


US EPA ARCHIVE DOCUMENT

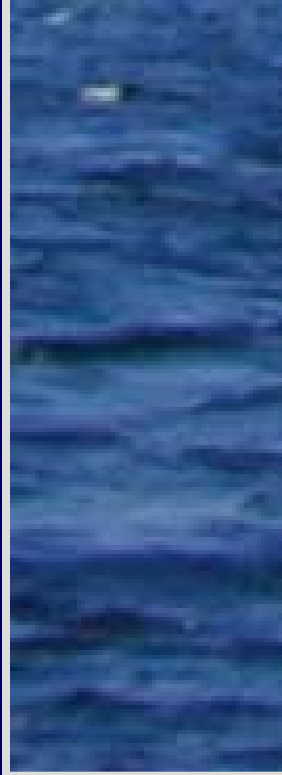


A remote sensing approach to
measure water quality in New
England lakes:

Where are we now and what's next?

Shane Bradt & James Haney
University of New Hampshire

- **Remote sensing of water**
- On-lake remote sensing
- What satellites could work?
- Next steps...



Steps in water RS

1. Collect lake spectral measurements from lakes paired with relevant limnological data
 - Chlorophyll, microcystins, CDOM, ect.
2. Characterize the spectral patterns found in New England lakes
3. Develop algorithms to measure water quality in New England lakes
4. Apply algorithms to satellite imagery to validate the techniques

Things to think about for water RS

1. How is water different than land?

a) Low reflectance

b) Rapid changes

c) Narrow bands of interest

==> return time of sensor

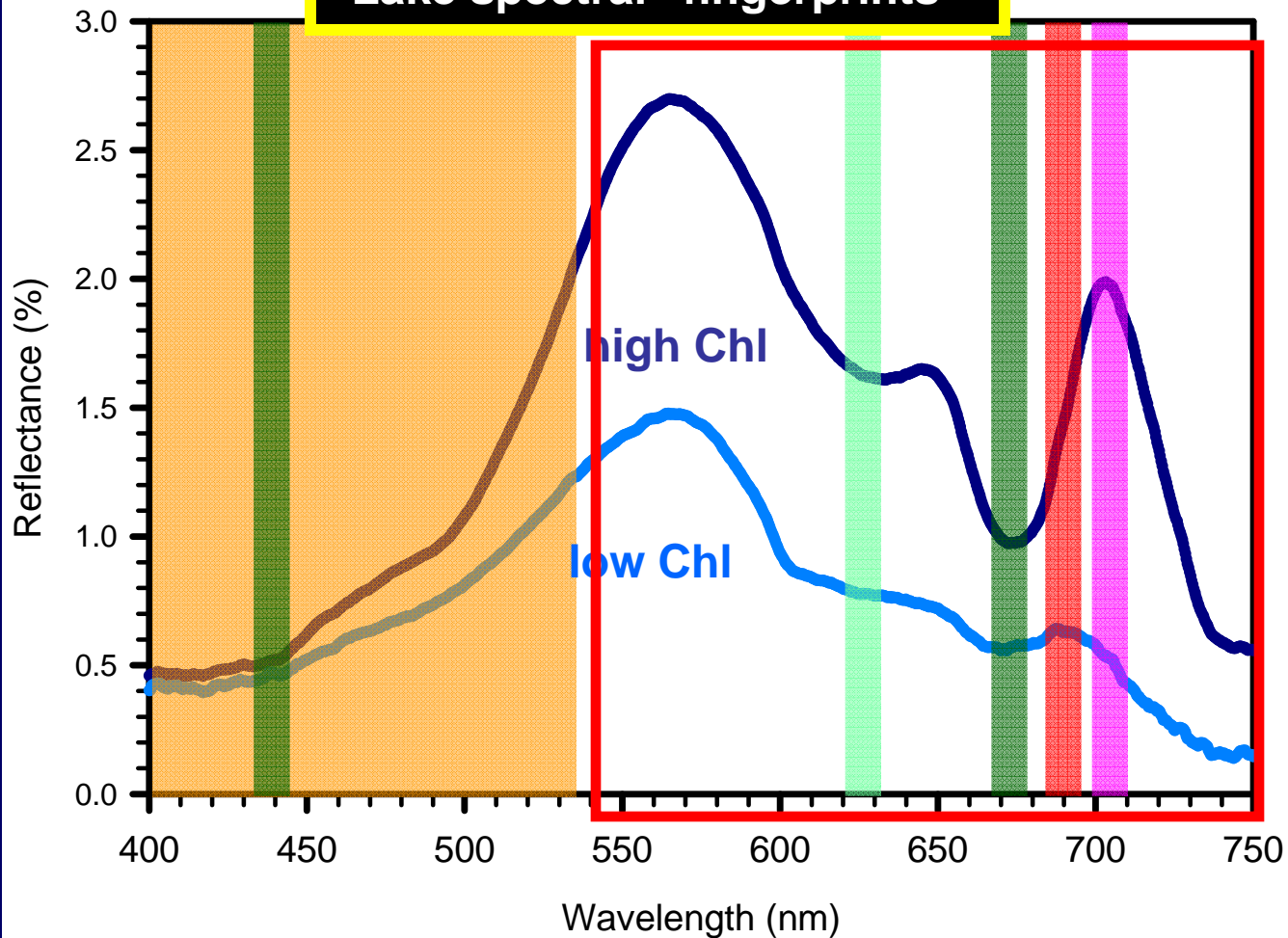
==> turn around time of data

==> atmospheric correction

==> spectral sensitivity

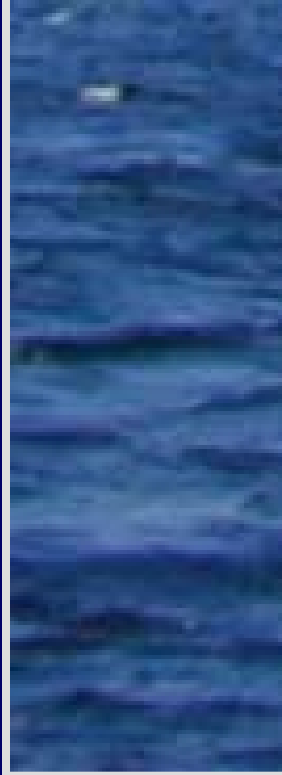
==> radiometric sensitivity

Lake spectral "fingerprints"

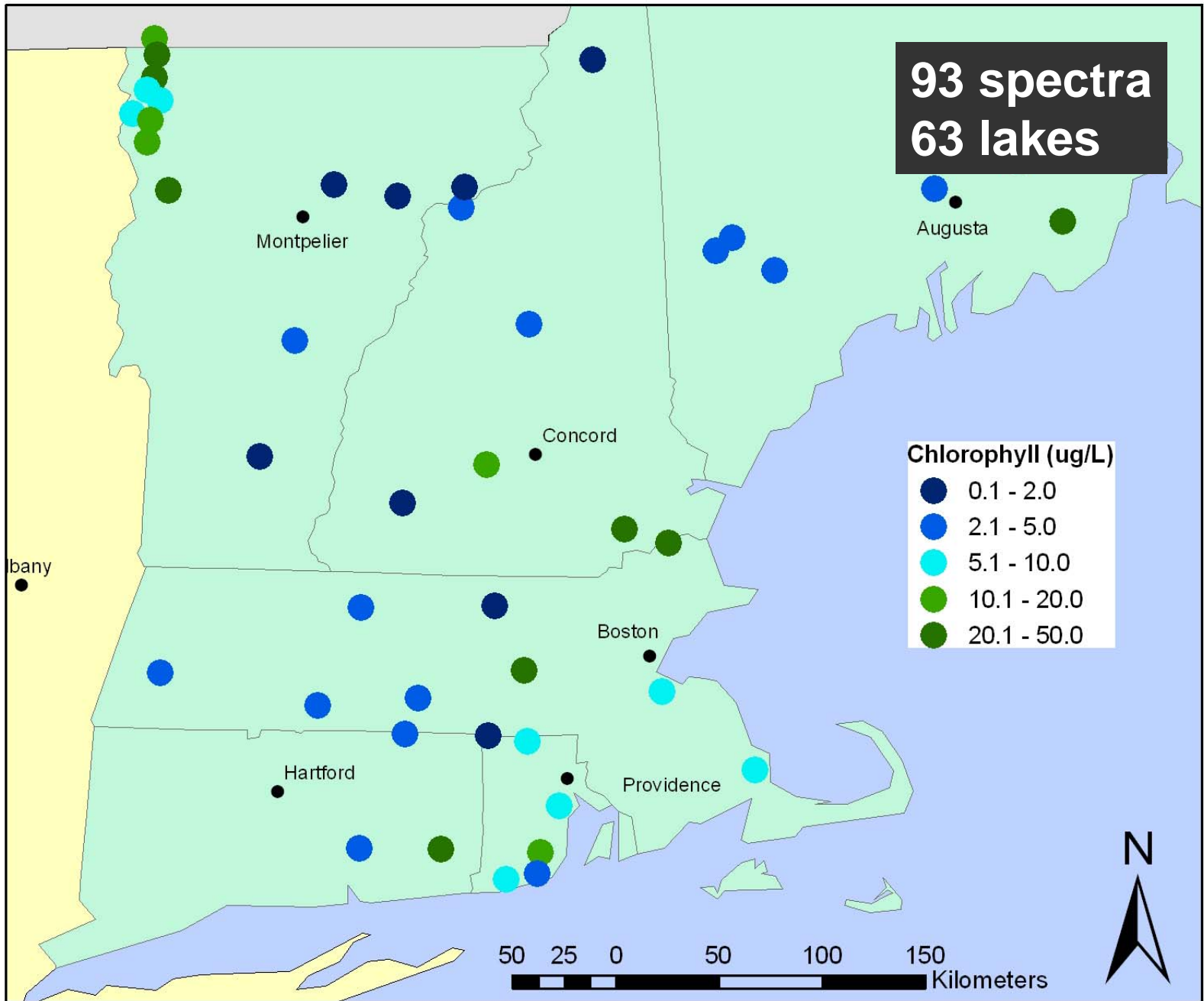
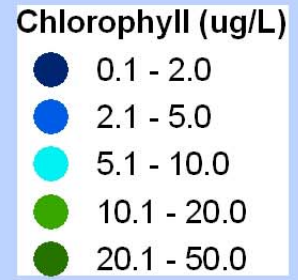


- Absorption by algae (chlorophyll)
- Absorption by cyanobacteria (phycocyanin)
- Fluorescence peak (seen in low chlorophyll lakes)
- Scattering peak (seen in high chlorophyll lakes)
- Absorption by CDOM

