Biogeochemical and Optical Analysis of Coastal DOM for Satellite Retrieval of CDOM, DOC, and Terrigenous DOM from the Northeastern U.S. Continental Margin

Antonio Mannino[1], Rachael Dyda[2], Peter Hernes[2], Stan Hooker[1], Kim Hyde[3], Mike Novak[1]

[1]NASA Goddard Space Flight Center,
[2]UC-Davis, [3]NOAA NEFSC

Funding: NASA Ocean Biology & Biogeochemistry, Interdisciplinary Science, Carbon Cycle Science Programs

Acknowledgements: M.E. Russ, X. Pan, K.C. Filippino, M. Mulholland, M. Twardowski, R. Morrison, J. Austin, E. Hofmann, M. Cottrell, D. Kirchman, ODU, US ECoS Team, NOAA ECOMon, NASA OBPG

Outline

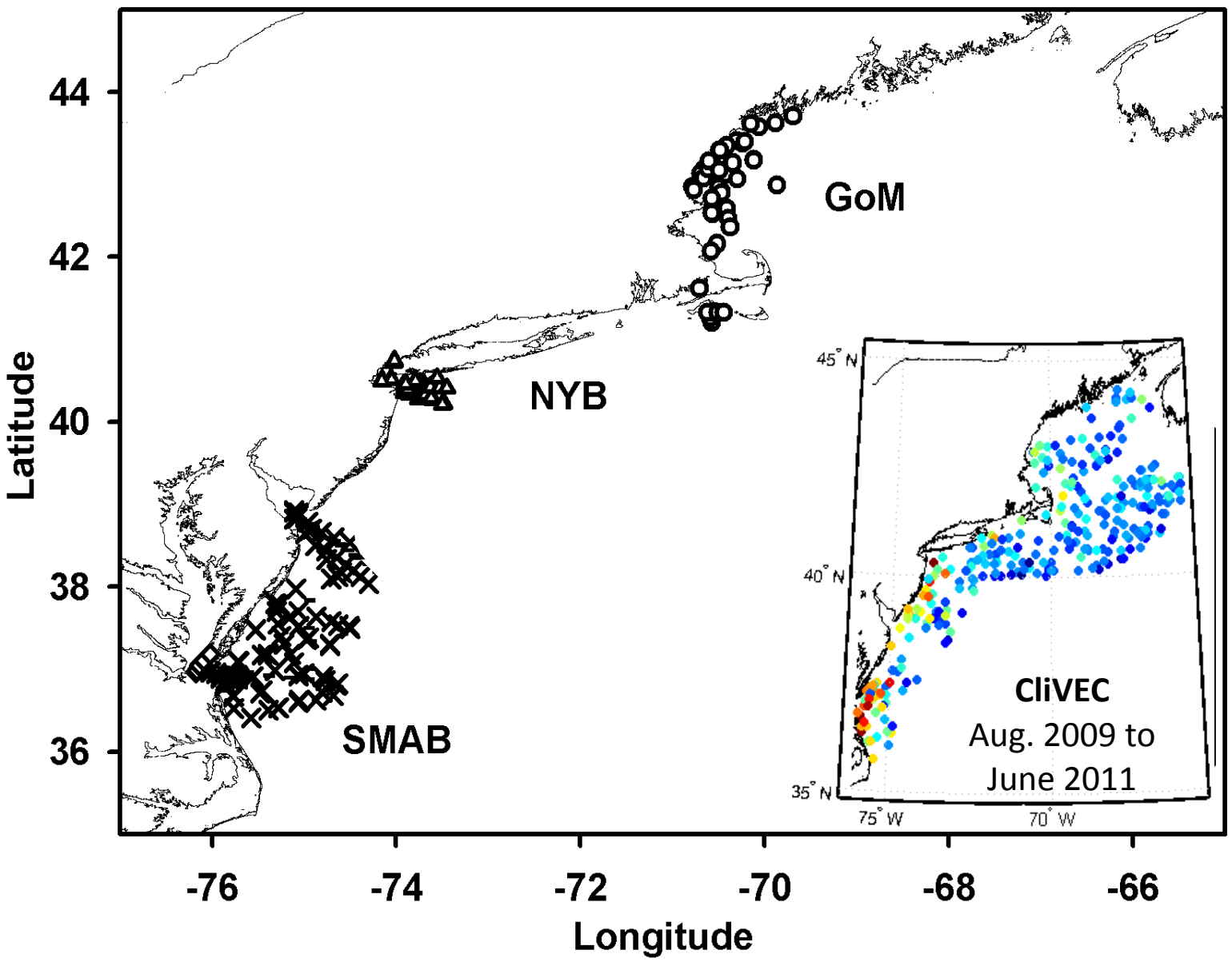
- Objectives
- CDOM:DOC Relationships
- Lignin Distributions
- Lignin:CDOM Relationships
- Satellite algorithm development for CDOM, DOC and Lignin Phenols

Objectives

- Link chemical and optical properties of DOM
- Link DOM optical/chemical properties to in situ radiometry
- Develop satellite algorithms for CDOM, DOC and Terrigenous DOM (Lignin Phenols).
- Identify processes that regulate distributions of CDOM, DOC and Lignin Phenols
- Apply field and satellite data to track and quantify fluxes of terrigenous and marine carbon within the continental margin along northeastern U.S.

GOAL: Investigate and quantify the contribution and impact of riverine carbon to continental margins and beyond

Field Sampling Stations



Gulf of Maine
April 26-30, 2007
May 26-28, 2007
June 6-8, 2007

New York Bight
May 5-9, 2007
Nov. 10-14, 2007
July 21-24, 2008
May 19-21,2009

Southern MAB
March 30-April 1, 2005
July 26-30, 2005
May 9-12, 2006
July 2-6, 2006

Ches. Bay Plume
May 27, 2005
Nov. 3, 2005
Sep. 6, 2006
Nov. 28, 2006
March 19, 2007
April 23, 2007
July 3, 2007
Aug. 16, 2007

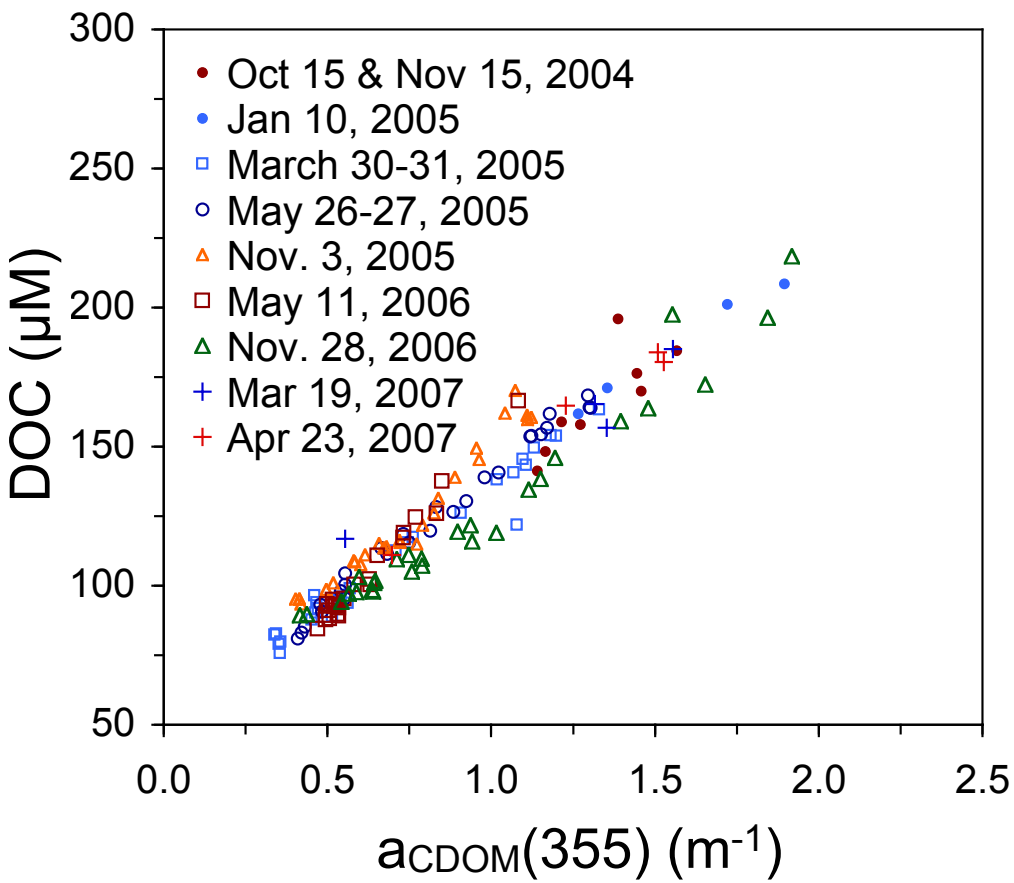
Lower CB: July 2004 to May 2006

Outline

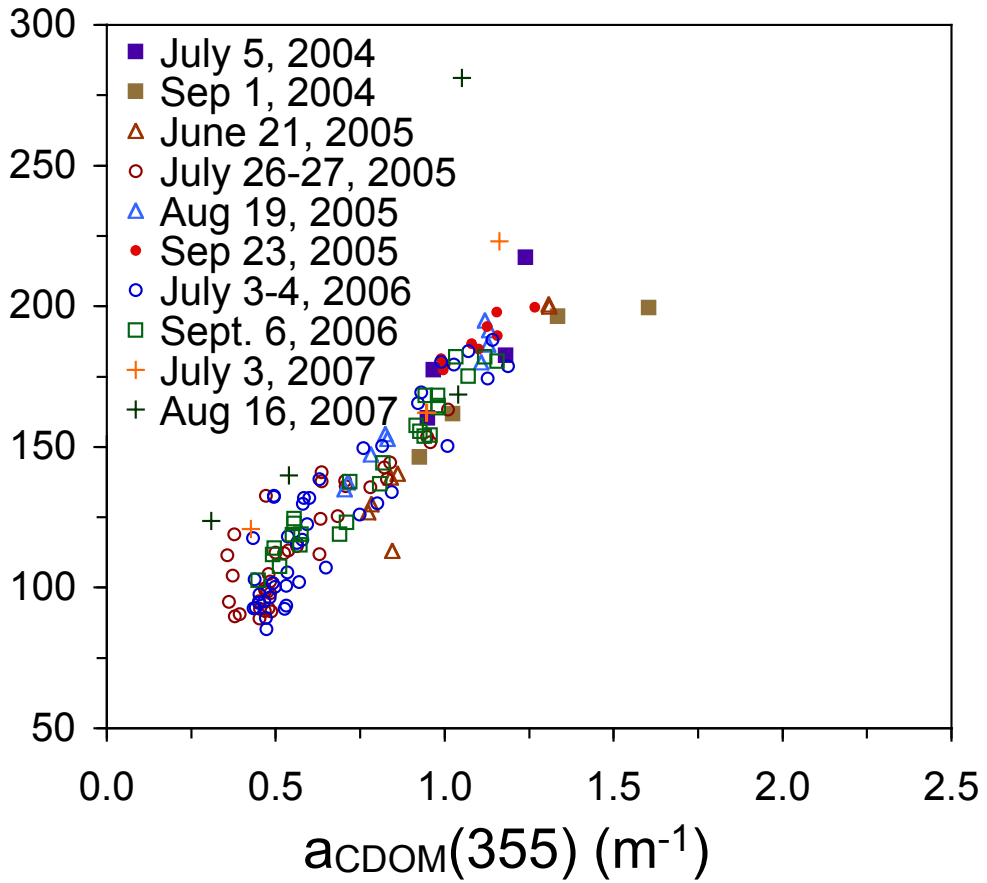
- Objectives
- CDOM:DOC Relationships
- Lignin Distributions
- Lignin:CDOM Relationships
- Satellite algorithm development for CDOM, DOC and Lignin Phenols

