Hyperspectral Measurements to Predict Marine Phytoplankton Biodiversity in Coastal Regions

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& NOAA Integrated Ocean Observatory System

Merging Remote Sensing Products and Taxonomic Composition for Potential Hyspiri Applications

Outline

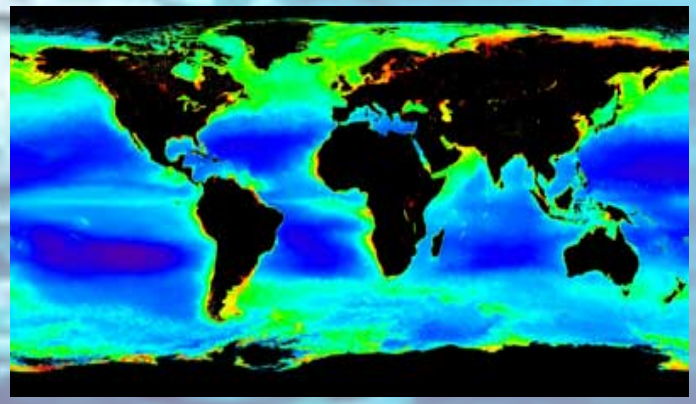
Phytoplankton Functional Types will allow improved our understanding of phytoplankton ecology, climate interactions, and elucidate carbon linkages.

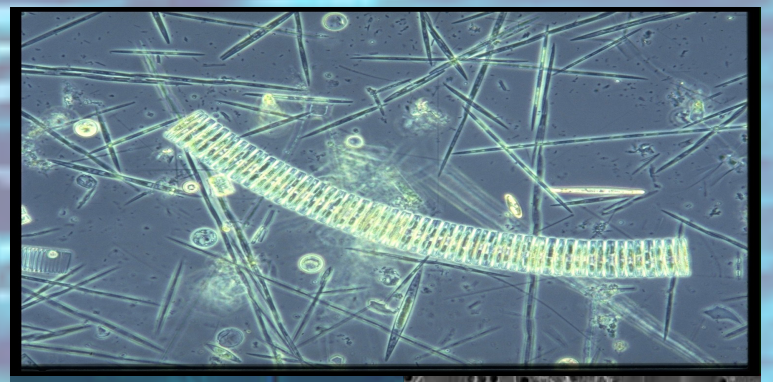
Hyperspectral Imaging combined with thermal bands will pave the road to deconvolving IOPS into Phytoplankton Functional Types

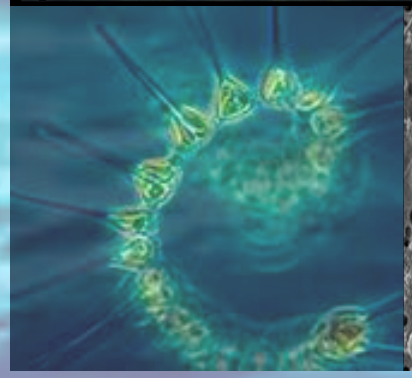
- → Matrix Inversion Applications
- → Understanding of Photophysiology

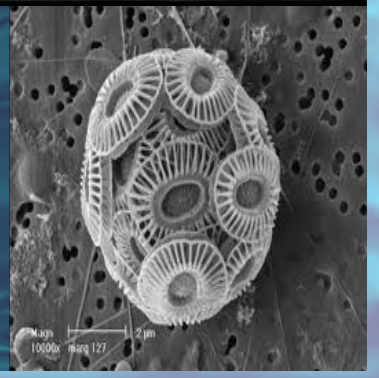
Presenting A Spatial Example of PFTs in the Gulf of Maine &

Temporal 2-year Time Series in the Mid Atlantic Bight.

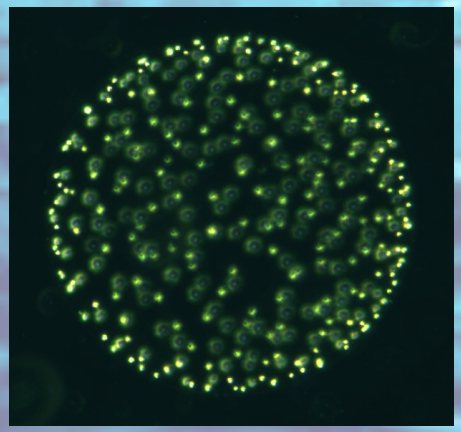


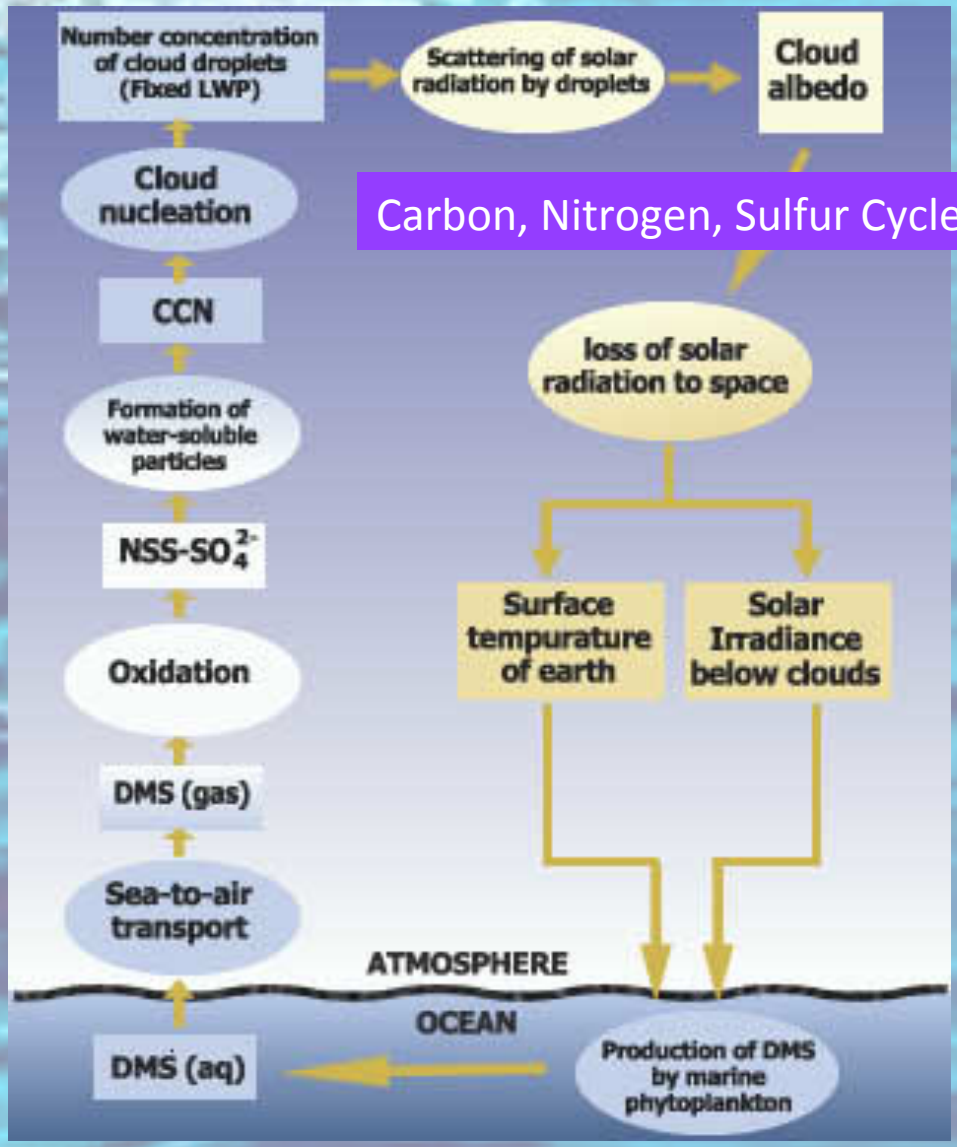






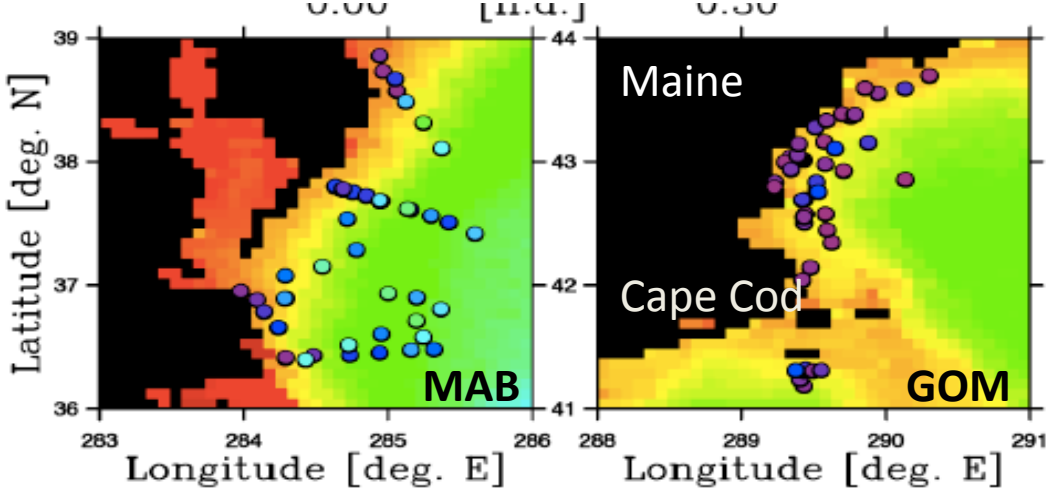
How do PFTs Link Biogeochemical Cycles?



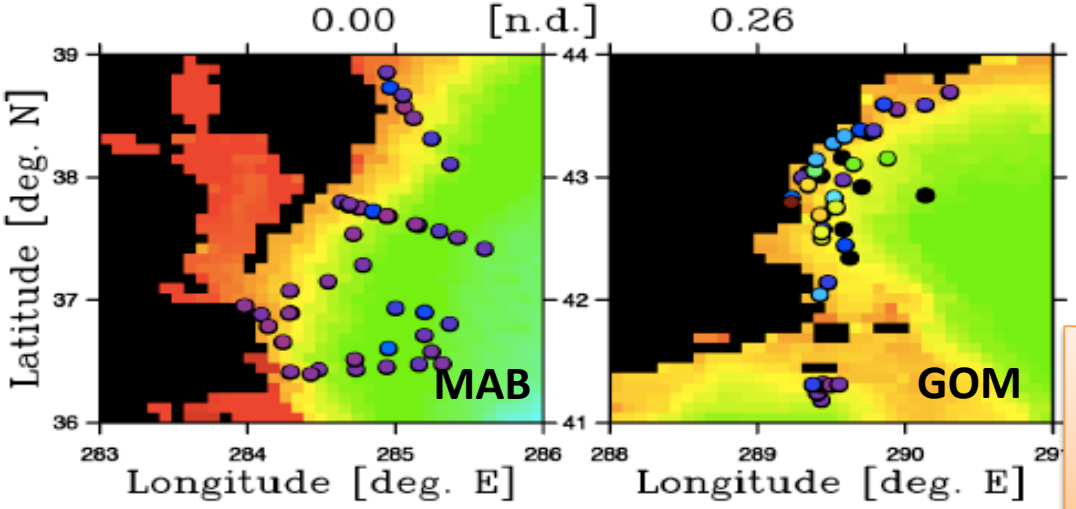


The Complexities of the Carbon Cycle

Phaeocystis to Chlorophyll a ratio



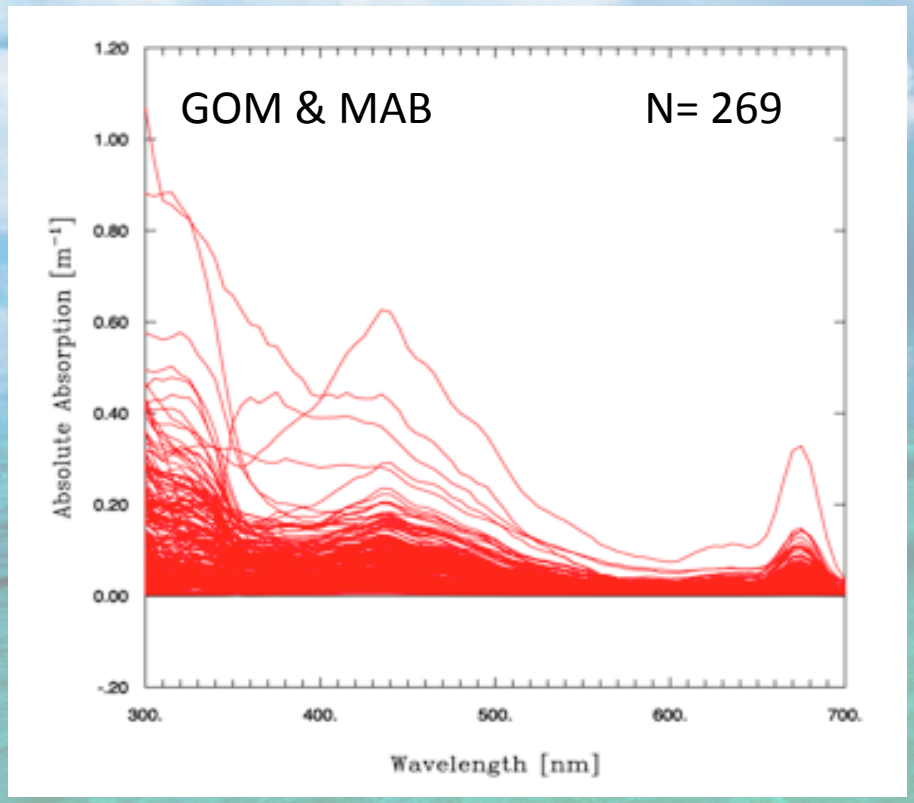
Dinoflagellate to Chlorophyll a ratio .

