Mannino, Dyda and Hernes

Biogeochemical and Optical Analysis of Coastal DOM for Satellite Retrieval of Terrigenous DOM in the U.S. Middle Atlantic Bight

Estuaries and coastal ocean waters experience a high degree of variability in the composition and concentration of particulate and dissolved organic matter (DOM) as a consequence of riverine/estuarine fluxes of terrigenous DOM, sediments, detritus and nutrients into coastal waters and associated phytoplankton blooms. Our approach integrates biogeochemical measurements (elemental content, molecular analyses), optical properties (absorption) and remote sensing to examine terrestrial DOM contributions into the U.S. Middle Atlantic Bight (MAB). We measured lignin phenol composition, DOC and CDOM absorption within the Chesapeake and Delaware Bay mouths, plumes and adjacent coastal ocean waters to derive empirical relationships between CDOM and biogeochemical measurements for satellite remote sensing application. Lignin ranged from 0.03 to 6.6 ug/L between estuarine and outer shelf waters. Our results demonstrate that satellite-derived CDOM is useful as a tracer of terrigenous DOM in the coastal ocean.

Biogeochemical and Optical Analysis of Coastal DOM for Satellite Retrieval of Terrigenous DOM in the U.S. Middle Atlantic Bight

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Outline

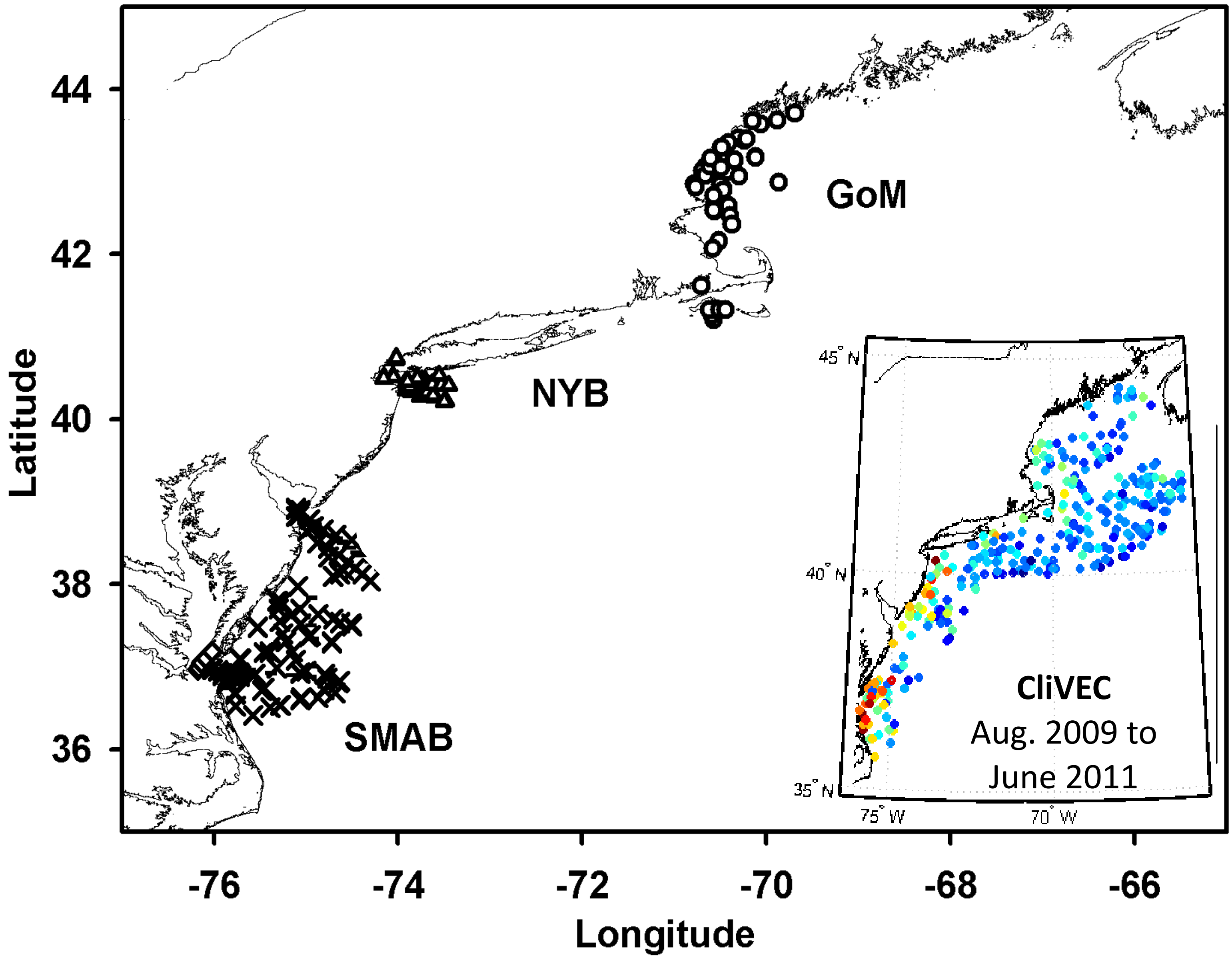
- Objectives
- CDOM:DOC Relationships
- Lignin Distributions
- Lignin:CDOM Relationships
- Satellite algorithm development for CDOM, DOC and Lignin Phenols

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

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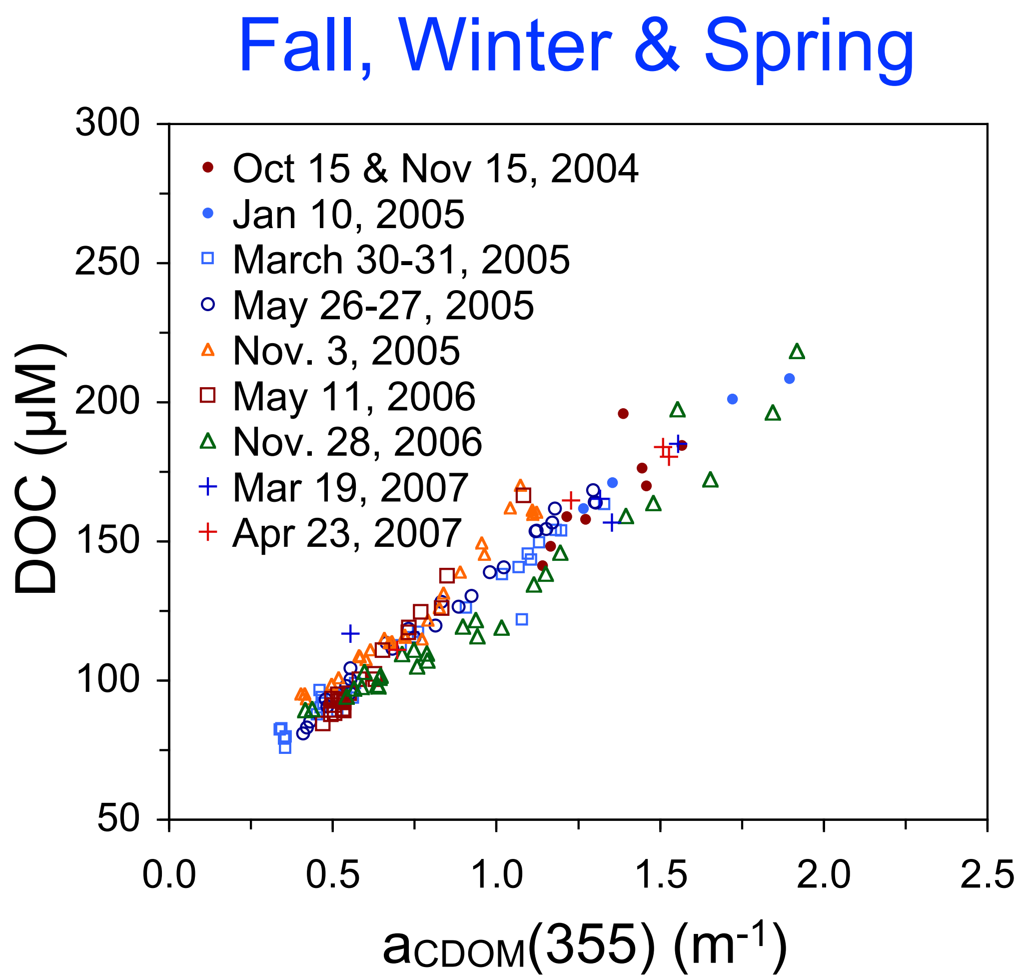
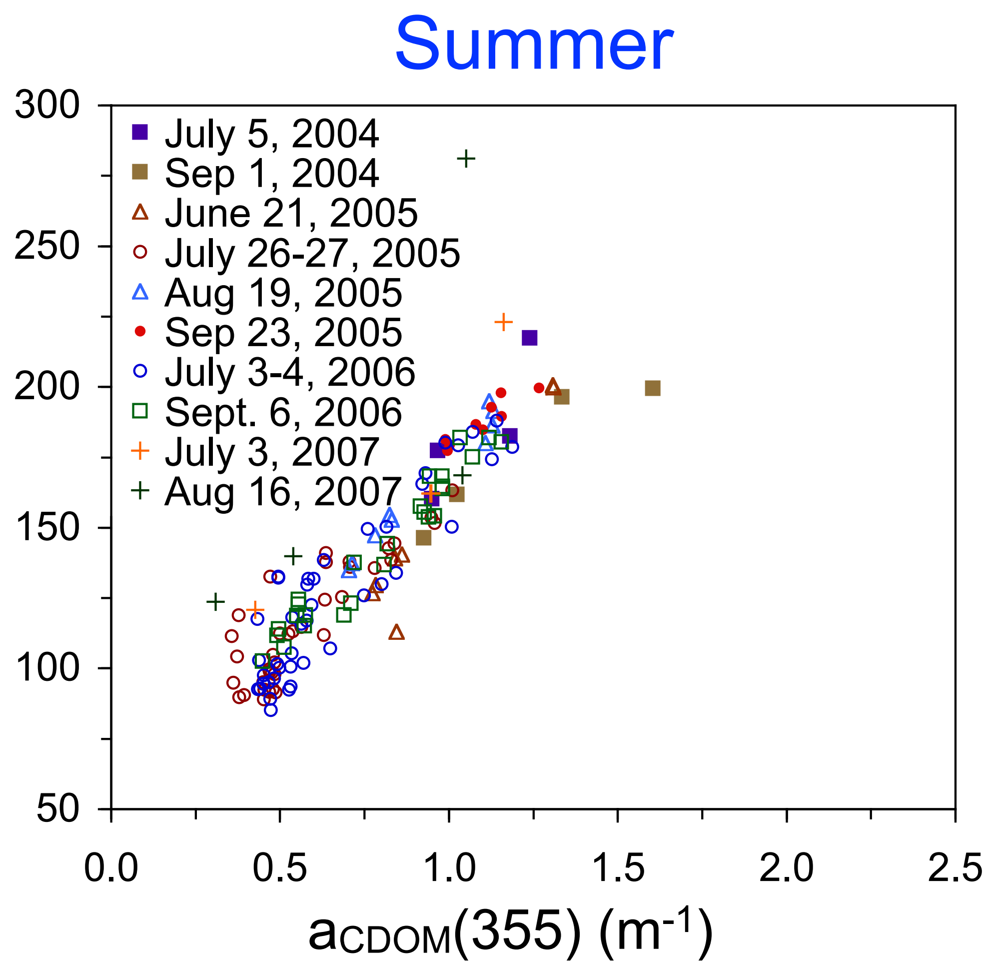
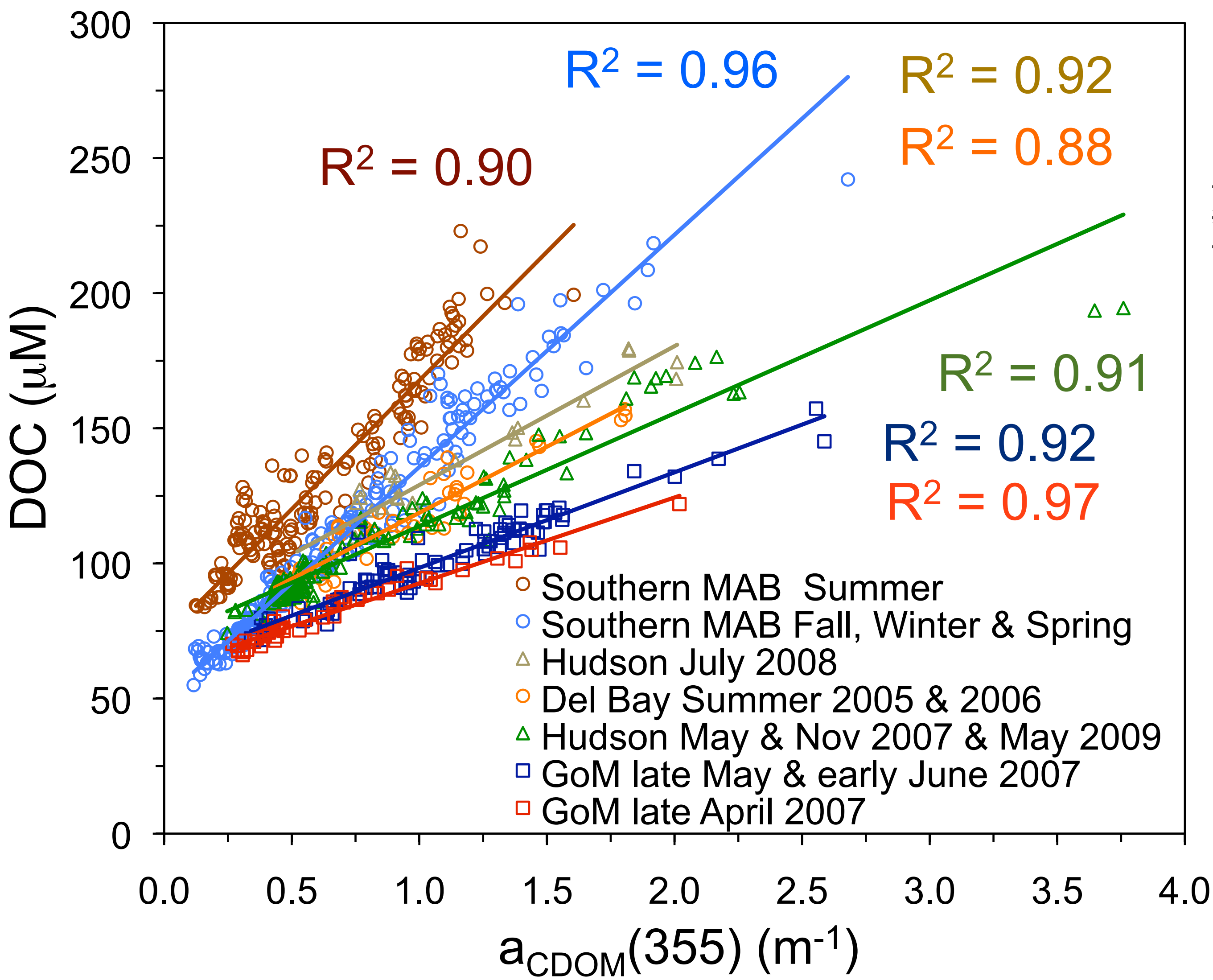
DOC:a_{CDOM} Chesapeake Bay Mouth & Plume