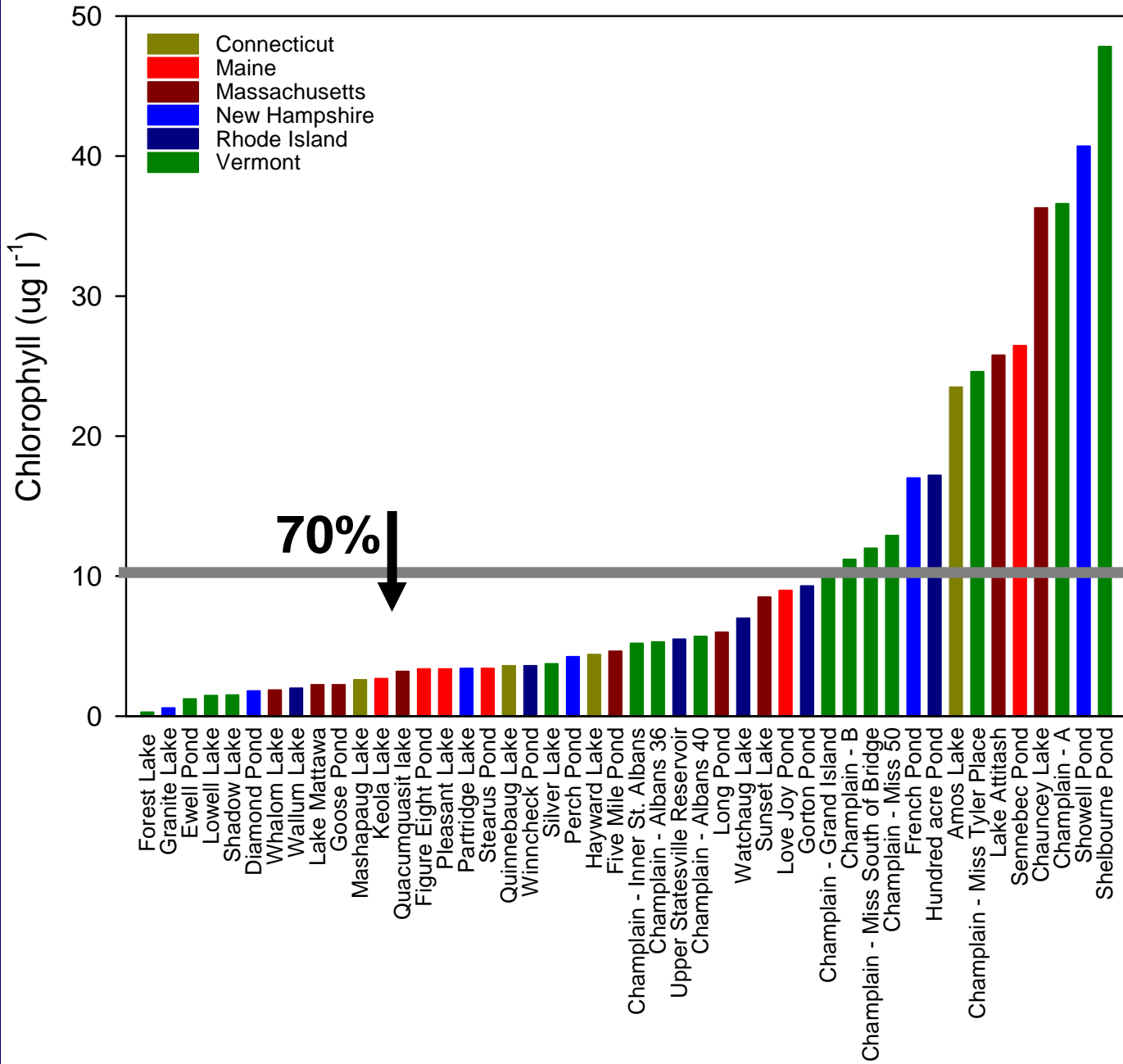
- Remote sensing of water
- **On-lake remote sensing**
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**93 spectra
63 lakes**



Chlorophyll in study lakes



400-750 nm
3 nm bands

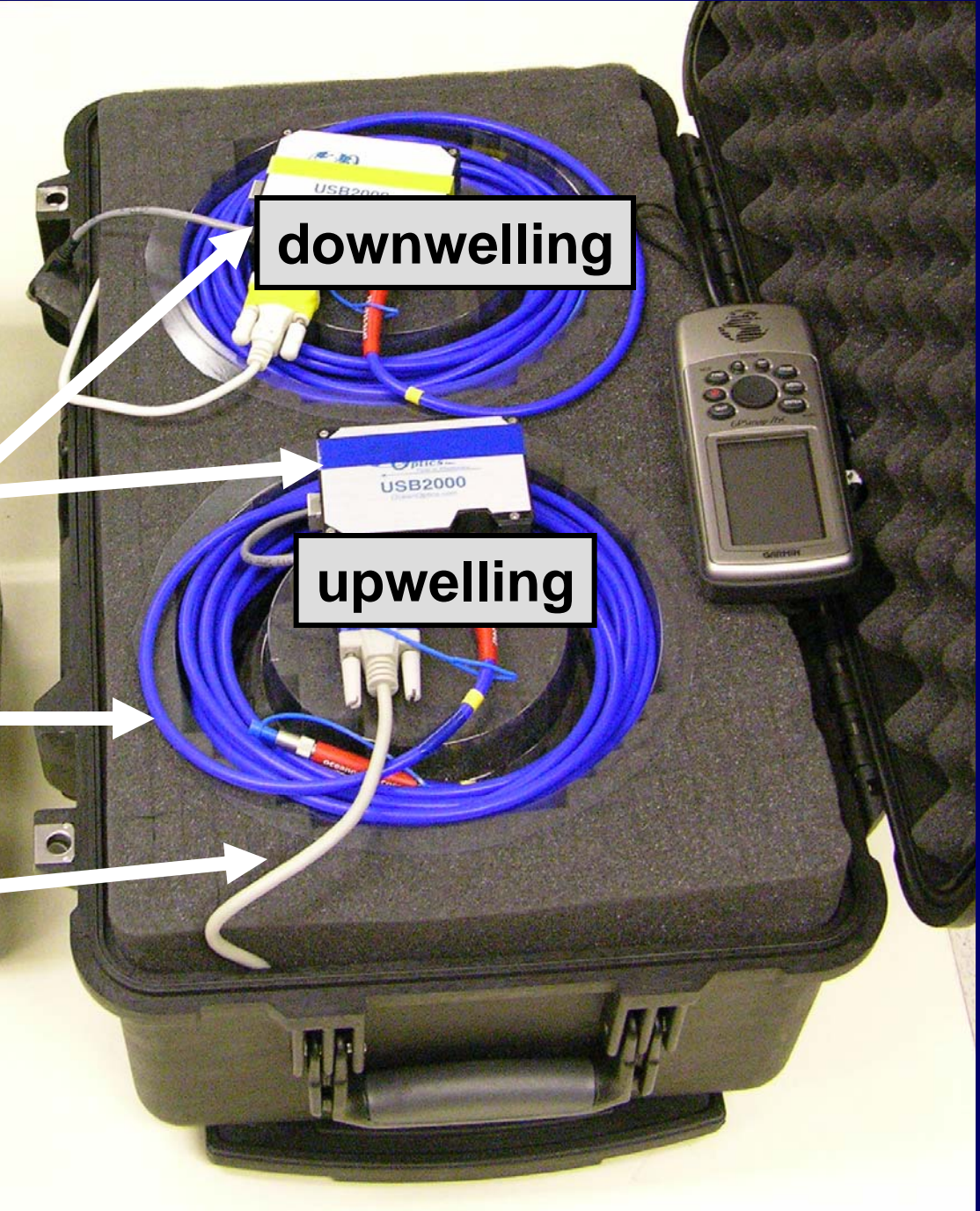
downwelling

upwelling

USB 2000 radiometers
(measure light, output data)

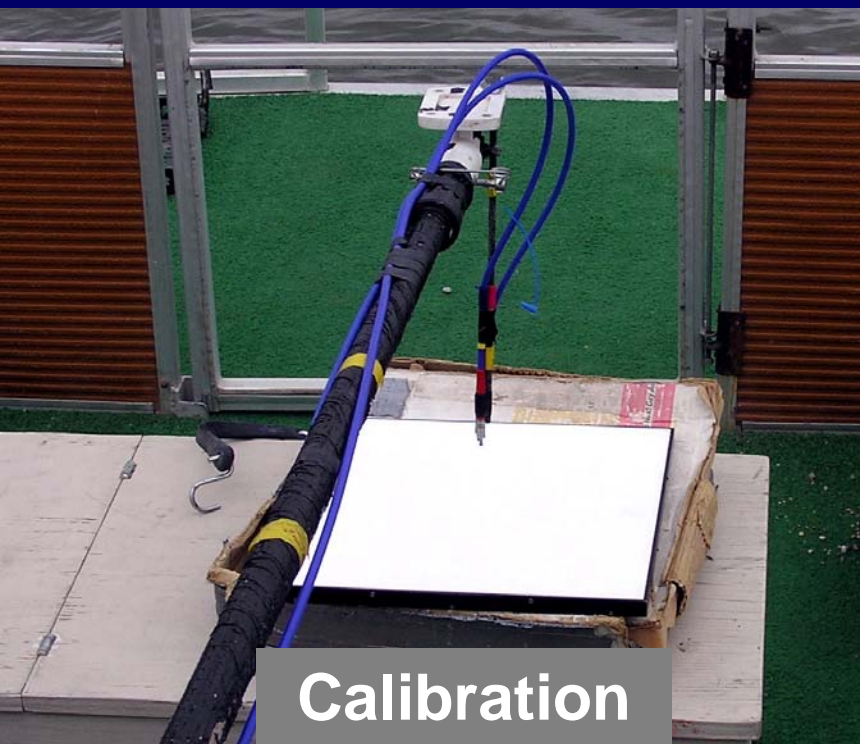
fiber optic cable
(transmit light)

serial cable
(transmit data)





