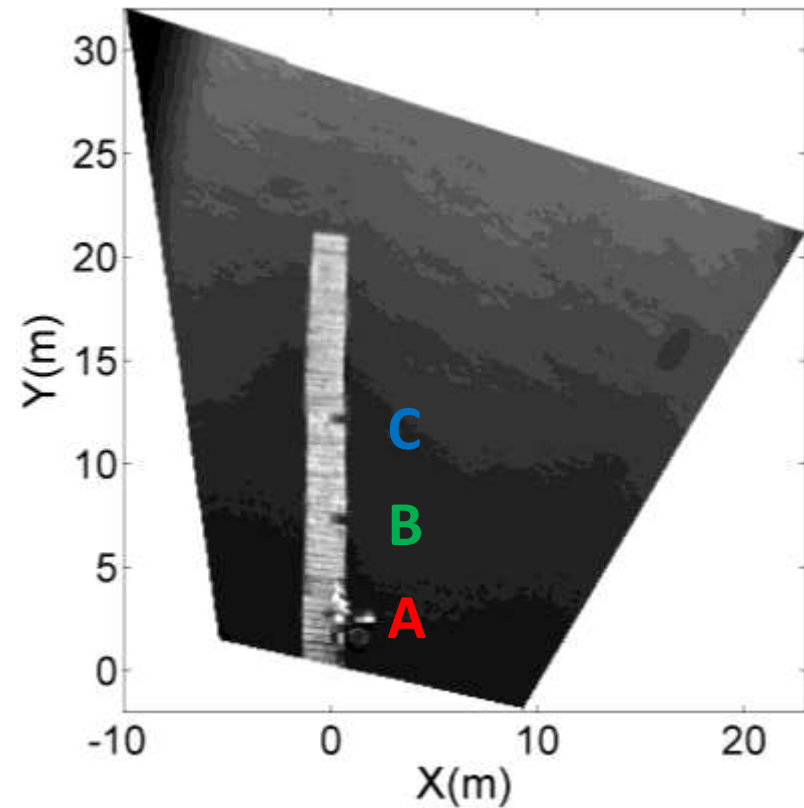
Fundings



Spatial Measurement

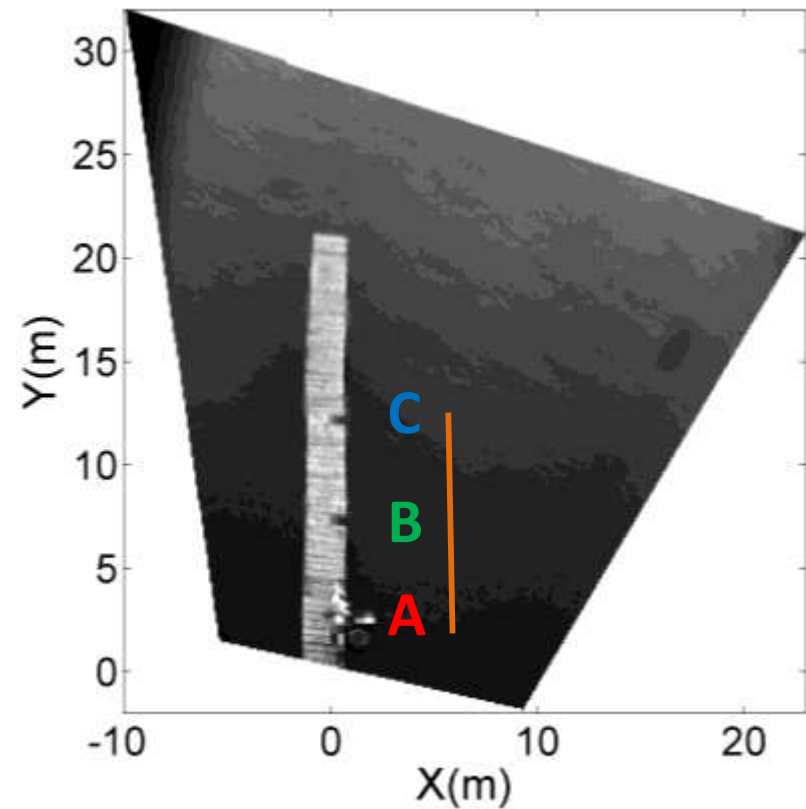
Geometric + Spatial Reflectance Calibration