DOC:a_{CDOM} Chesapeake Bay Mouth & Plume

Fall, Winter & Spring

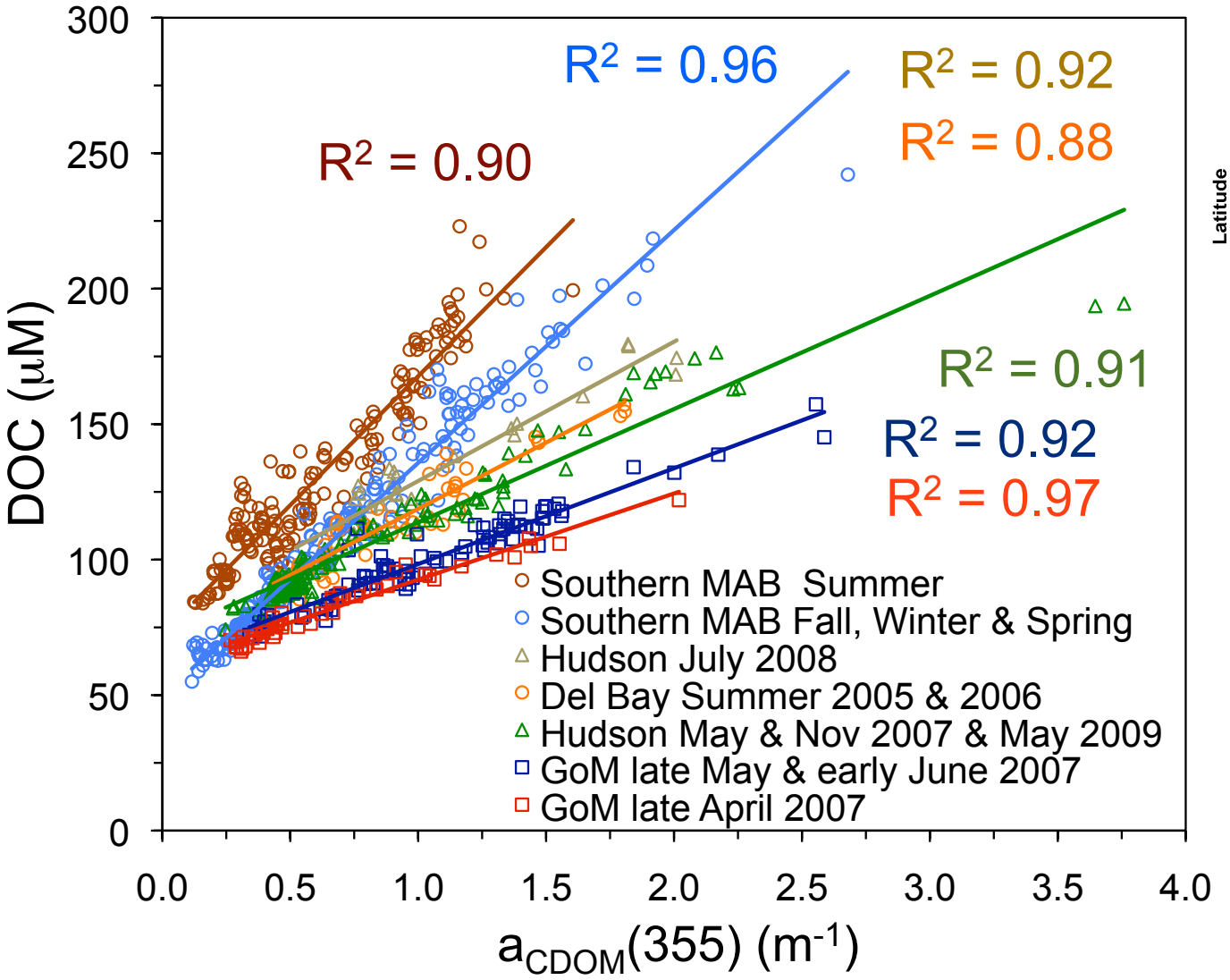


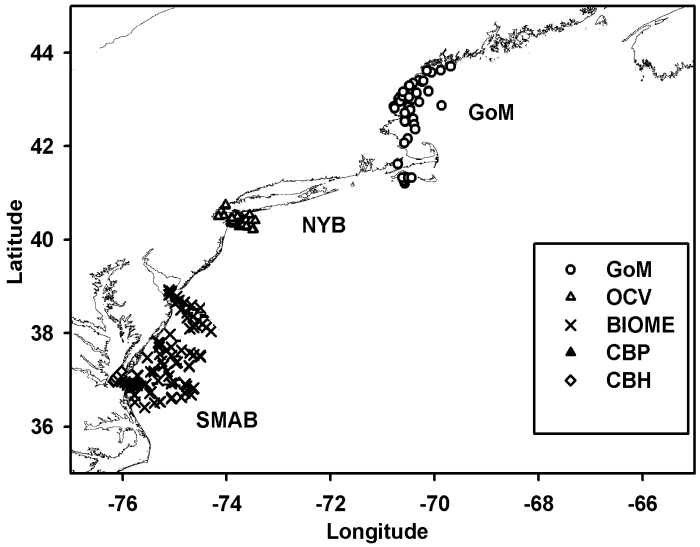
Summer



- Interannual consistency in DOC to a_{CDOM} relationships

Regional & Seasonal DOC:a_{CDOM} Relationships



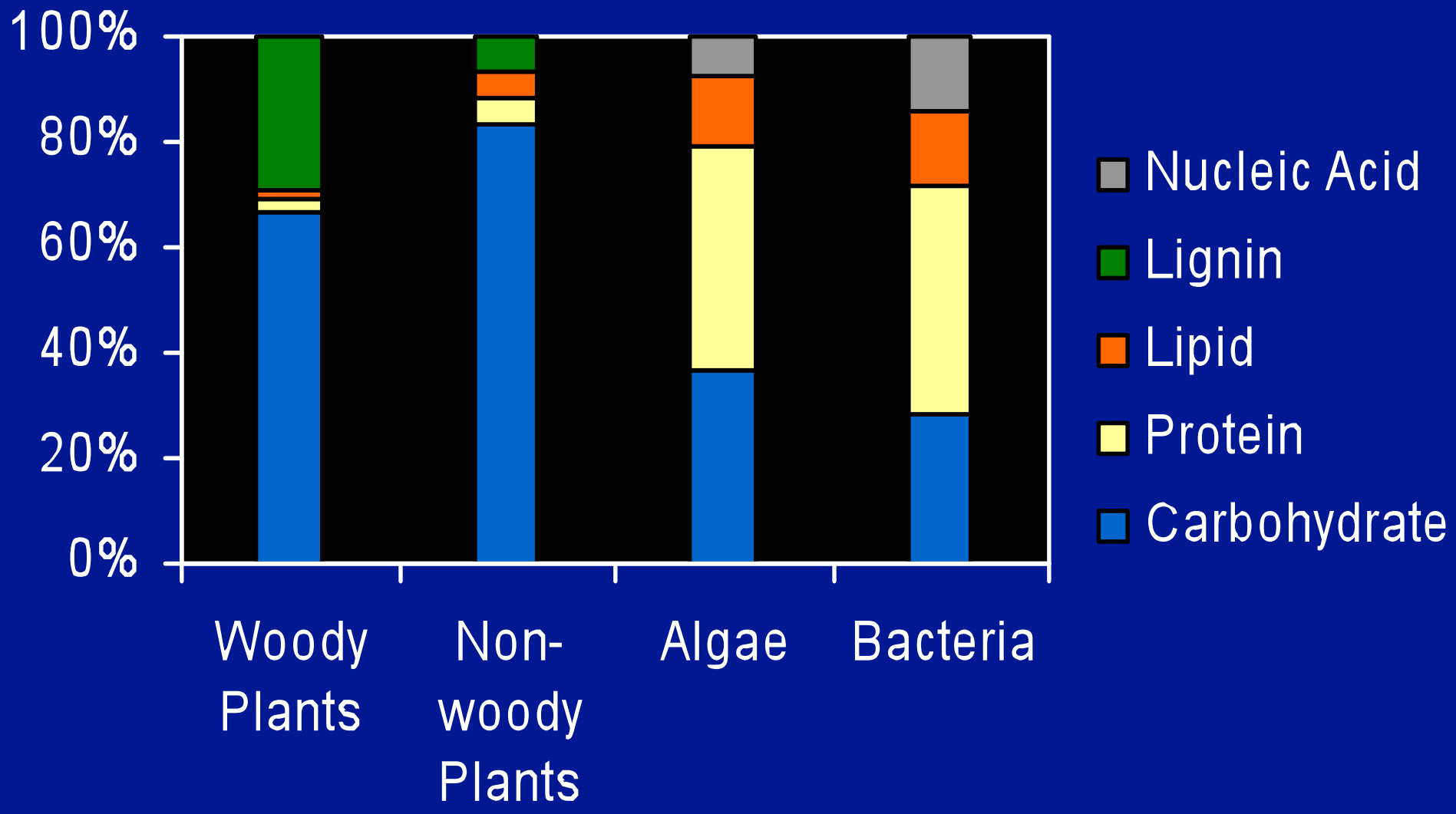


- DOC per unit a_{CDOM} increases from N to S: differences in source materials, such as more colored terrestrial DOM exported to the GoM due to the absence of large estuaries where the DOM can be degraded.
- Seasonal shift in DOC to a_{CDOM} relationships from accumulation of DOC from NCP and photooxidation of CDOM between spring and fall.

Outline

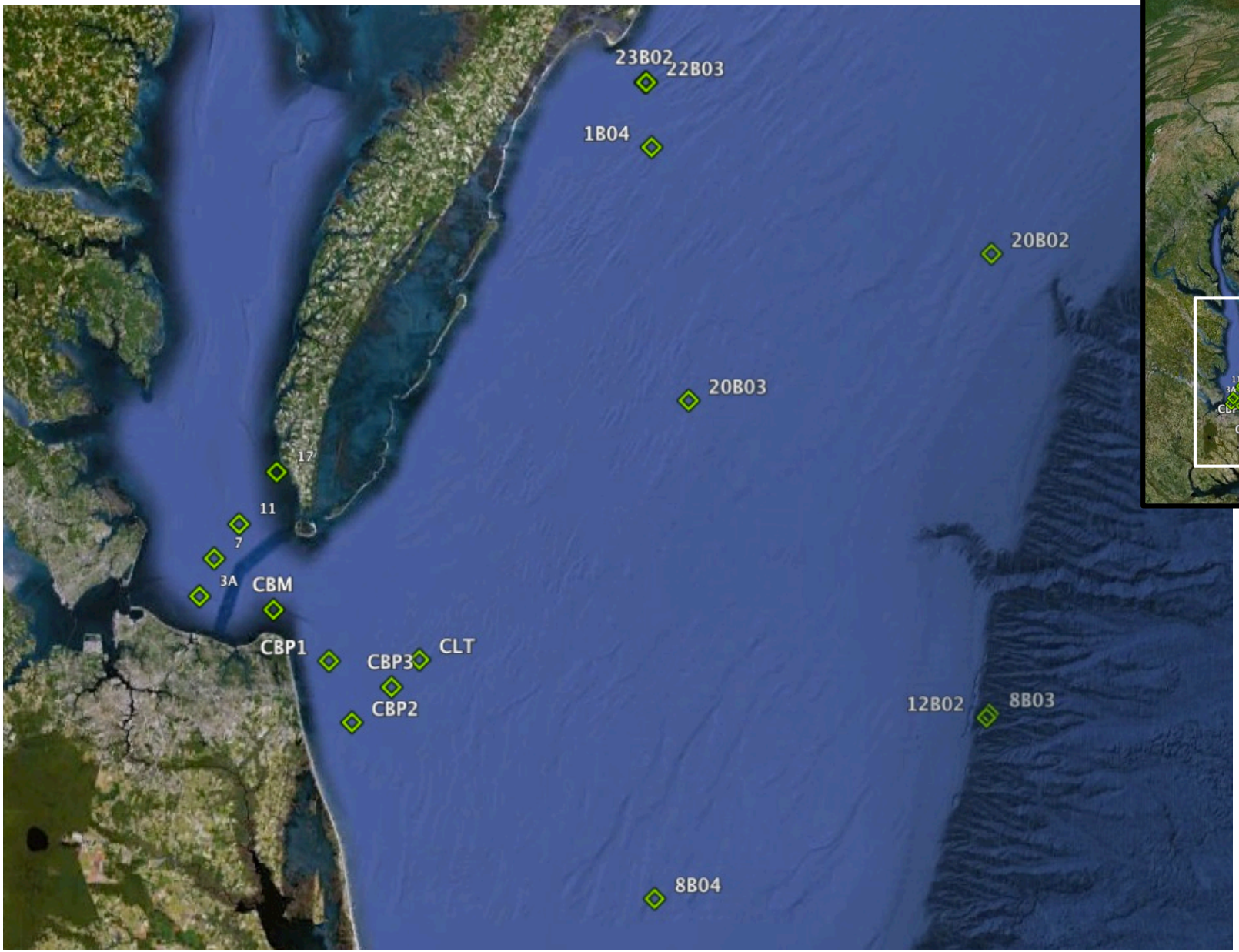
- Objectives
- CDOM:DOC Relationships
- Lignin Distributions
- Lignin:CDOM Relationships
- Radiometry:CDOM Relationships
- Satellite-derived CDOM, DOC, Lignin