Upwelling

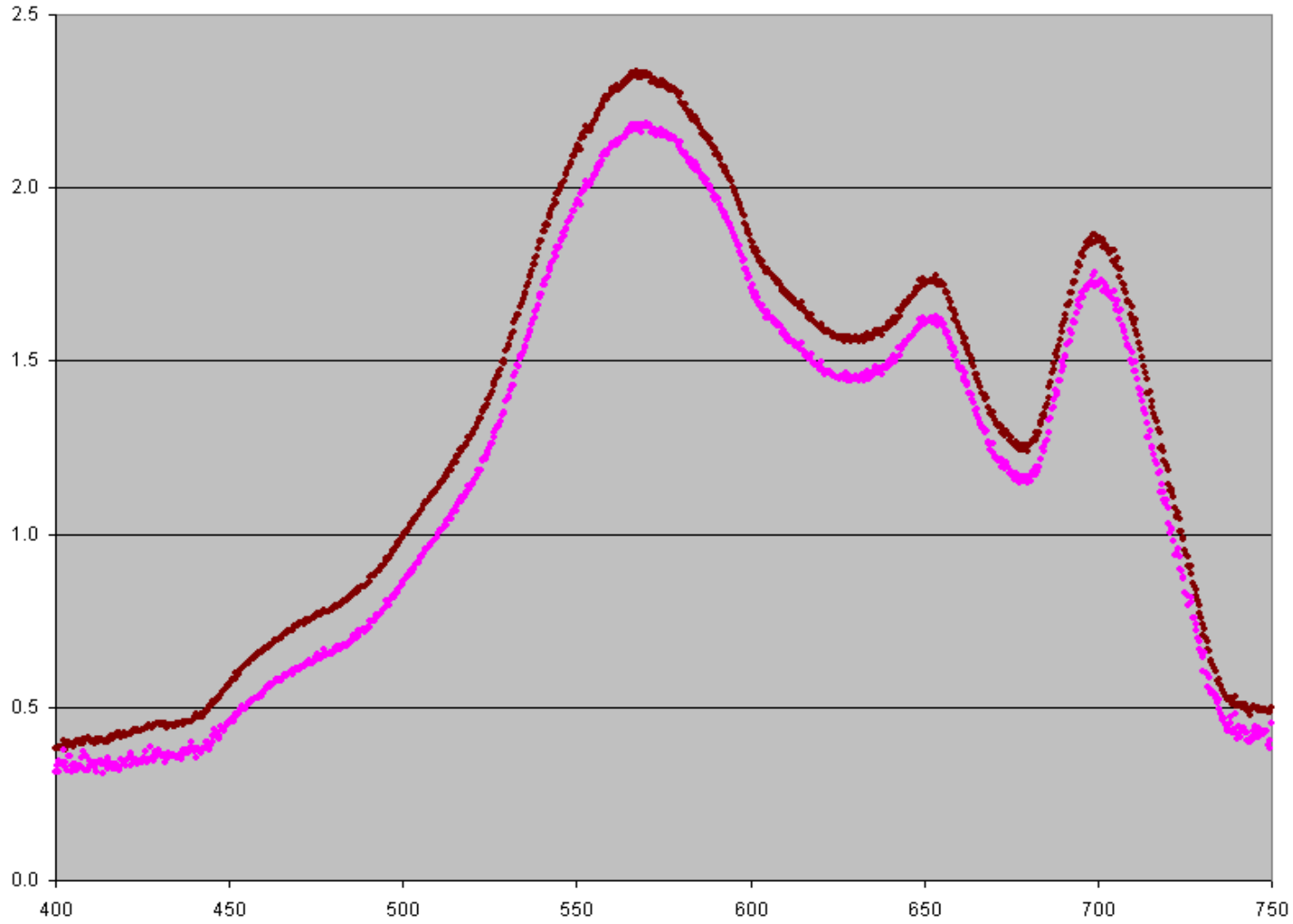


Calibration



Downwelling

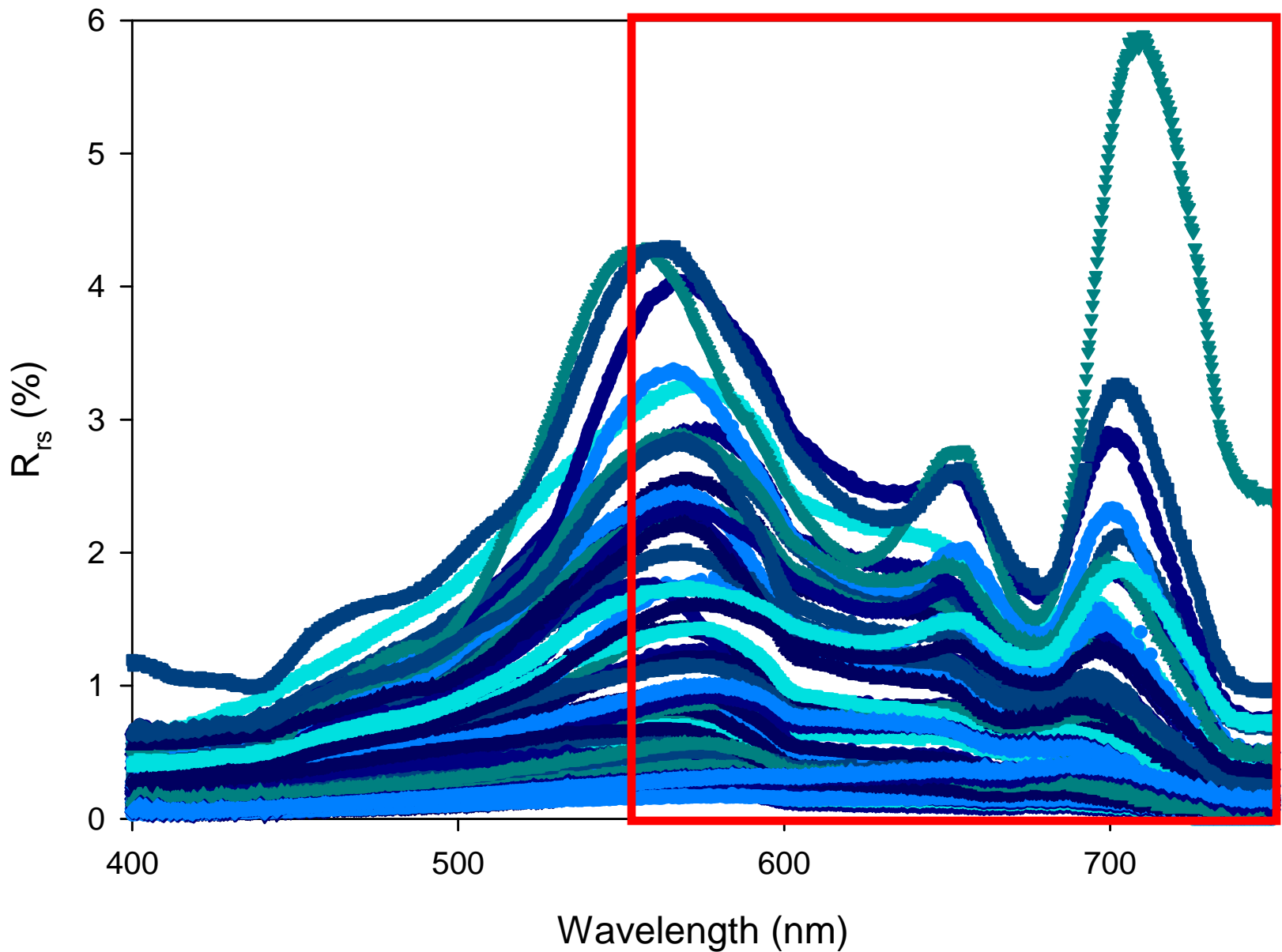
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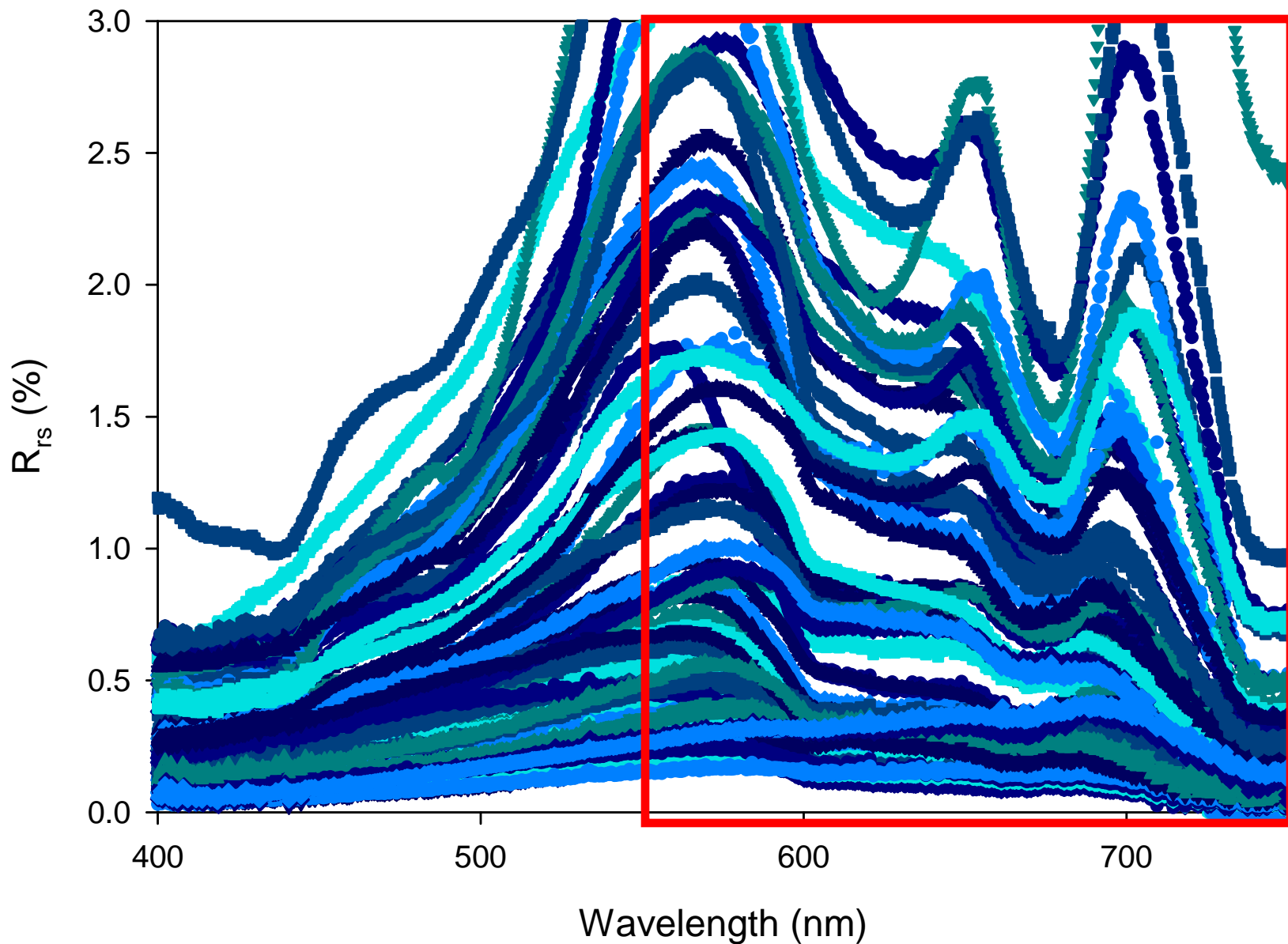
• Rrs
• 10 cm

75 nm)
75 nm)
50 nm)
25 nm)

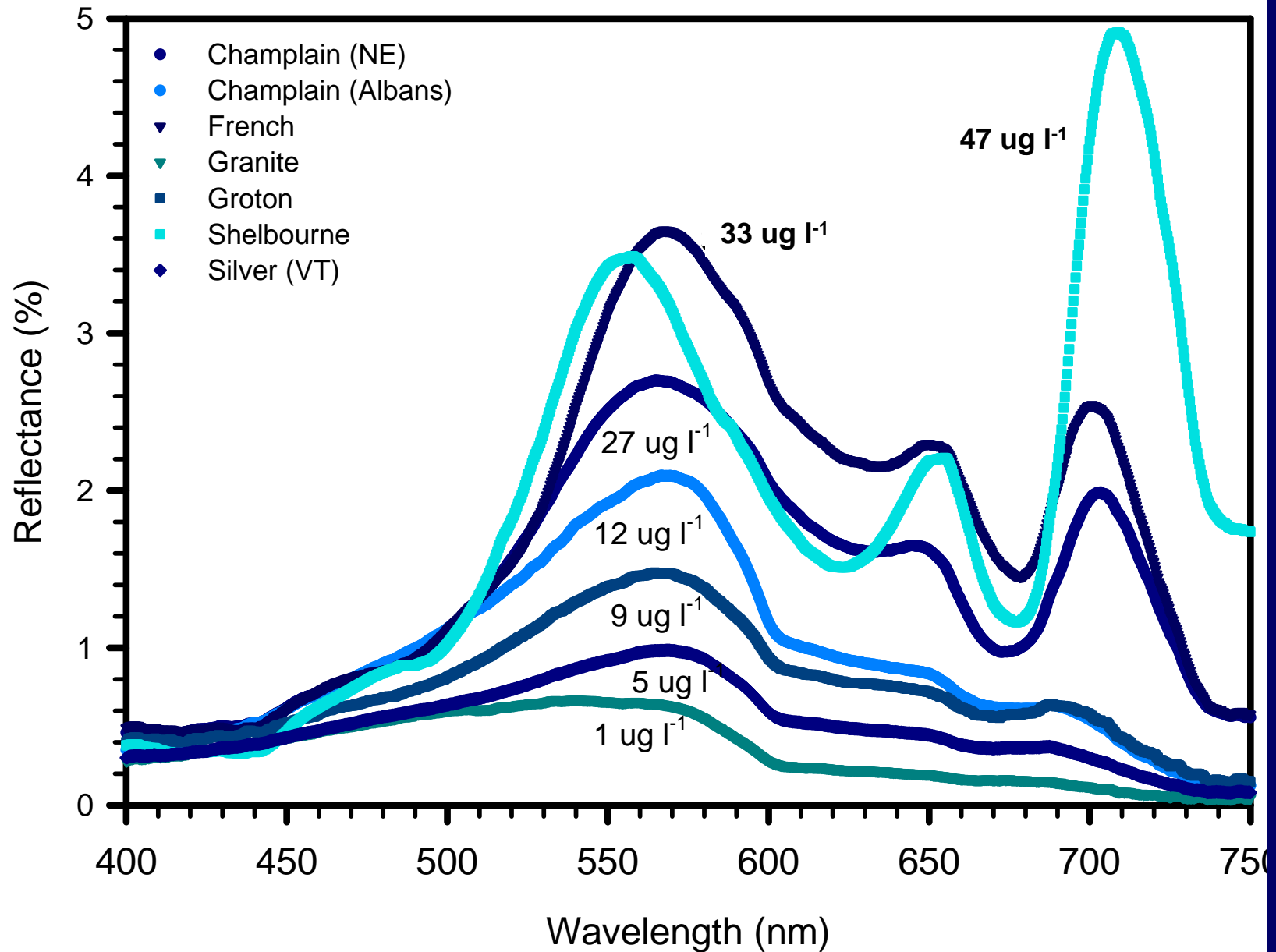
All remote sensing reflectance spectra (n=93)