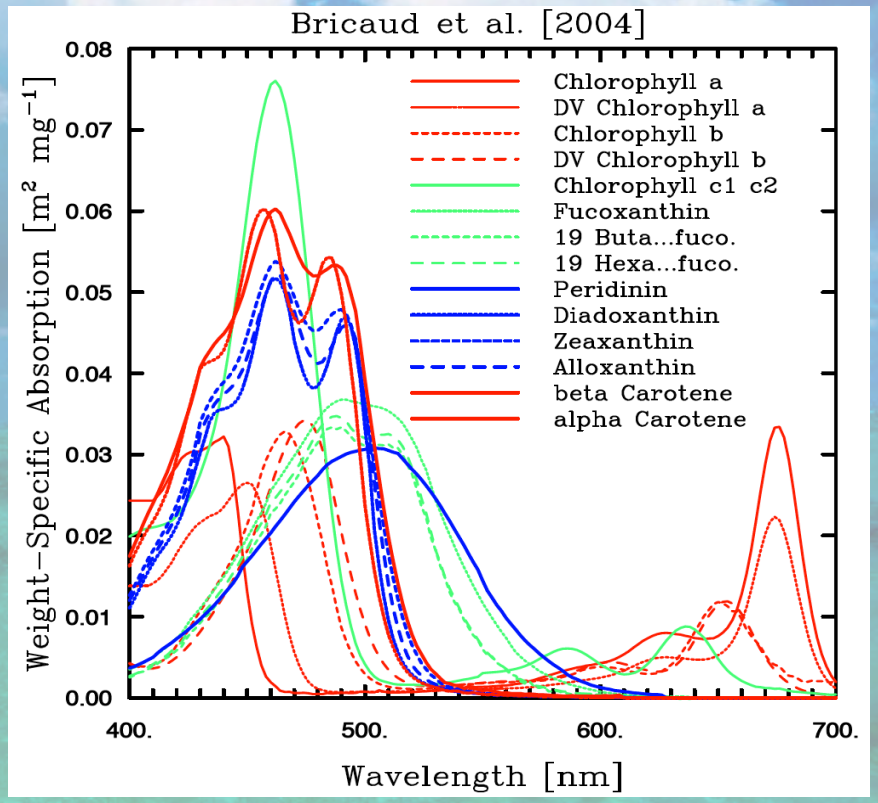


Moisan et al. 2011, Moisan et al., J. Continental Research

Hyperspectral Measurements by Hyspiri will potentially:

1) Increase the Accuracy of Measuring "Gausian Bands" of Pigments which contribute to Rrs and,
2) Understanding Physiological Acclimation to Temperature, Light, & Nutrients

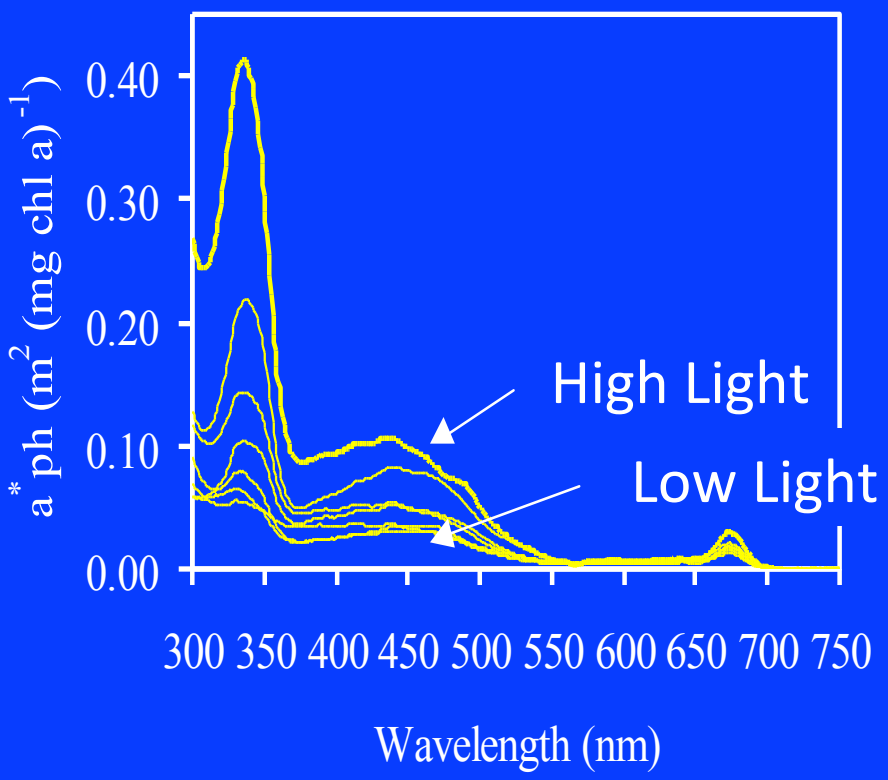




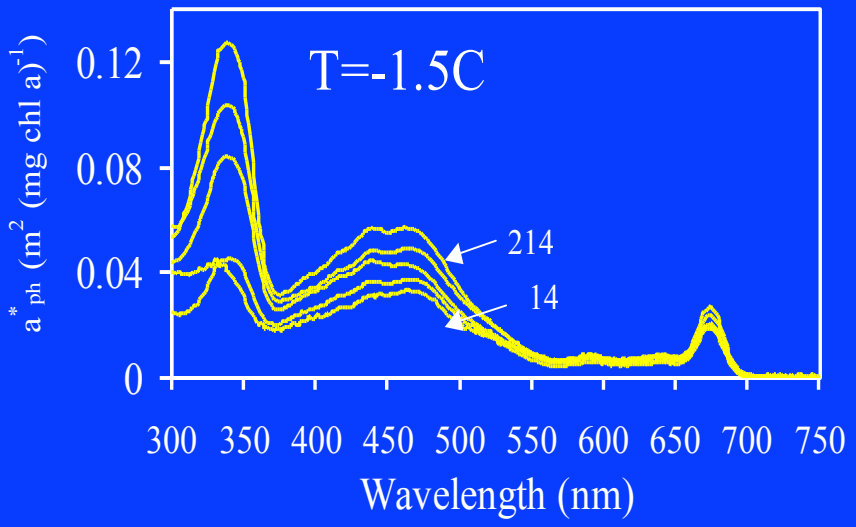
Bidigare et al., 1990, Bricaud et al. 2004, Moisan et al. 2011

Incorporate Physiology into Models:

Chl a-specific Absorption Varies significantly with Light



And Temperature……



Moisan and Mitchell 1999
Moisan et al. 2001

Estimating Phytoplankton Functional Types with Hyperspectral Measurements

Satellite-derived

PAR

Temperature

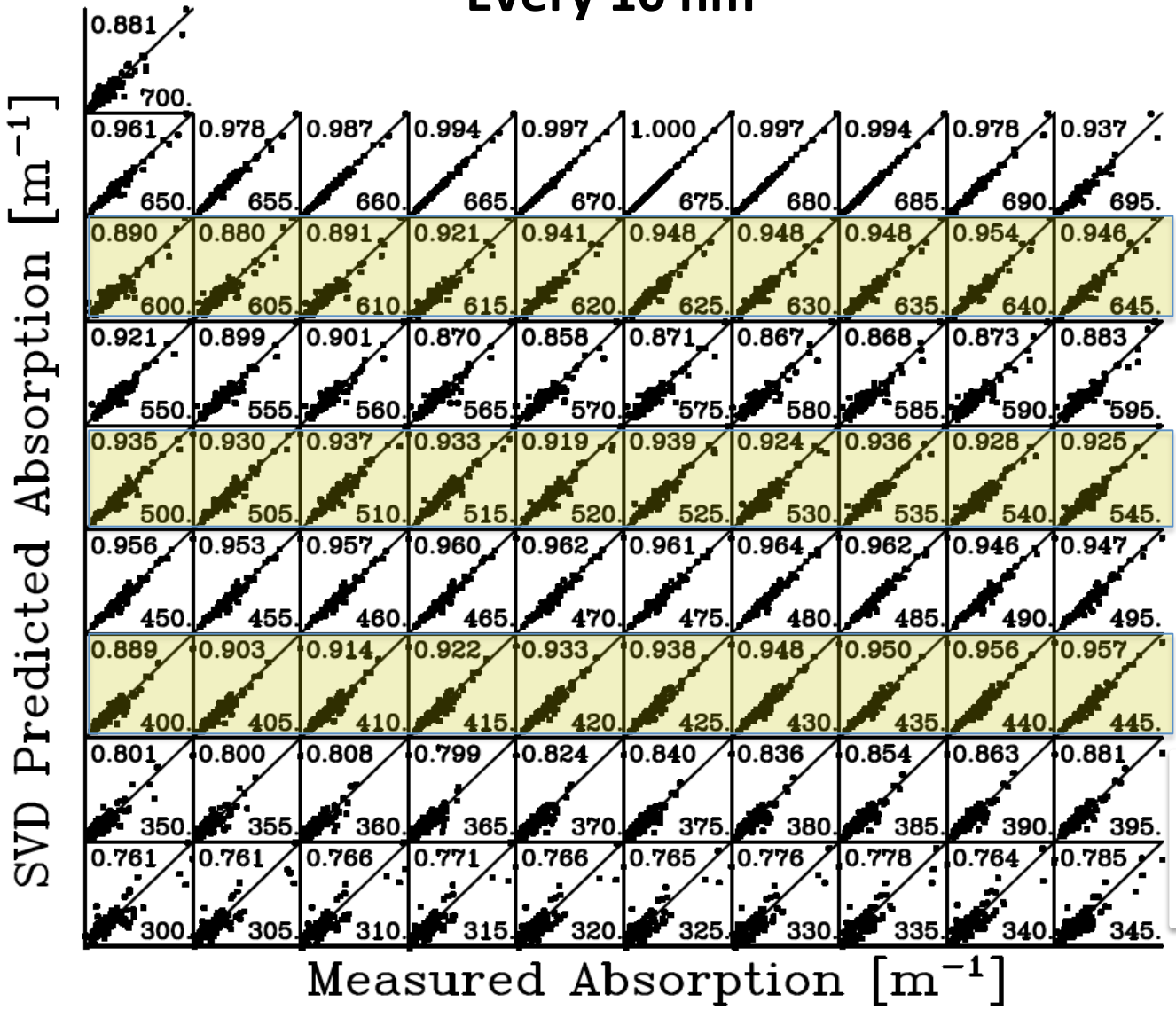
Chlorophyll a

Phytoplankton Absorption Properties (a_{ph})