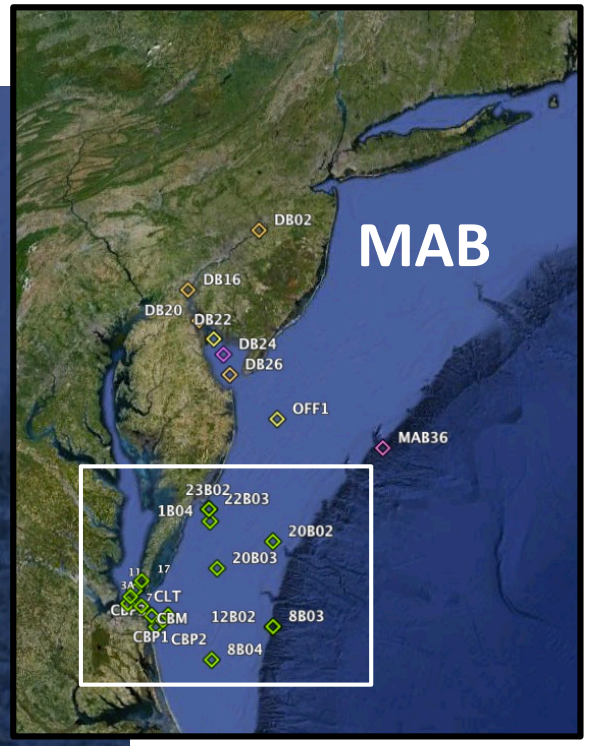
Biochemical Composition of Sources



Delaware Bay Lignin Stations

Chesapeake MAB Lignin Stations





SMAB

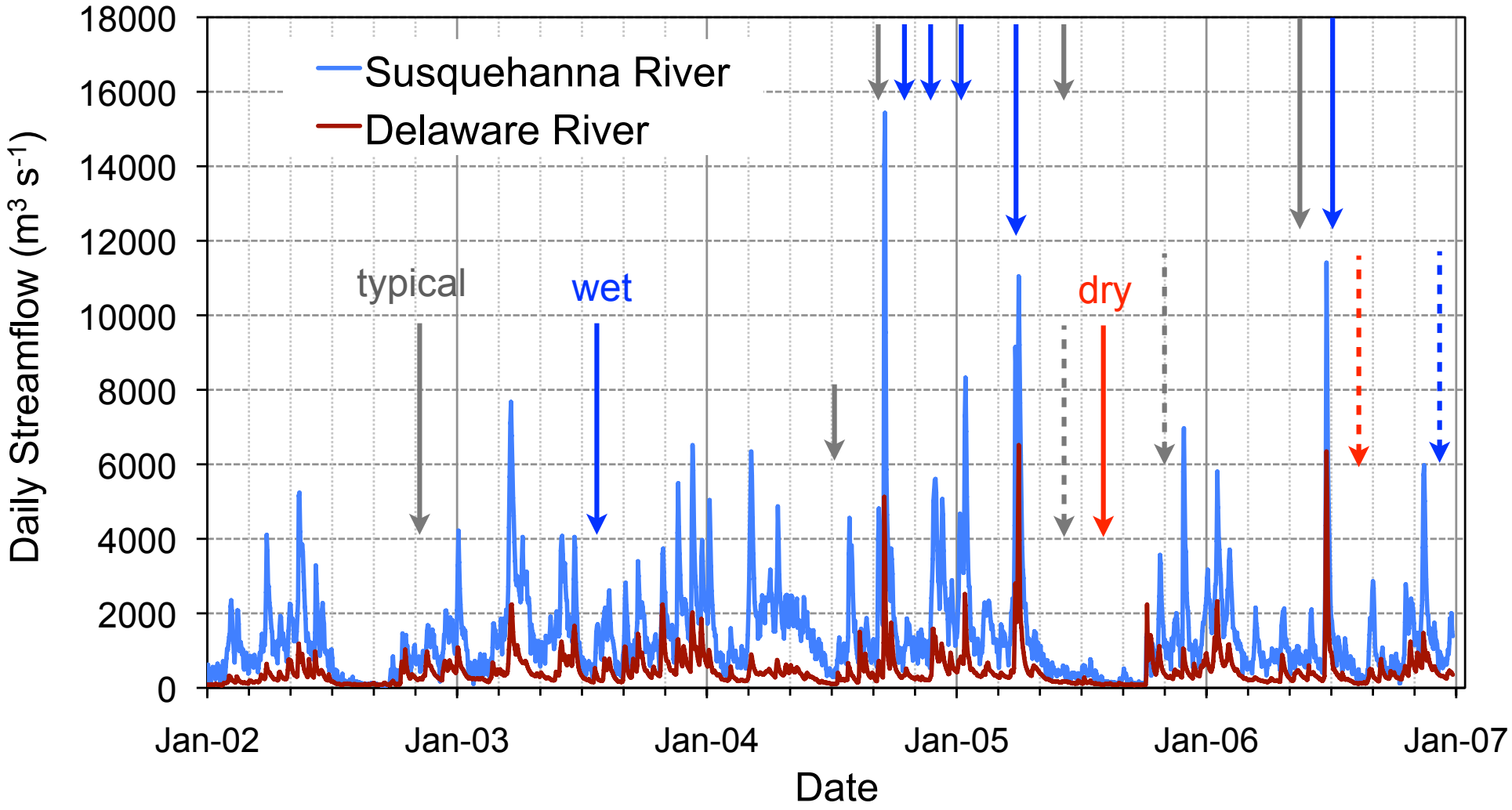
March 30-April 1, 2005
July 26-30, 2005
May 9-12, 2006
July 2-6, 2006

CB Plume

May 27, 2005
Nov. 3, 2005
Sep. 6, 2006
Nov. 28, 2006

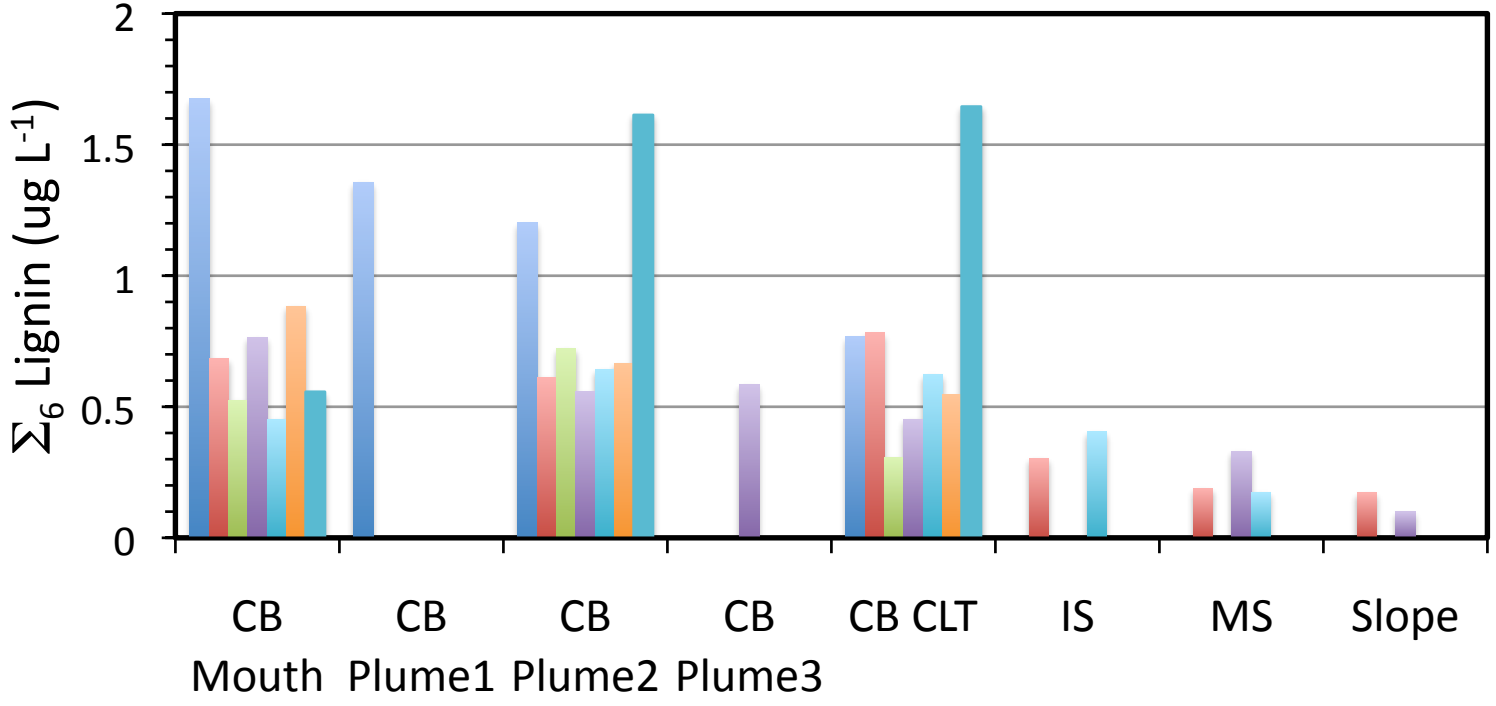
Lower Chesapeake Bay: **July 04, Sept. 04, Oct. 04, Nov. 04, Jan. 05, May 05**

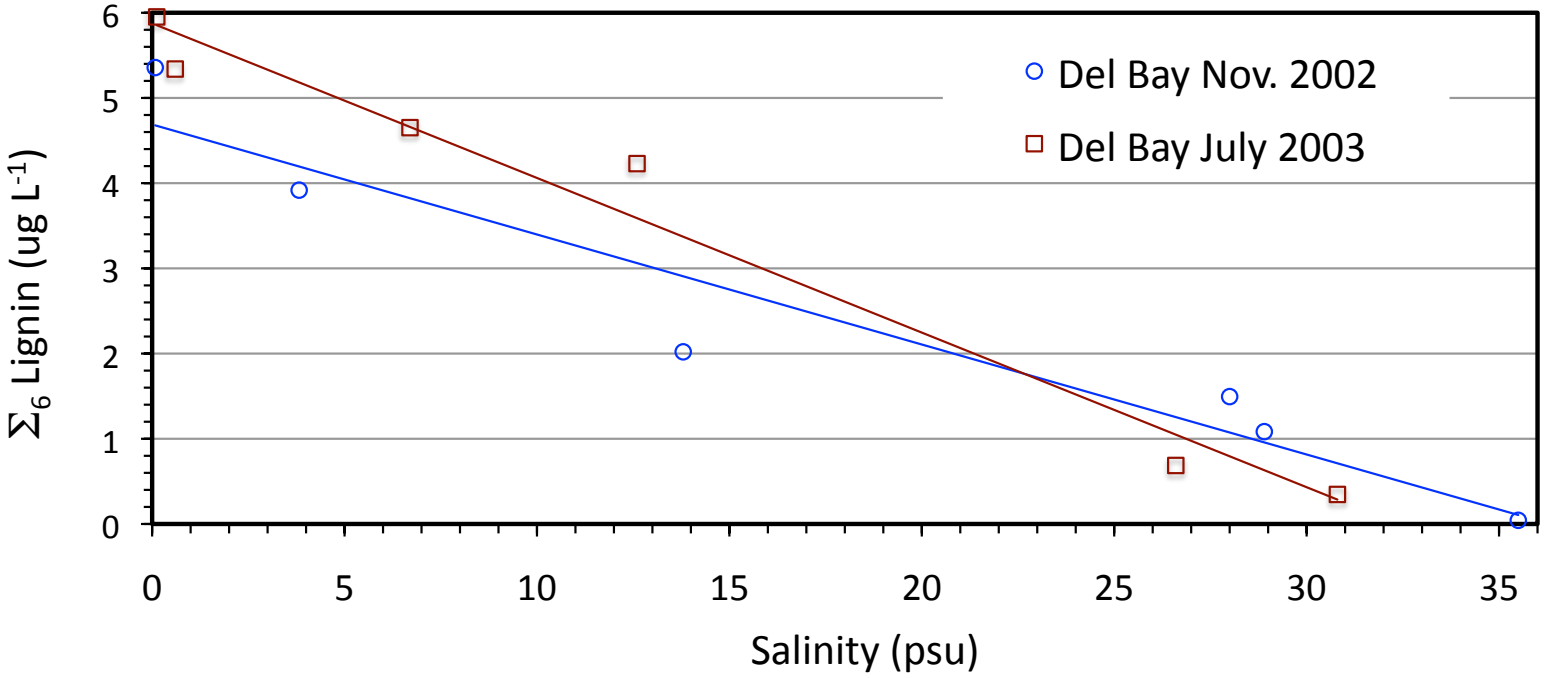
Freshwater Discharge into Delaware Bay and Chesapeake Bay