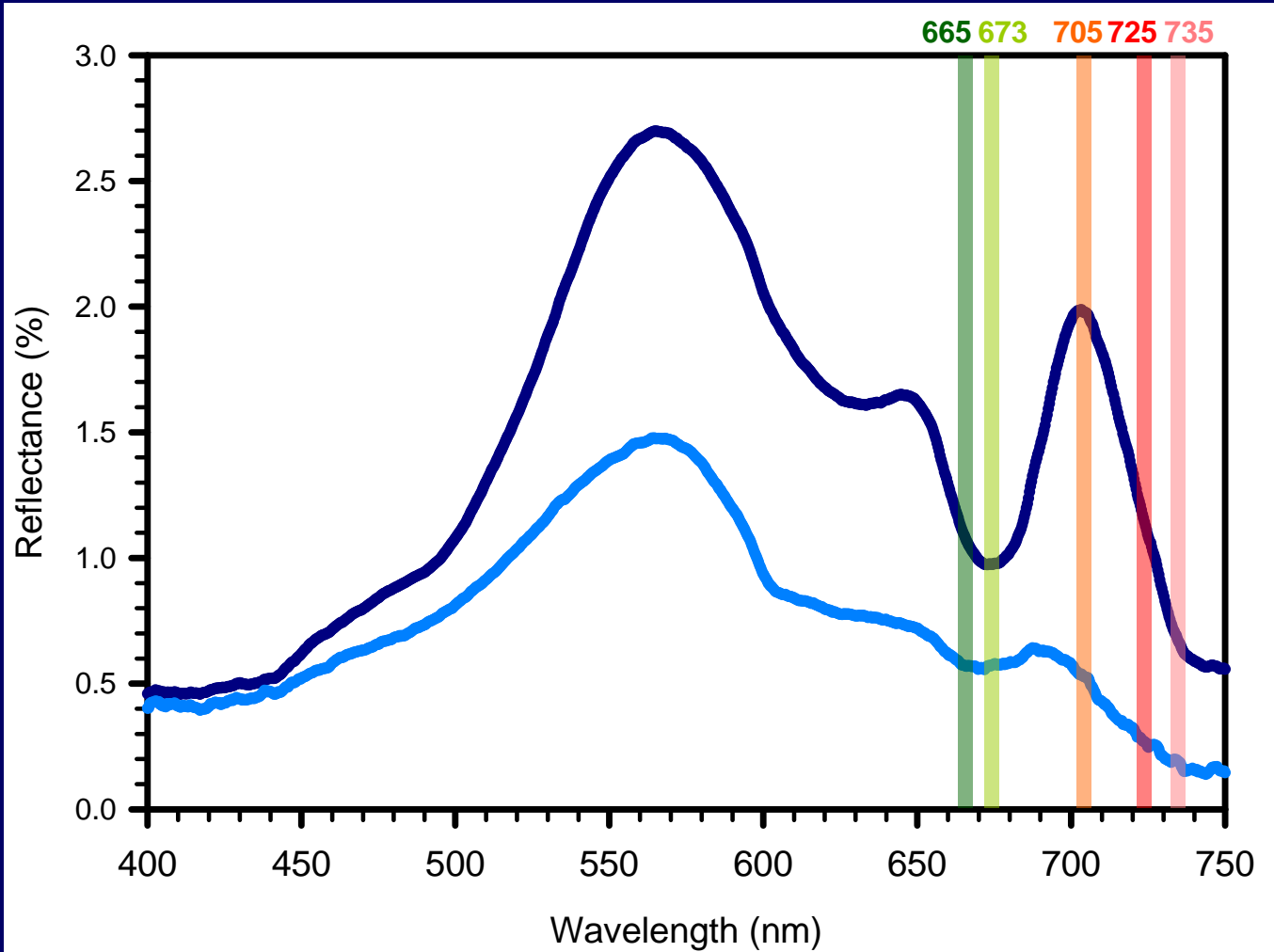
All remote sensing reflectance spectra (n=93)



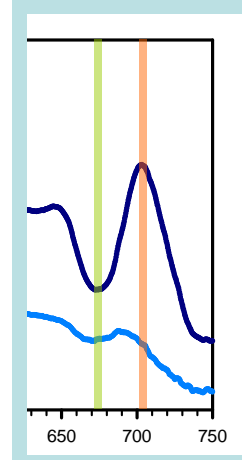
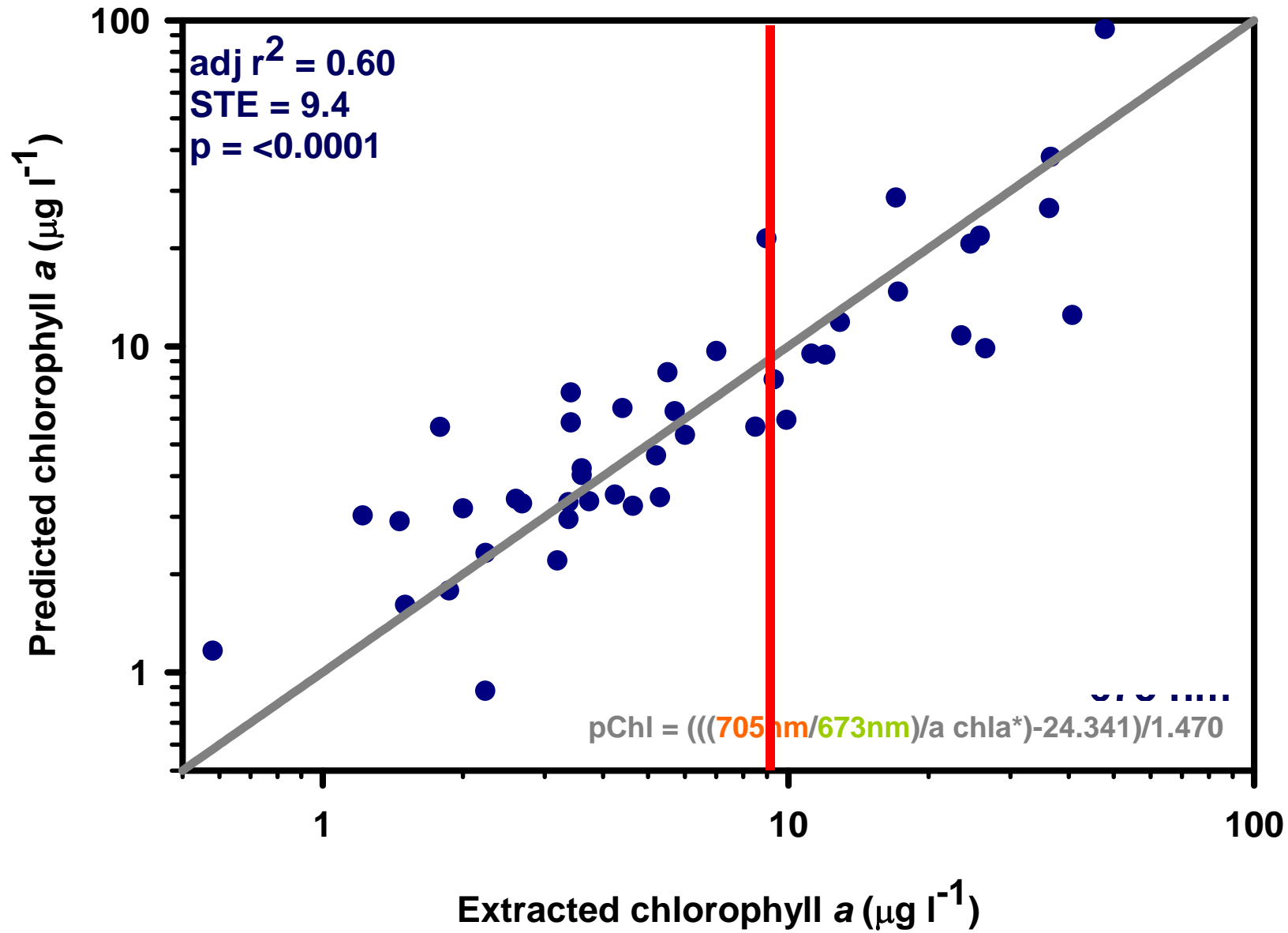
Spectral response to chlorophyll



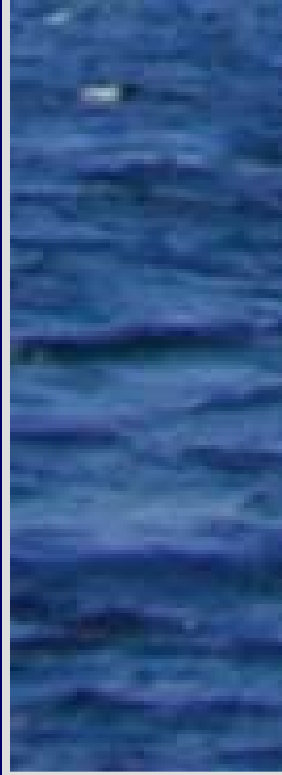
Dall'Olmo & Gitelson 2005



<10 ug / L chl – not so good...



- Remote sensing of water
- On-lake remote sensing
- **What satellites could work?**
- Next steps...