Calibration from **C**

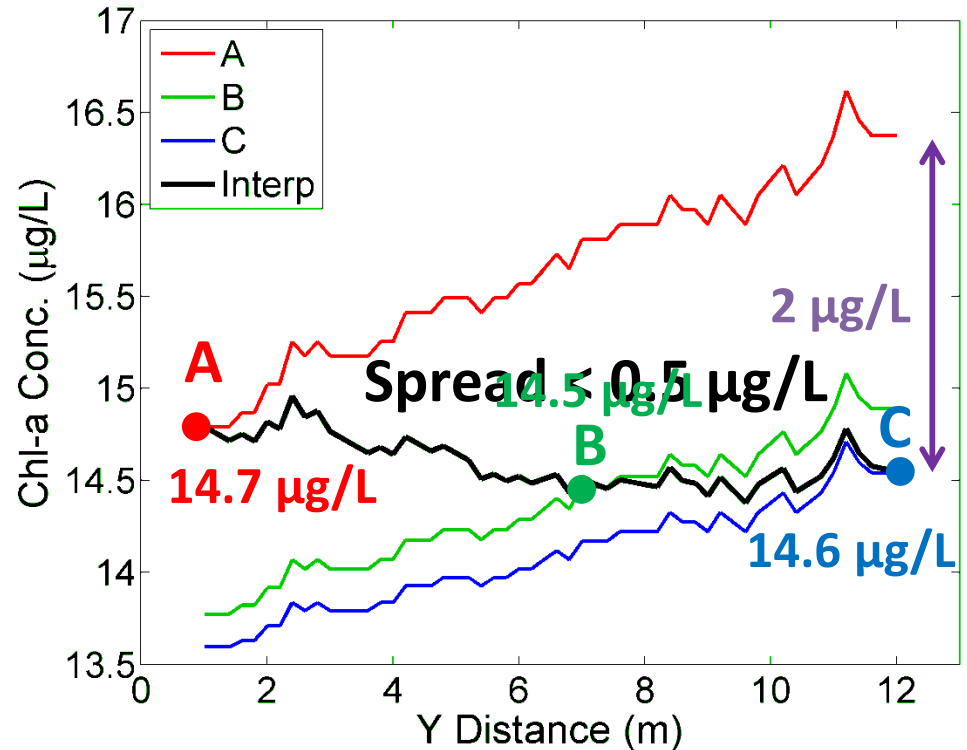


Fluorometer indicates
homogeneous Chl-a conc.