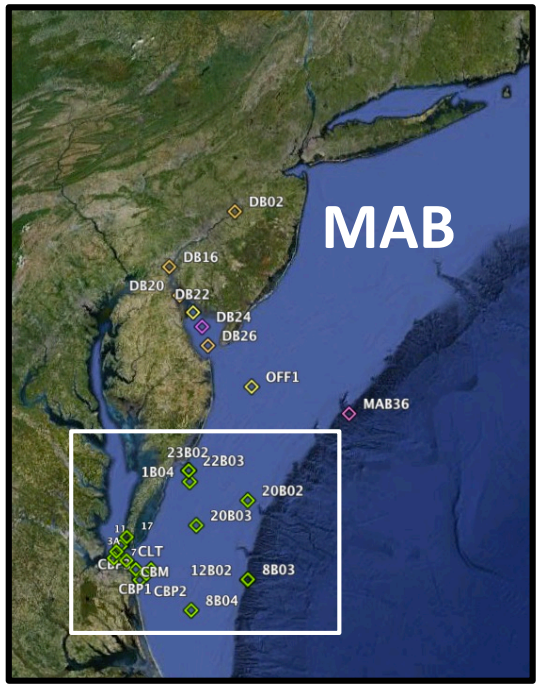


Data courtesy of USGS

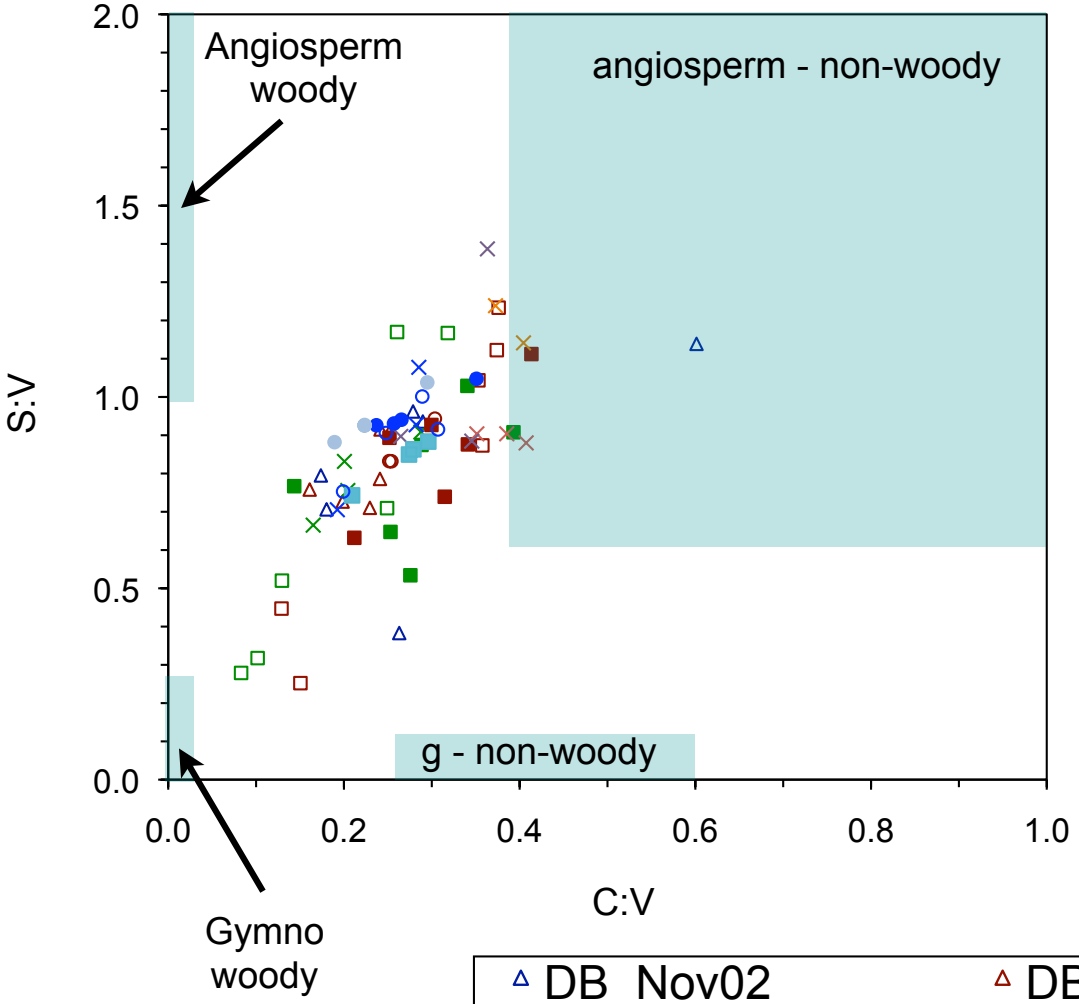
Lignin Distributions

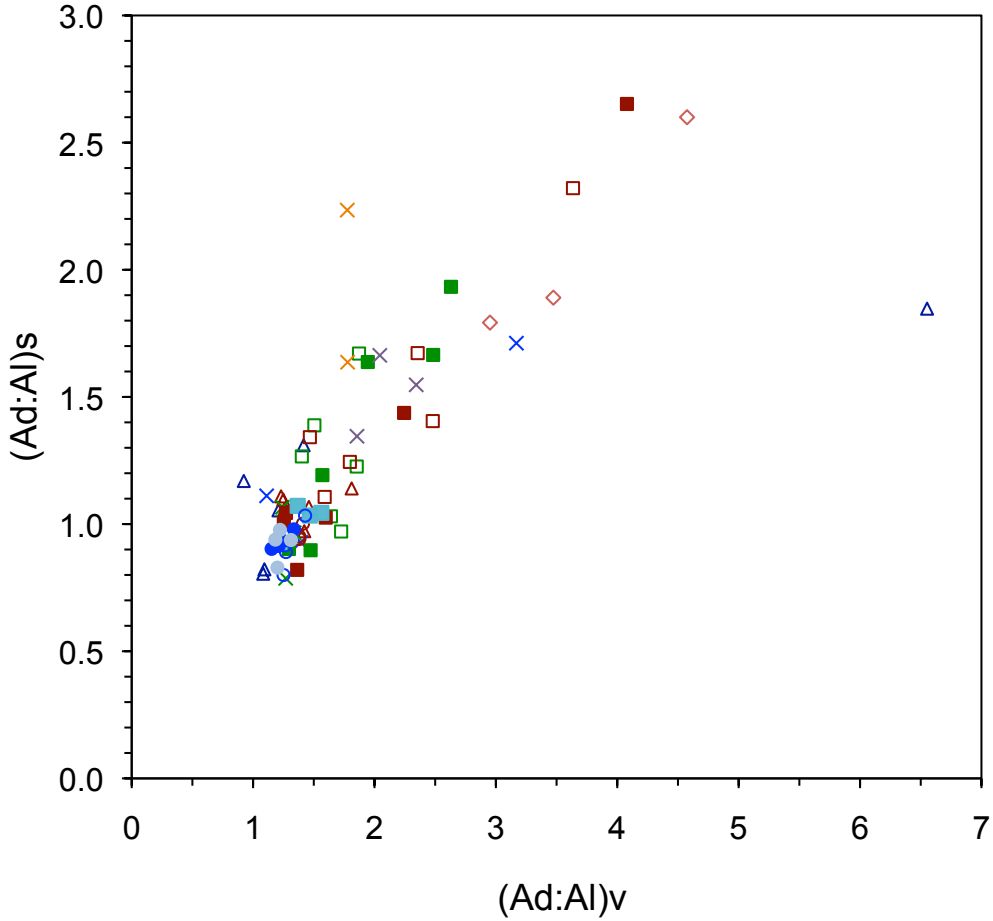






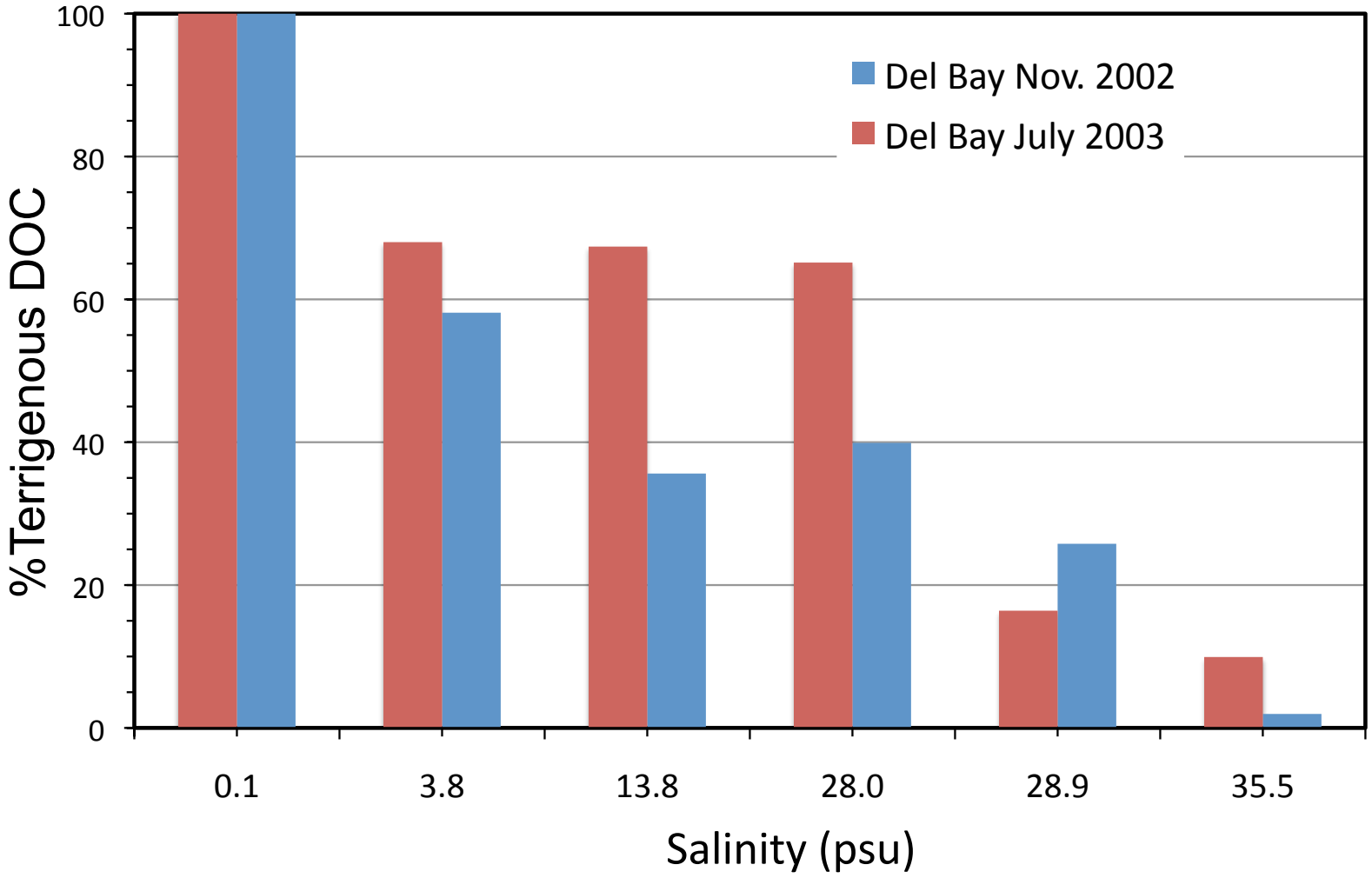
Lignin Source & Degradation Parameters





DB_Nov02
DB_July03
B01_Apr05
B02_July05
D01_May05
D02_Nov05
B03_May06
B04_July06
D03_Sep06
D04_Nov06
CBM02_July04
CBM03_Sep04
CBM04_Oct04
CBM05_Nov04
CBM06_Jan05
CBM07_May06

