Phytoplankton Functional Type Analyses & Global Particle Size Distribution Estimation: Status

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UC Santa Barbara

With help from:

Rebecca Lawson, Tiho Kostadinov, Stéphane Maritorena, Norm Nelson, Nathalie Guillocheau, …

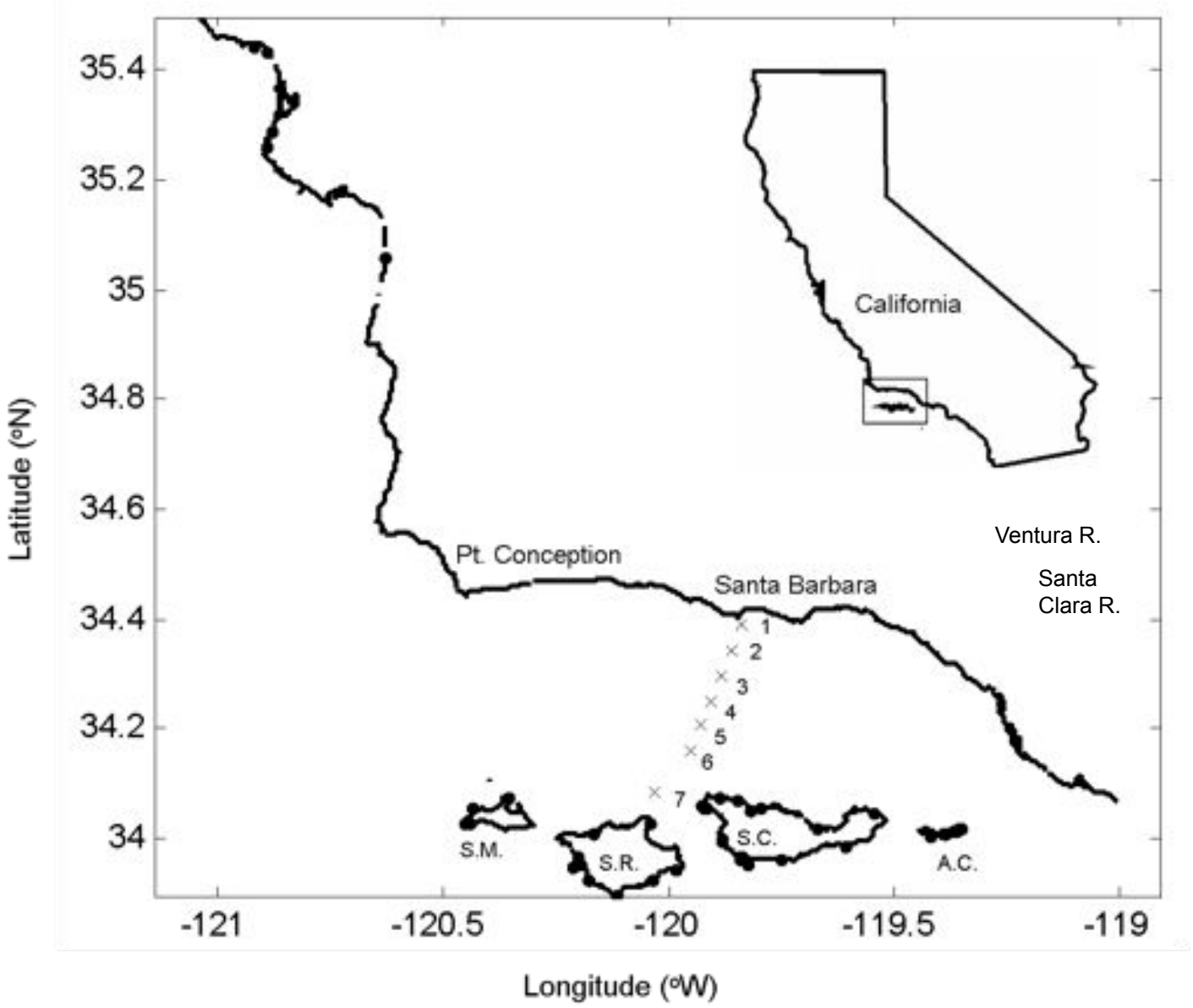
Phytoplankton Functional Type modeling from Plumes & Blooms

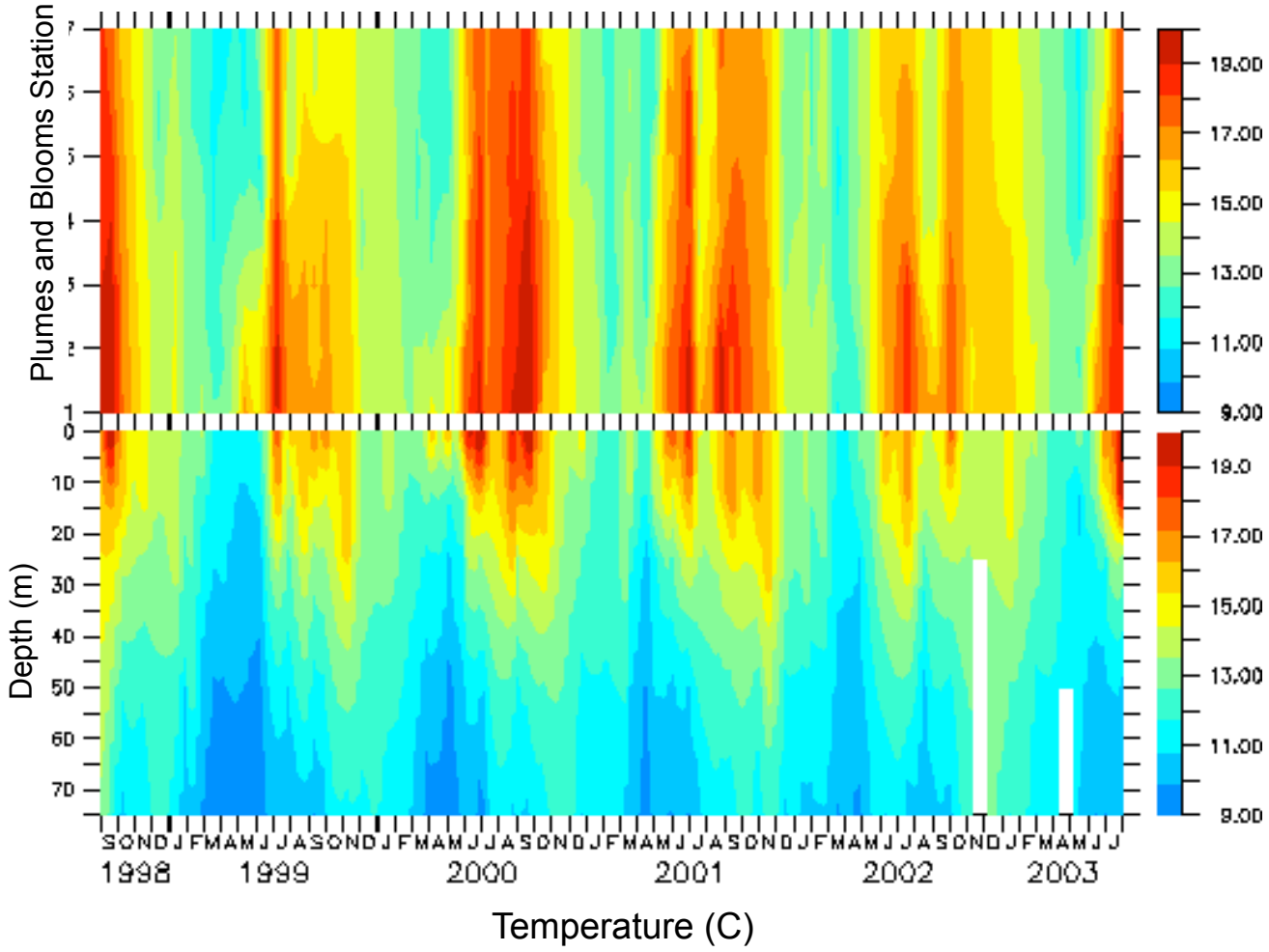
- Dealing with the HPLC issue
  - 1998-2003 CHORS - Anderson et al. [2007-JGR]
  - 2006-present Horn Point
- Preliminary results relating PFTs & IOPs