Satellite sensors useful for lake RS

Agency

Purpose

Satellite

Landsat TM

NASA

Land

Landsat

SeaWiFS

NASA

Sea/Land

OrbView-2

MERIS

ESA

Sea/Land

Envisat



MODIS

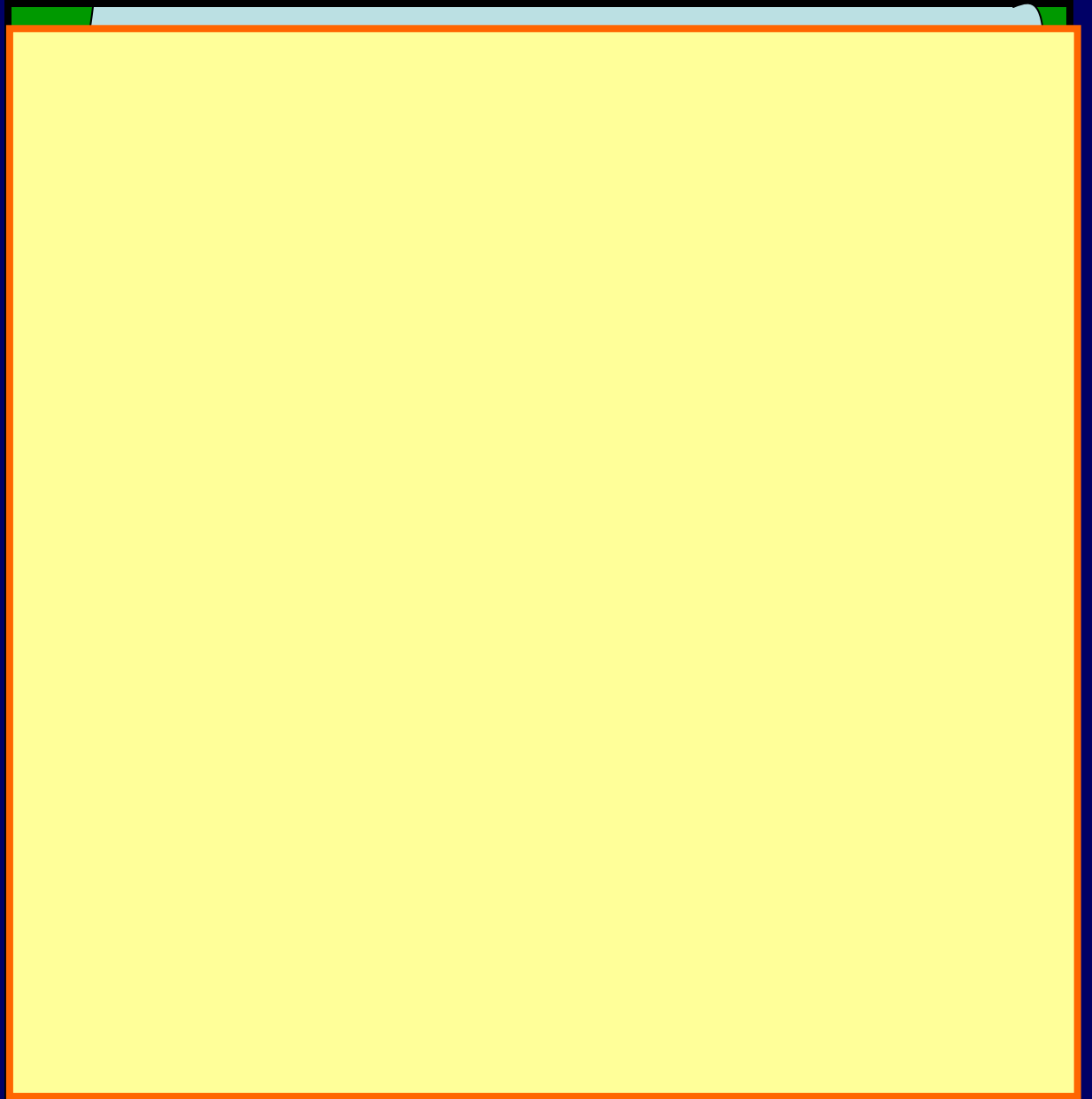
NASA

Sea/Land

Aqua & Terra

SPATIAL RESOLUTION

-  Landsat
-  MERIS
-  MODIS
-  SeaWiFS



SPATIAL RESOLUTION

Landsat

MERIS

MODIS

SeaWiFS **1100 m**

number of pixels

2 North

163 South



SPATIAL RESOLUTION

Landsat

MERIS

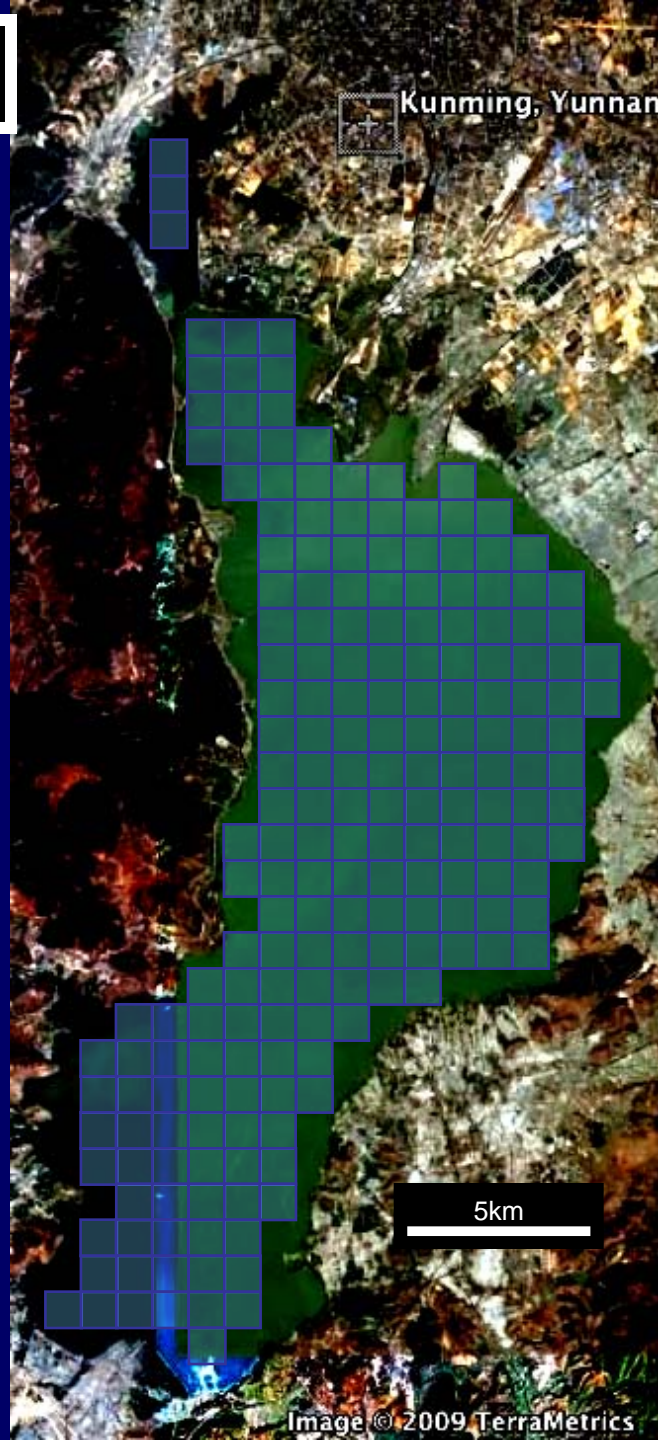
MODIS **1000 m**

SeaWiFS

number of pixels

3 North

197 South



SPATIAL RESOLUTION

Landsat

MERIS **300 m**

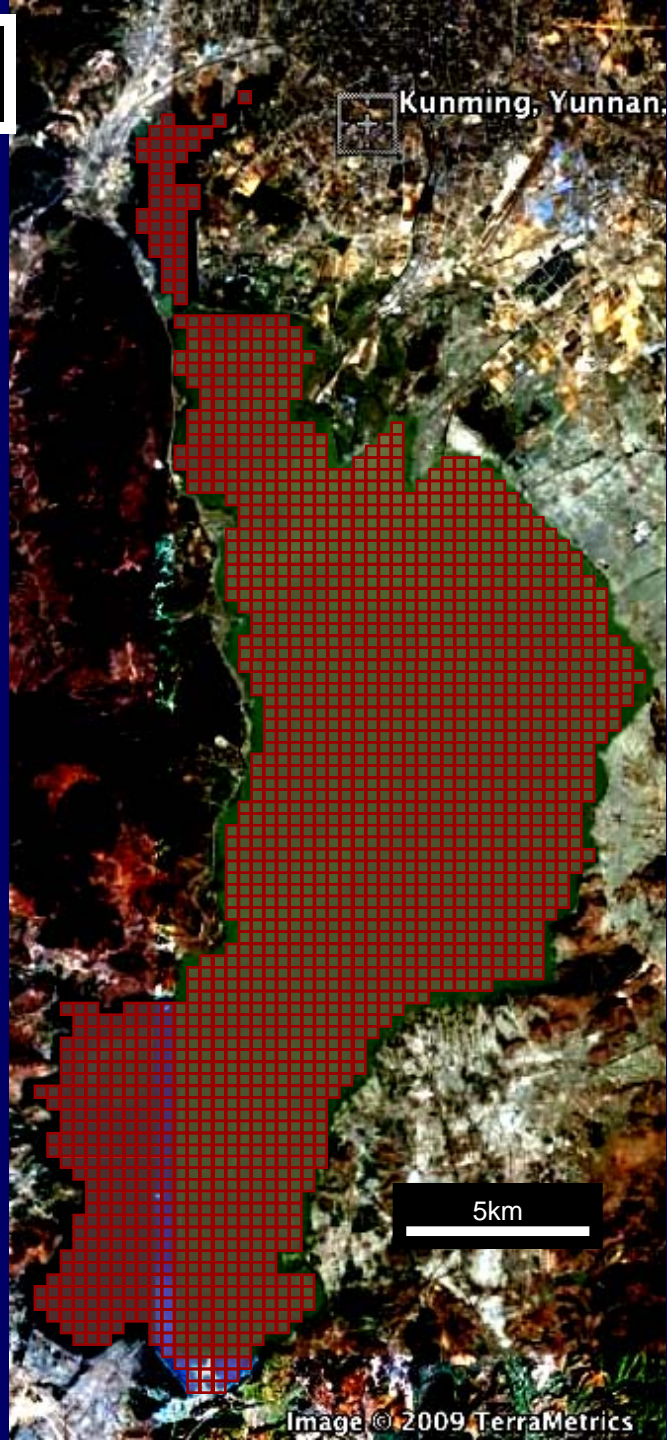
MODIS

SeaWiFS

number of pixels

51 North

1000+ South



SPATIAL RESOLUTION



Landsat

30 m



MERIS



MODIS



SeaWiFS

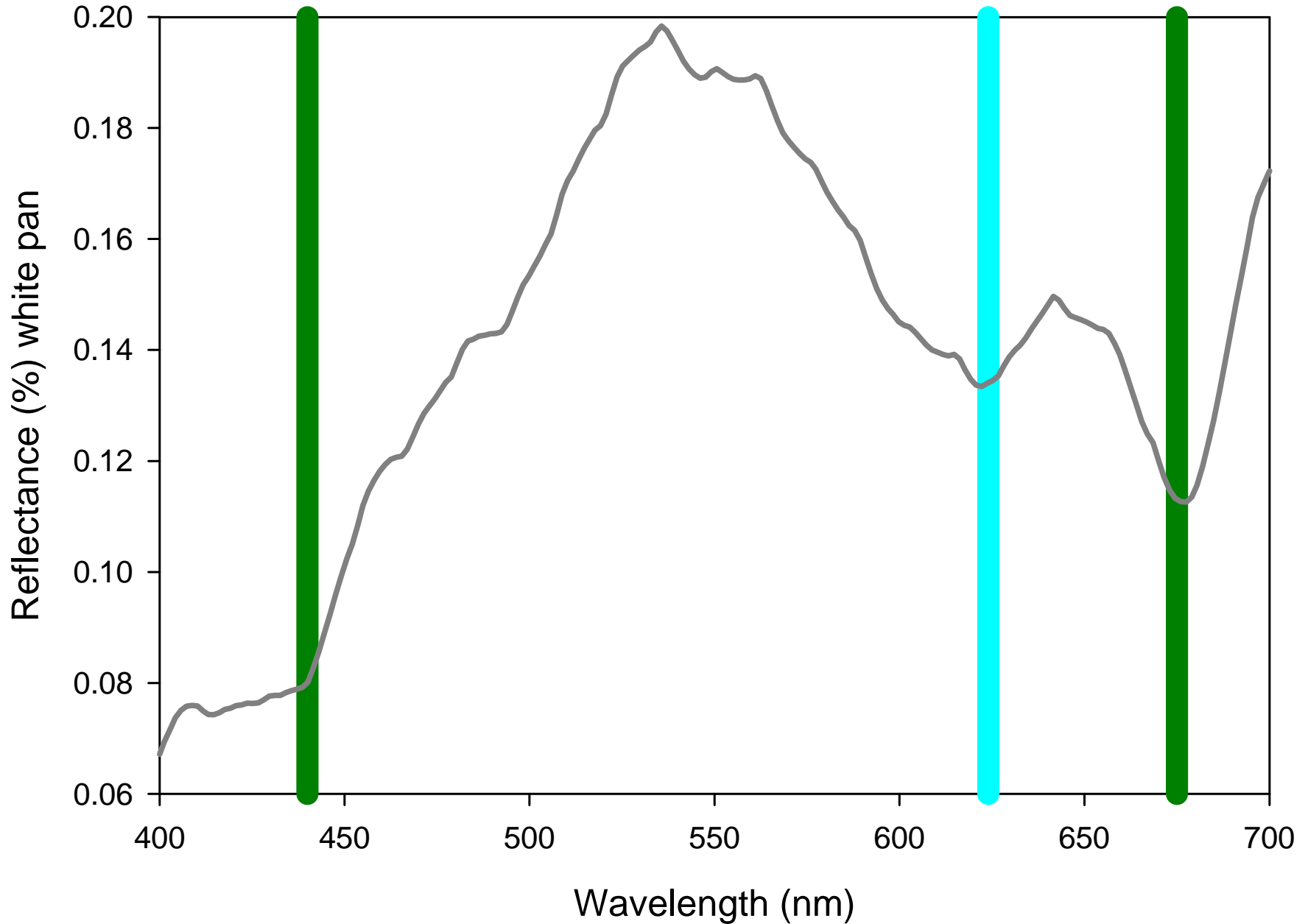
number of pixels

100's North

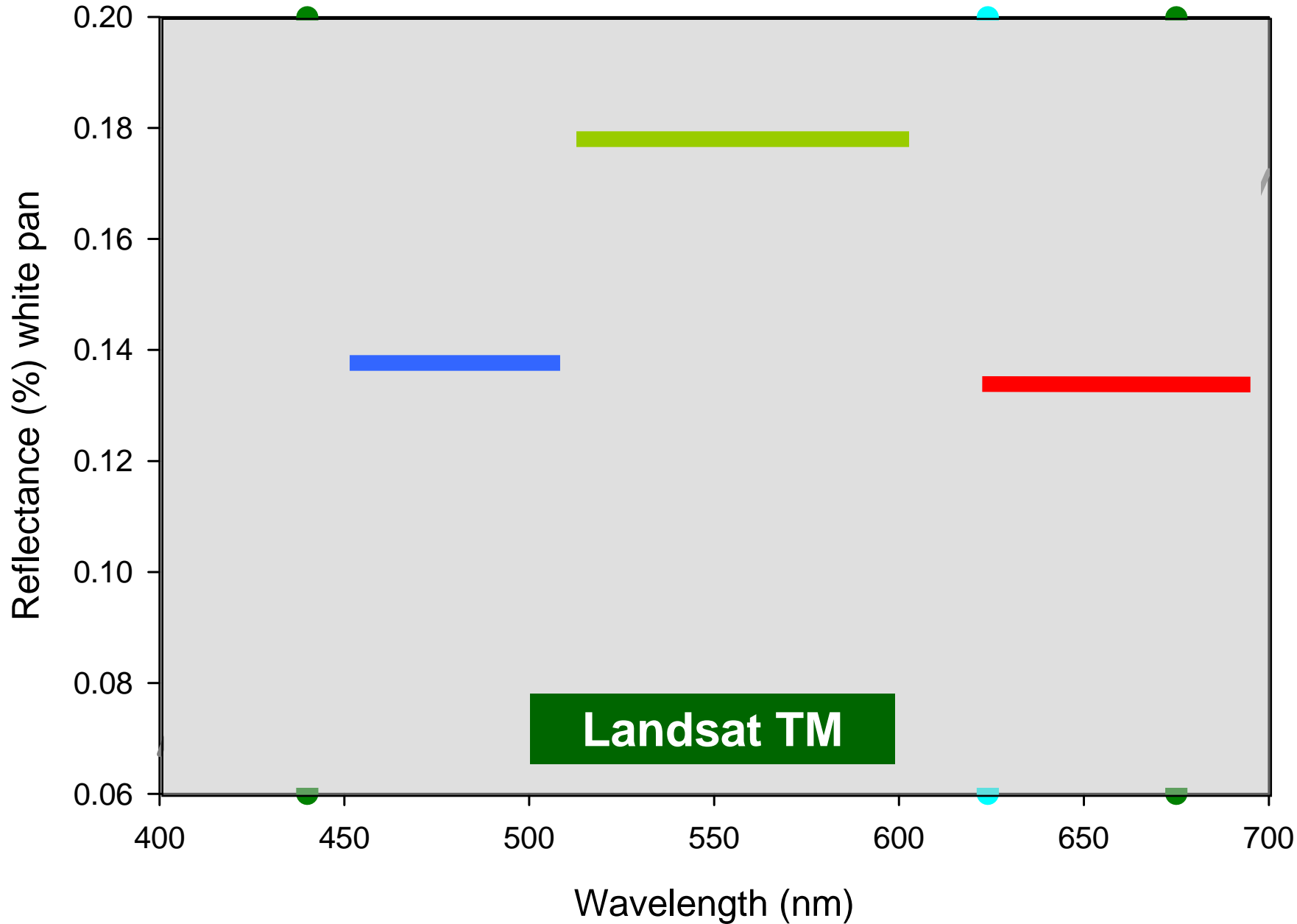
1000's South