Terrigenous DOC Estimates



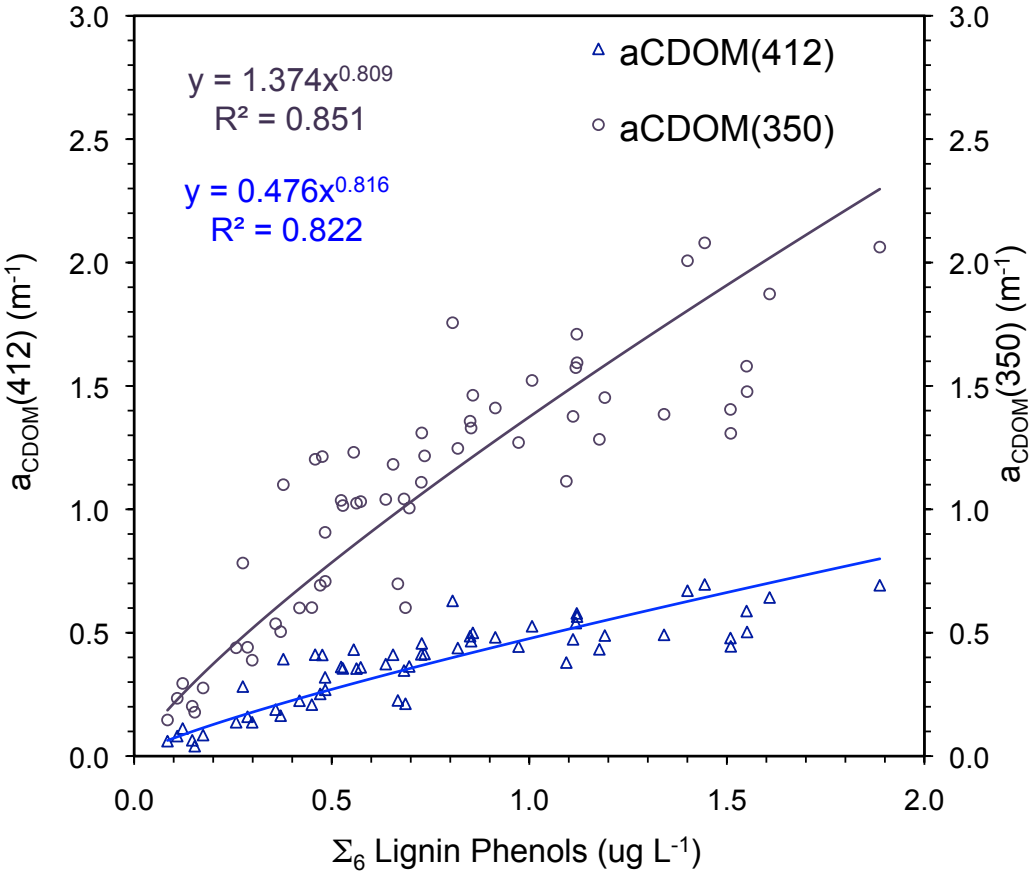
$[Lignin/DOC]_O / [Lignin/DOC]_R * 100$

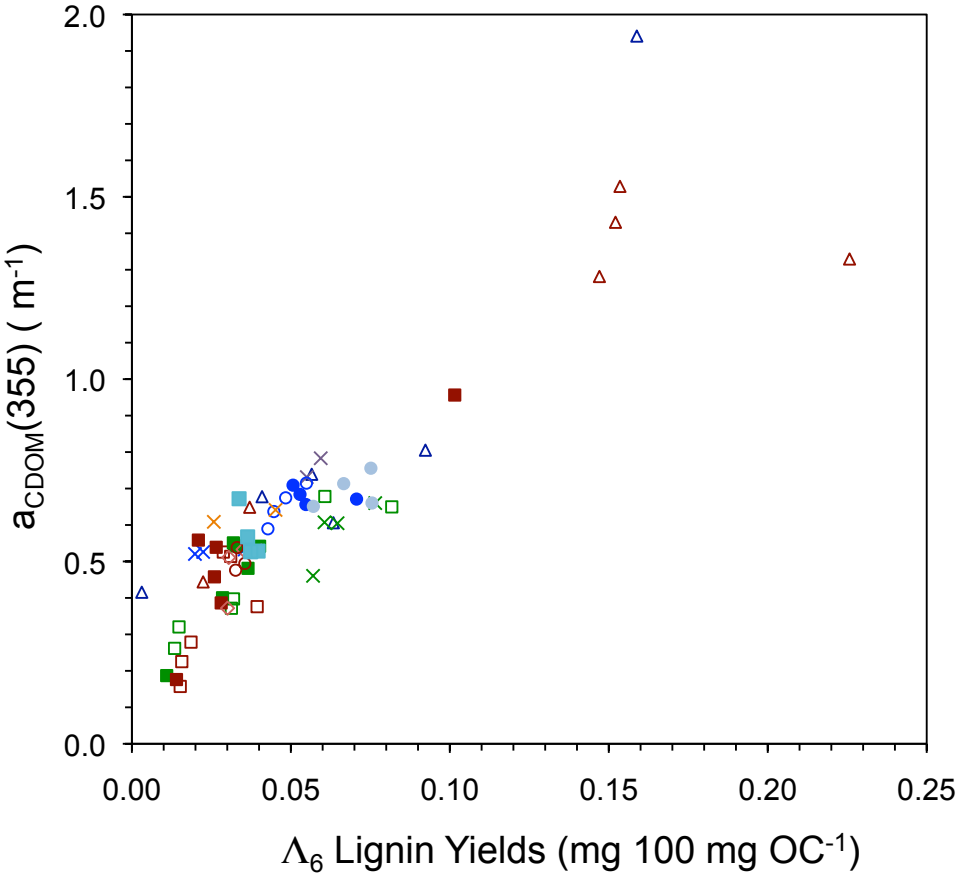
proportion of ocean to river lignin yields

Outline

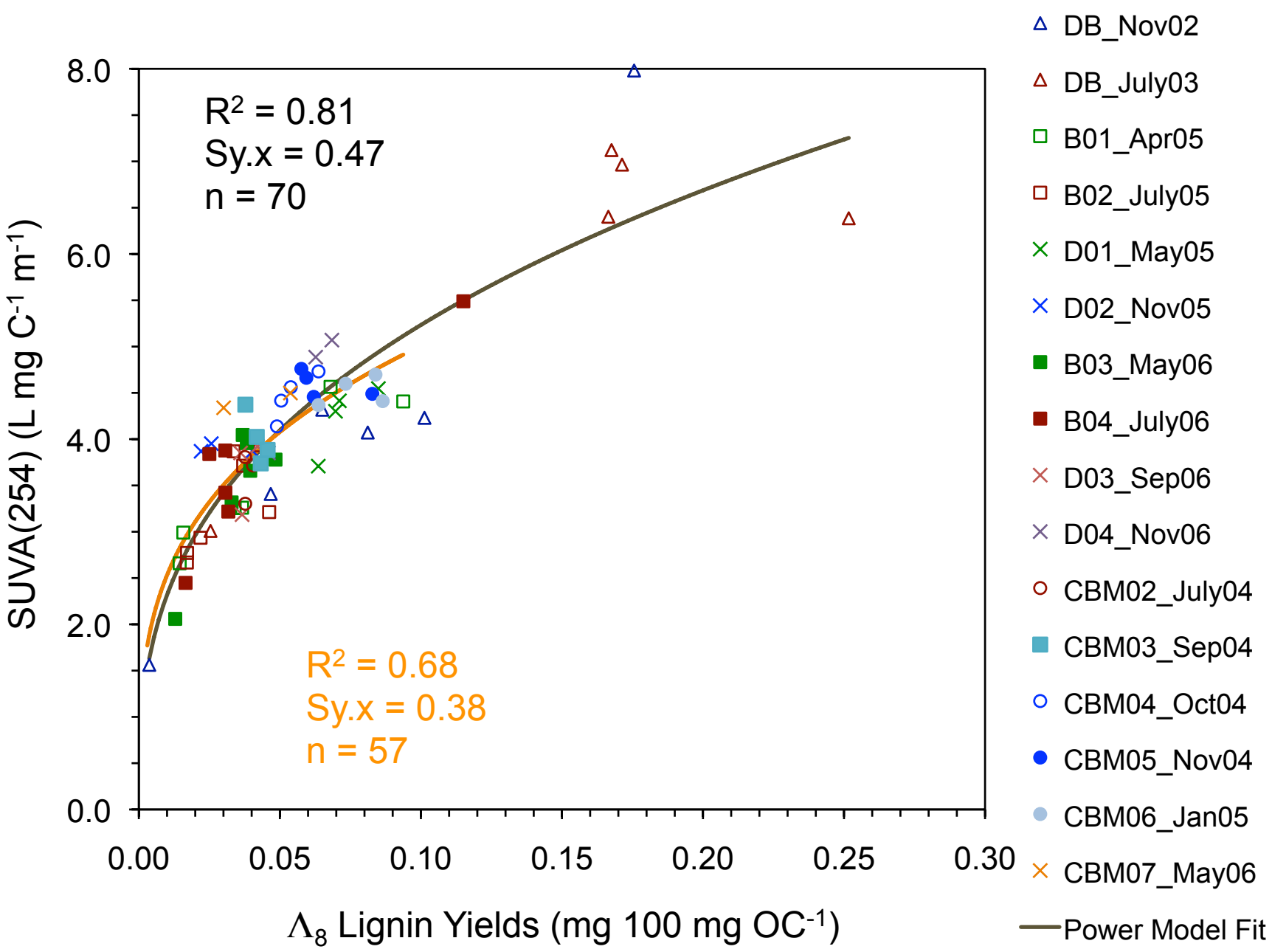
- Objectives
- CDOM:DOC Relationships
- Lignin Distributions
- Lignin:CDOM Relationships
- Satellite algorithm development for CDOM, DOC and Lignin Phenols