Matrix Inversion through Singular Value Decomposition

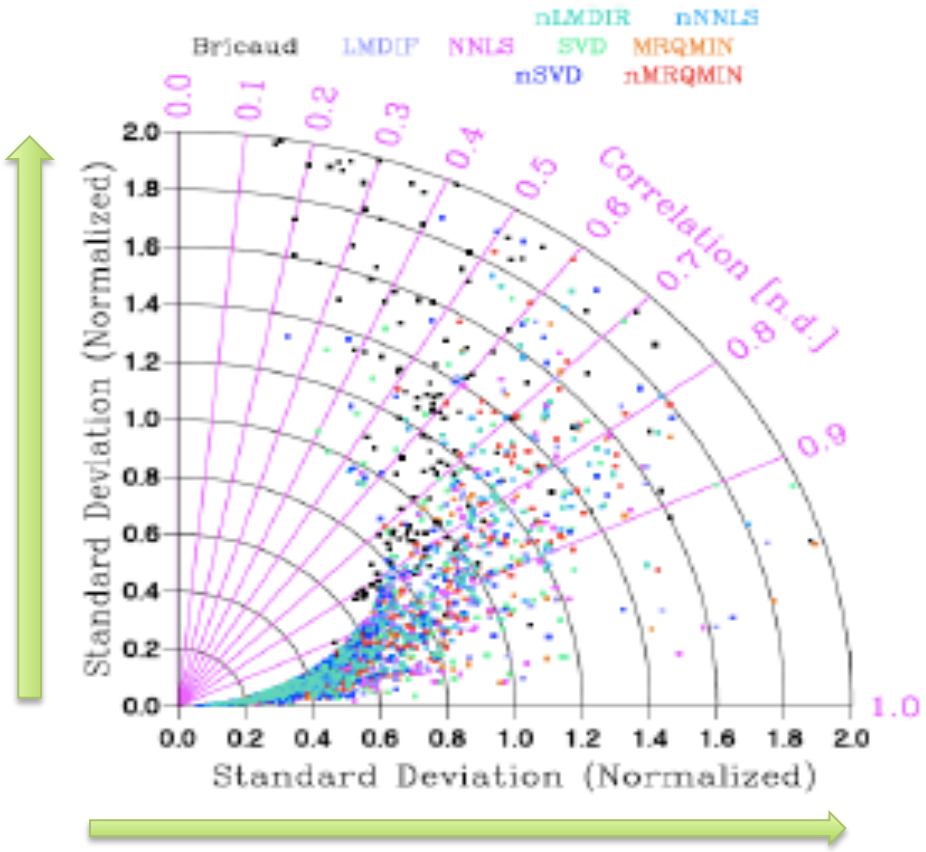
~14 marker pigments (Diatoms, Phaeocystis, Chlorophytes, dinoflagellates, & physiology)

Matrix Inversion Model Prediction of Absorption Every 10 nm

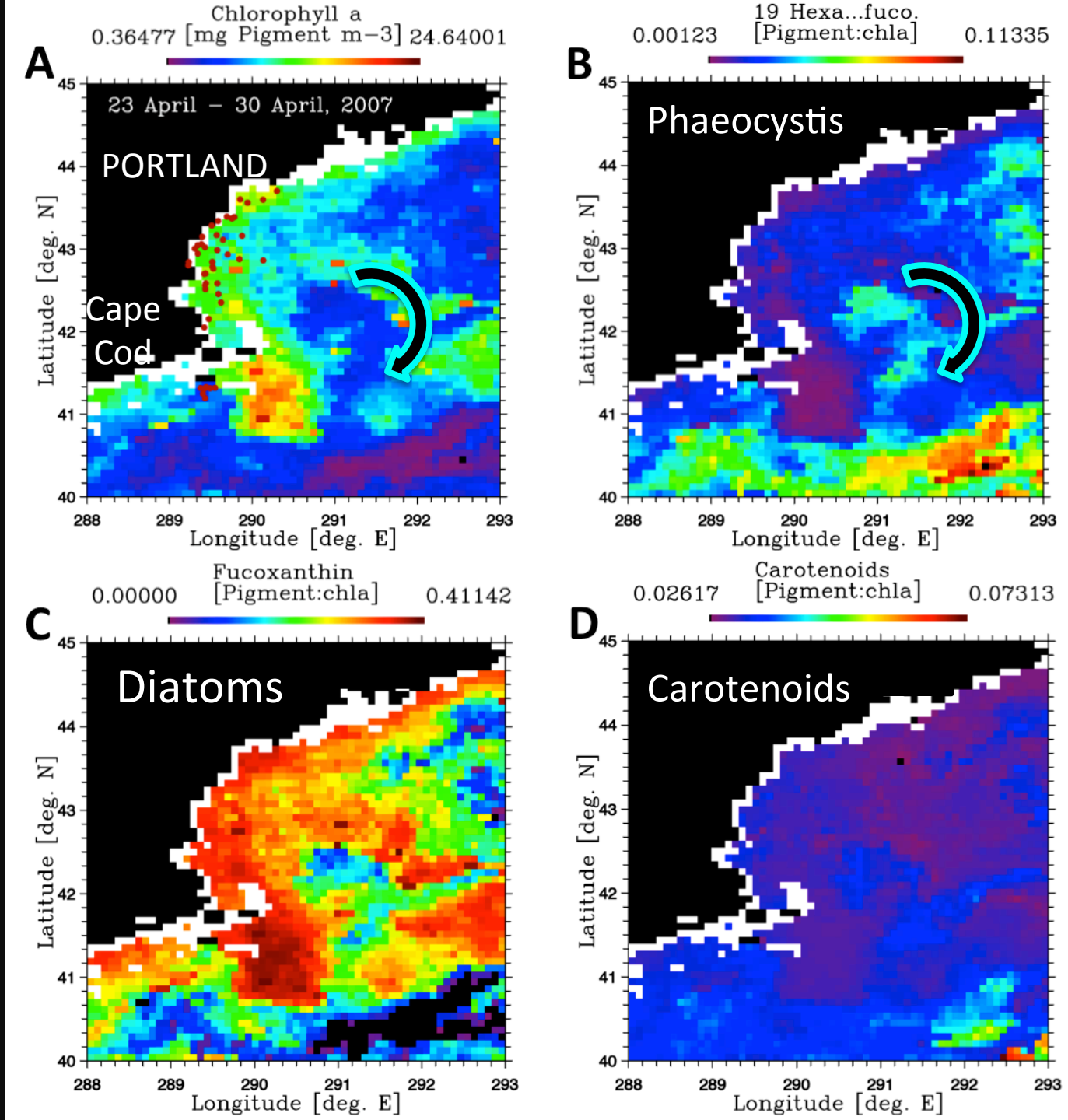


Error lower in the UV ~20%

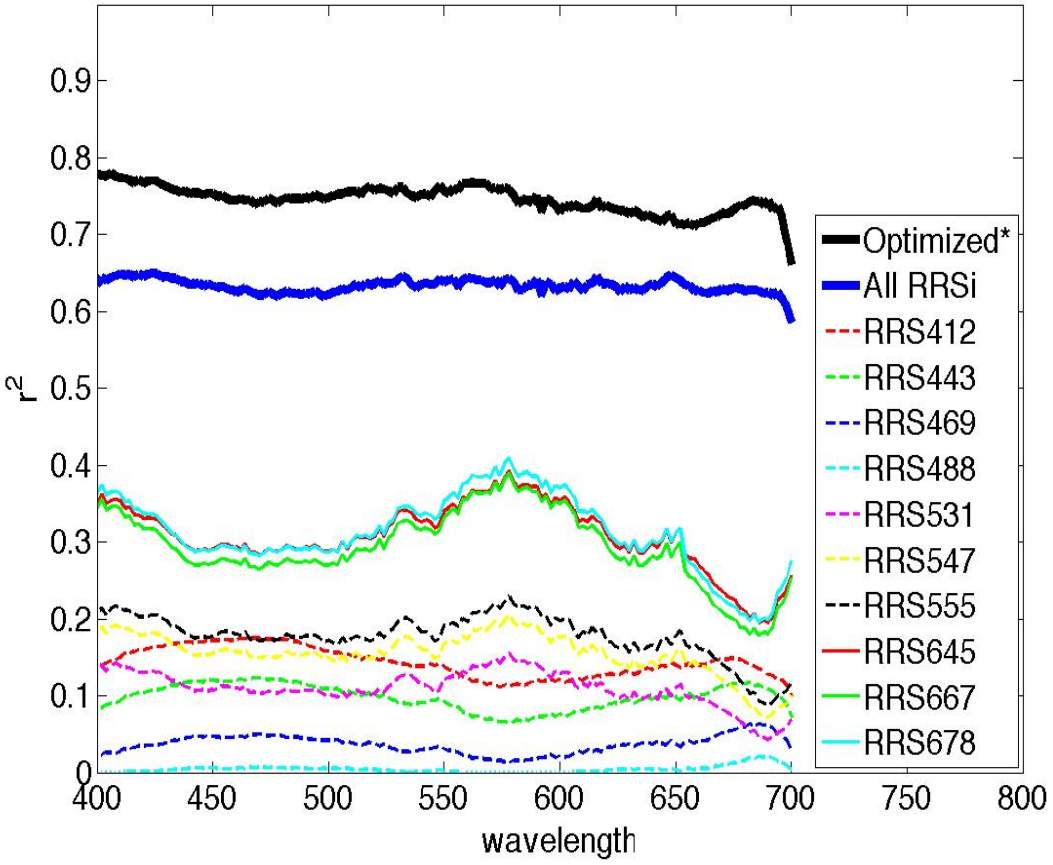
Taylor Plot: Matrix Inversion Algorithm for Absorption

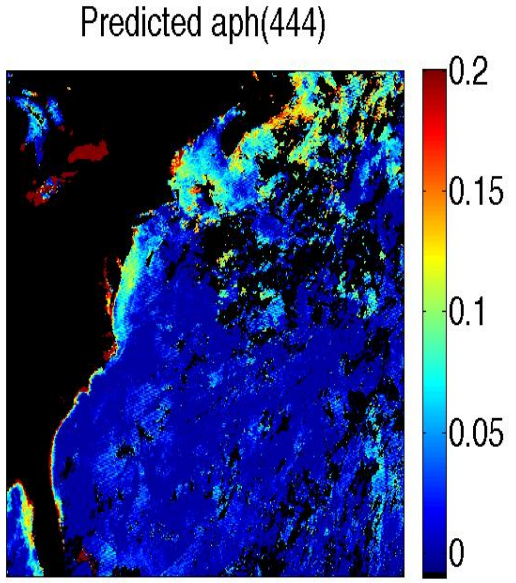


Increasing Error

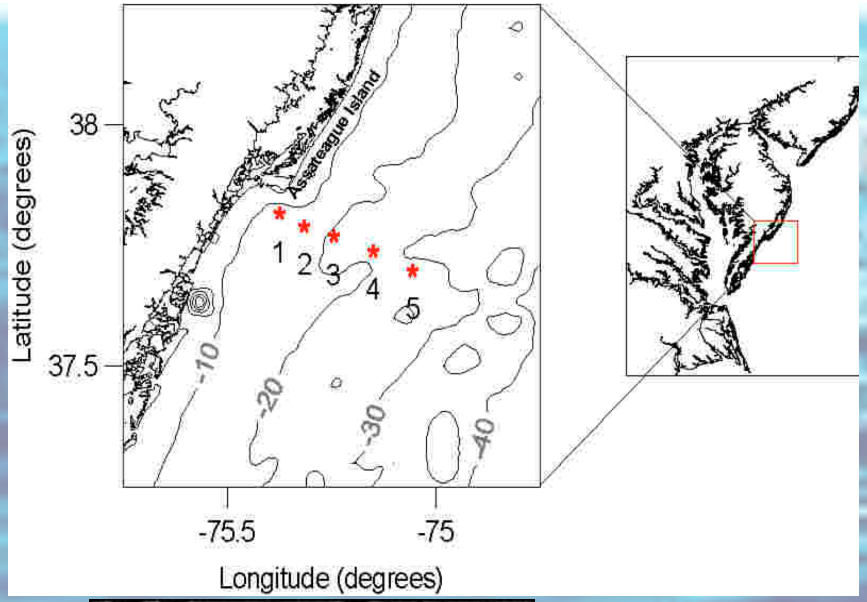

A
Chlorophyll a
0.36477 [mg Pigment m−3] 24.64001
23 April – 30 April, 2007
PORTLAND
Cape Cod
B
19 Hexa...fuco.
[Pigment:chla]
0.00123
0.11335
Phaeocystis
C
Fucoxanthin
[Pigment:chla]
0.00000
0.41142
Diatoms
D
Carotenoids
[Pigment:chla]
0.02617
0.07313
Carotenoids
Latitude [deg. N]
Longitude [deg. E]
40
41
42
43
44
45
288
289
290
291
292
293

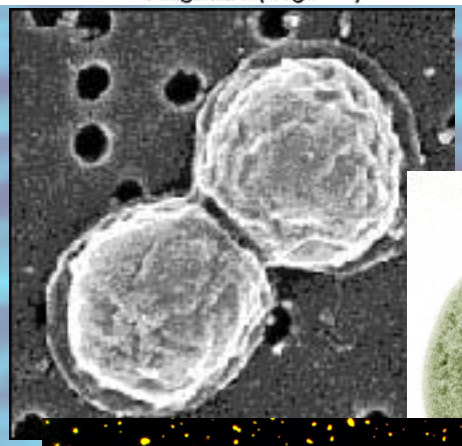
Stepwise Regression with Variable Selection for Prediction of Absorption