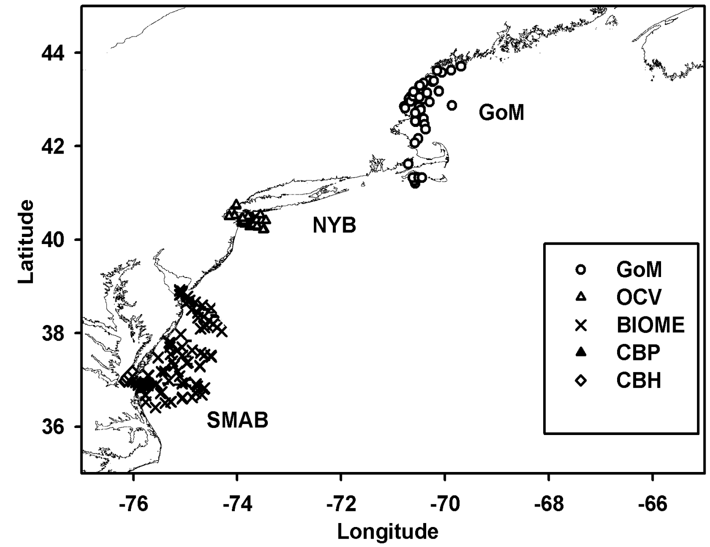




- Interannual consistency in DOC to a_{CDOM} relationships

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.

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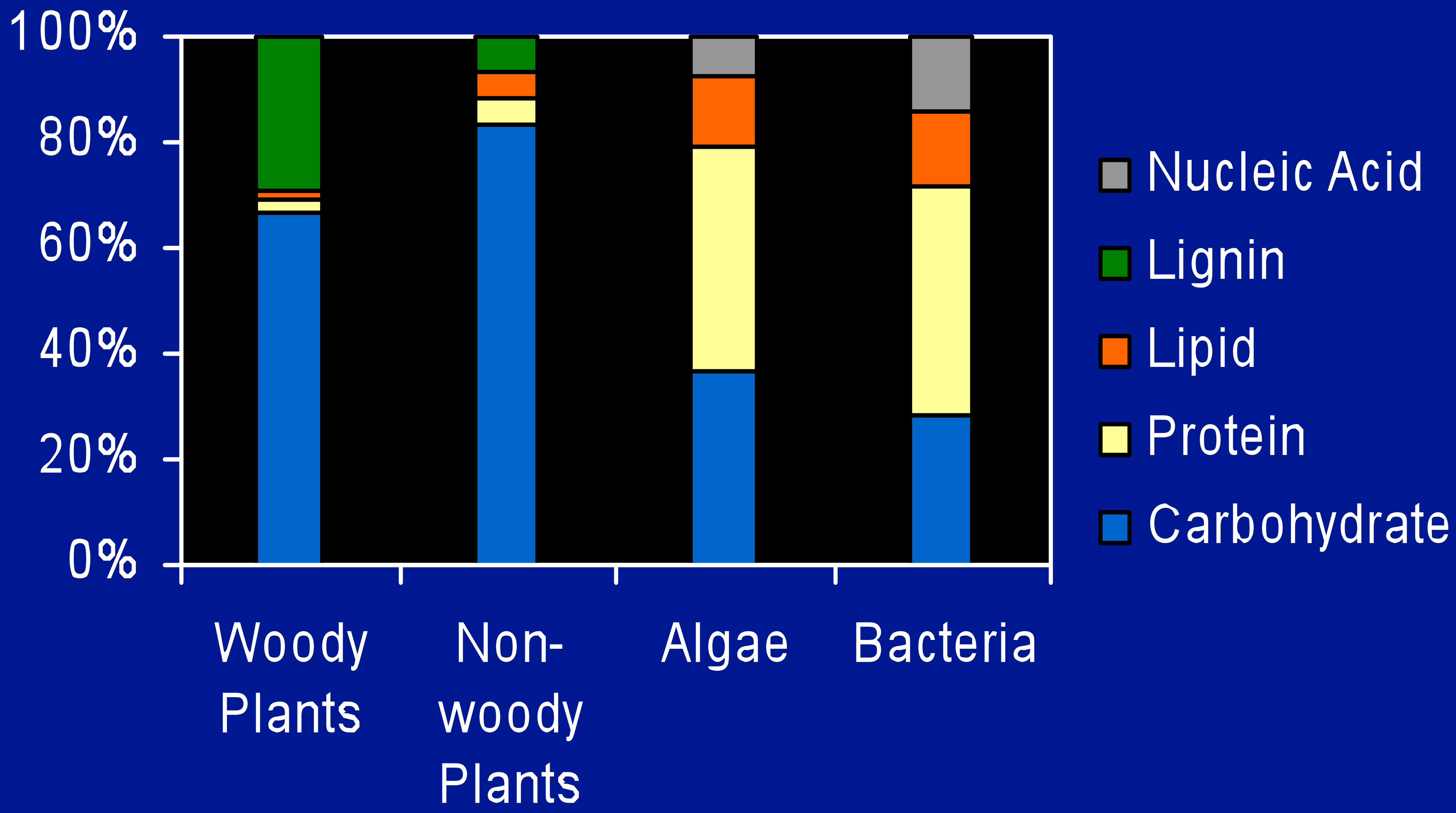
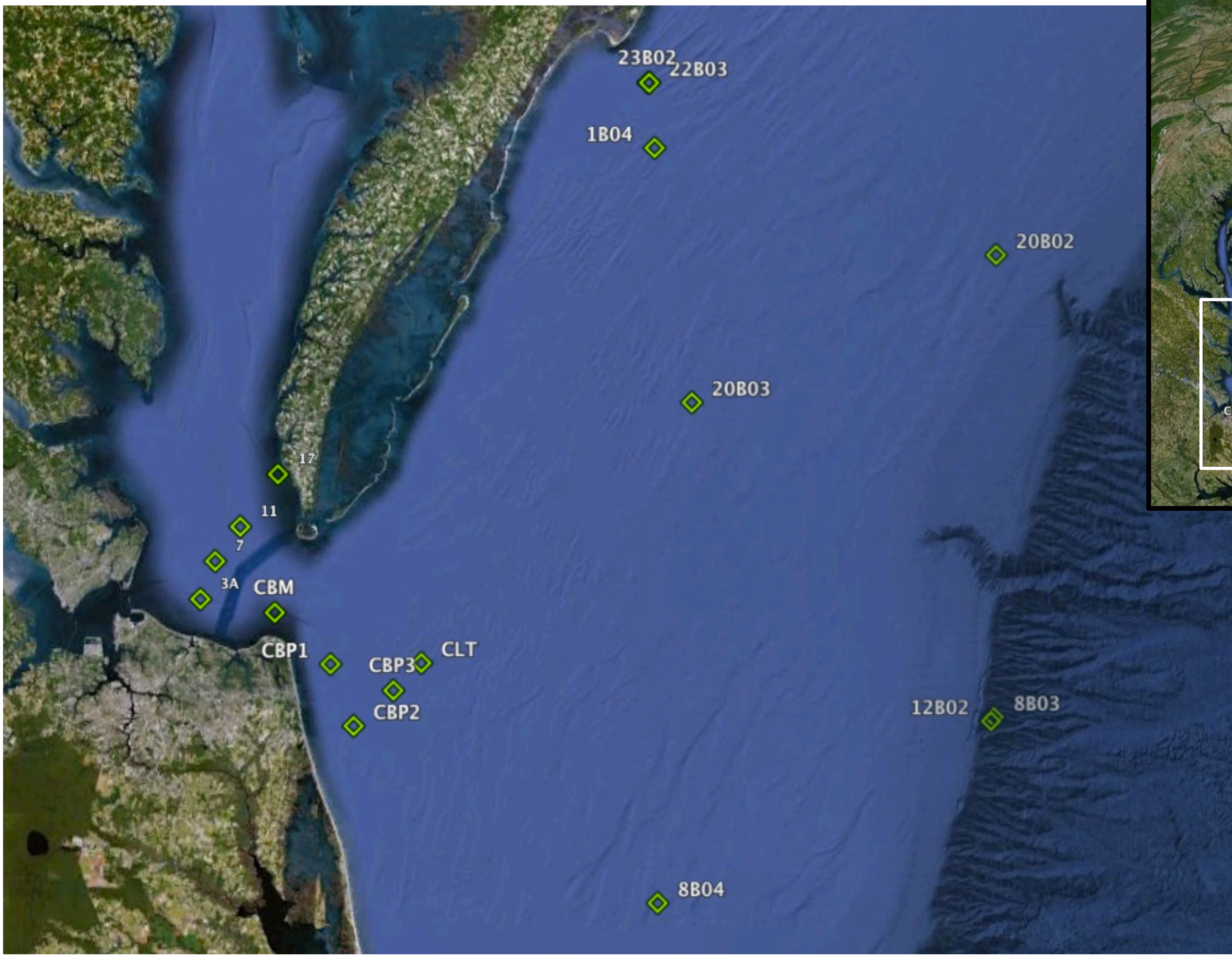
- Radiometry:CDOM Relationships
- Satellite-derived CDOM, DOC, Lignin