a_{CDOM} versus Lignin Phenols

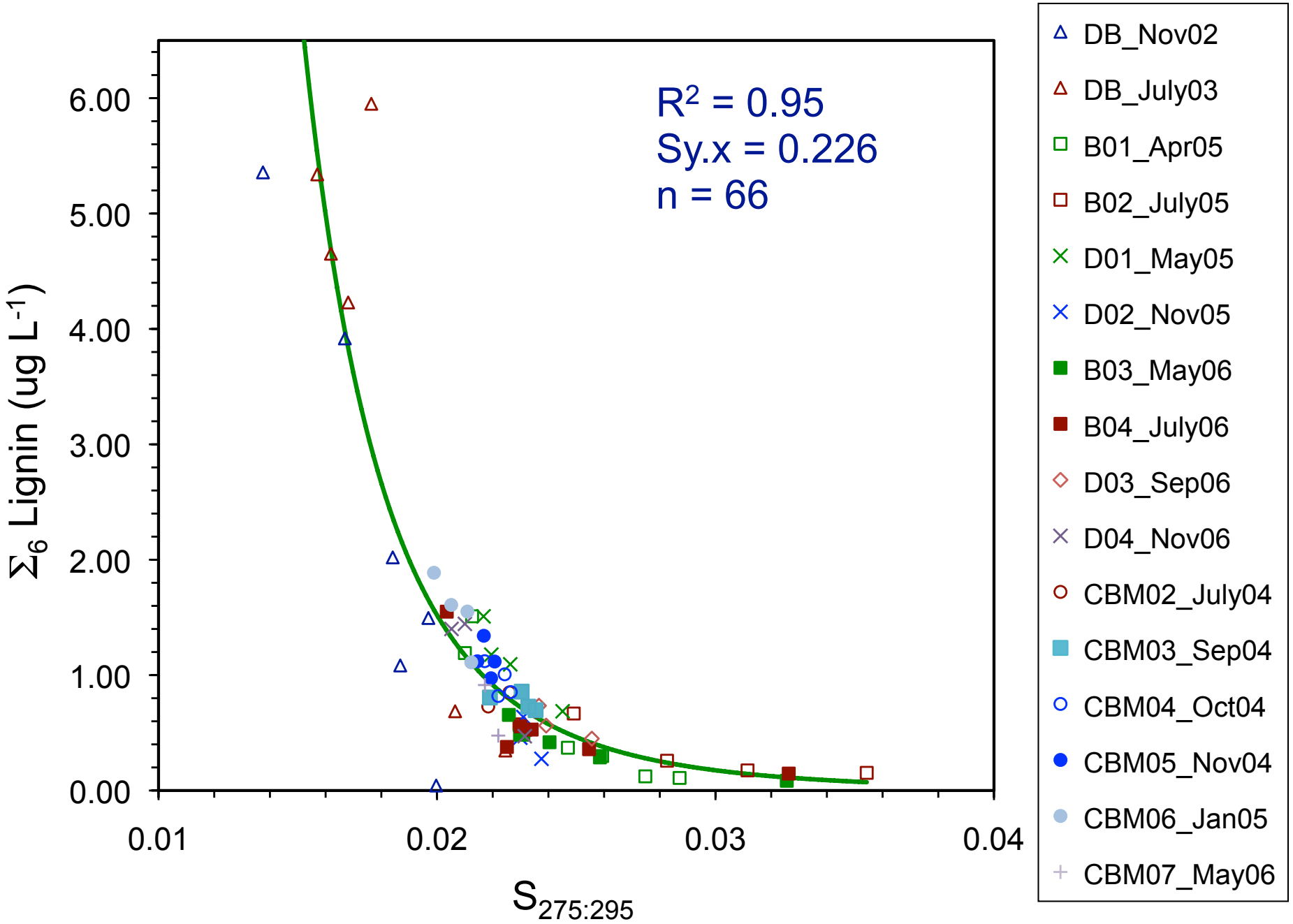




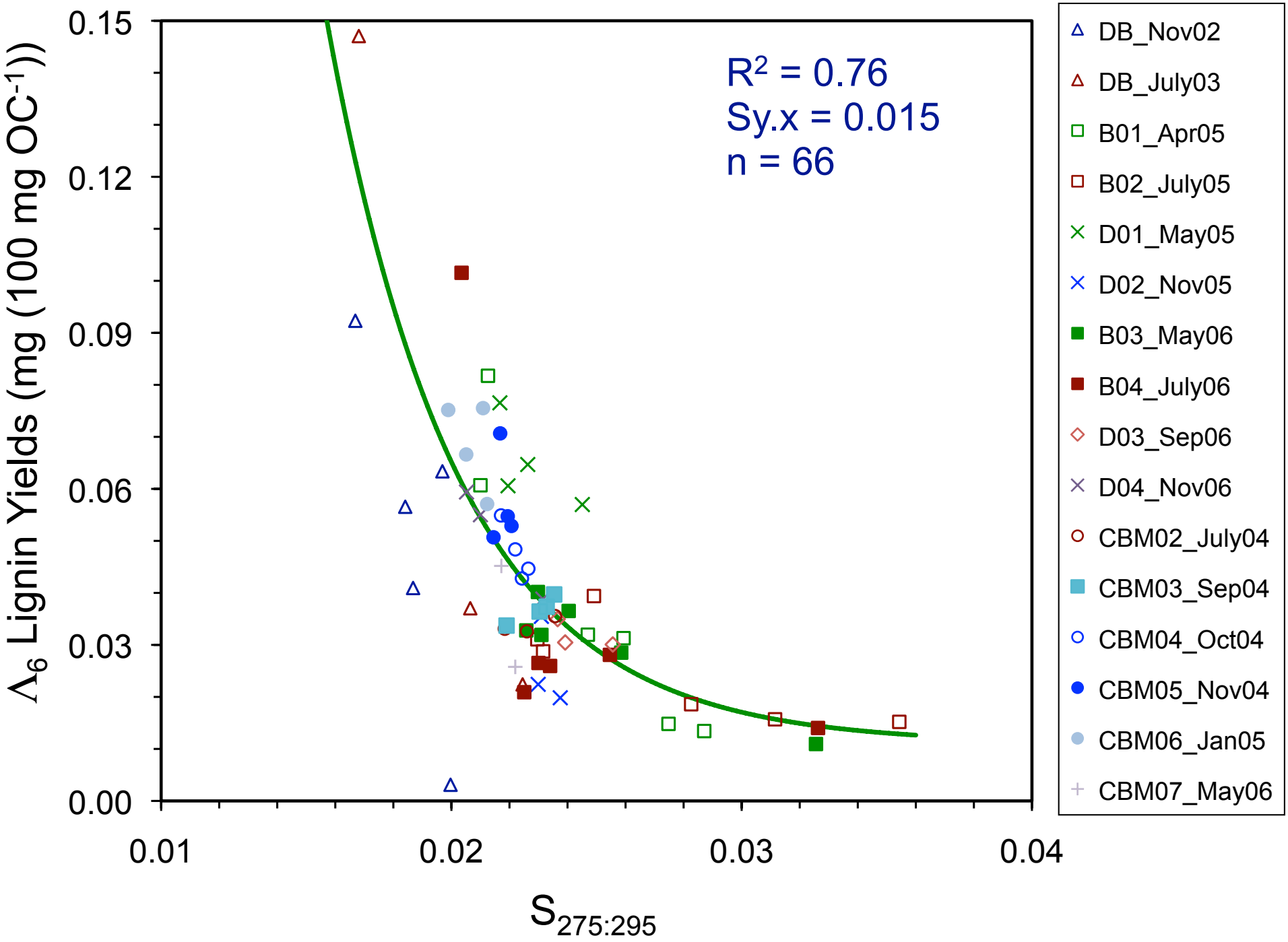
Lignin Phenol to $SUVA_{254}$ Relationships



$S_{CDOM(275:295)}$ versus Lignin Phenols



$S_{CDOM(275:295)}$ versus Lignin Yields



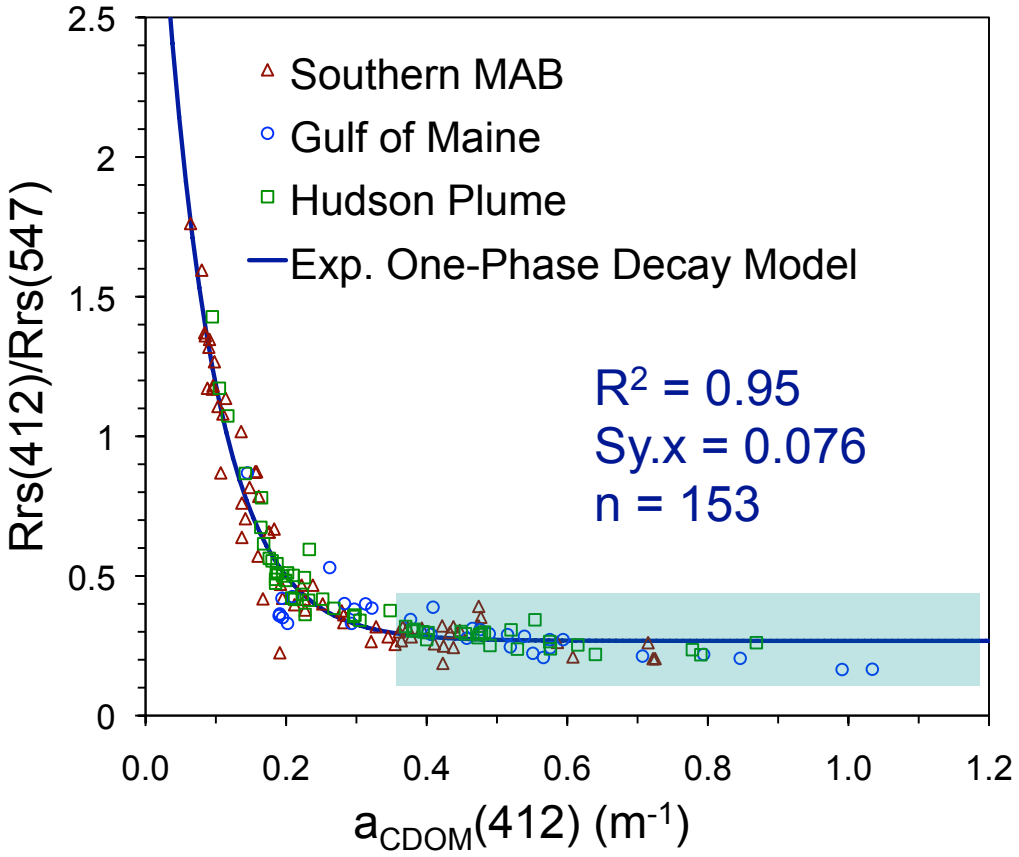
Outline

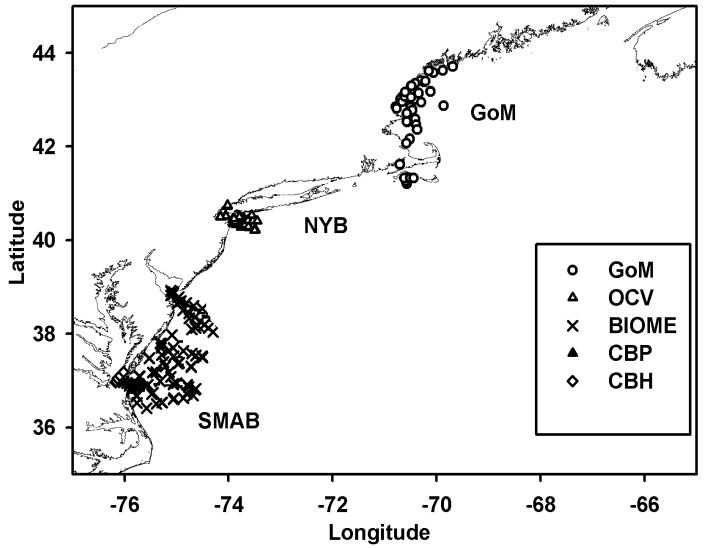
- Objectives
- CDOM:DOC Relationships
- Lignin Distributions
- Lignin:CDOM Relationships
- Satellite algorithm development for CDOM, DOC and Lignin Phenols

Types of Algorithms

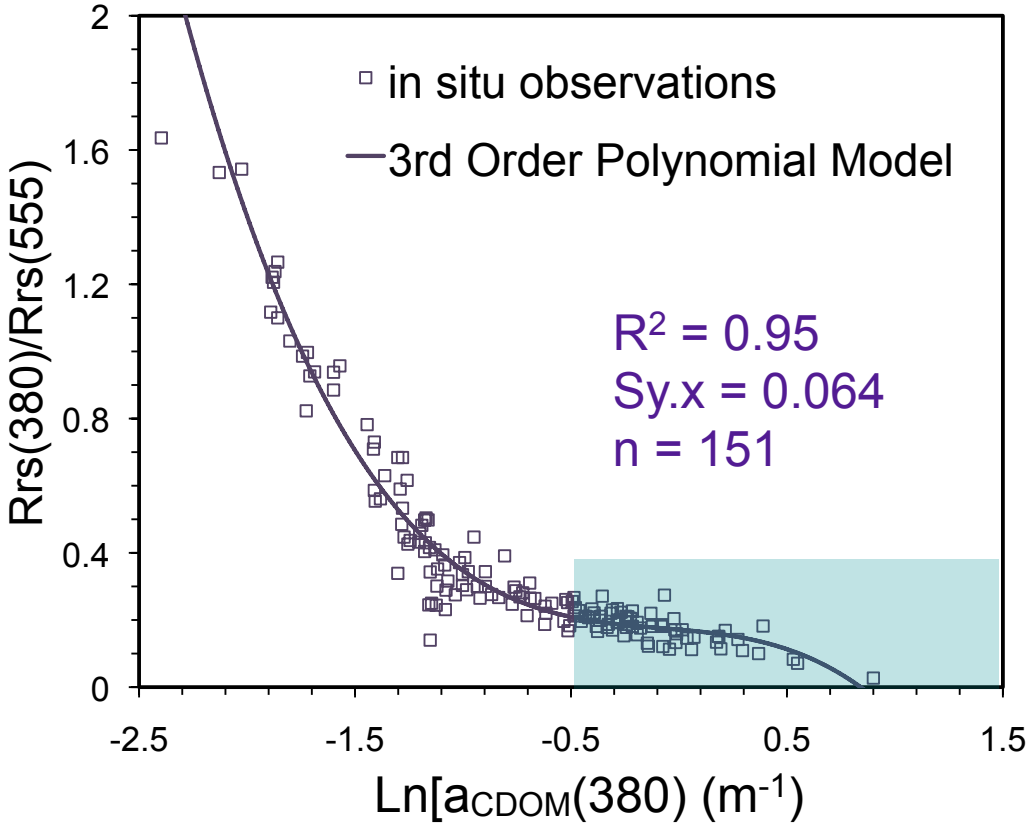
- Band ratios (ex. OC4)
- Semi-analytical (ex. GSM01, QAA, GIOP)
- IOP based algorithms (DOC from CDOM)
- Multivariate algorithms
- Machine Learning
  - Neural networks
  - Vector support machines
  - Gaussian process models