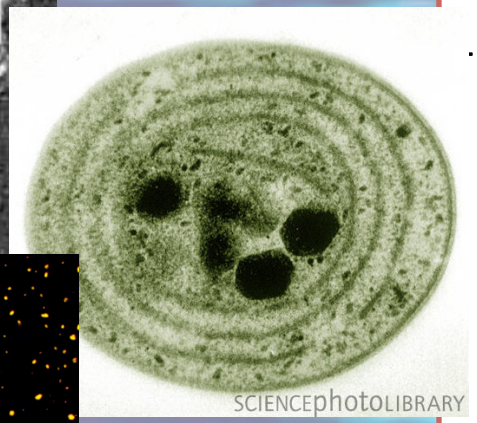


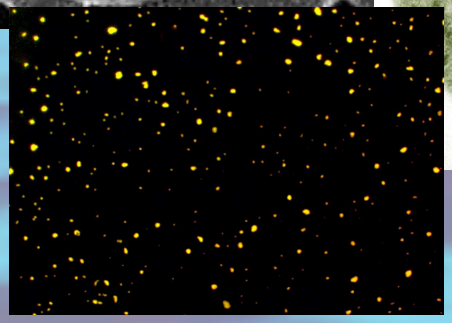


Includes Physiological Responses to Temperature & Light







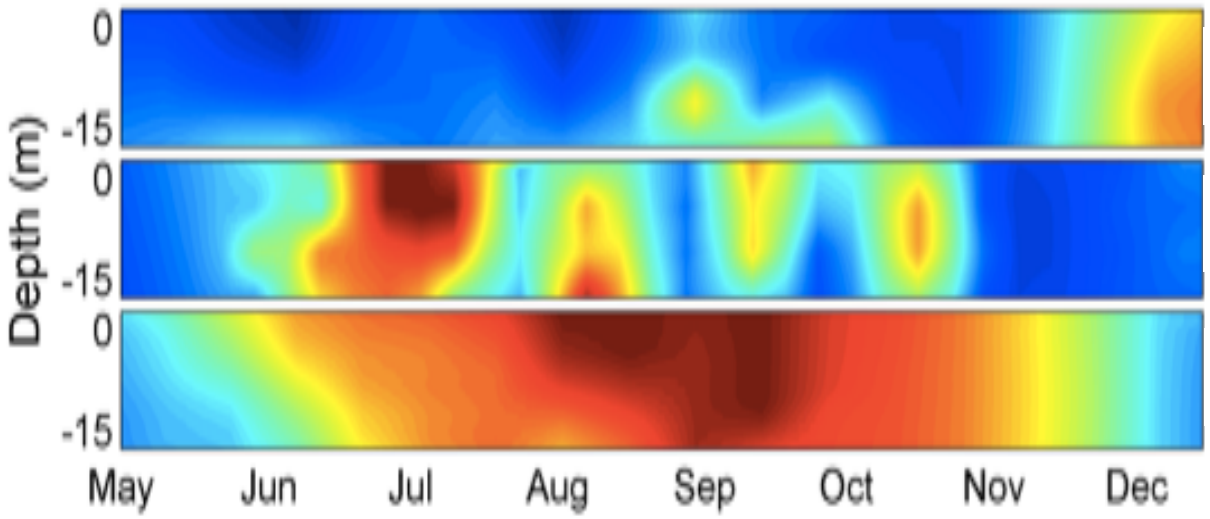


Temporal Dynamics of Cyanobacteria:

- 2-year biweekly Coastal Transect in Virginia-NASA Wallops Flight Facility
- Punctuated Blooms of Cyanobacteria in Response to Temperature
- Patches of Cyanobacteria persisted for 3-4 weeks and could be observed at 60 m resolution during a 19 day cycle

Cyanobacterial Blooms Induced by Temperature and limited by Grazing by Nanoflagellates

Station 3 of COBY Transect

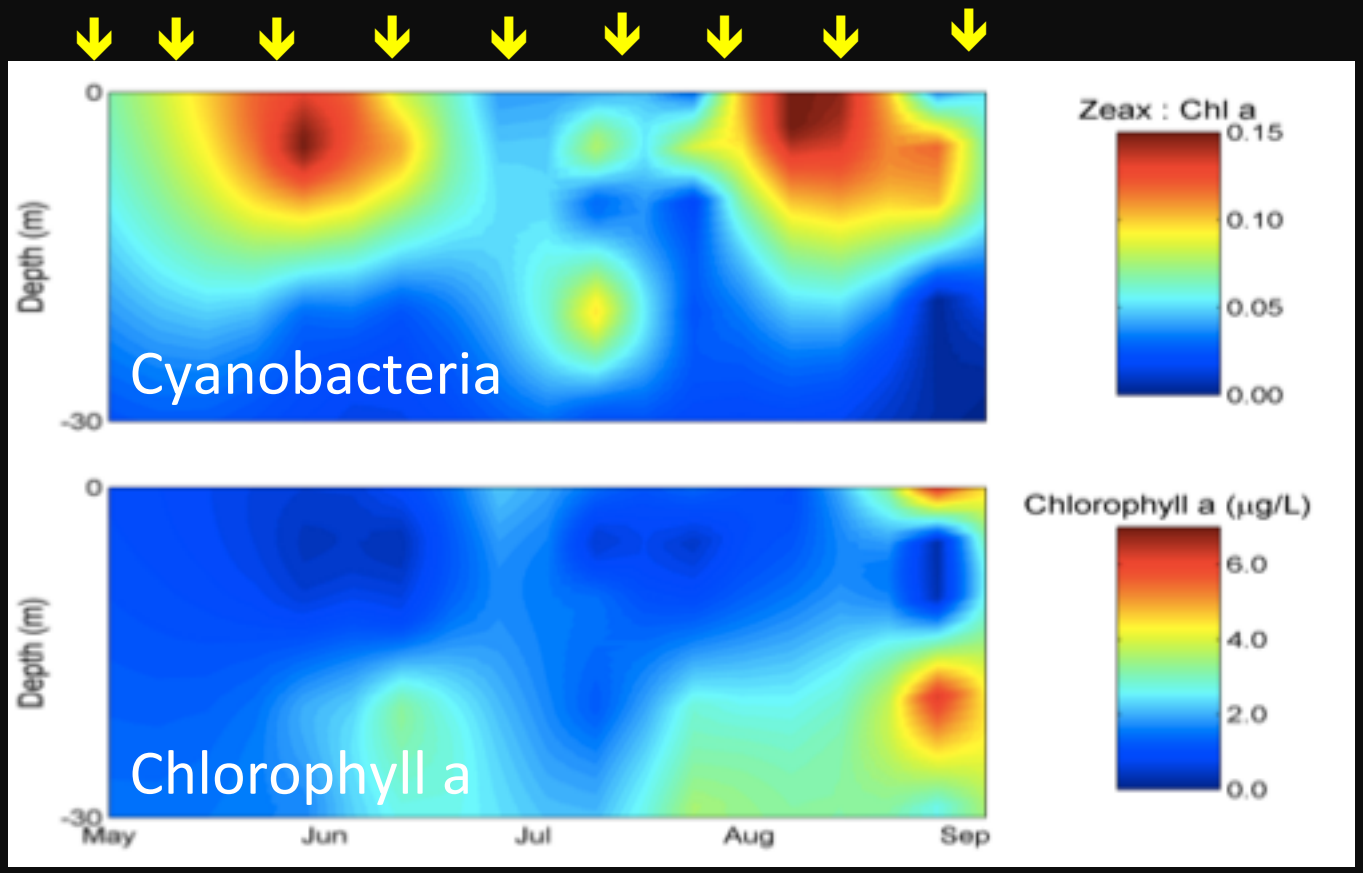


R^2 values of Temperature and Cyanobacteria = 0.80

U.S. Integrated Ocean Observing System

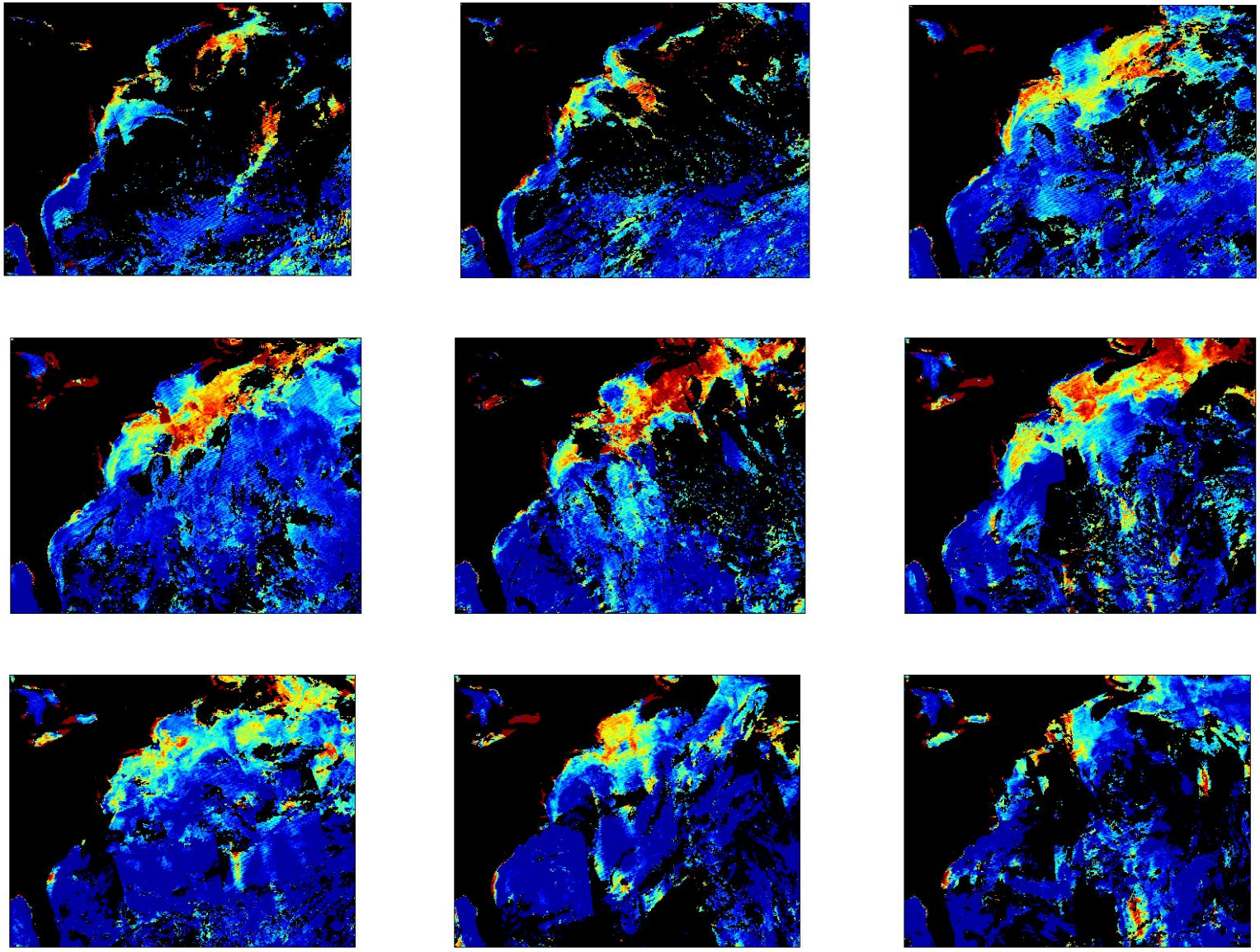
Moisan et al. 2011, J. Cont. Shelf Research

Punctuated Cyanobacteria Blooms in the Context Of 19 Day Return Events for Hyspiri



Station 5: Integrated Ocean Observing System Time Series During Spring

Predicted aph(444) from Feb 1st- June 9th 2007 every 16 days
the scale is from 0 (blue) to 0.2(red)