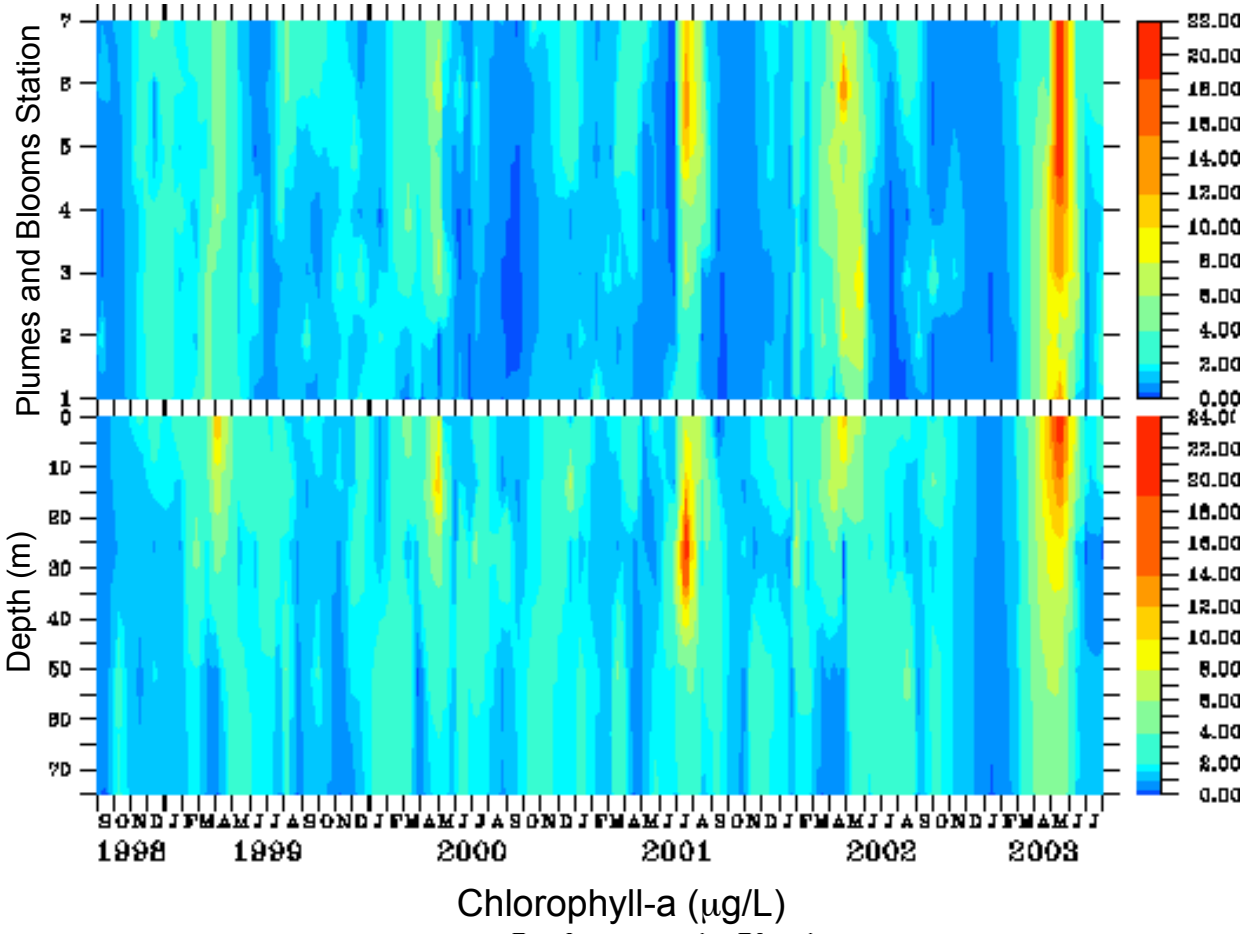
Particle Size Distribution Estimation

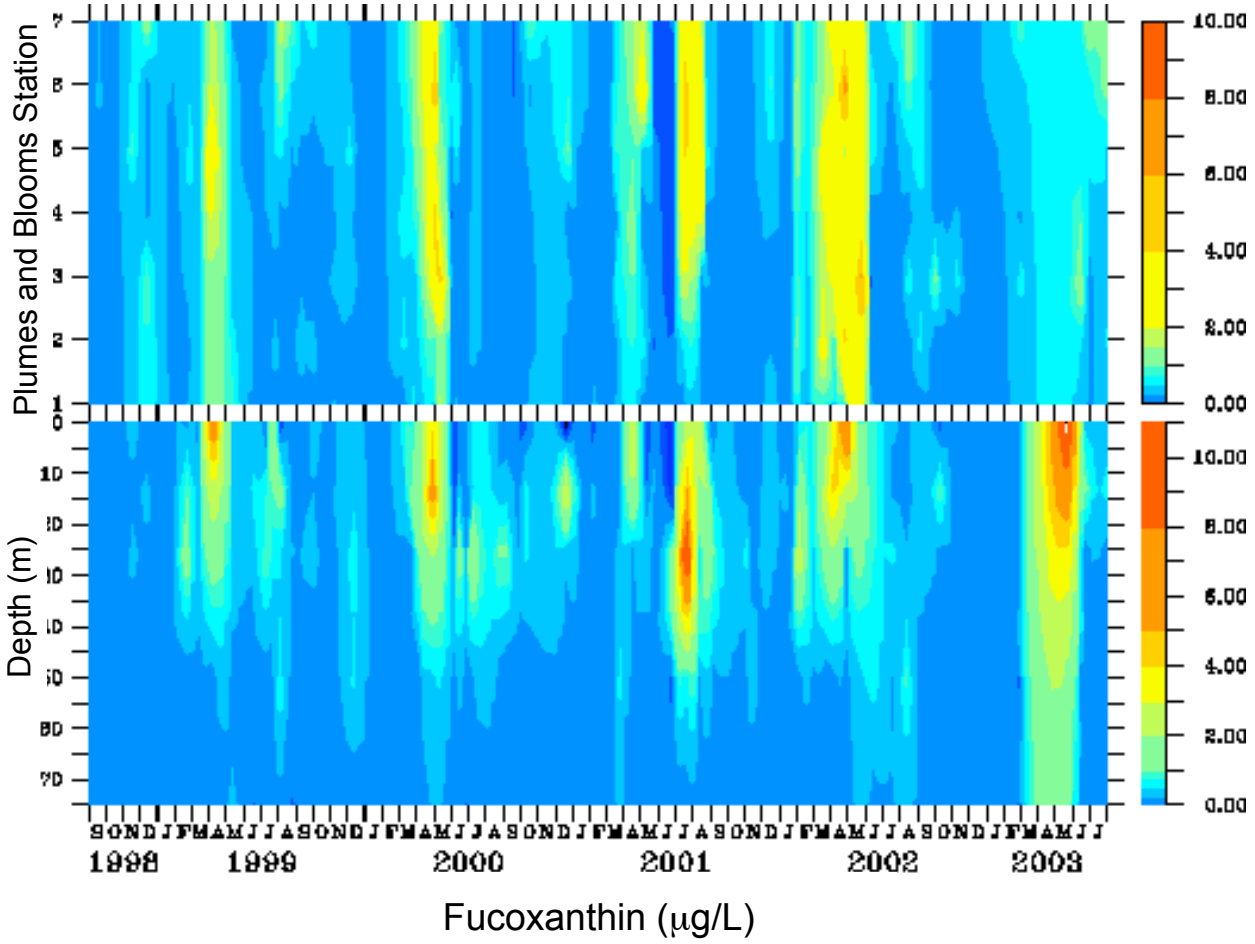
- Results from Kostadinov et al. JGR [2009]