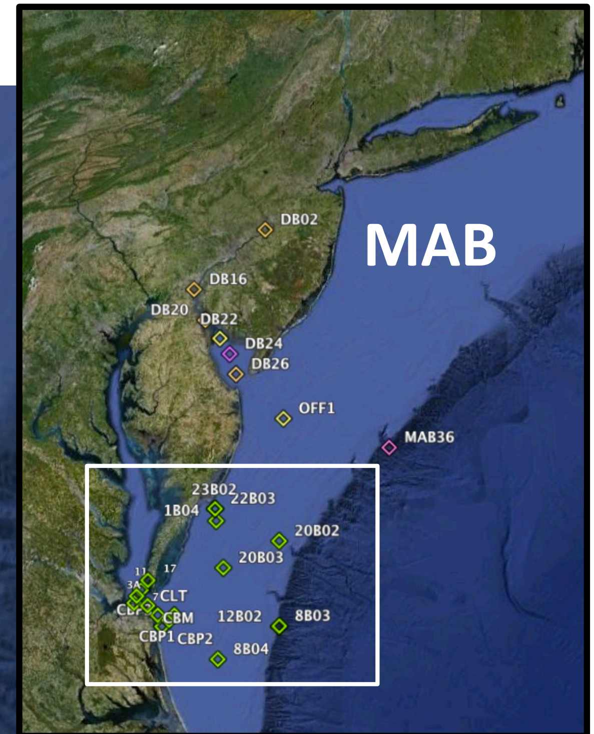
Biochemical Composition of Sources



Delaware Bay Lignin Stations

Chesapeake MAB Lignin Stations





SMAB

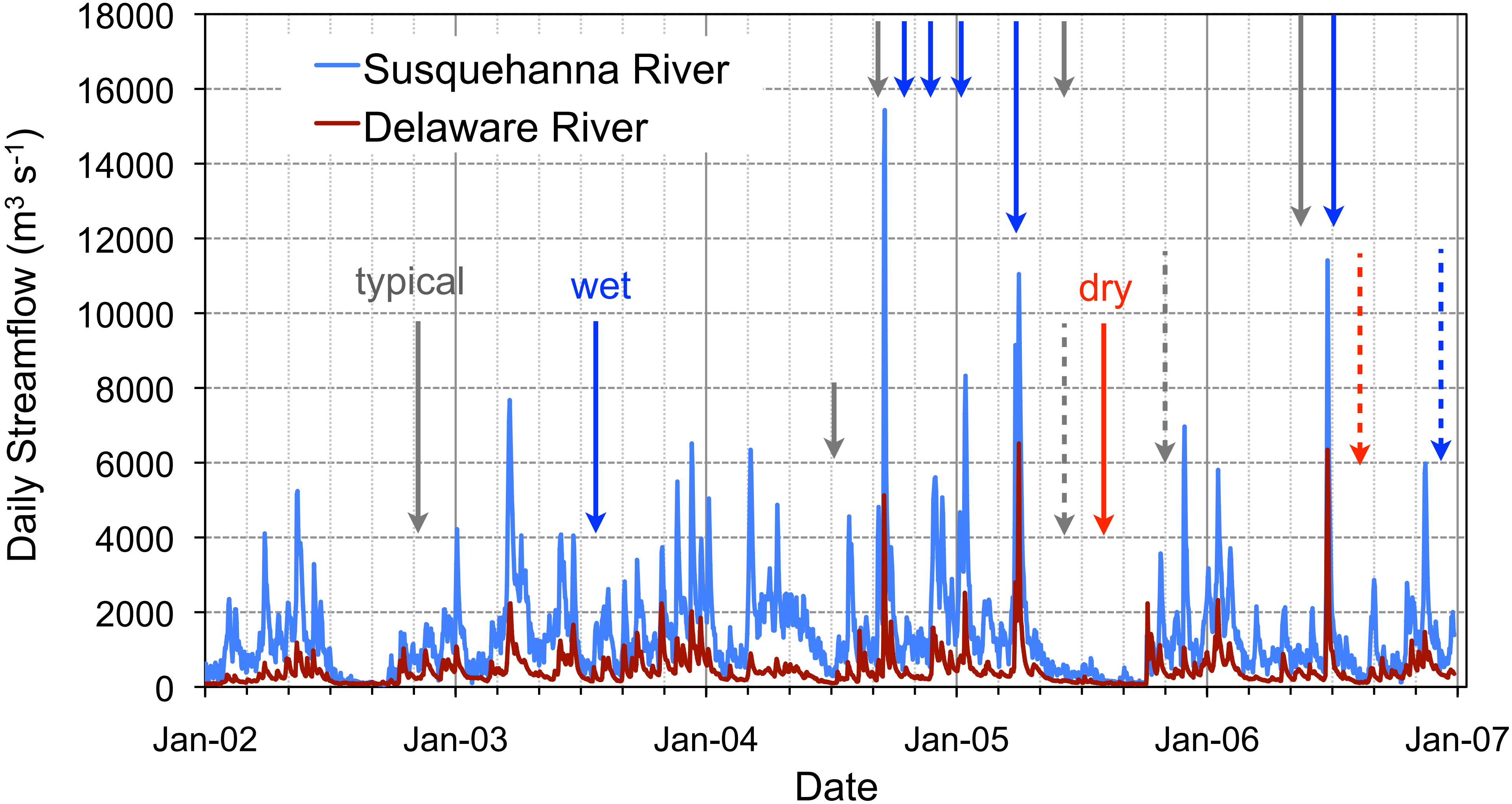
March 30-April 1, 2005
July 26-30, 2005
May 9-12, 2006
July 2-6, 2006

CB Plume

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

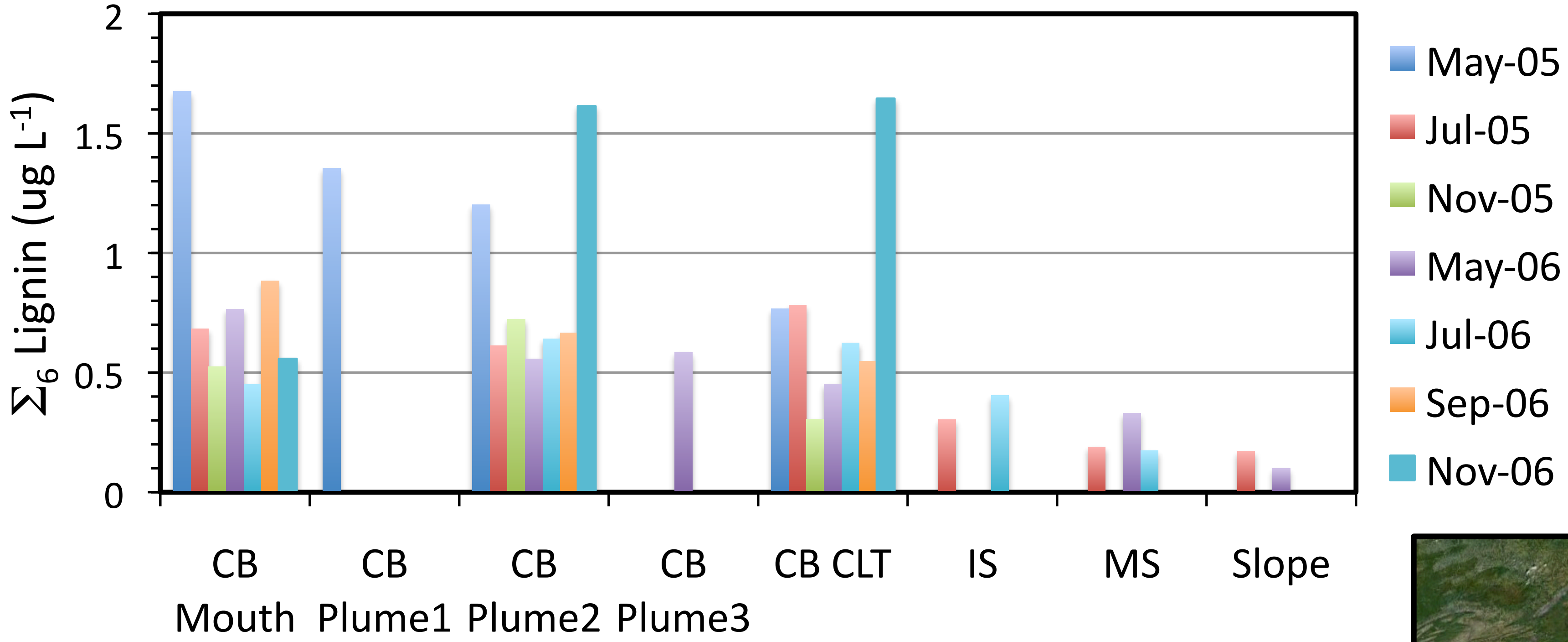
Lower Chesapeake Bay: July 04, Sept. 04, Oct. 04, Nov. 04, Jan. 05, May 05