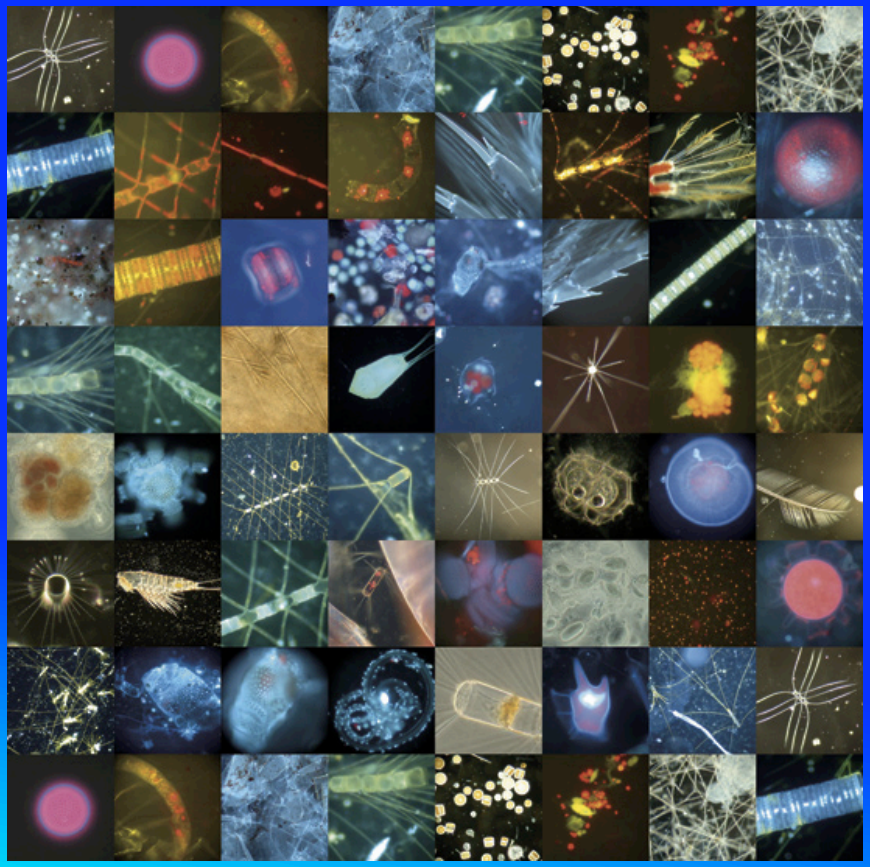


Conclusions

1) PFTs may be indicators of Temperature, Ecological Indicators for Changes in Climate, and may indicate trophic linkages and carbon flow;

2) PFTs are the Next step to incorporating ecological interactions into biogeochemical models which utilize chlorophyll a and Carbon as ecological currency, and;

3) Hyspiri has the technological impetus to demonstrate phytoplankton diversity with multiple wave bands and input of physiological responses to temperature and PAR.



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R/V Huge R. Sharp

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Kristen Blattner
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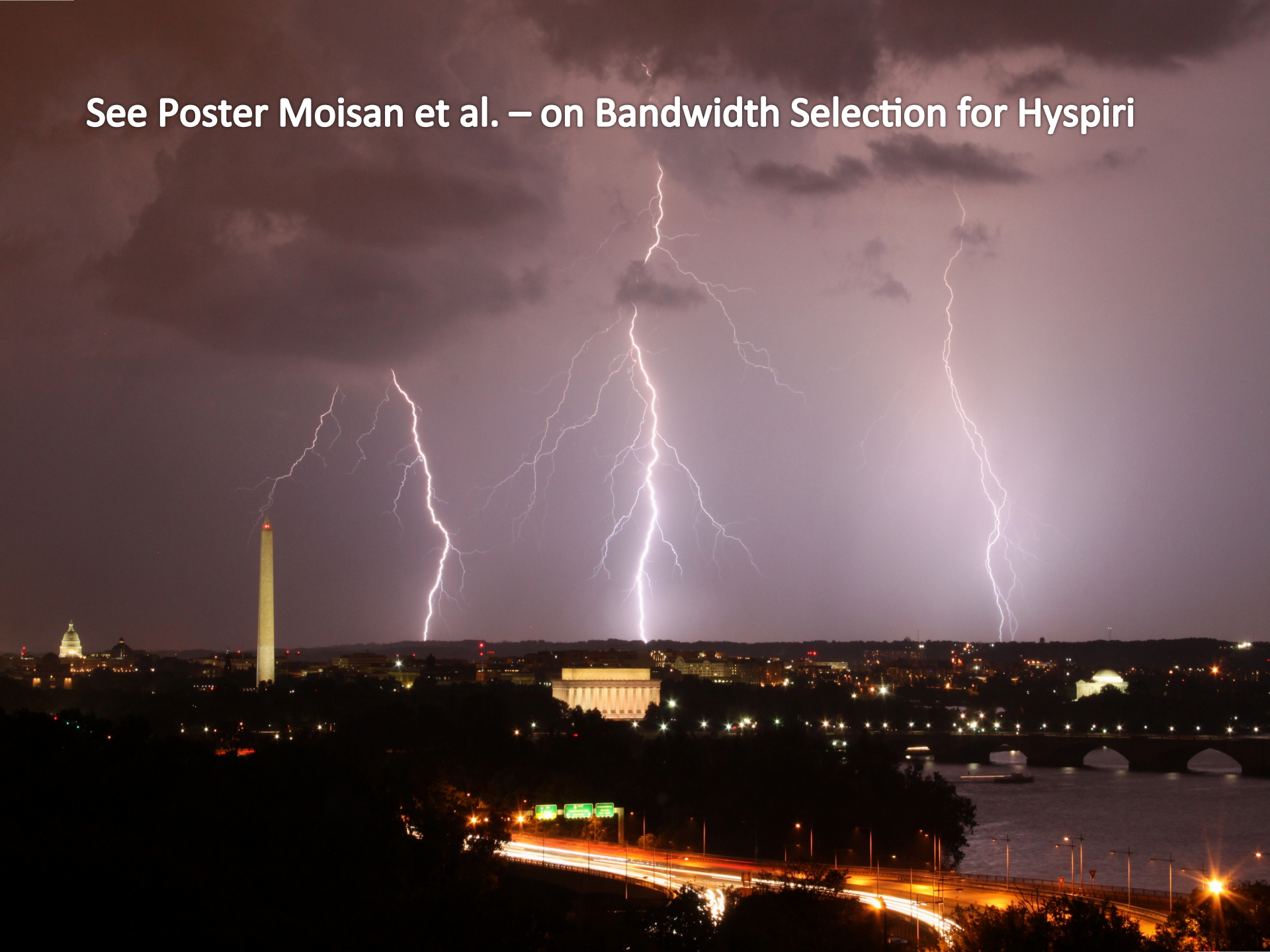
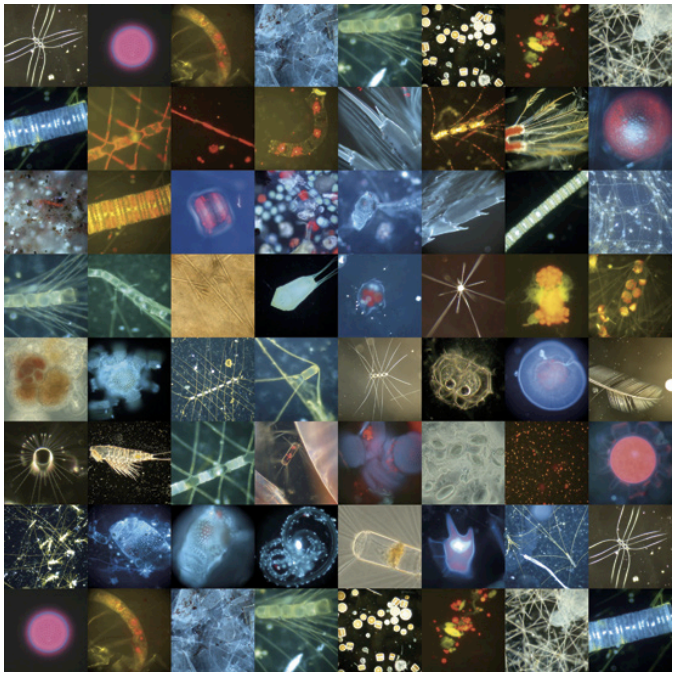
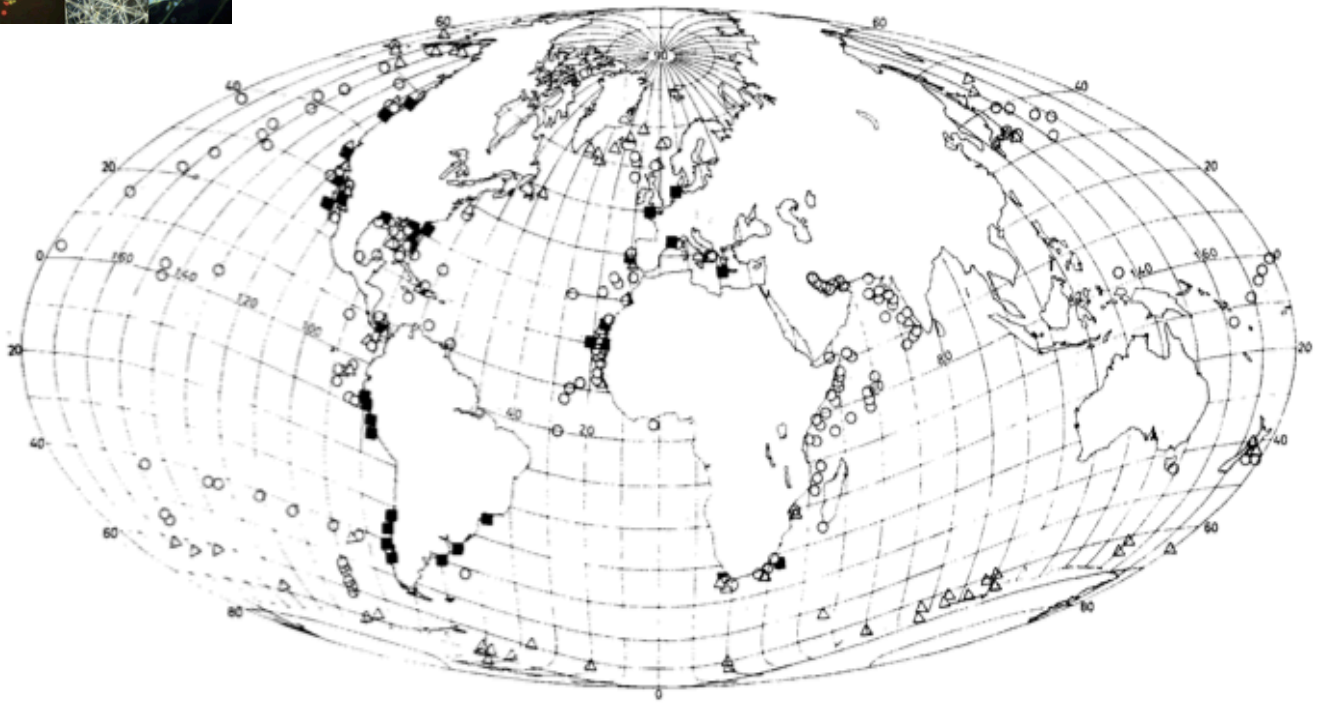
Dr. Noba Ohi (postdoc)
Dr. Jose Blanco (postdoc)

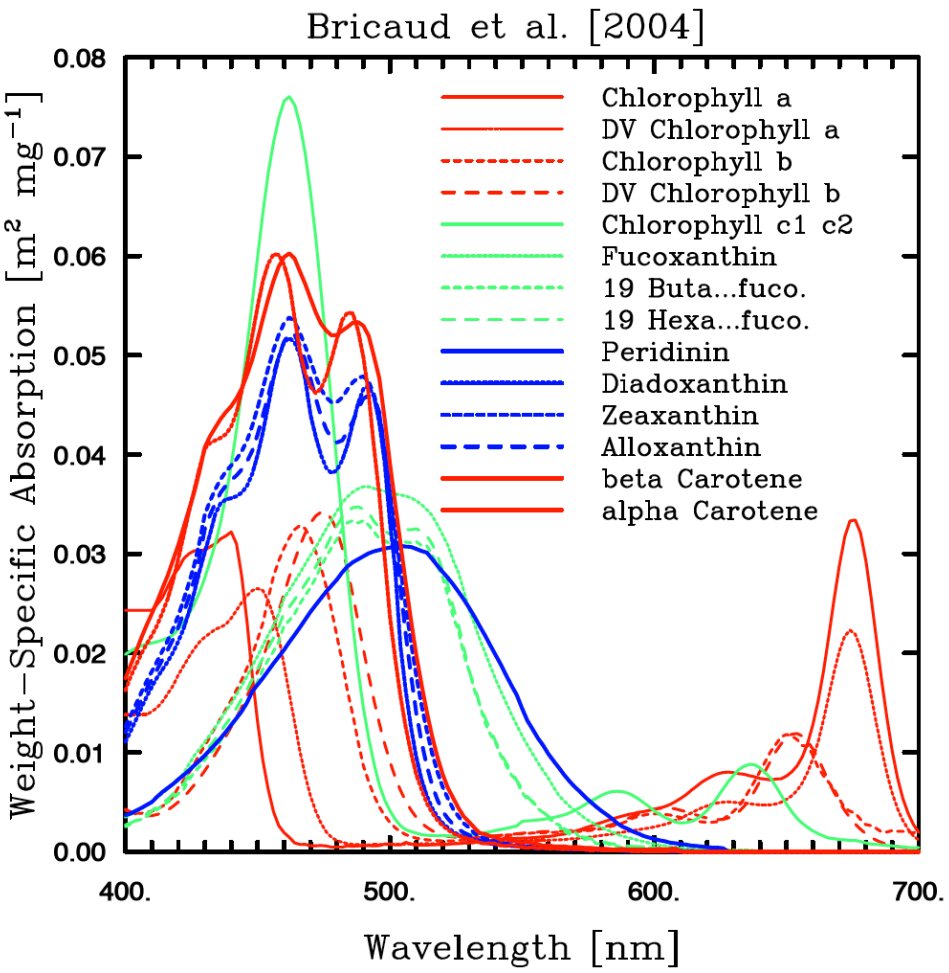
Funding by NASA Biodiversity Program
and NOAA Integrated Ocean Observing System