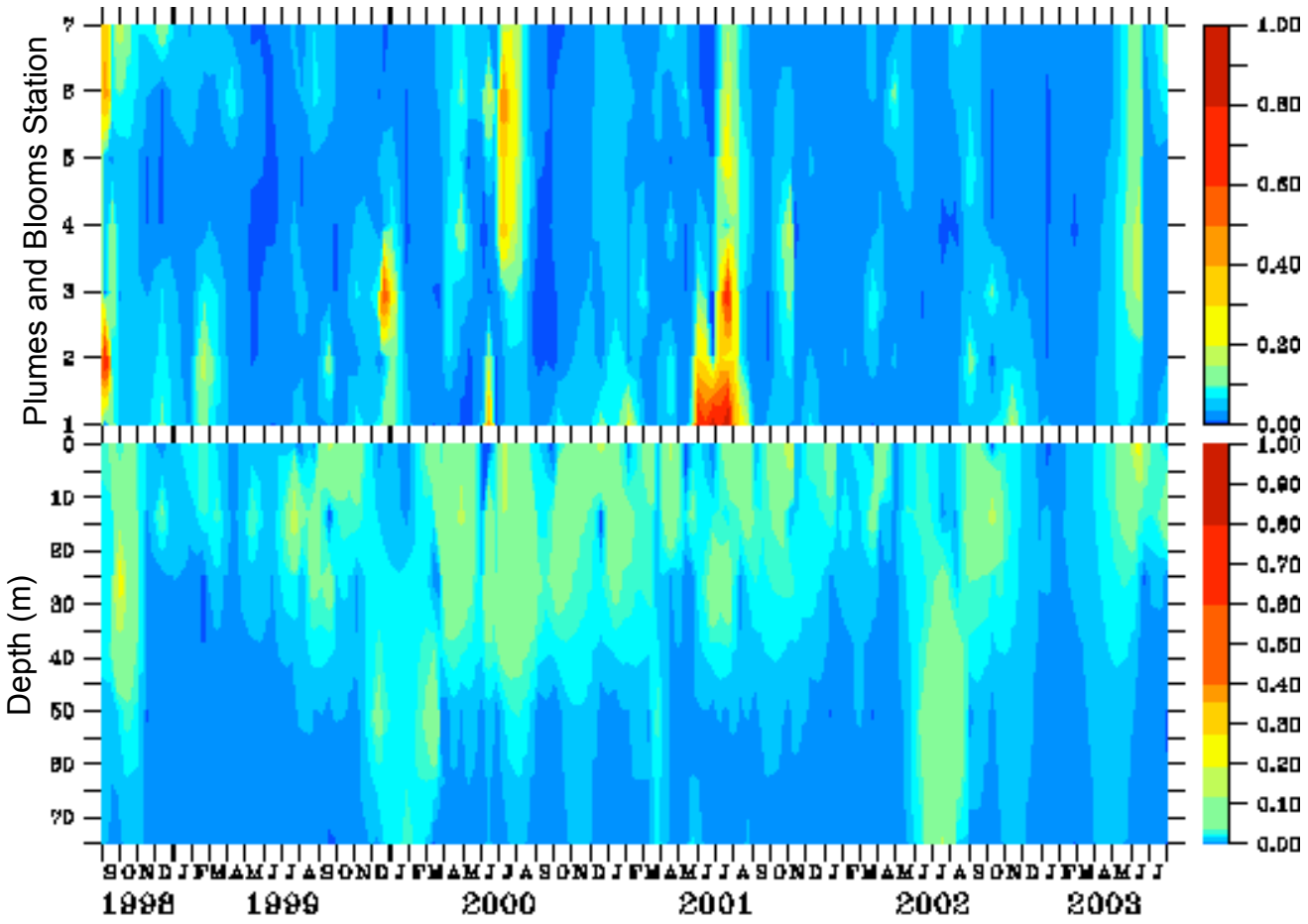
Plumes and Blooms - Santa Barbara Channel




Plumes and Blooms Station
Depth (m)
0
10
20
30
40
50
60
70
19.00
17.00
15.00
13.00
11.00
9.00
19.0
17.00
15.00
13.00
11.00
9.00
S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J
1998
1999
2000
2001
2002
2003
Temperature (C)


Plumes and Blooms Station
Depth (m)
1998
1999
2000
2001
2002
2003
Chlorophyll-a (μg/L)