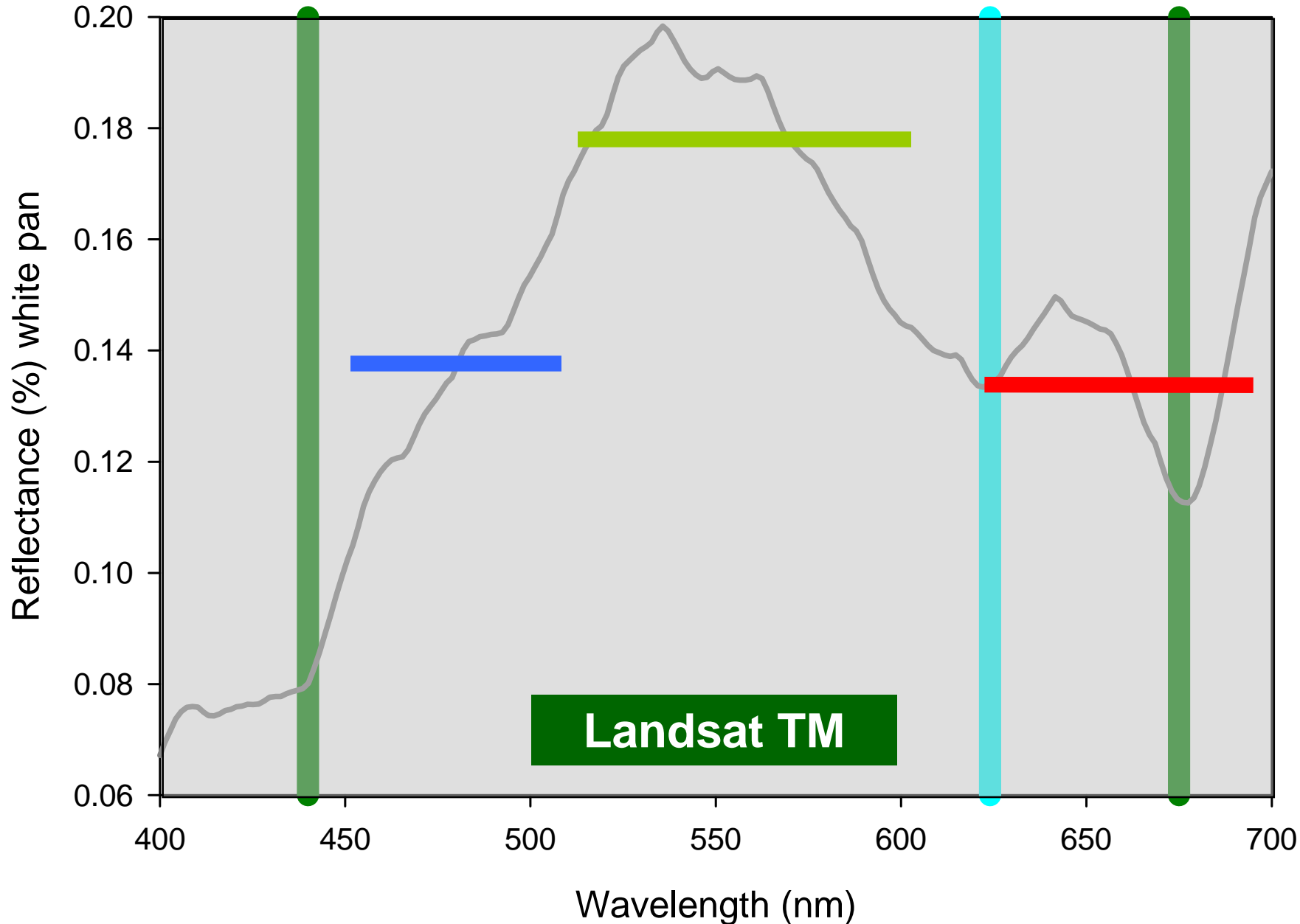
SPECTRAL RESOLUTION



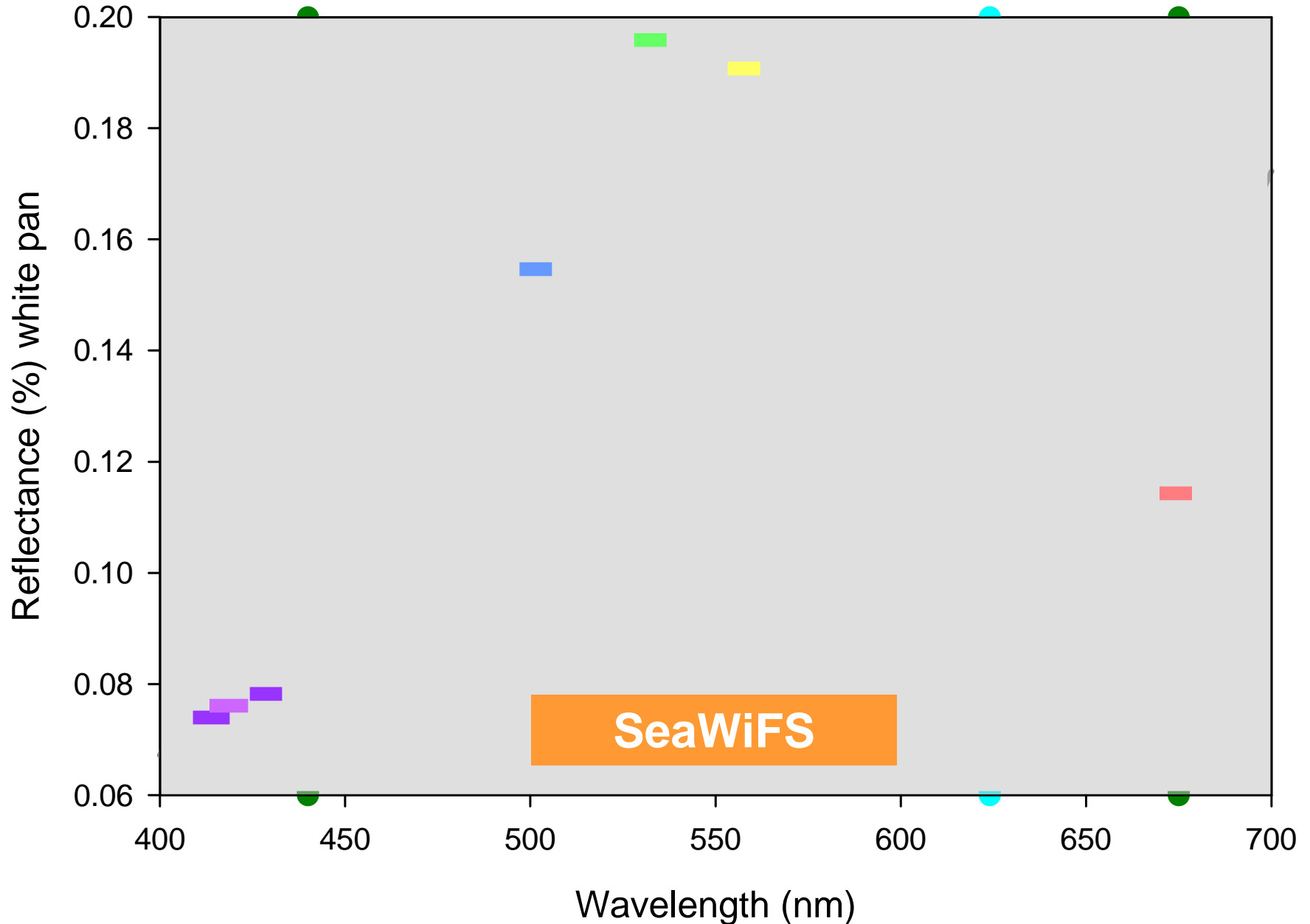
SPECTRAL RESOLUTION



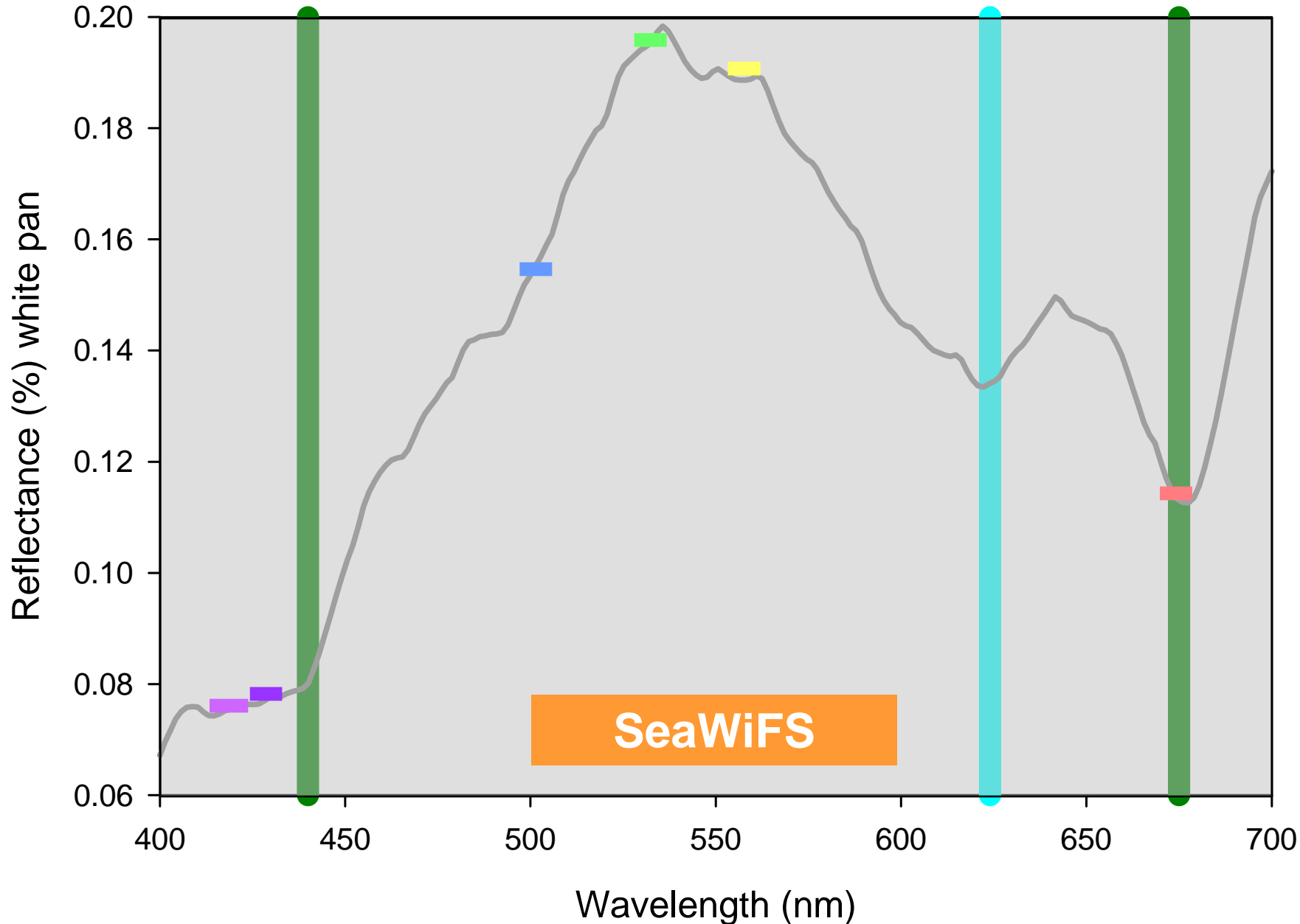
SPECTRAL RESOLUTION



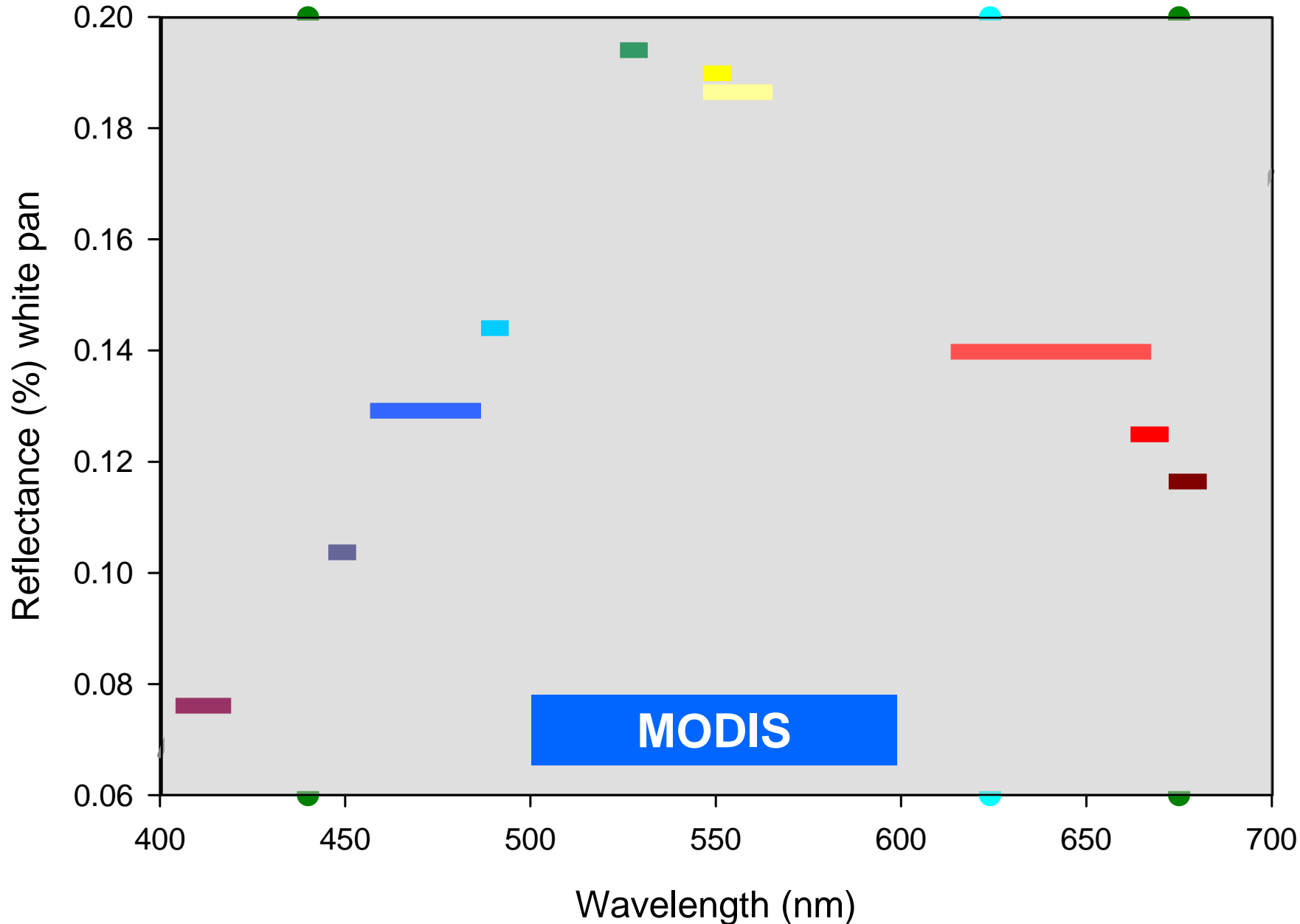
SPECTRAL RESOLUTION



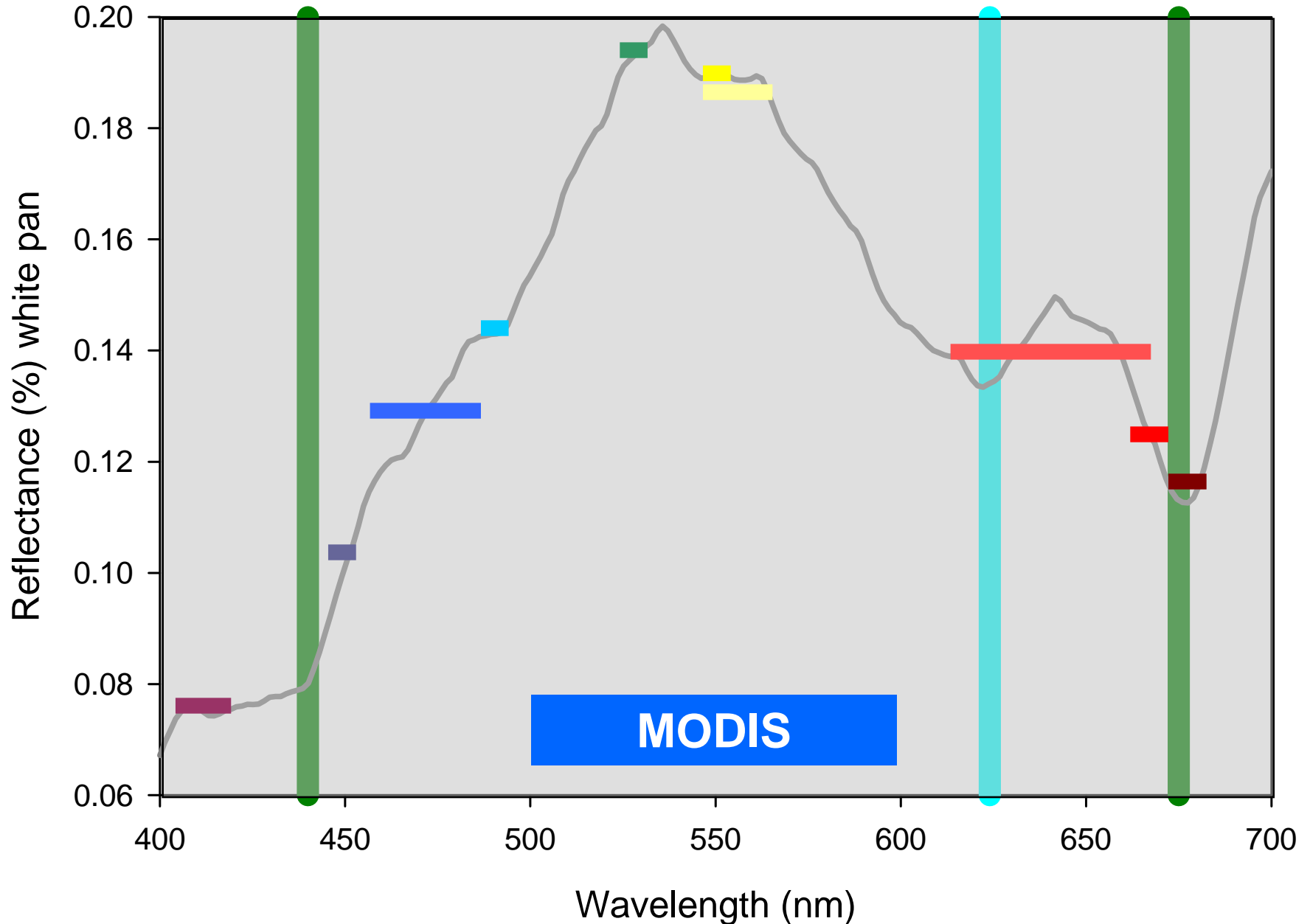
SPECTRAL RESOLUTION



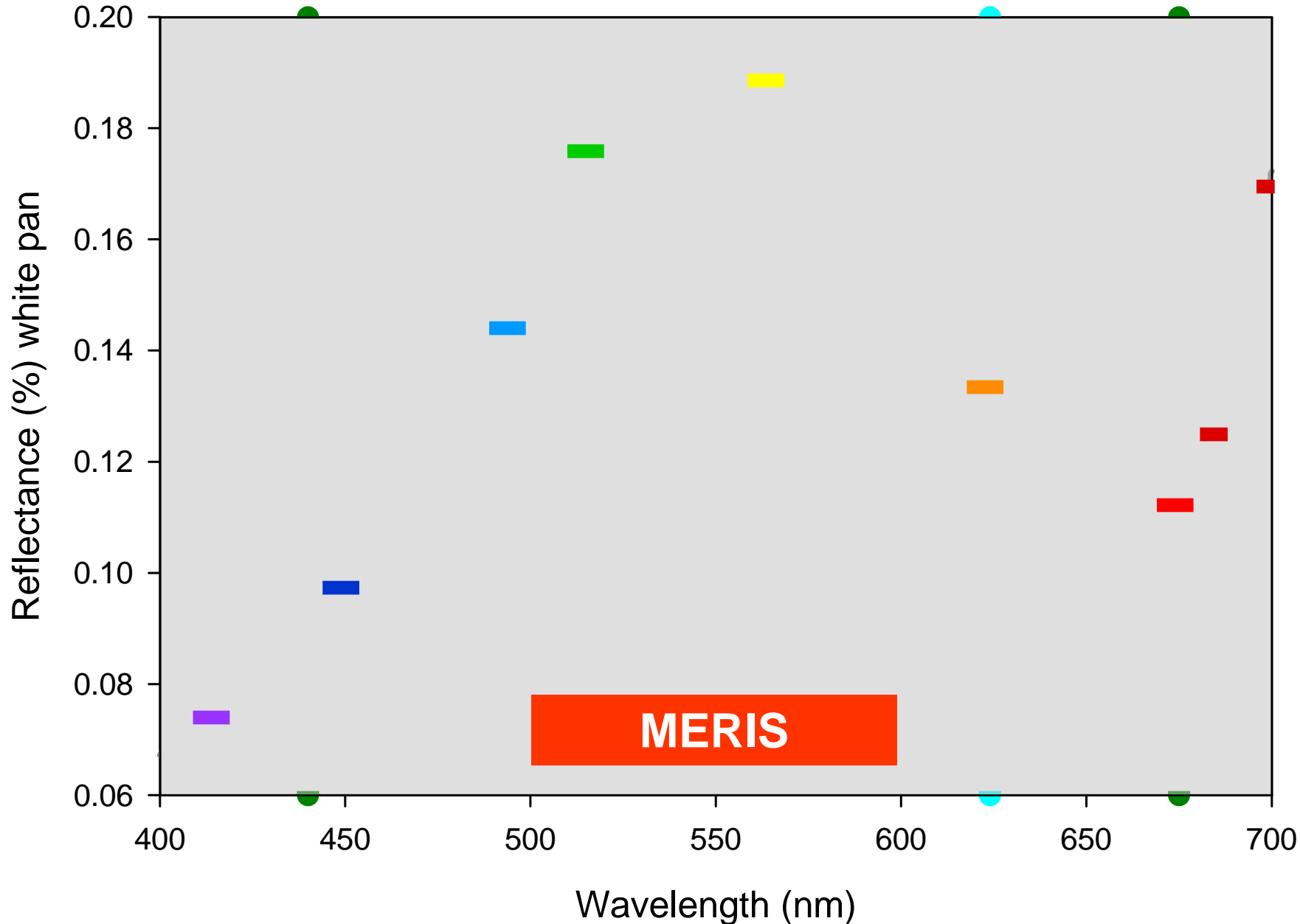
SPECTRAL RESOLUTION



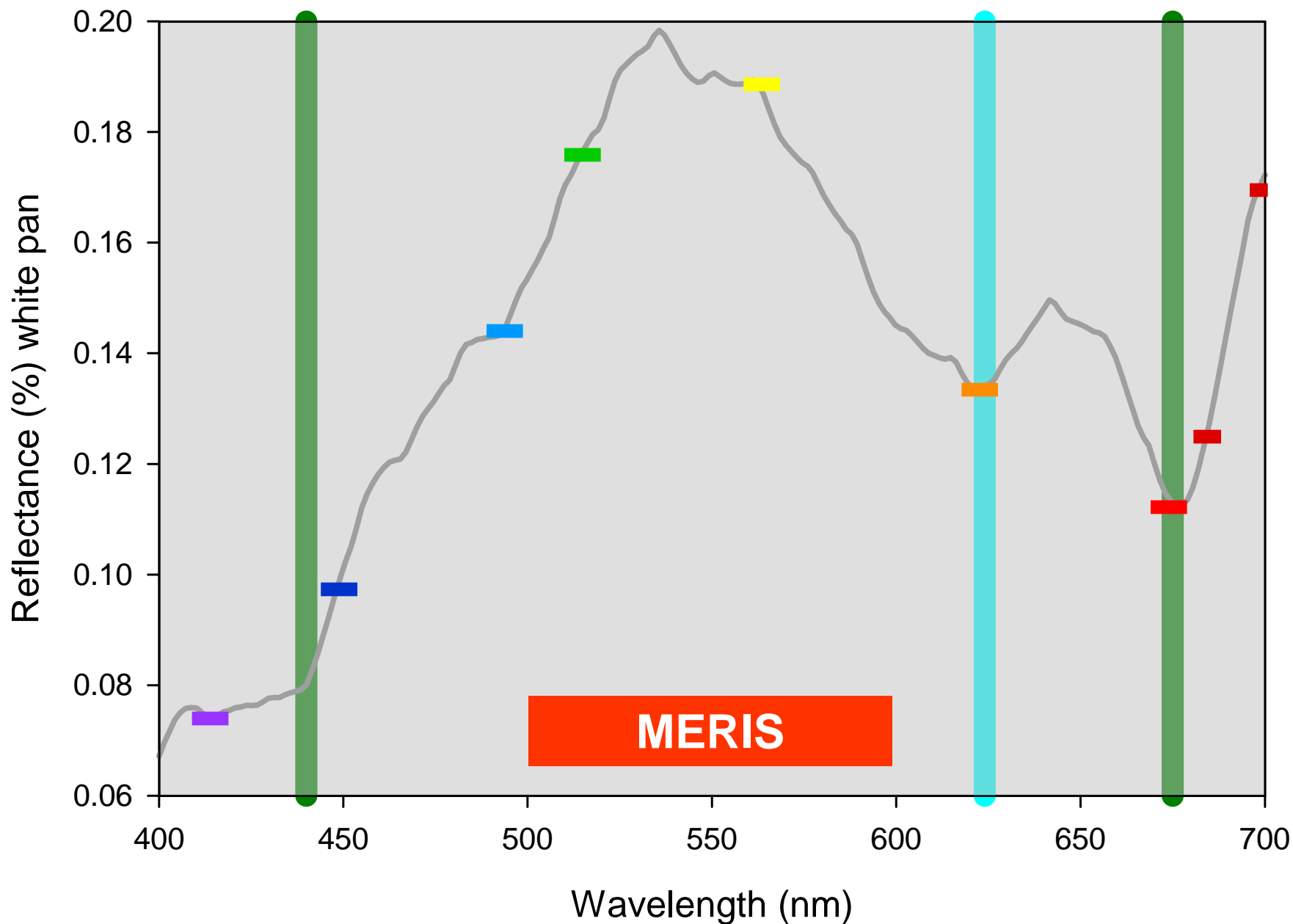
SPECTRAL RESOLUTION



SPECTRAL RESOLUTION



SPECTRAL RESOLUTION



Deciding which sensor to use for lake RS

Small lakes	Spatial resolution – pixel size
Large lakes	Spatial resolution – pixel size
Dynamics	Temporal resolution – repeat time
Sensitivity	Radiometric resolution – bits
Chlorophyll in lakes	Spectral resolution – bands important for chlorophyll
Cyanobacteria in lakes	Spectral resolution – bands important for phycocyanin
Ease of access online	Website design and access