See Poster Moisan et al. – on Bandwidth Selection for Hyspiri




60
50
90
60
50
100
60
80
60


90
60
20
0
160
140
120
100
80
60
40
20
0
20
40
60
80



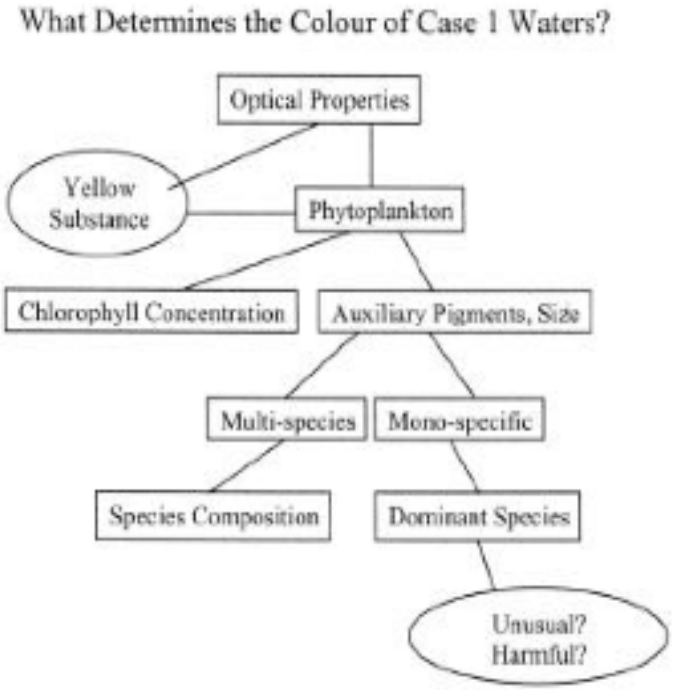
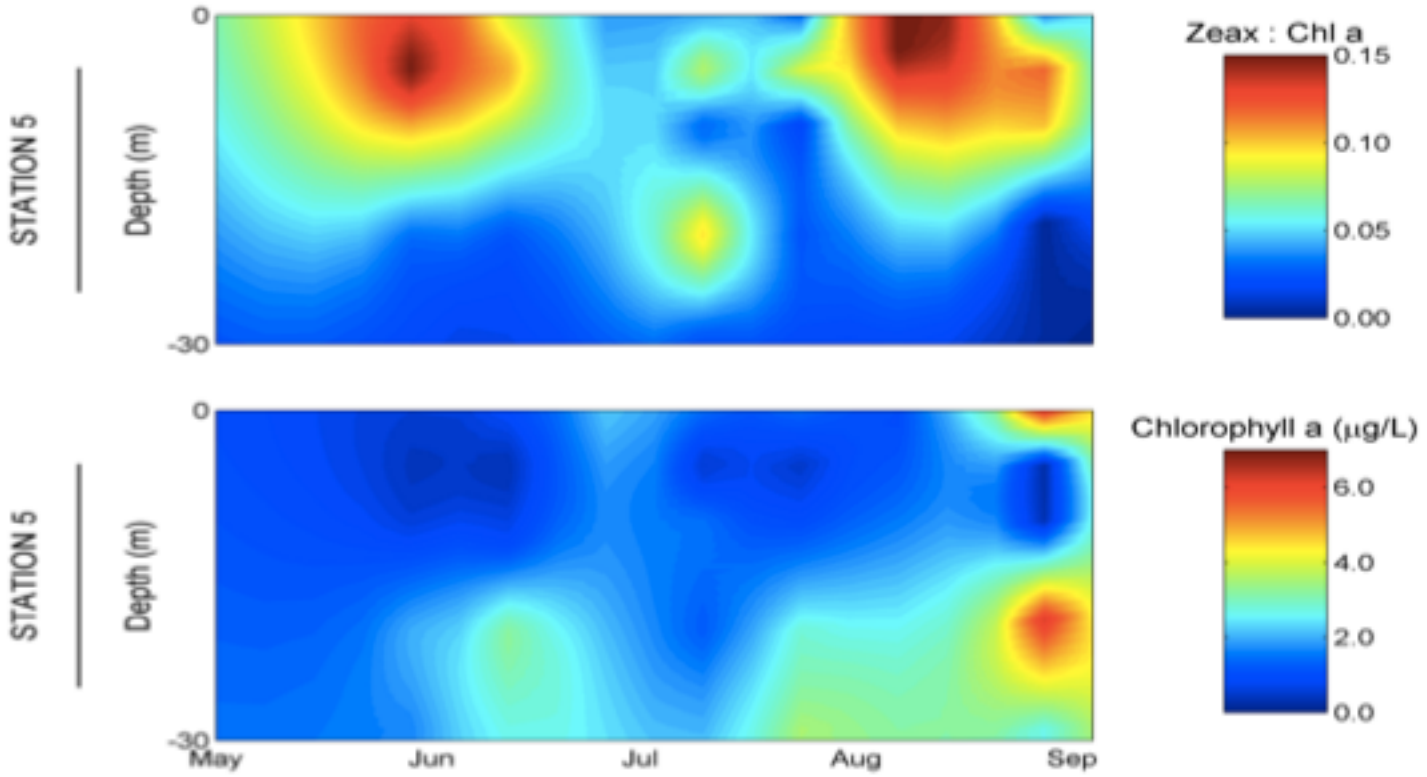


Fig. 7— Schematic diagram showing sources of variations in phytoplankton absorption characteristics in the aquatic environment. These in turn influence ocean colour.

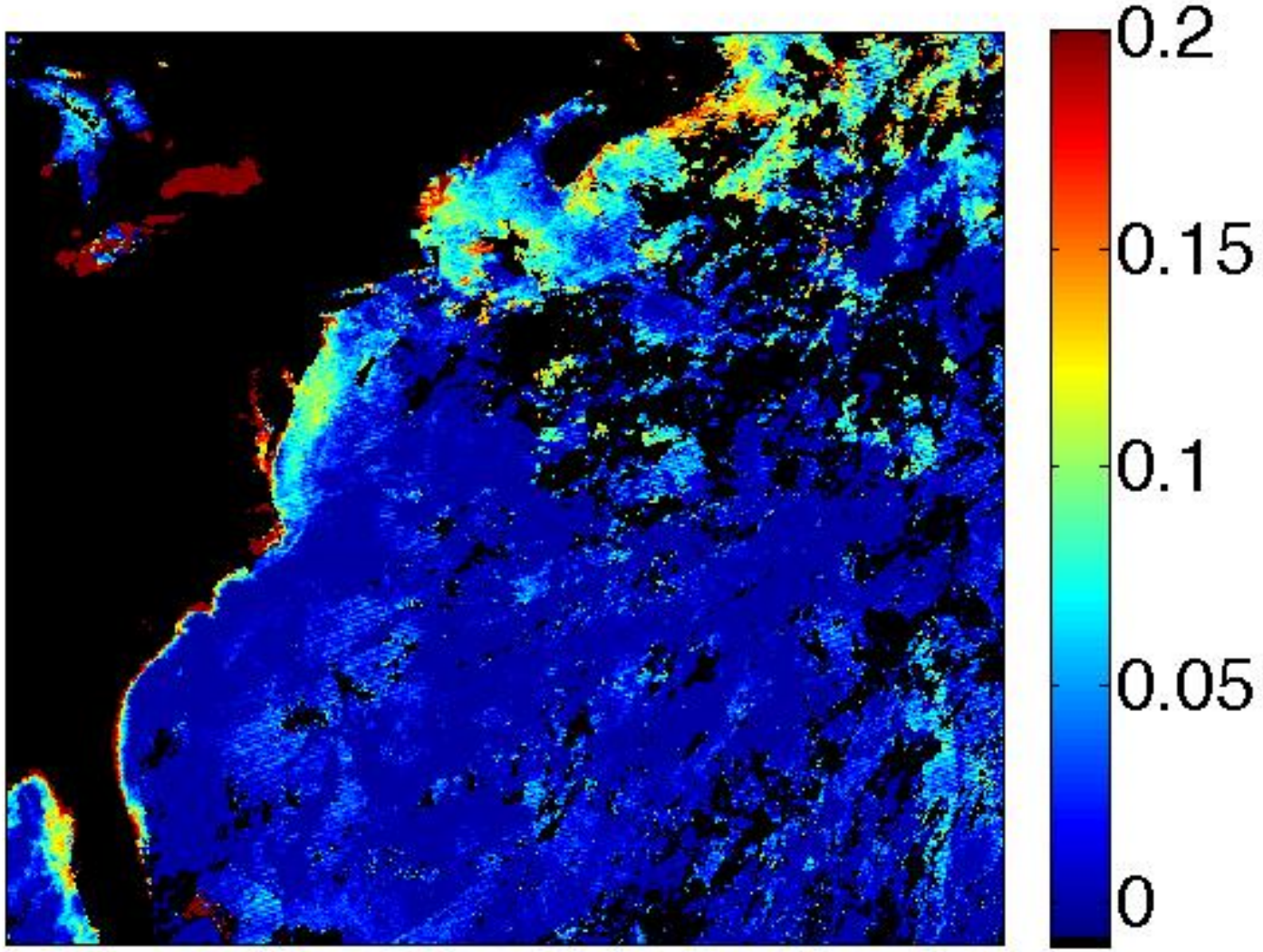
Bidigare et al., 1990, Bricaud et al. 2004,
Moisan et al. 2011

XXXXXXXXX _____



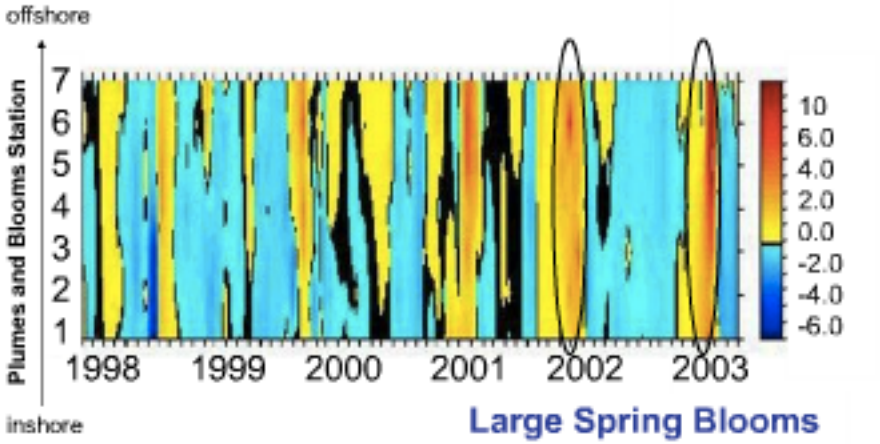
Moisan et al. 2011, J. Cont. Shelf Research

Predicted aph(444)