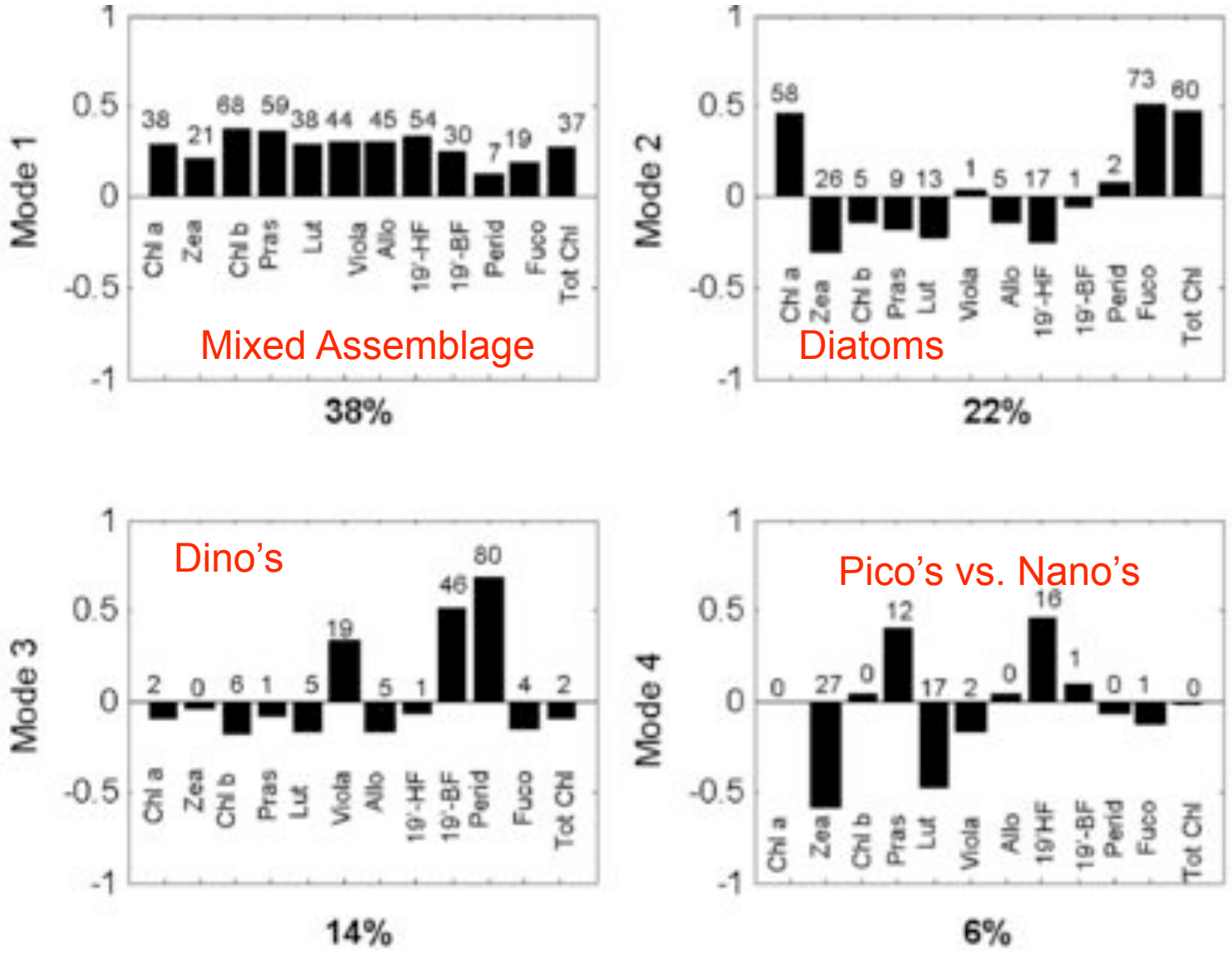

Plumes and Blooms Station
Depth (m)
1998
1999
2000
2001
2002
2003
Fucoxanthin (μg/L)


Plumes and Blooms Station
Depth (m)
1998
1999
2000
2001
2002
2003
Peridinin (μg/L)

Phytoplankton Pigments

Pigments	Abbreviation	Taxonomic Significance	Size class
Peridinin	Per	dinoflagellates	micro (>20 μm)
19'butanoyloxy-fucoxanthin	But	chromophytes nanoflagellates	nano (2 - 20 μm)
Fucoxanthin	Fuco	Diatoms	micro (>20 μm)
Violaxanthin	Viol	photo-protection	
19'hexanoyloxy-fucoxanthin	Hex	chromophytes nanoflagellates	nano (2 - 20 μm)
Alloxanthin	Allo	cryptophytes	nano (2 - 20 μm)
Zeaxanthin	Zea	cyanobacteria prochlorophytes	pico (>2 μm)
Lutien	Lut	photo-protection	
Chlorophyll b	Chl b	green flagellates prochlorophytes	nano (2 - 20 μm)
Chlorophyll a	Chl a		

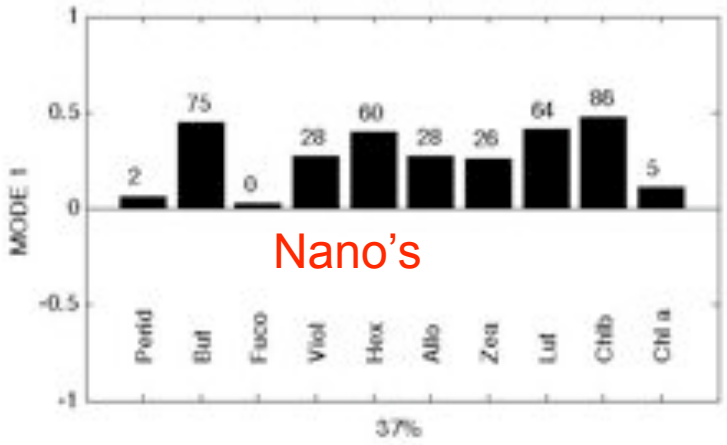
EOF Loadings & Correlations

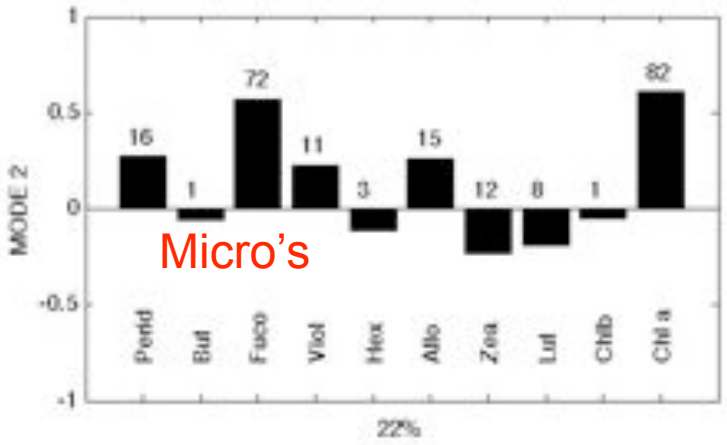


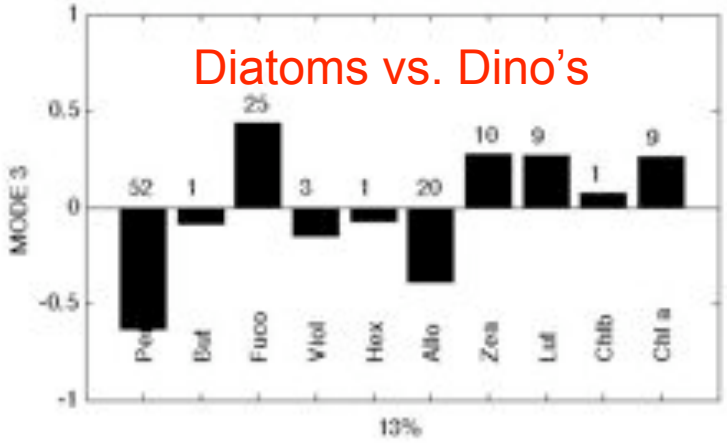
Anderson et al. [2007 - JGR]