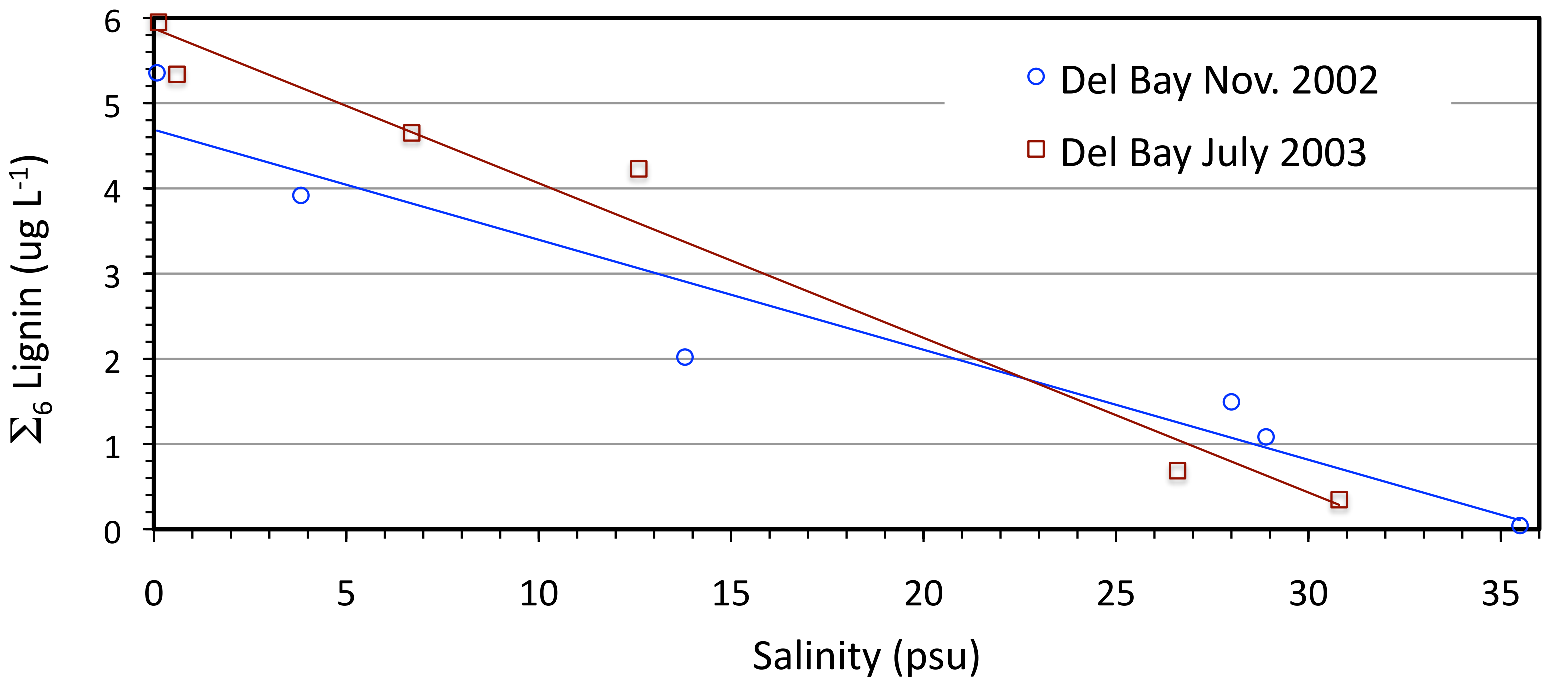
Freshwater Discharge into Delaware Bay and Chesapeake Bay