Sep 27 2005

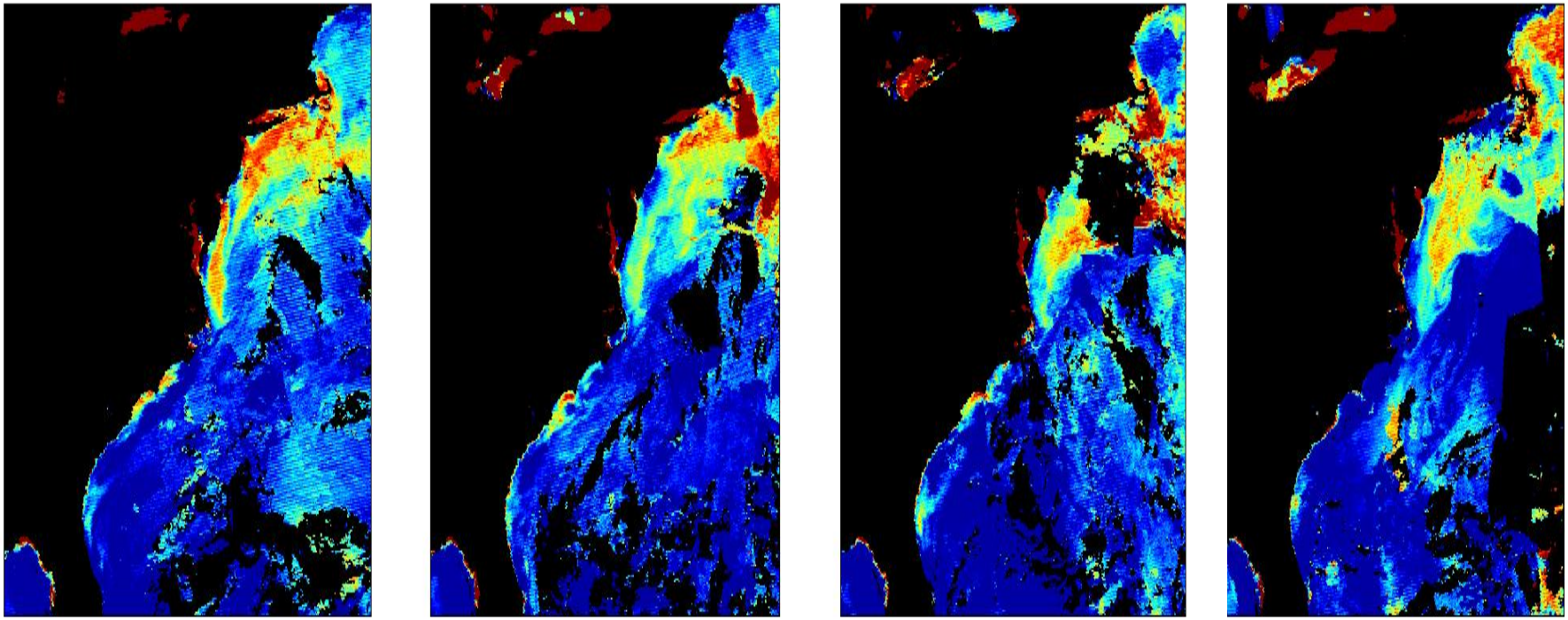
Mapping in Space and Time



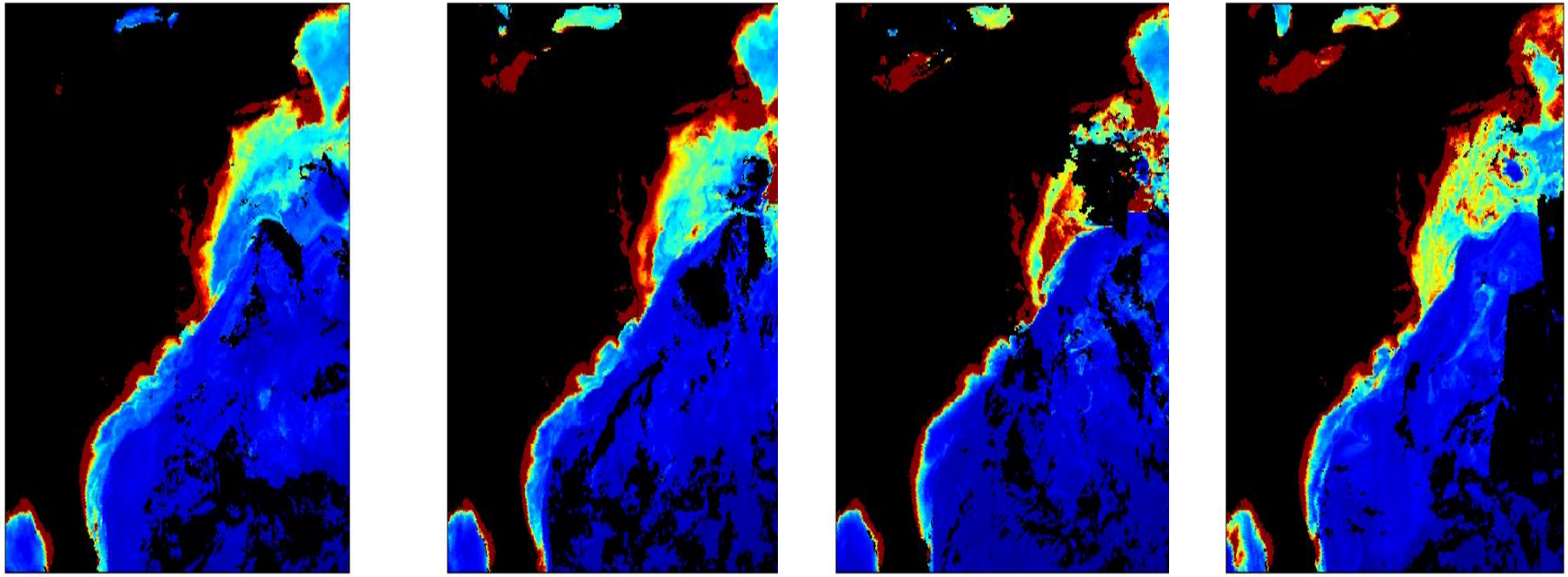
Large Spring Blooms Dominated by *Pseudo-nitzschia* spp.