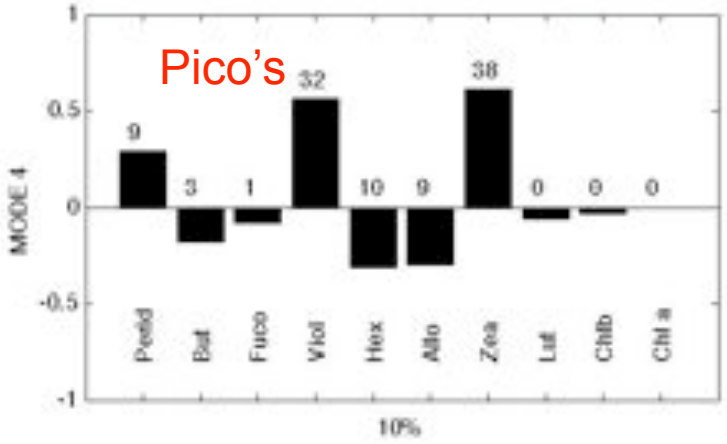
1998-2003 CHORS HPLC Analyses

EOF Modes for Diagnostic Pigments - 11/2005 – 8/2009







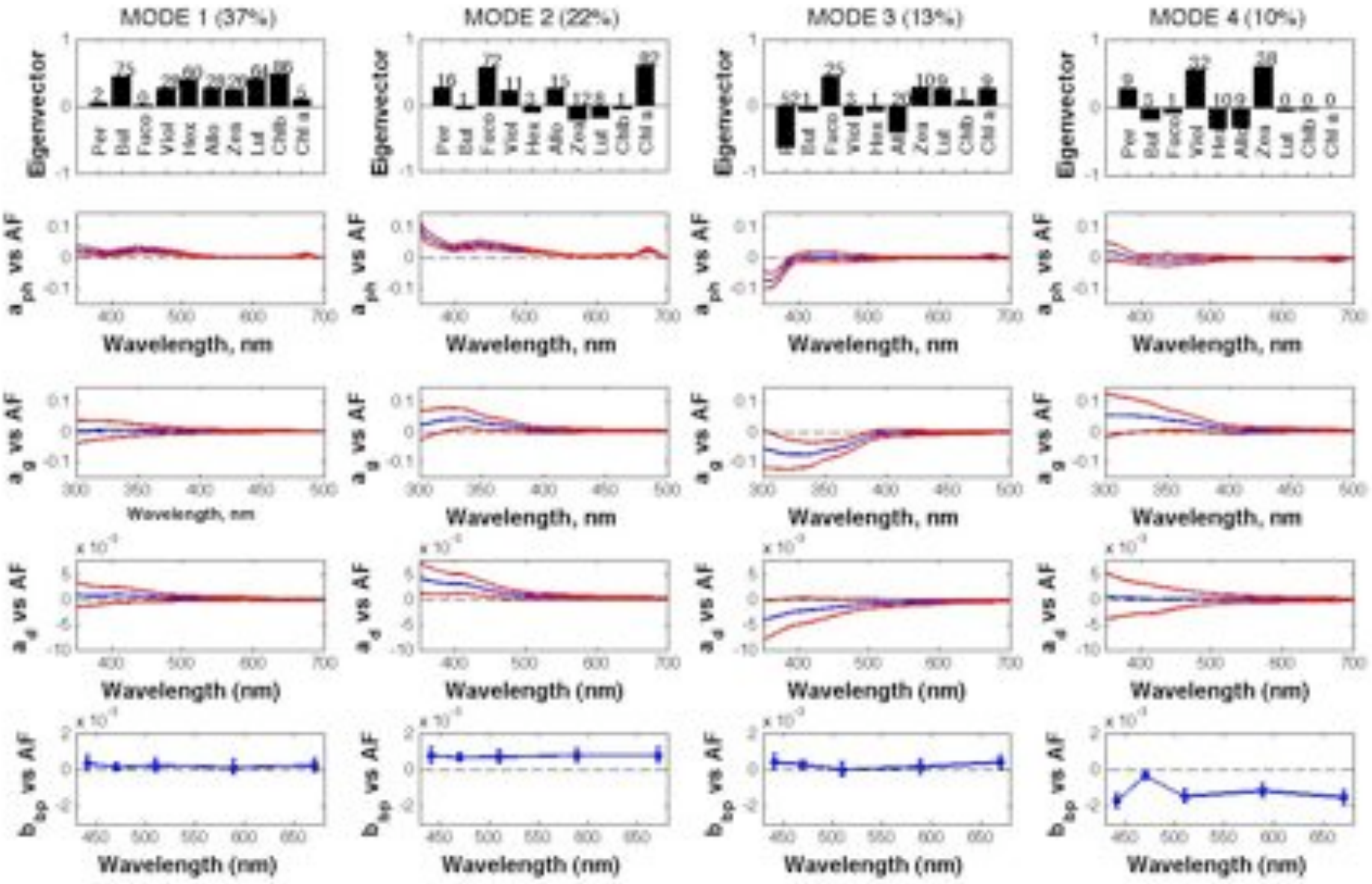


Rebecca Lawson Poster at Wed Evening

Horn Point HPLC

Relationship between PFT EOF Amplitudes & IOP's

Nano's | Micro's | Diatoms vs Dino's | Pico's

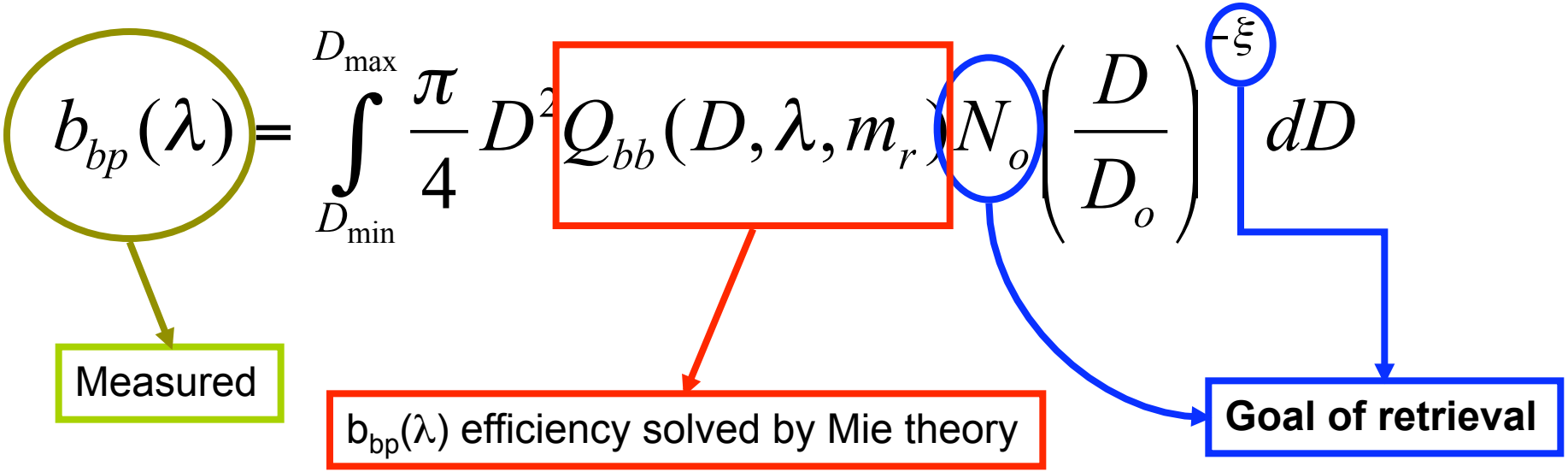


PnB PFT Modeling Results

- EOF analyses provides straight-forward way of distinguishing Phytoplankton Functional Types
  - To O(1) robust to HPLC source (CHORS vs. Horn Point)
  - New HPLC shows more clarity in separation of modes
- Preliminary assessment of the relationship to ocean color relevant IOP's
  - Suggests a coupling between PFT's & all IOP's - not just for phytoplankton absorption
  - Interesting UV absorption signals with dino/diatom mode
  - Building blocks for future PFT algorithms