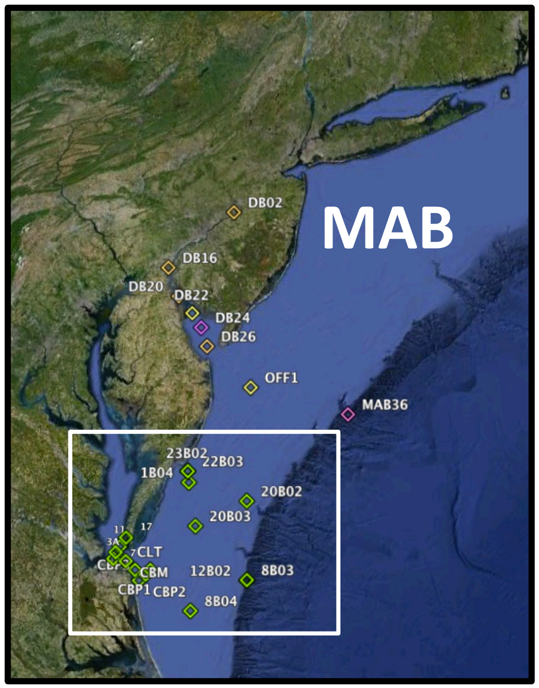


Data courtesy of USGS

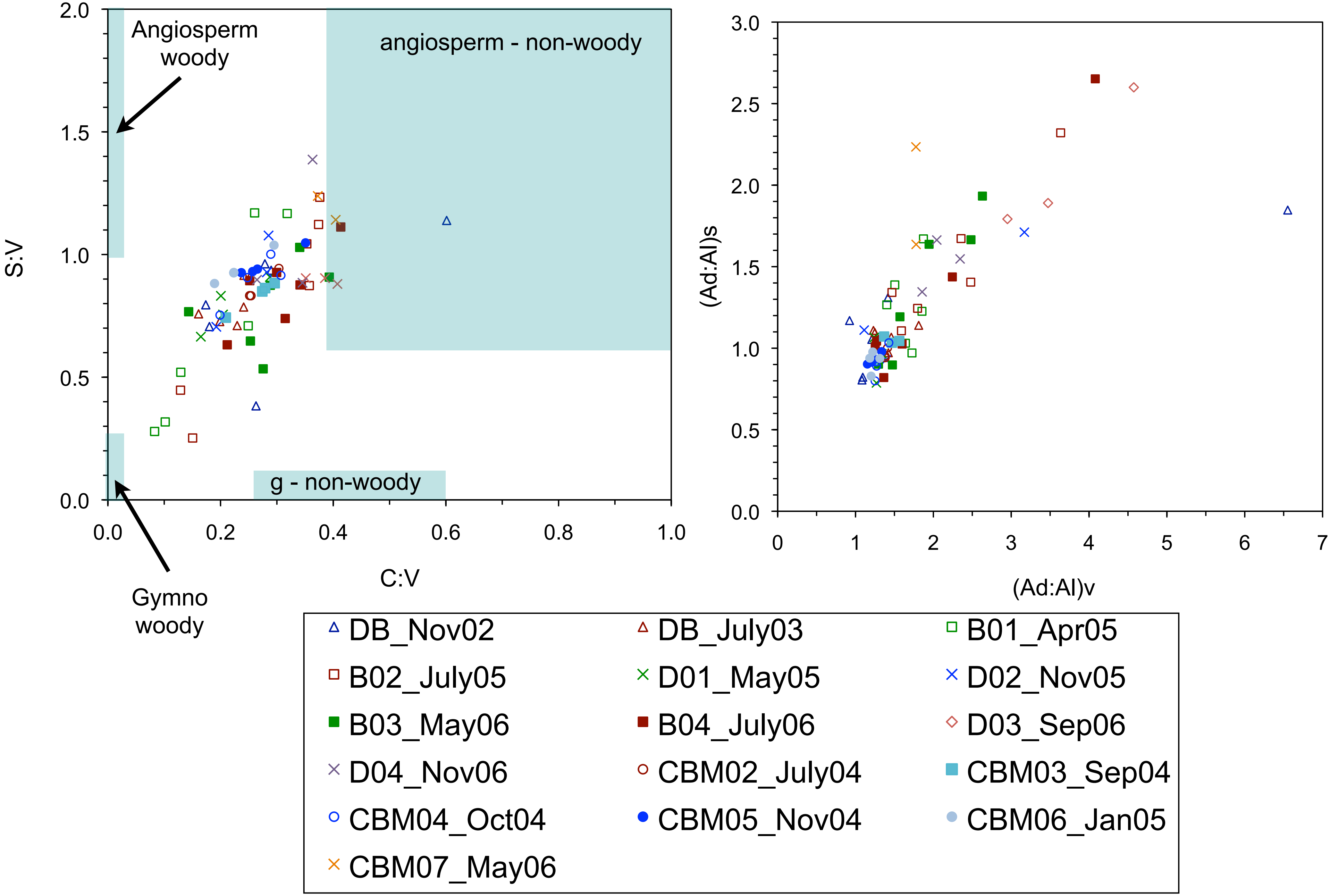
Lignin Distributions



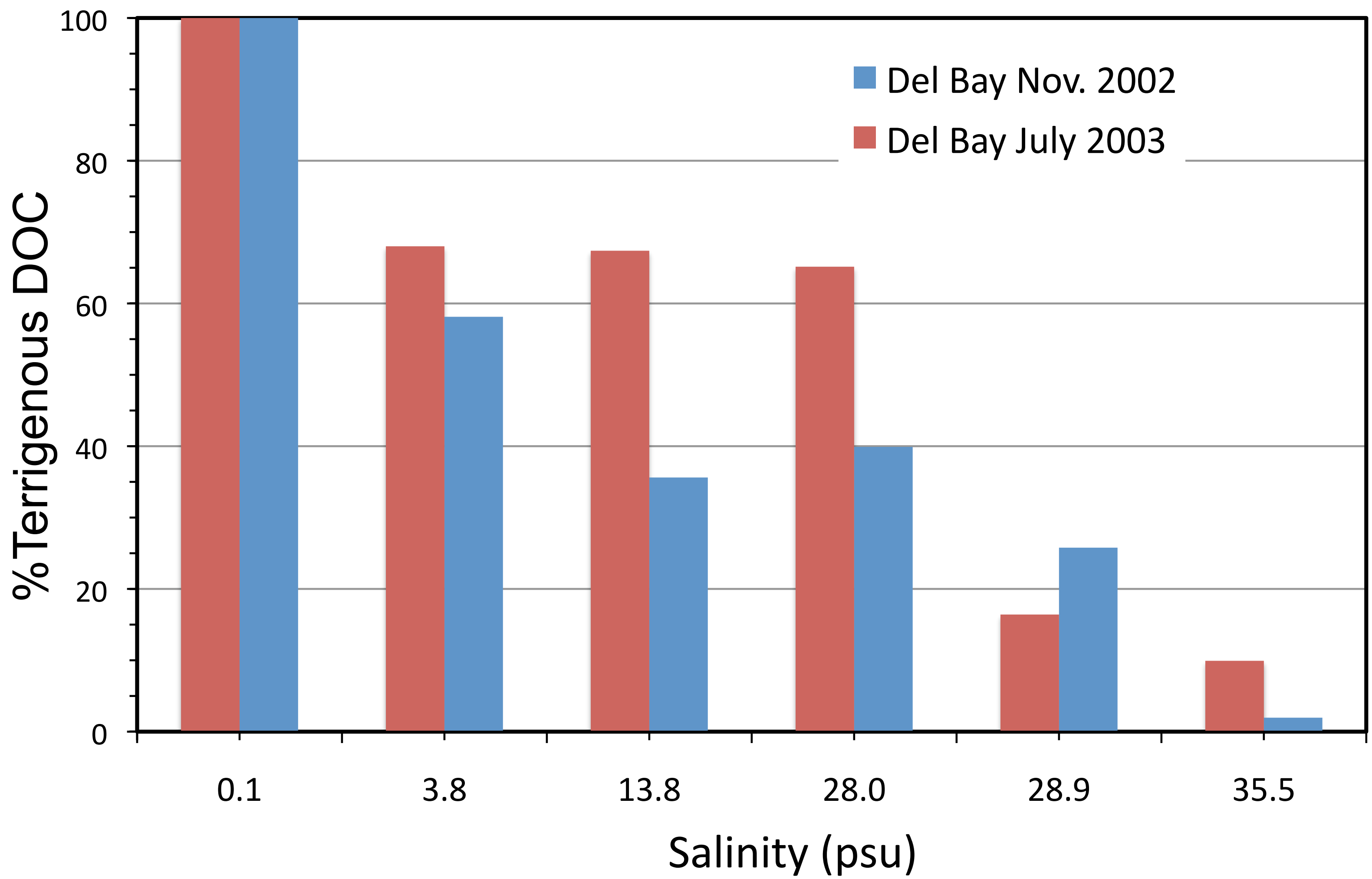




Lignin Source & Degradation Parameters



Terrigenous DOC Estimates



$[\text{Lignin/DOC}]_O$ / $[\text{Lignin/DOC}]_R$ * 100

proportion of ocean to river lignin yields

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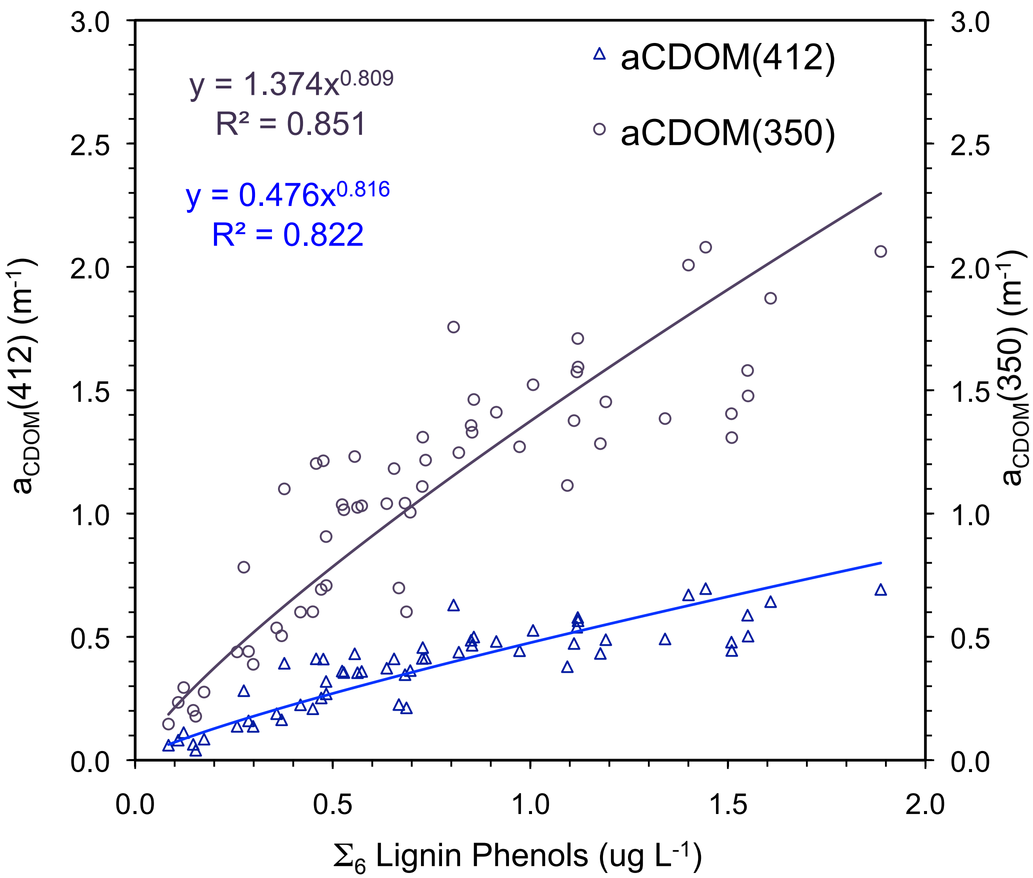
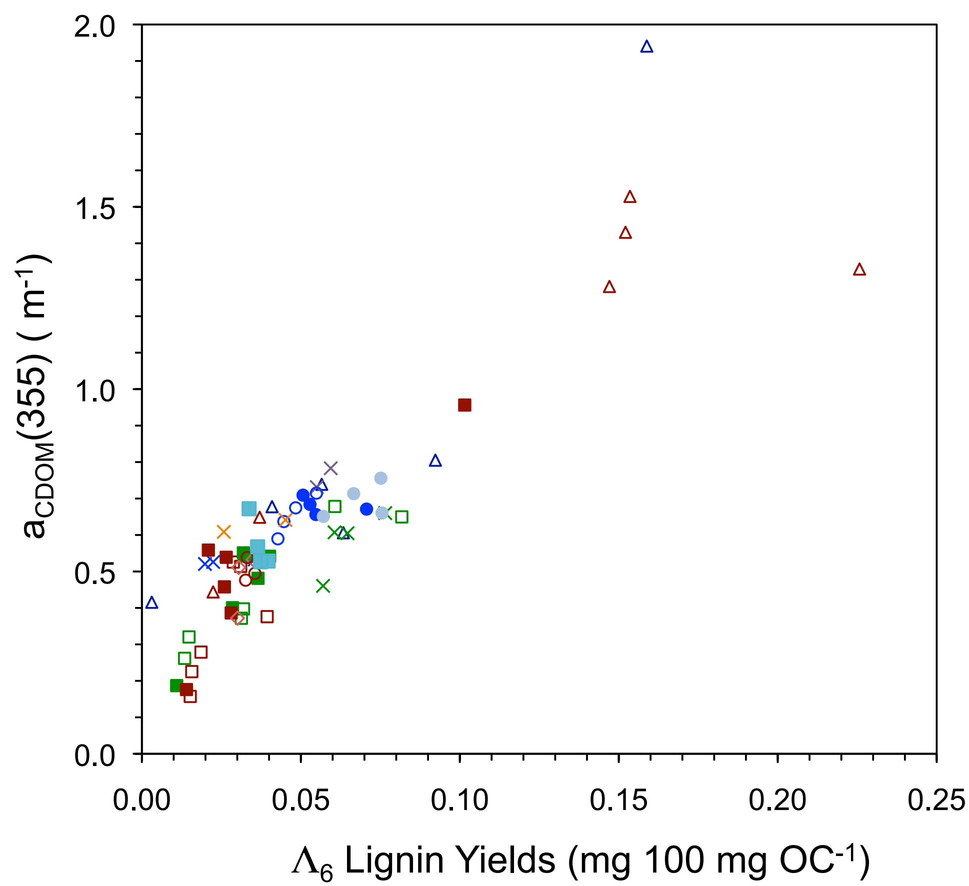
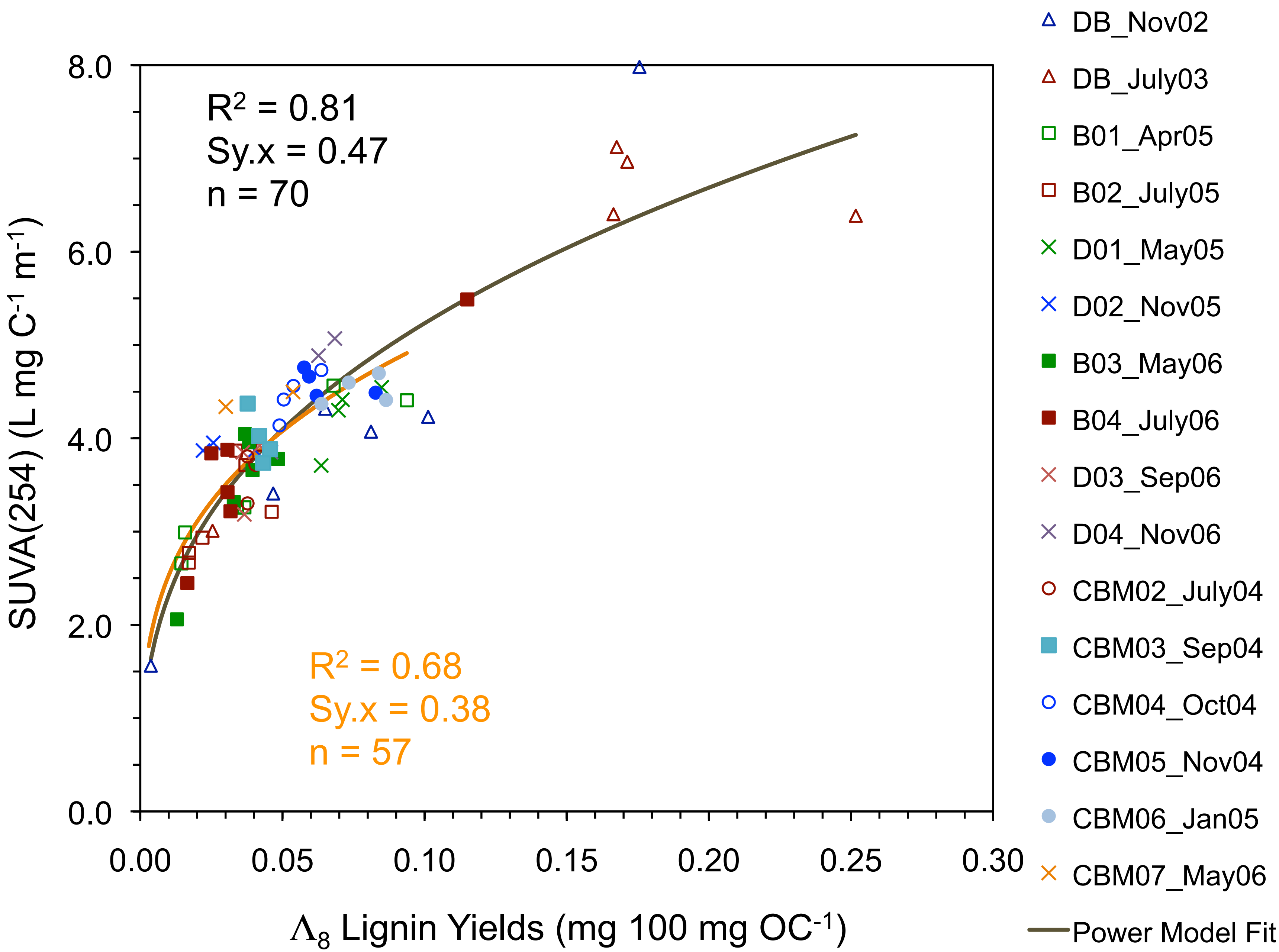
a_{CDOM} versus Lignin Phenols