Turn around	Data processing and distribution
Extent	Size of footprint
Historic	Date of satellite launch

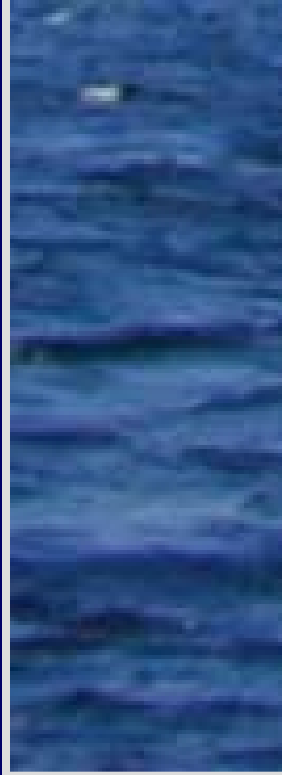
Landsat TM**MERIS****MODIS****SeaWiFS****Small lakes****Large lakes****Repeat time****Sensitivity****Chlorophyll
in lakes****Cyanobacteria
in lakes****Ease of access
online****Turn around****Extent****Historic**

Bad



Best

- Remote sensing of water
- On-lake remote sensing
- What satellites could work?
- **Next steps...**



Next Steps

- Create best possible algorithms for variety of satellite platforms using spectra
- Apply algorithms to real satellite data and check with ground collected lake data
- Determine best system and use for each satellite platform
- Look for other uses for on-lake remote sensing (boat, aerial, volunteers, ect.)

Acknowledgements

Funding

UHN Graduate School, USDA, NH Space Grant,
Project Lake Watch (NSF), NEIWPCC - EPA
Region I, UNH Cooperative Extension

UNH Remote Sensing

Dr. Janet Campbell, Dr. Rudiah Morrison, Dr.
Mark Dowell, Mike Nowak, Tim Moore, Doug
Vandemark

UNH Limnology

Sonya Carlson, Travis Godkin, Dr. Leland
Jahnke, Jeff Schloss, Bob Craycraft, Field
Limnology classes ('02-'04)

Ocean Optics Class 2004

Dr. Emmanuel Boss (UMaine), Dr. Colin Roesler
(Bigelow Labs), Dr. Curt Mobley (Sequoia Sci.),
Wayne Slade (UMaine)

CALMIT Nebraksa

Bryan Leavitt (UNL), Giorgio Dall'Olmo (UNL),
Dr. John Schalles (Creighton)

EPA Region I & ORD

Darryl Keith, Hillary Snook, Andrew Brock, Jeffery
Barrett, Gabriela Martinez

New England States

CT Department of Environmental Protection
ME Department of Environmental Protection
MA Department of Environmental Protection
NH Department of Environmental Services
URI Cooperative Extension
VT Department of Environmental Conservation