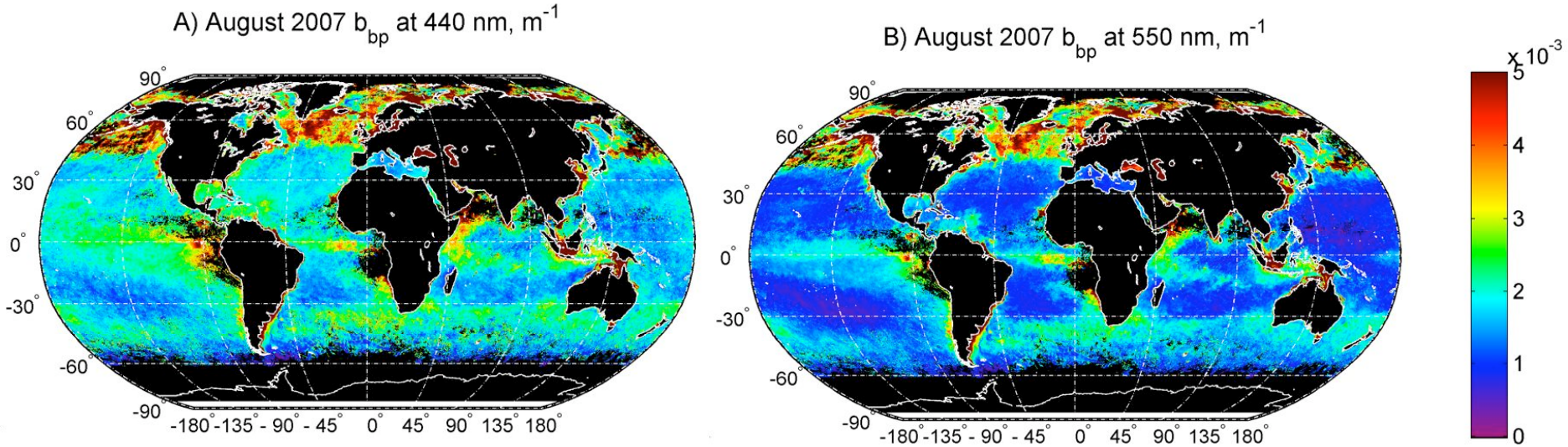
Retrieving the PSD

Constrain PSD using spectral backscatter & Mie

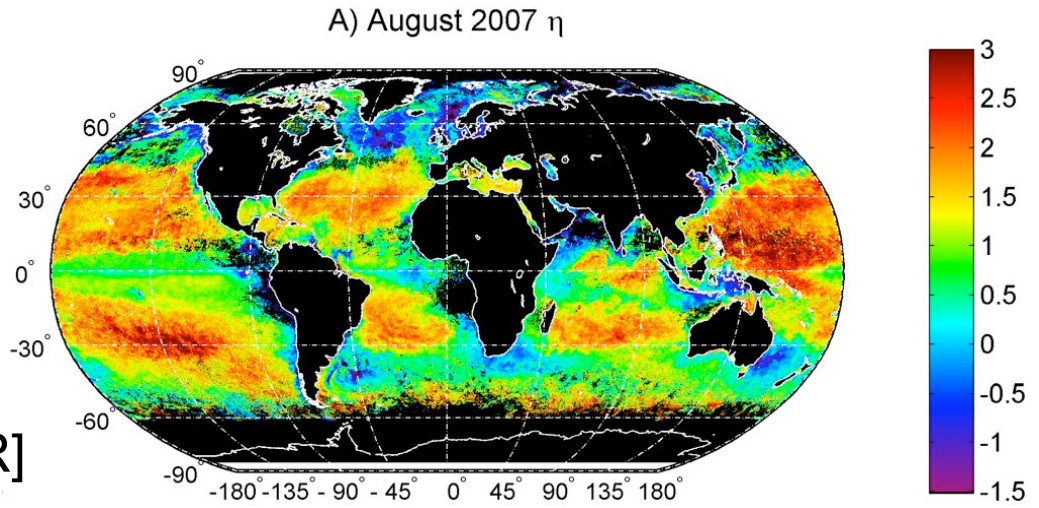


Kostadinov et al. [2009 - JGR]