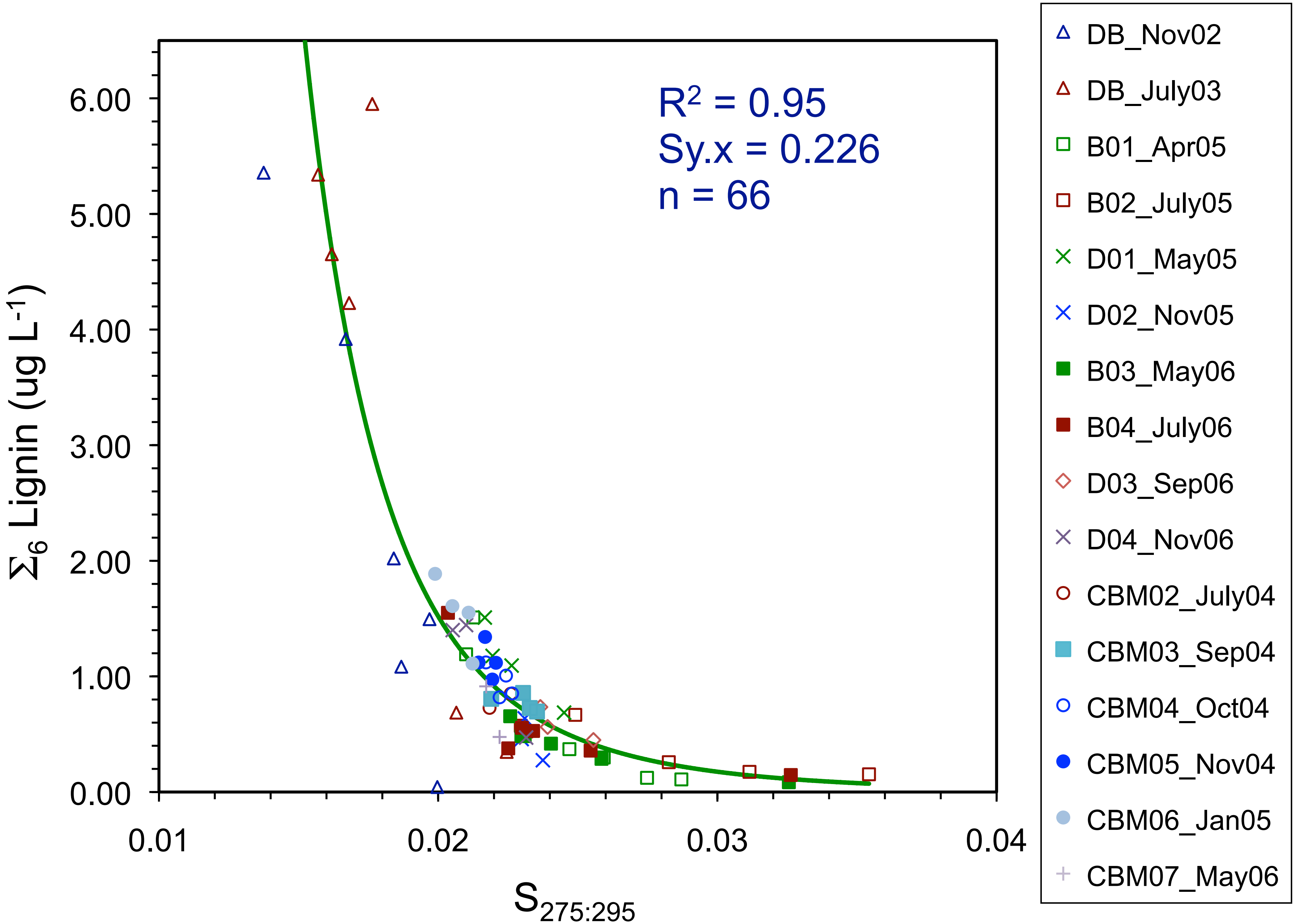




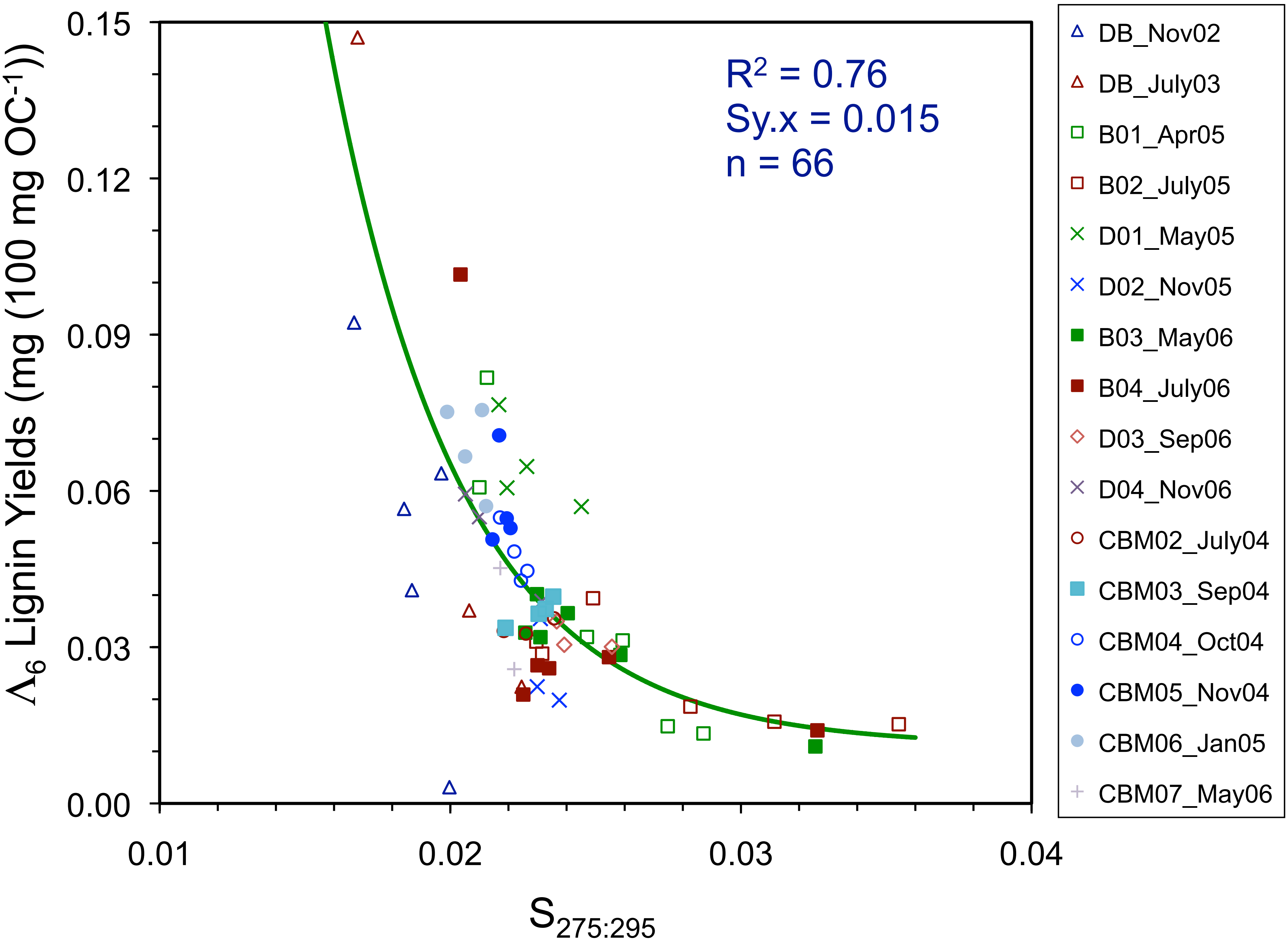
Lignin Phenol to SUVA$_{254}$ Relationships



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



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



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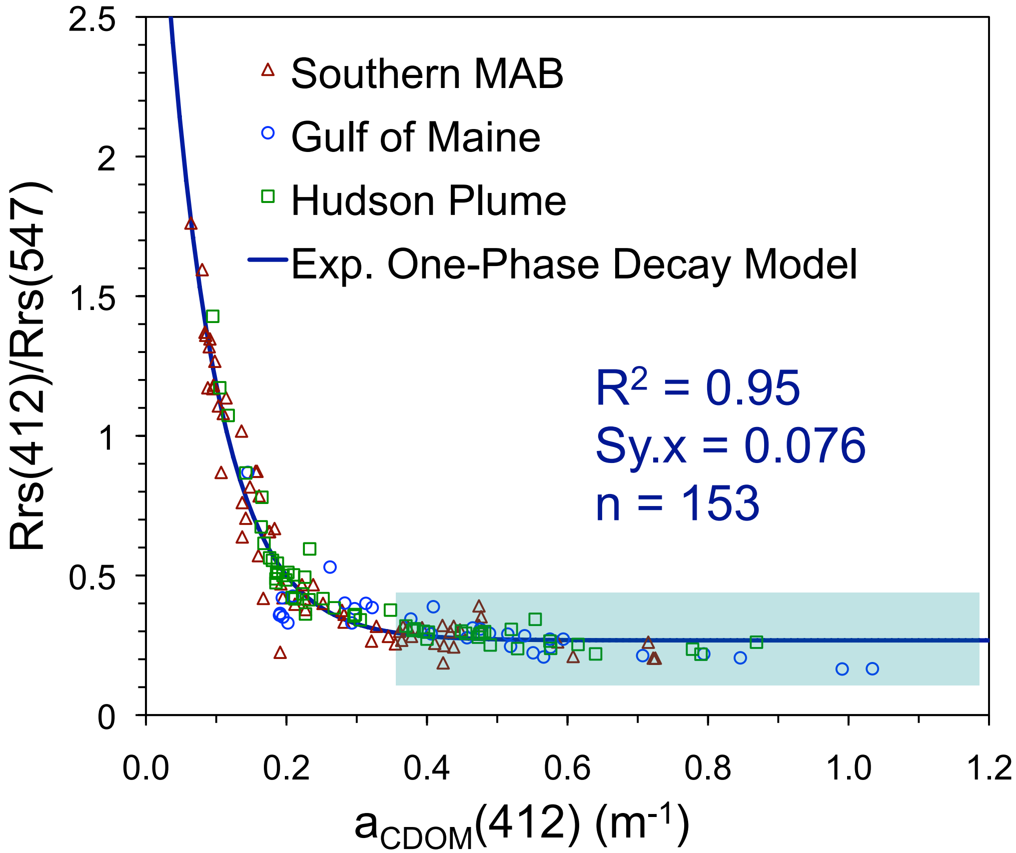
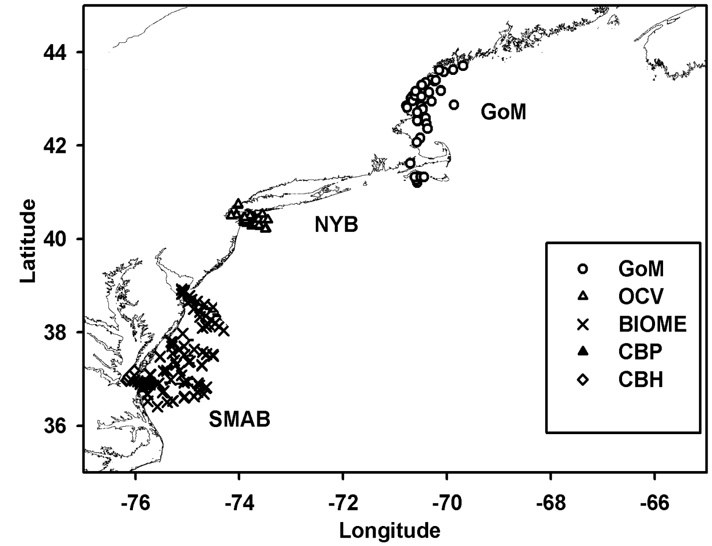
Types of Algorithms