CDOM Algorithm Development

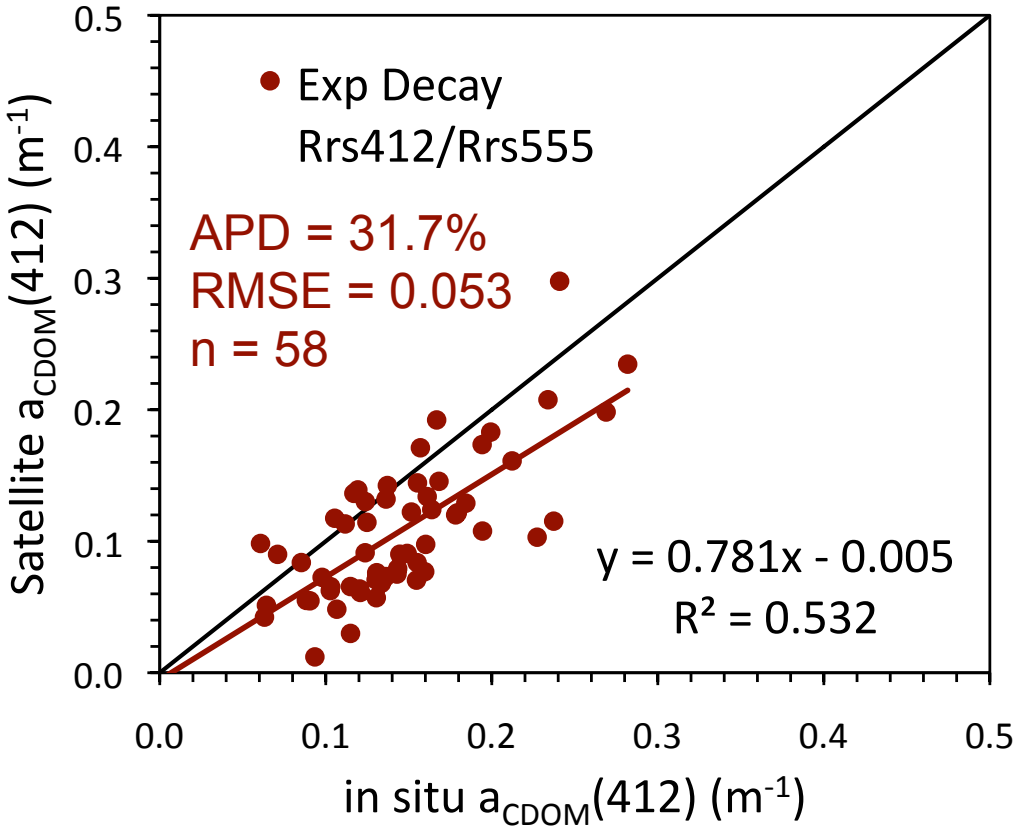


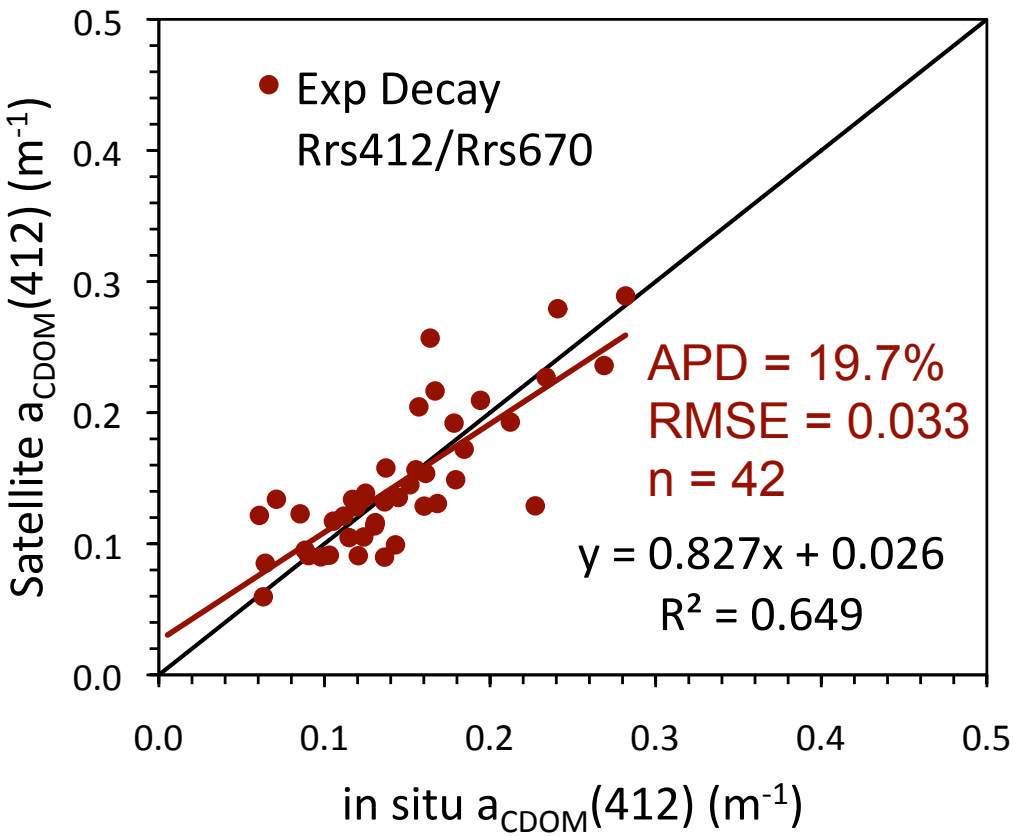


in situ remote sensing reflectance (Rrs) band ratios versus a_{CDOM}



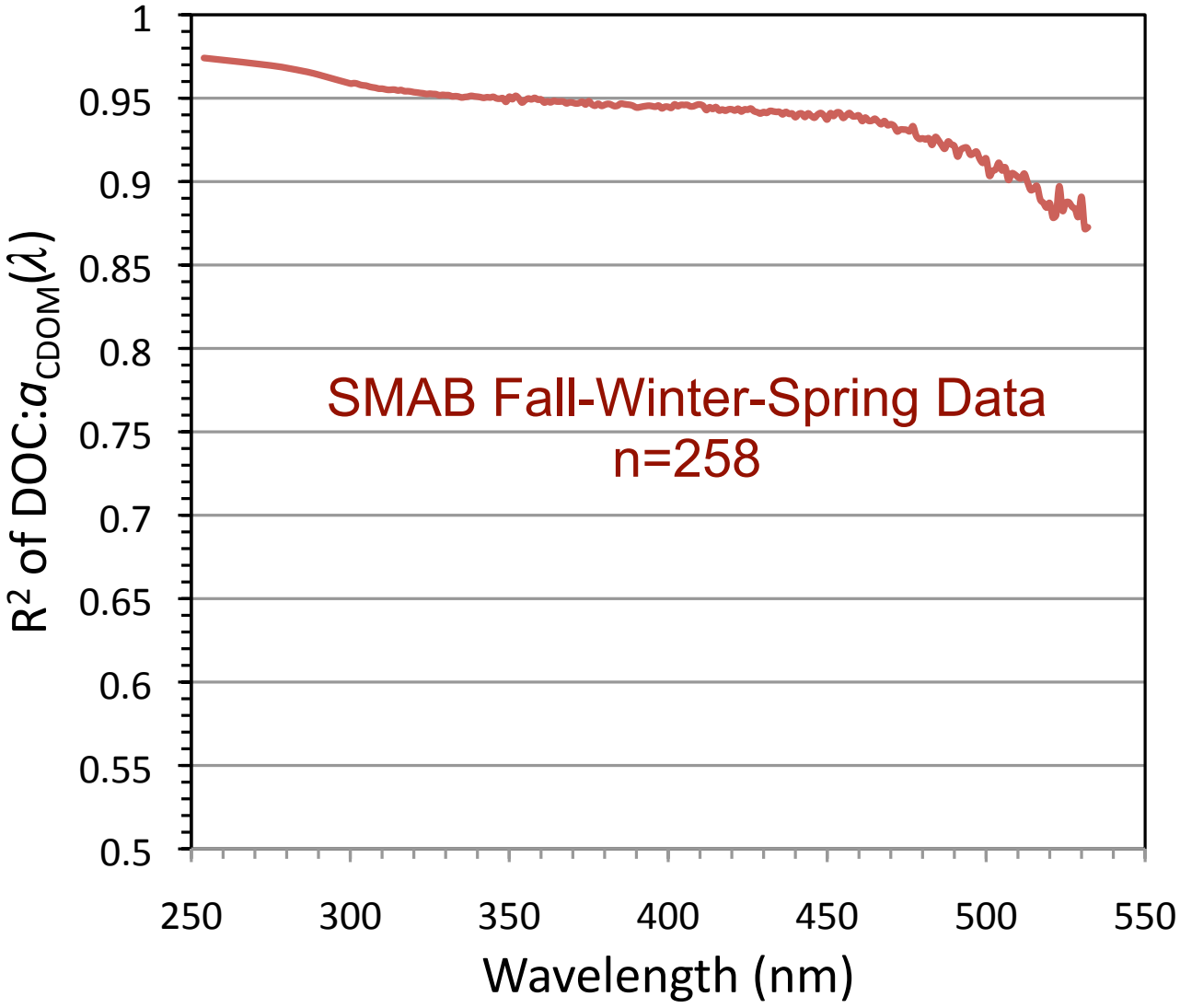
Validation of SeaWiFS CDOM Algorithms





APD = Absolute Percent Difference

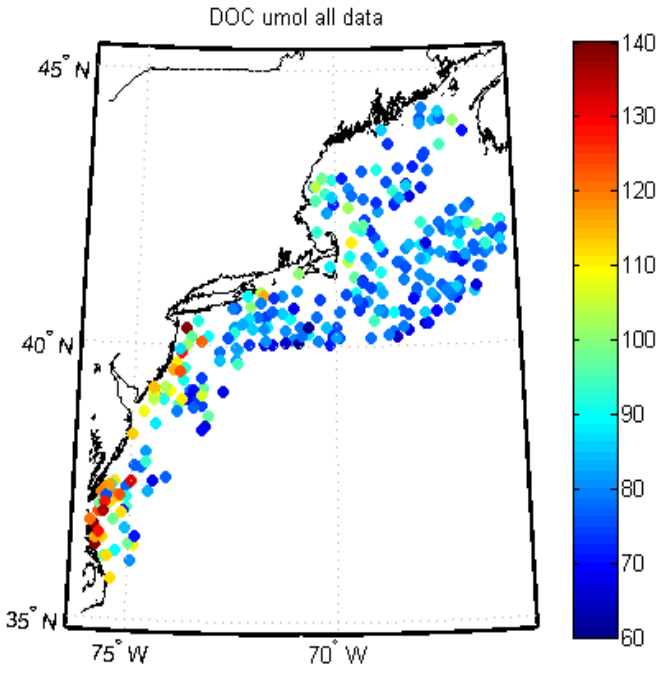
DOC:a_{CDOM} Correlation with Wavelength Relevance to CDOM & DOC algorithms