Spatial Imaging for Chl-a



Chl-a Conc. Transect



Lighting varies spatially

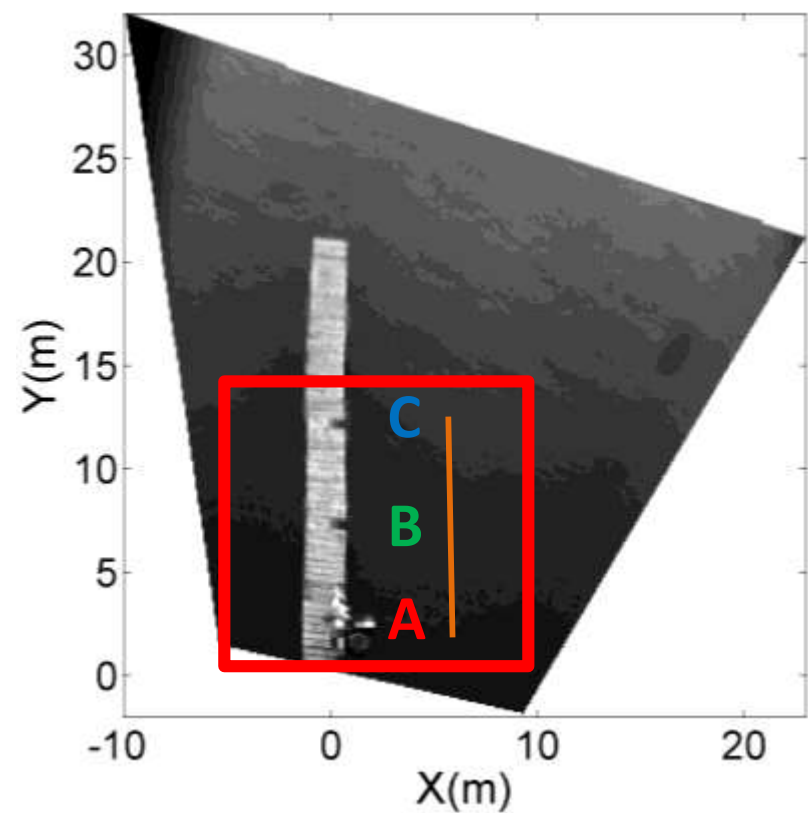


Reflectance cal. varies spatially



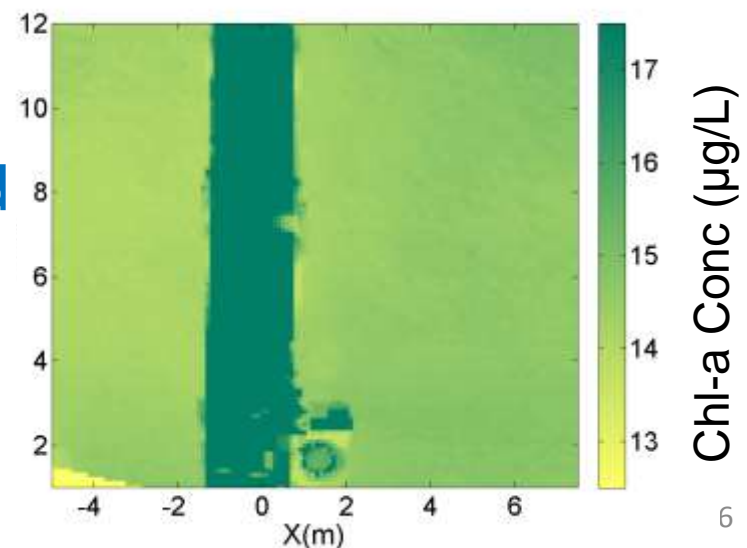
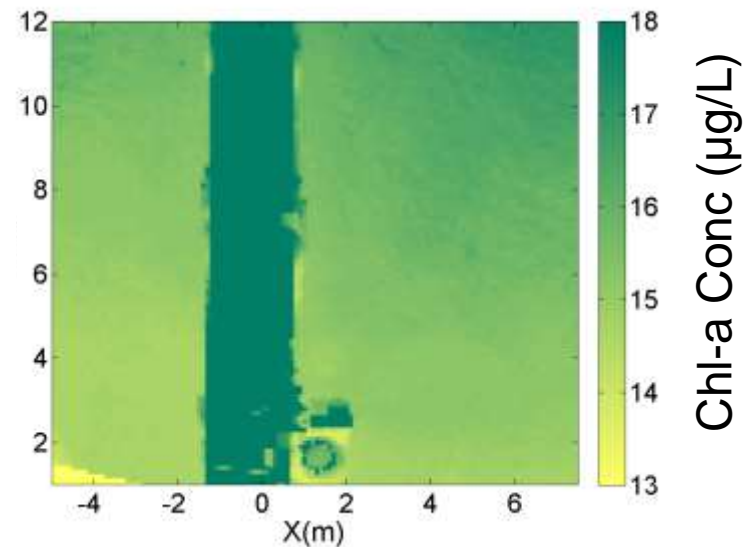
Spatially interpolate reflectance calibration

Spatial Imaging for Chl-a



Original
Calibration

Interpolated
Calibration



Spatial Interpolation →
Homogenous Lake Conc.