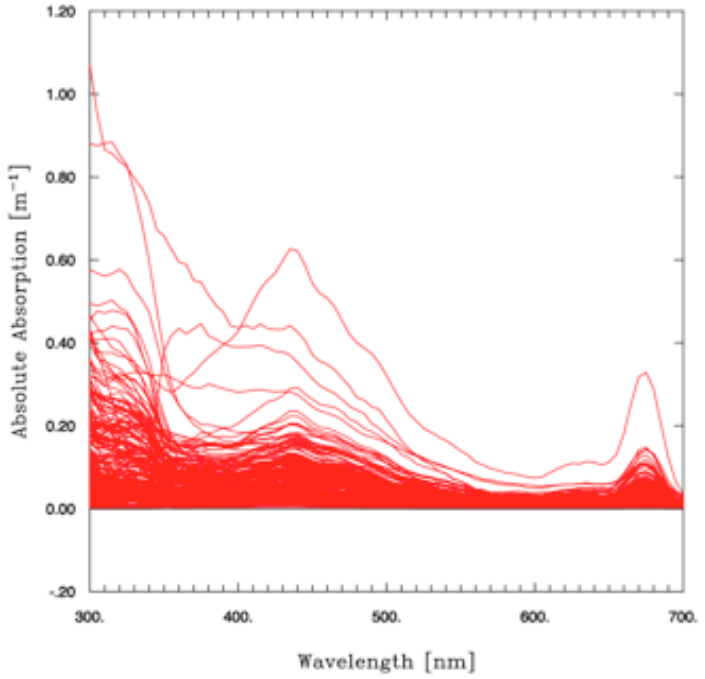
Anderson et al., *submitted*

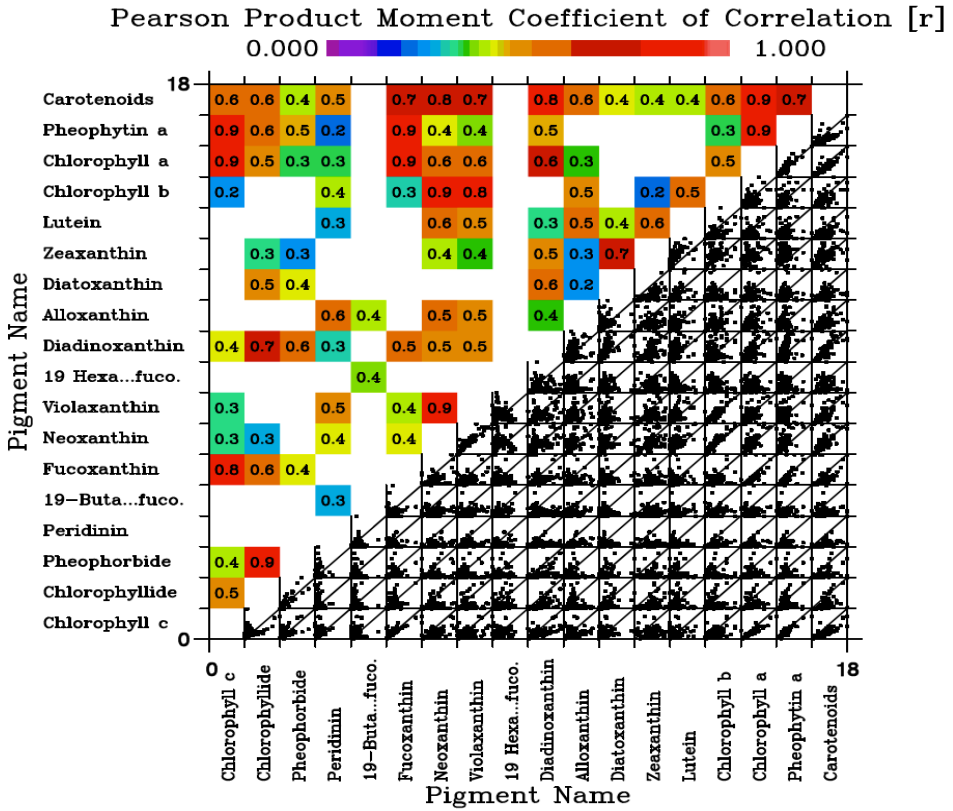
Temporal



Chl a

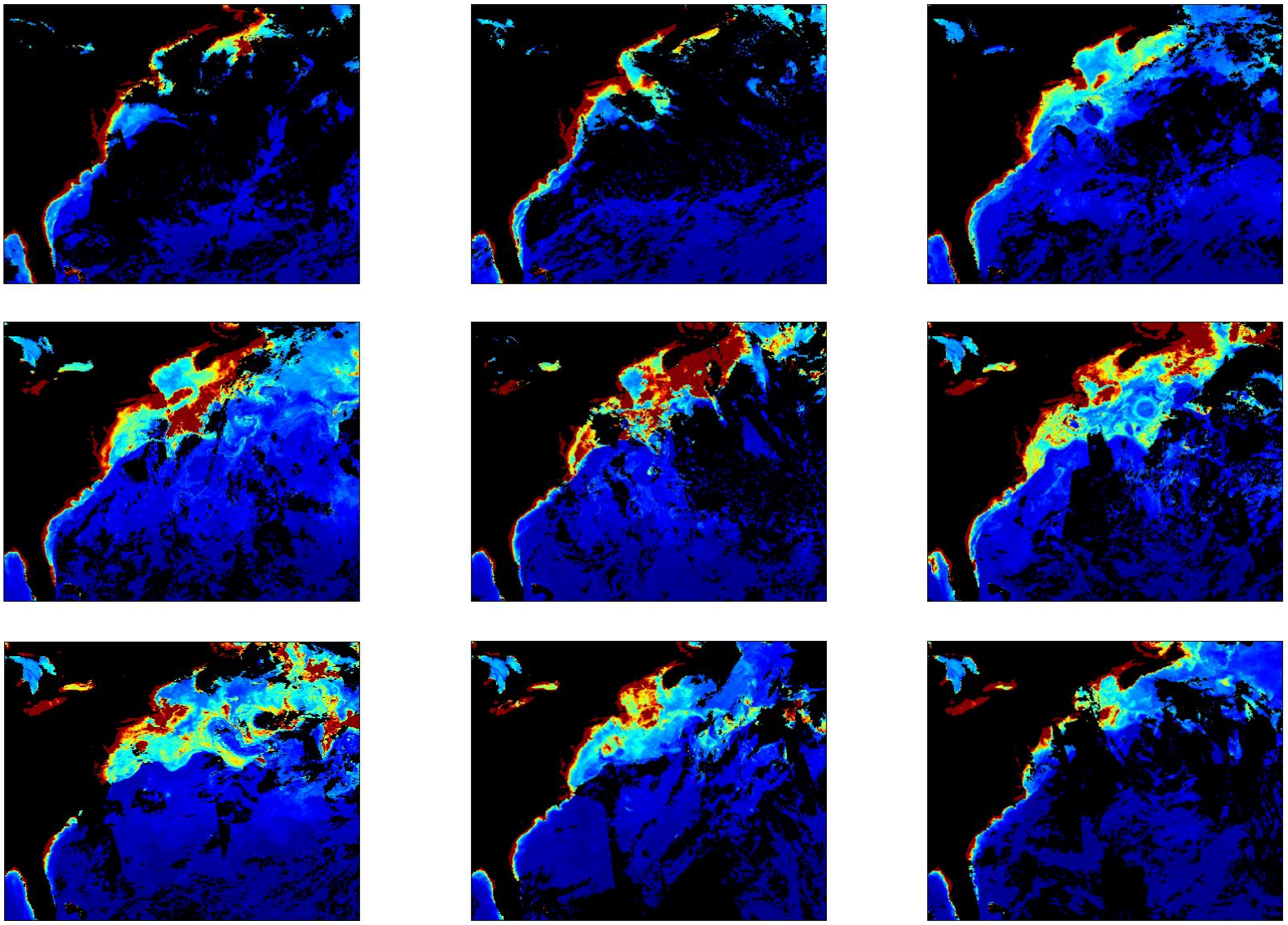






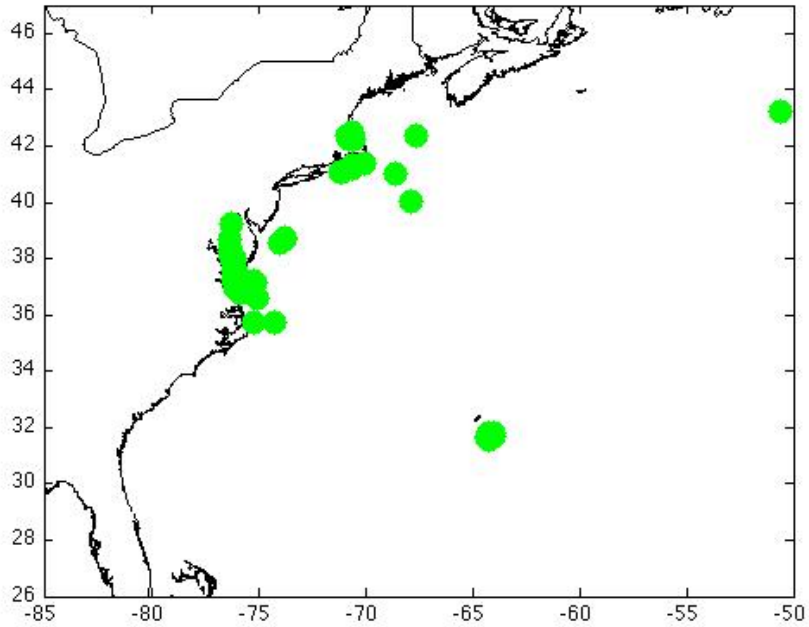
Moisan et al. 2011

Chl a from Feb 1st- June 9th 2007 every 16 days
the scale is from 0 (blue) to 2(red)



Predicting aph from Satellite Products

Data Location
260 datapoints from 2002-2008



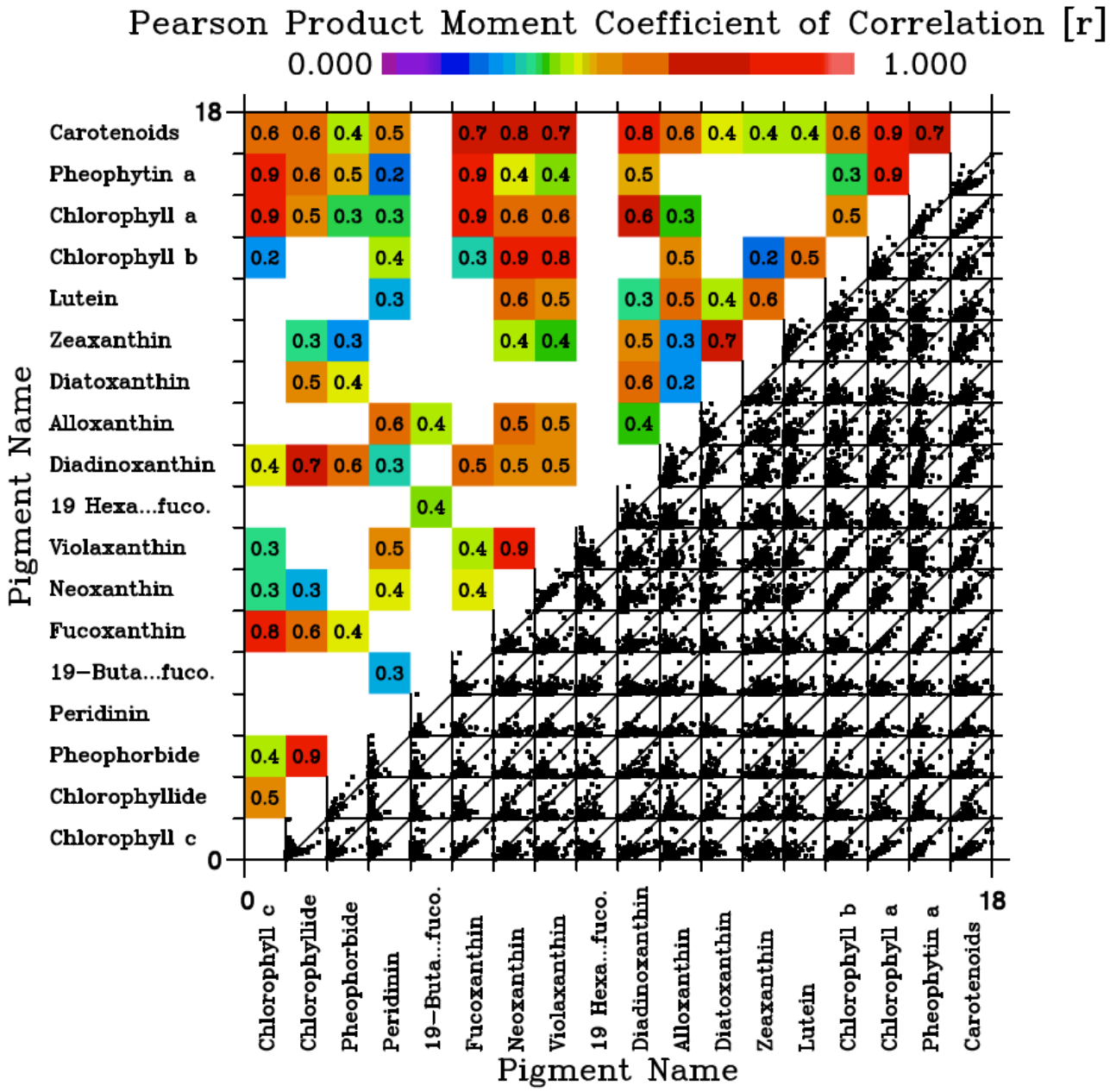
Using multiple linear regression on satellite products

N= 270 samples

- -NASA MAA Cruise (Gulf of ME)
- - NOAA BIOME Cruise
- - NASA GSFC/WFF COBY Crusise
- - SEABASS Data Base

Ex:

$$aph(\lambda) = B_0(\lambda) + B_1(\lambda)*RRS412 + B_2(\lambda)*RRS443 + B_3(\lambda)*RRS469 + \ldots\ldots$$


Pearson Product Moment Coefficient of Correlation [r]
0.000
1.000
Pigment Name
Carotenoids
Pheophytin a
Chlorophyll a
Chlorophyll b
Lutein
Zeaxanthin
Diatoxanthin
Alloxanthin
Diadinoxanthin
19 Hexa...fuco.
Violaxanthin
Neoxanthin
Fucoxanthin
19−Buta...fuco.
Peridinin
Pheophorbide
Chlorophyllide
Chlorophyll c
18
0
Chlorophyll c
Chlorophyllide
Pheophorbide
Peridinin
19−Buta...fuco.
Fucoxanthin
Neoxanthin
Violaxanthin
19 Hexa...fuco.
Diadinoxanthin
Alloxanthin
Diatoxanthin
Zeaxanthin
Lutein
Chlorophyll b
Chlorophyll a
Pheophytin a
Carotenoids
Pigment Name

Future Directions for Hyspiri

- Will show significant changes in the Distribution of IOPs (Absorption) and Chlorophyll a
  -as shown by 8-day binned averages of Chlorophyll a

- High spectral resolution will allow for the retrieval of characteristics of the phytoplankton community and the Carbon Cycle

- Will allow for understanding Coastal Processes which have ephemeral responses on time scales of weeks which do not match the chlorophyll a distribution

Objectives

The Proposed Resolution of Hyspiri will potentially Resolve Phytoplankton Biomass:

1) Prediction and Observation of Inherent Optical Properties

2) Taxonomic Composition by phytoplankton marker pigments;

3) Combine Temperature Relationships with PFTS.

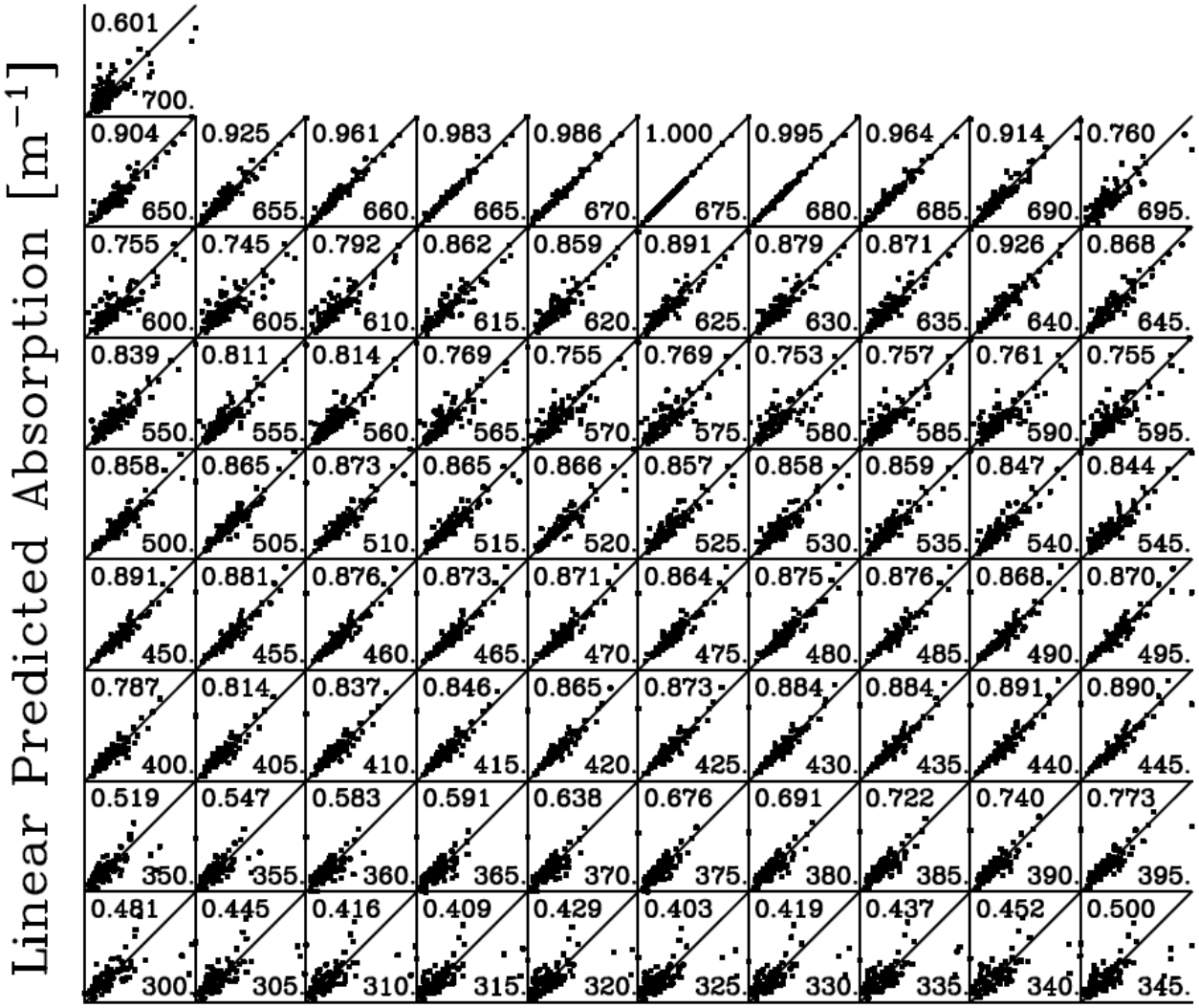
- Example in the Gulf of Maine with Phaeocystis and diatoms

- Resolve the spatial dynamics of two different populations of Diatoms and Phaeocystis (& others)

- Example in the Mid-Atlantic Bight

-Blooms of Cyanobacteria

Linear-predicted Model based on Chlorophyll a, Light, & Temperature



Moisan et al. 2011, Moisan et al. accepted J. Continental Research