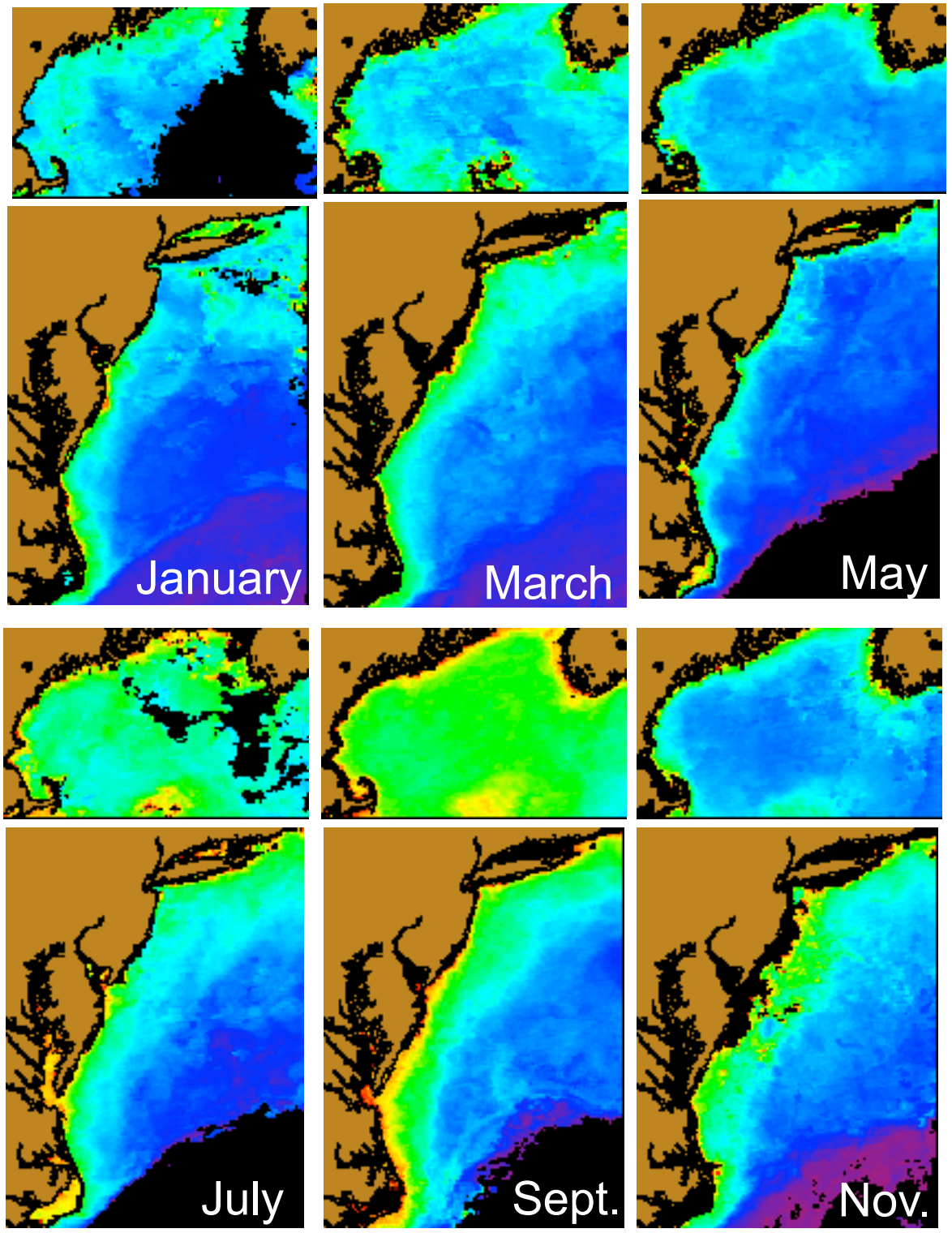


DOC can be derived from wide range of $a_{CDOM}(\lambda)$

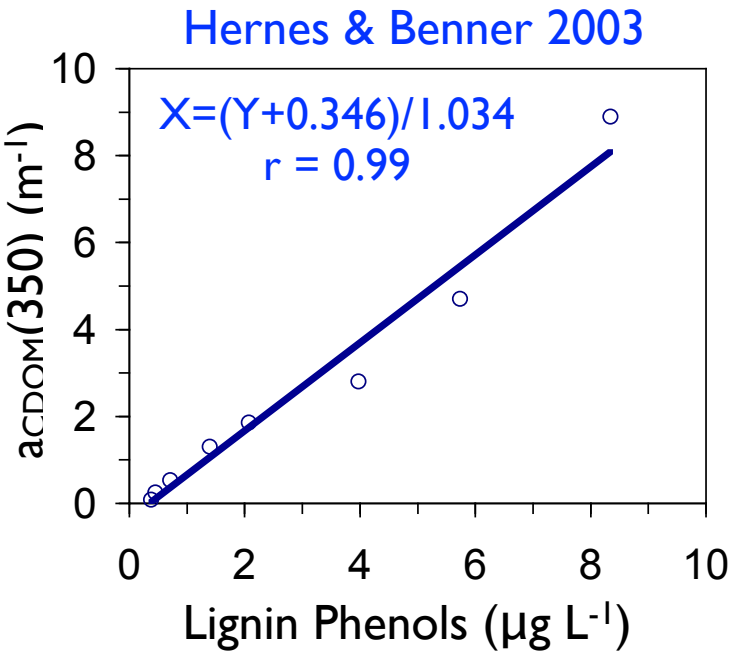
Credit: Aron Stubbins for idea for this plot

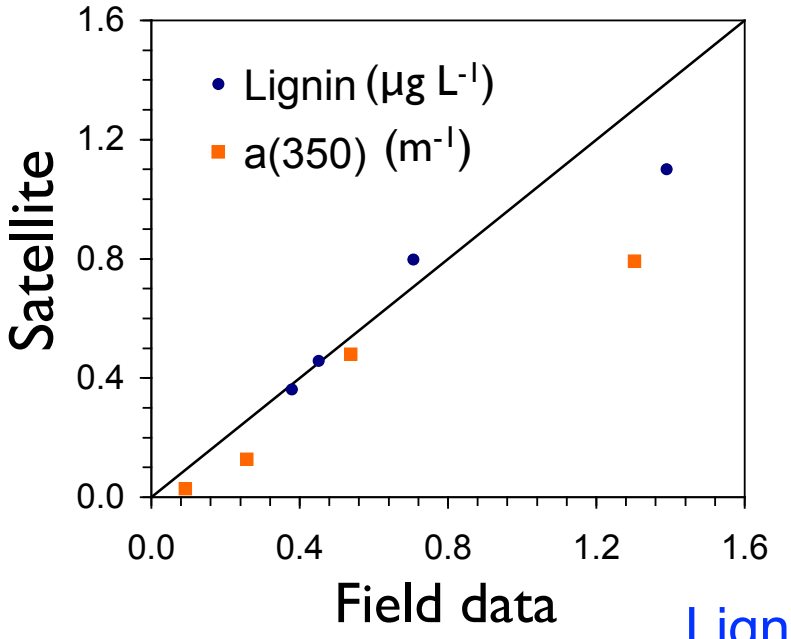
DOC 2004 Monthly Composites - MODIS-A 4km



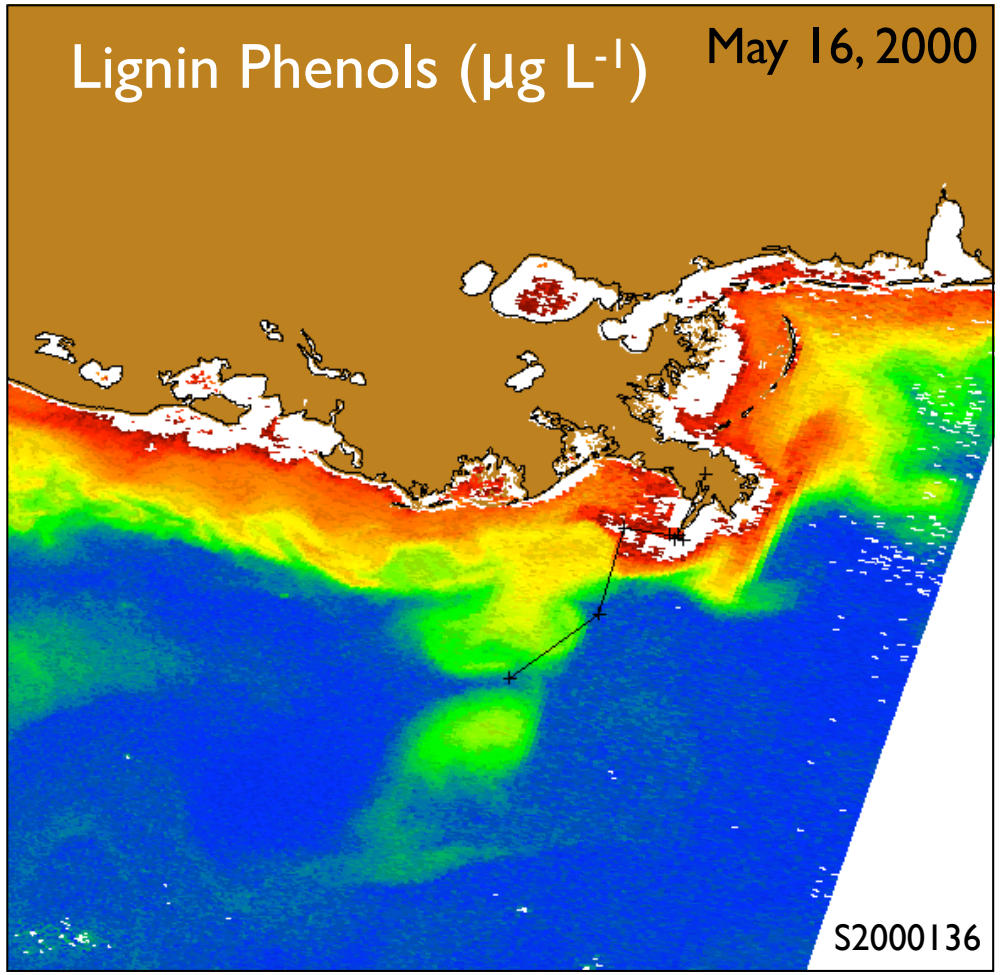


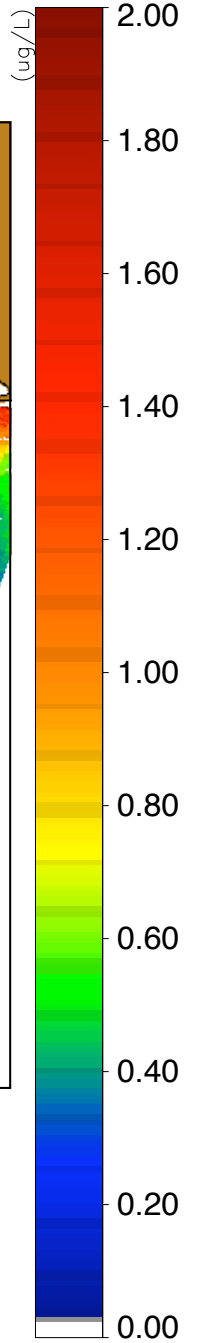
Terrigenous DOM from Space - AGU 2007





Mississippi River Plume





Lignin Phenols: APD = 10 ± 8.8%

DOC and CDOM Yields

Drainage Area	% Drainage of Contiguous US	% DOC Flux vs. Mississippi	DOC yield (gC m^2 yr^{-1})	CDOM yield a_{350} (yr^{-1})	DOC Load (kg yr^{-1})	CDOM Load a_{350} (m^2 yr^{-1})
Atchafalaya	3.3	56.6	4.92	10.6	1.19×10^9	2.56×10^{12}
Columbia	9.1	19.2	0.61	0.93	4.04×10^8	6.16×10^{11}
Mississippi	40.1	100	0.72	1.25	2.10×10^9	3.65×10^{12}
Potomac	**0.4**	**2.11**	**1.48**	**2.62**	**4.43×10^7**	**7.84×10^{10}**
South Atlantic Bight	4.3	45.4	3.04	7.43	9.55×10^8	2.33×10^{12}
Susquehanna	**1.0**	**3.97**	**1.17**	**1.75**	**8.23×10^7**	**1.23×10^{11}**

Source: Rob Spencer, in prep.

Summary

- Relationships of optical properties (a_{CDOM} and S) with biogeochemical variables (DOC and lignin phenols) are robust and driven primarily by terrestrial contributions into coastal waters.
  - Black carbon contributions also likely (Mannino et al. 2004).
- Satellite-derived lignin phenol distributions (DOM) are within reach now, but would be more robust with UV-capable satellite sensors.
  - currently need to extrapolate CDOM parameters from the UV to satellite radiometry in the visible.
    - much more problematic for $S_{275:295}$