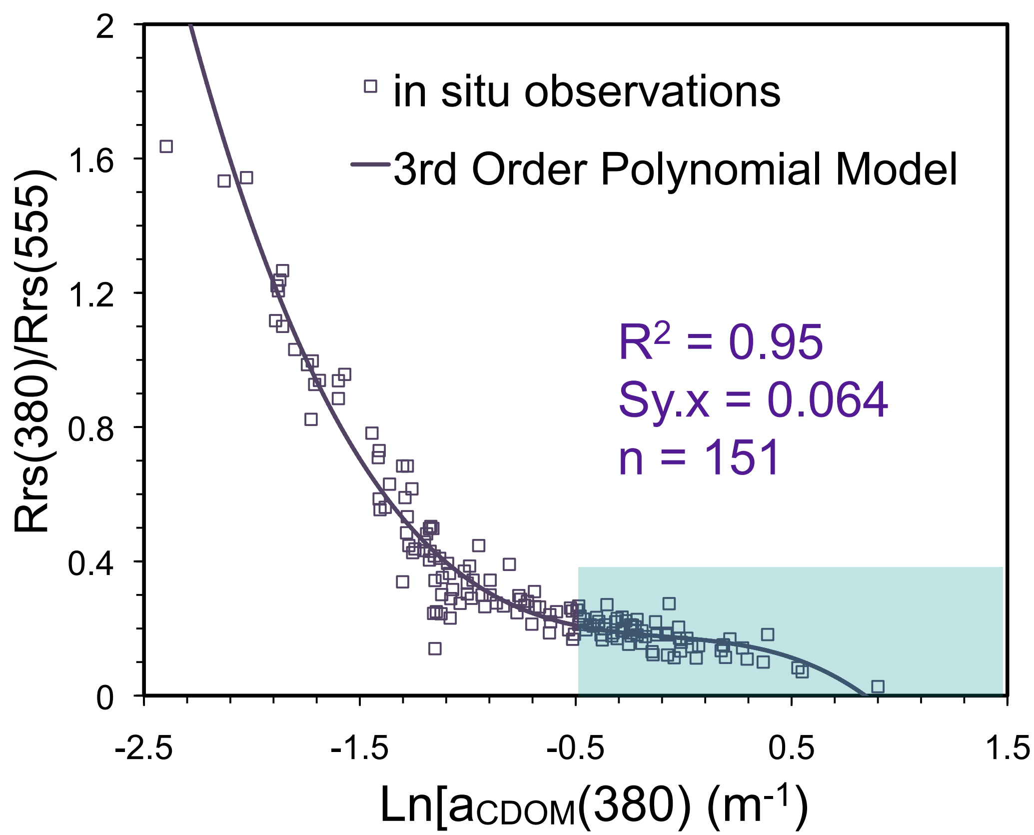
- Band ratios (ex. OC4)
- Semi-analytical (ex. GSM01, QAA, GIOP)
- IOP based algorithms (DOC from CDOM)
- Multivariate algorithms
- Machine Learning
  - Neural networks
  - Vector support machines
  - Gaussian process models