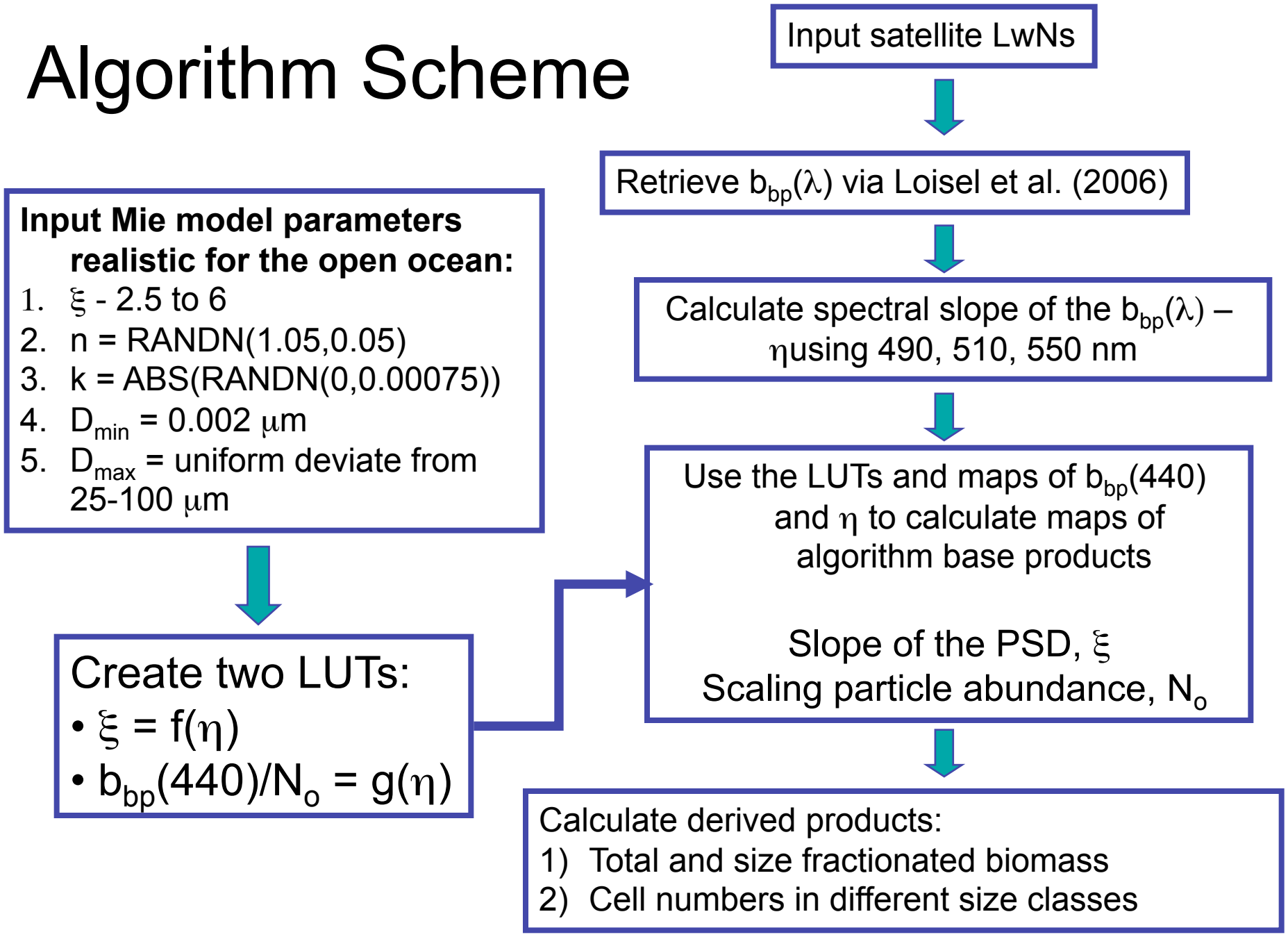
Retrieving Backscatter Spectrum

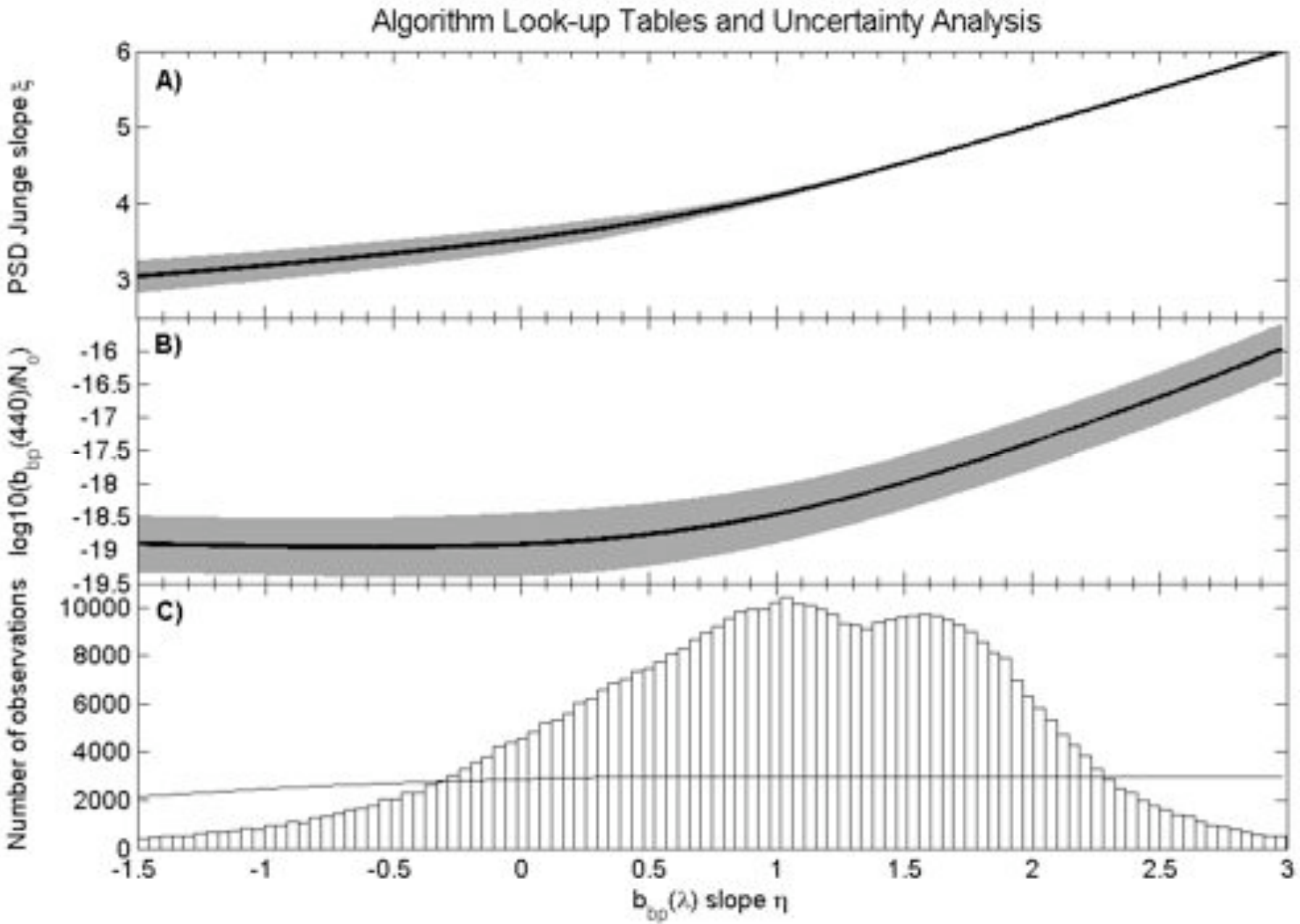


- Loisel & Stramski [2000] model retrieves $b_{bp}(\lambda)$
- Estimate spectral slope, η, from $b_{bp}(\lambda) = b_{bp}(\lambda_o)\ (\lambda/\lambda_o)^{-\eta}$
- Follows Loisel et al. [2006 - JGR]



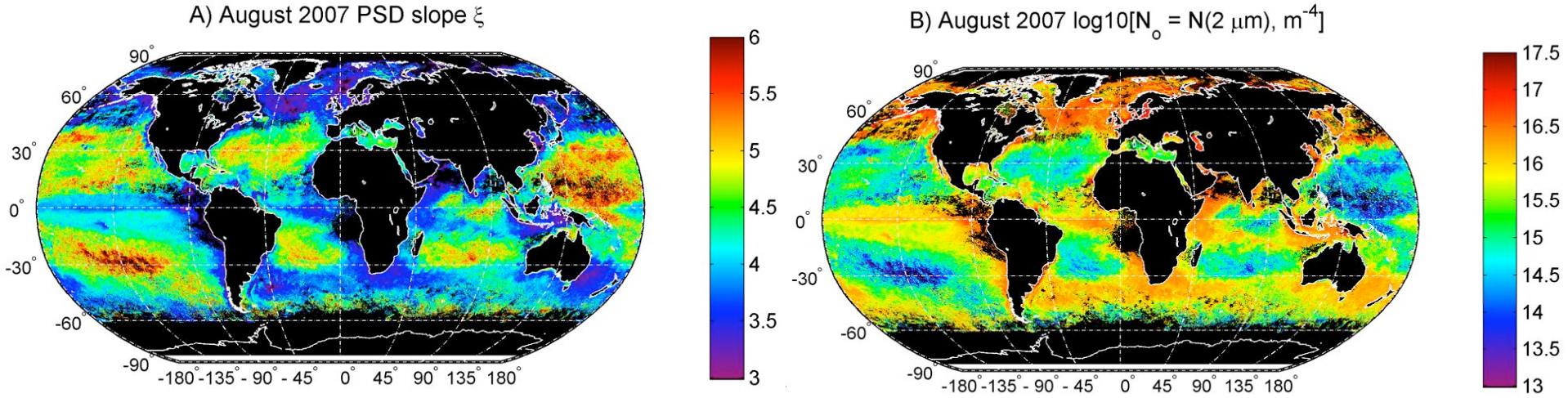
Algorithm Scheme





Kostadinov et al. [2009 - JGR]