CDOM Algorithm Development

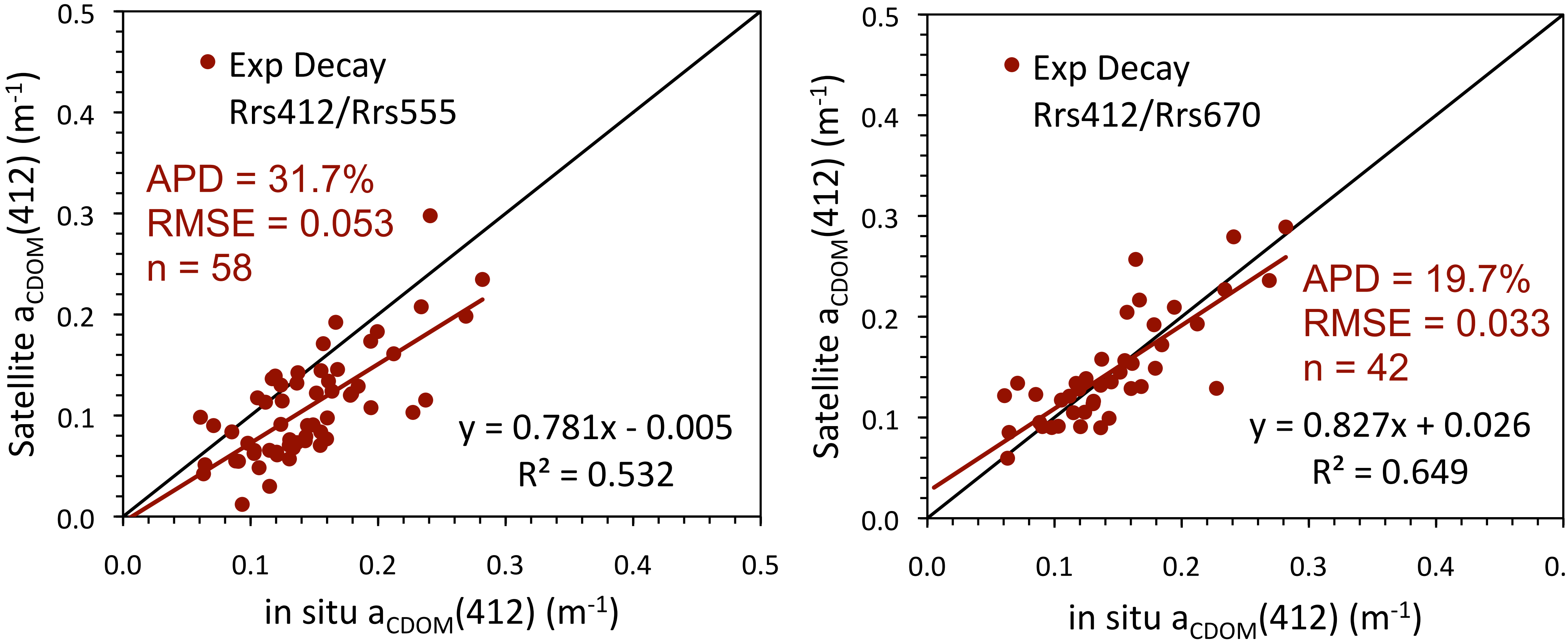




in situ remote sensing reflectance (Rrs) band ratios versus a_{CDOM}

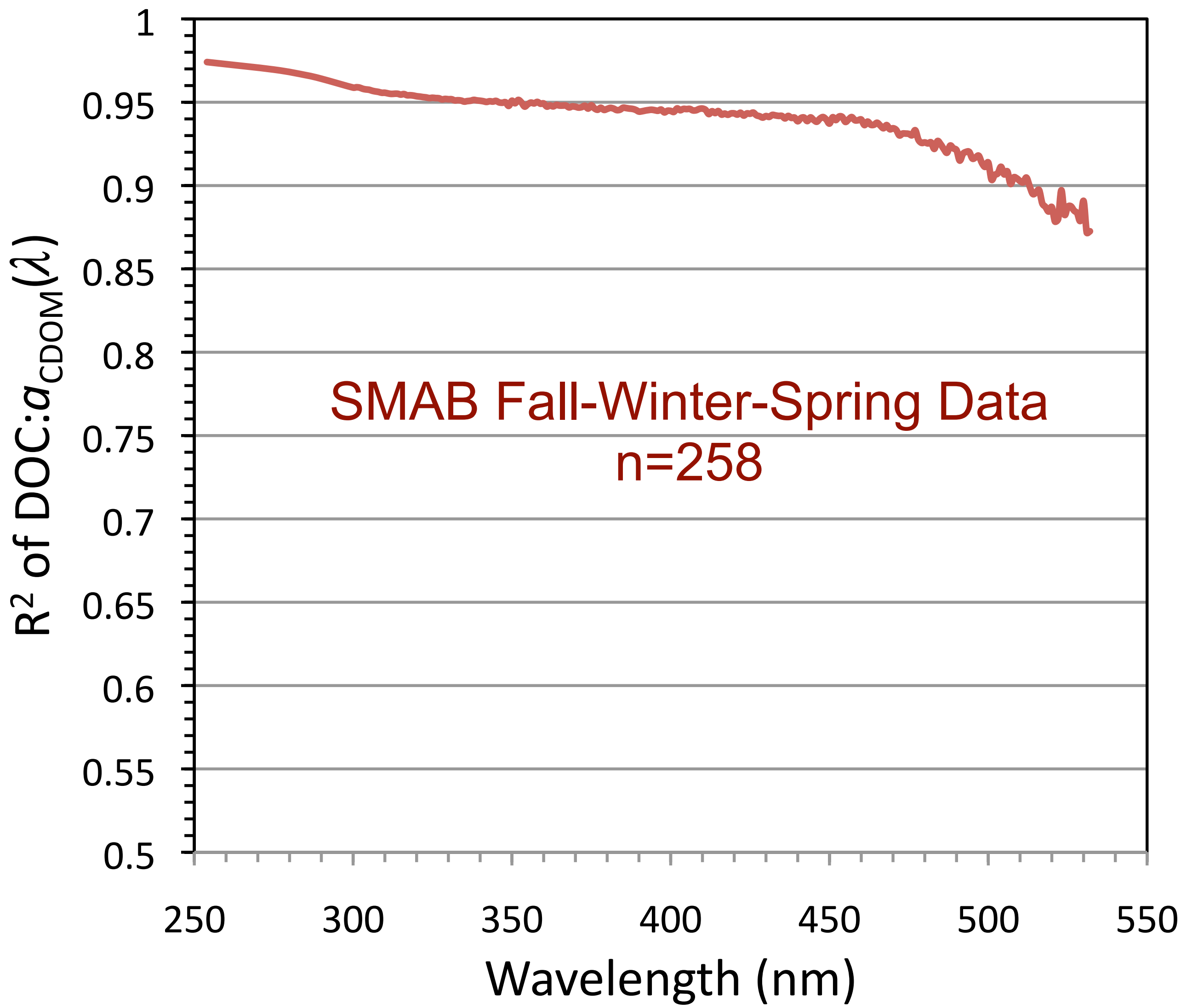


Validation of SeaWiFS CDOM Algorithms



APD = Absolute Percent Difference

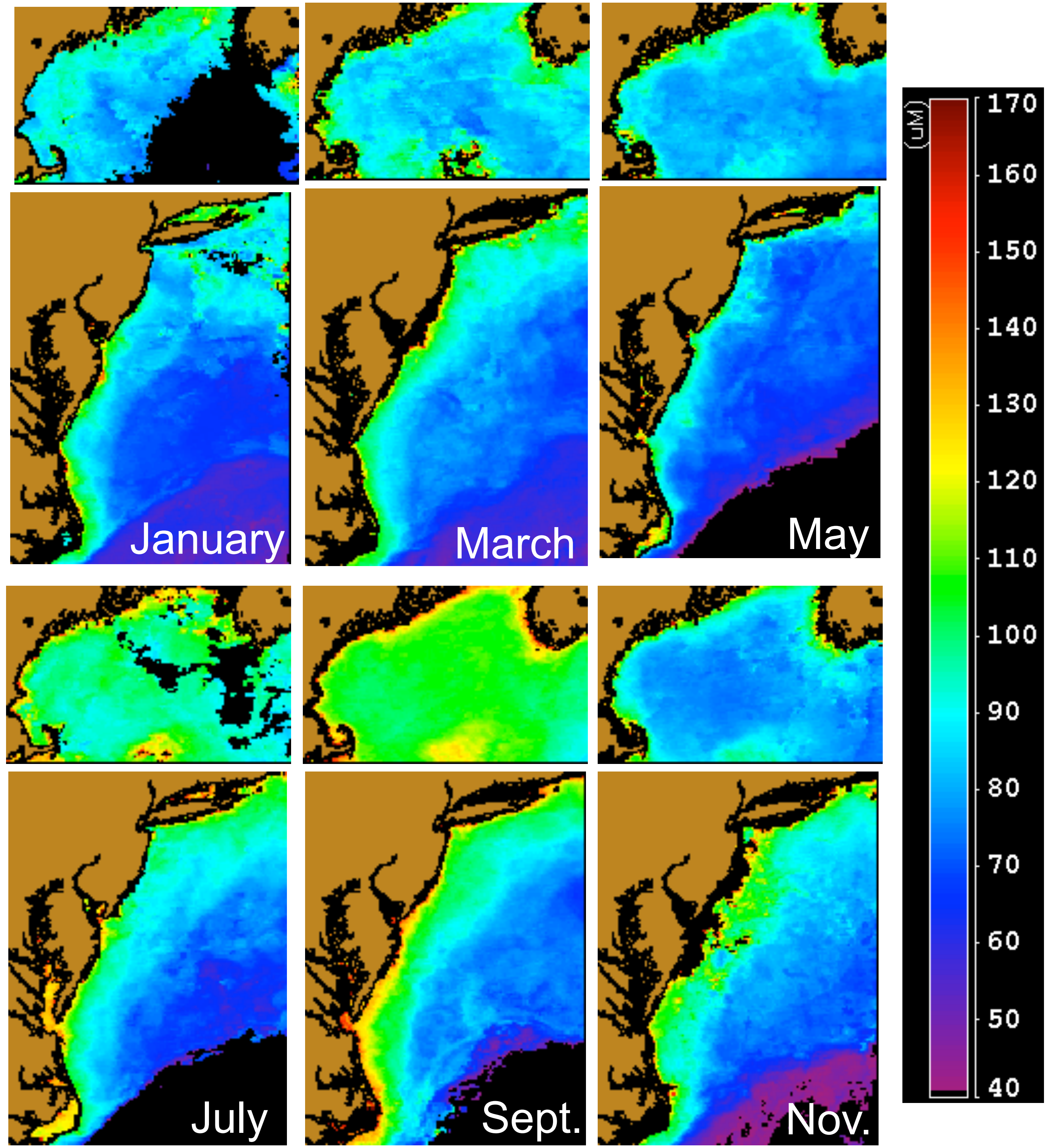
DOC:a_{CDOM} Correlation with Wavelength Relevance to CDOM & DOC algorithms

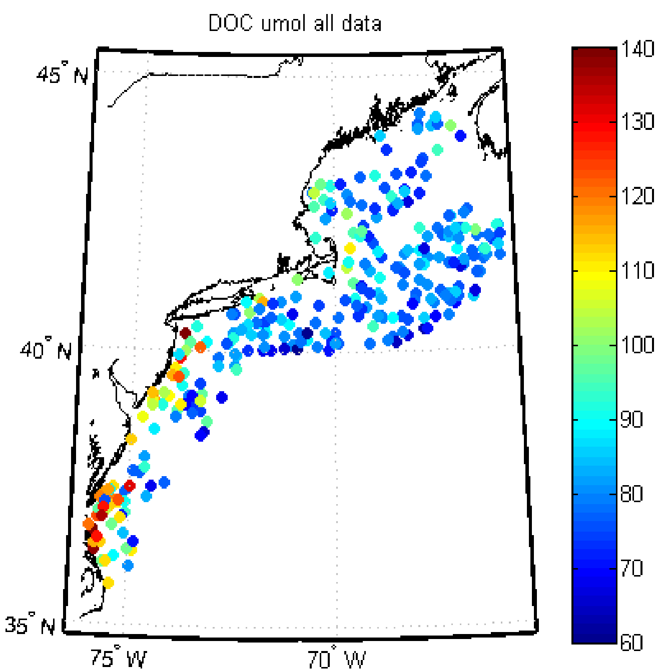


DOC can be derived from wide range of $a_{CDOM}(\lambda)$

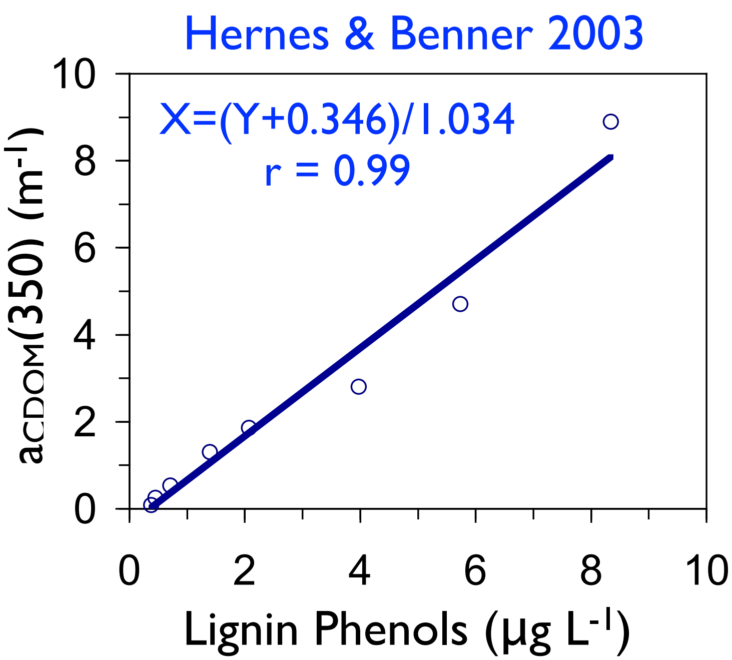
Credit: Aron Stubbins for idea for this plot

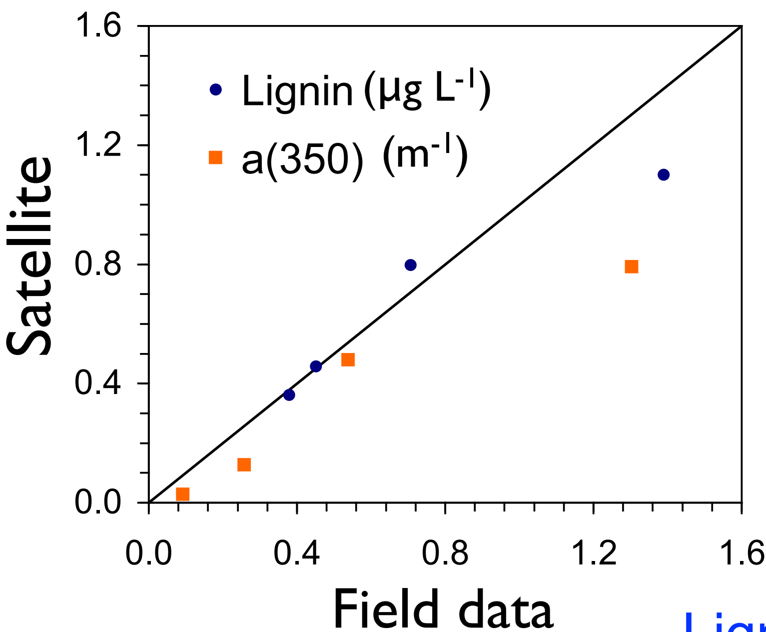
DOC 2004 Monthly Composites - MODIS-A 4km



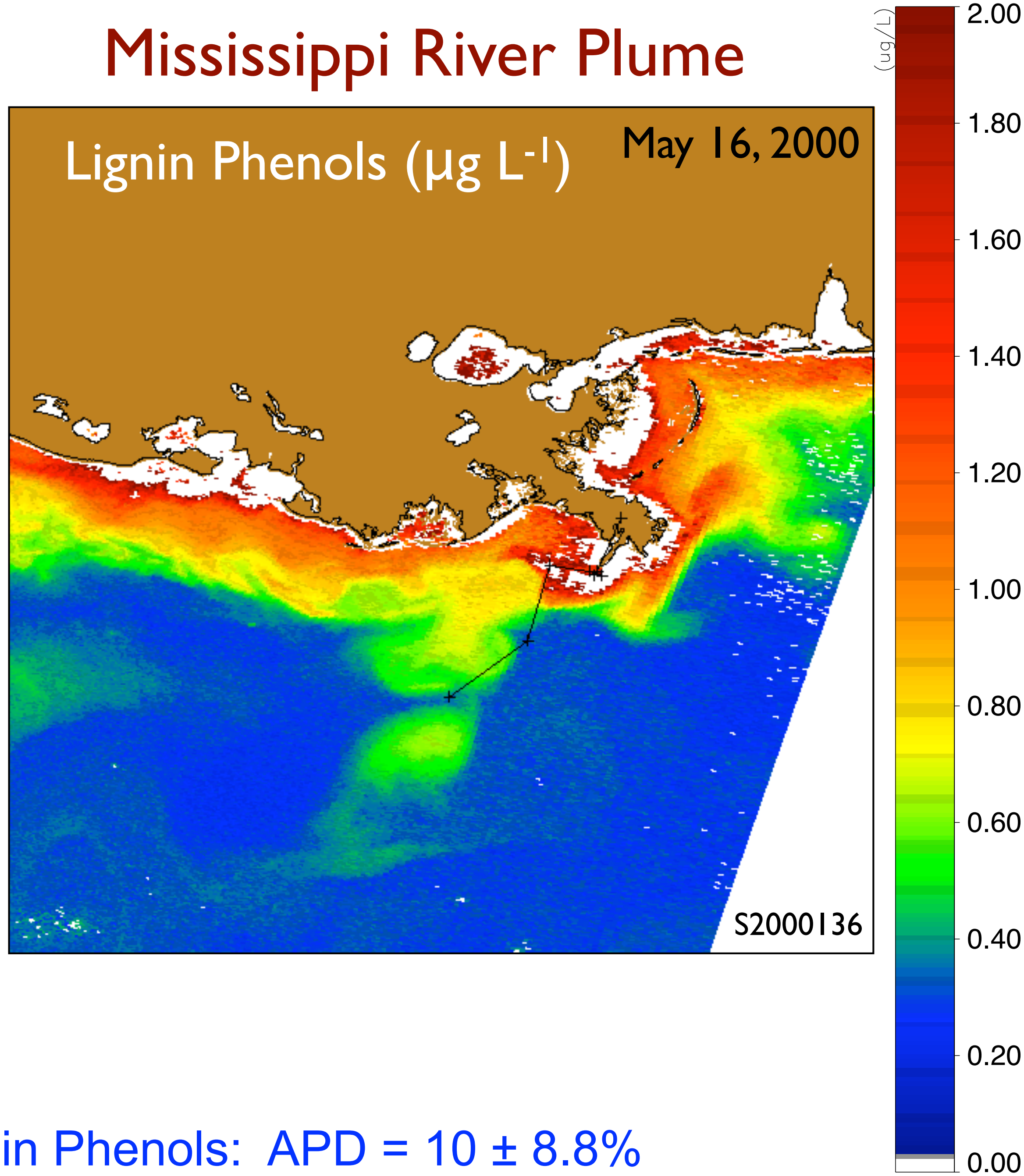


Terrigenous DOM from Space - AGU 2007





Mississippi River Plume



Lignin Phenols: APD = 10 ± 8.8%

DOC and CDOM Yields

Drainage Area	% Drainage of Contiguous US	% DOC Flux vs. Missi ssippi	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 $S_{275:295}$