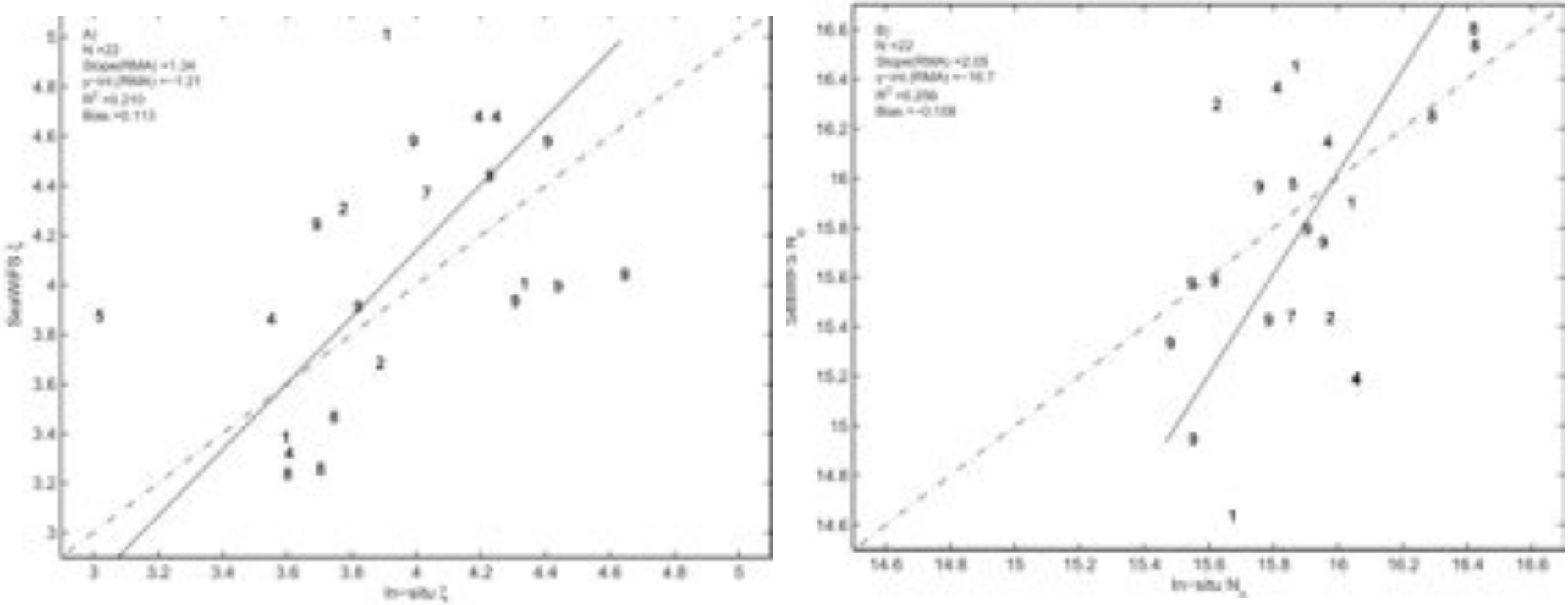
Power Law PSD Parameters



$$N(D) = N_o (D/D_o)^{-\xi}$$

- High slopes (ξ) in oligotrophic water - low in eutrophic oceans
- High scaling abudndances (N_o) in productive waters - low in oligotrophic oceans

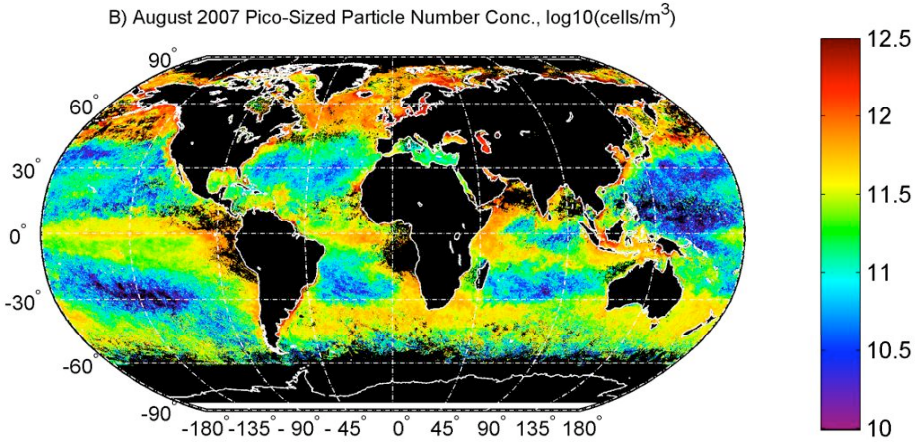
Power Law PSD Parameters



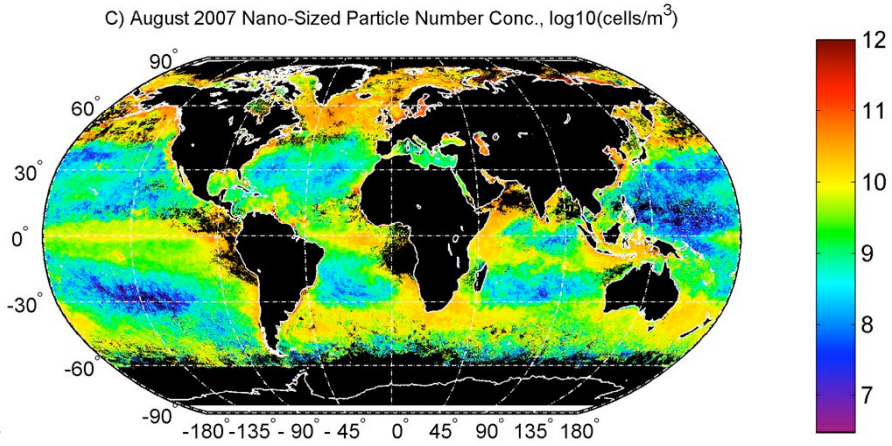
- Validation with available N(D) observations is OK
- Need more N(D) data (and protocols to make them)

Partitioning Number Concentration

Pico-particles (0.5 μm to 2 μm)



Nano-particles (2 μm to 20 μm)



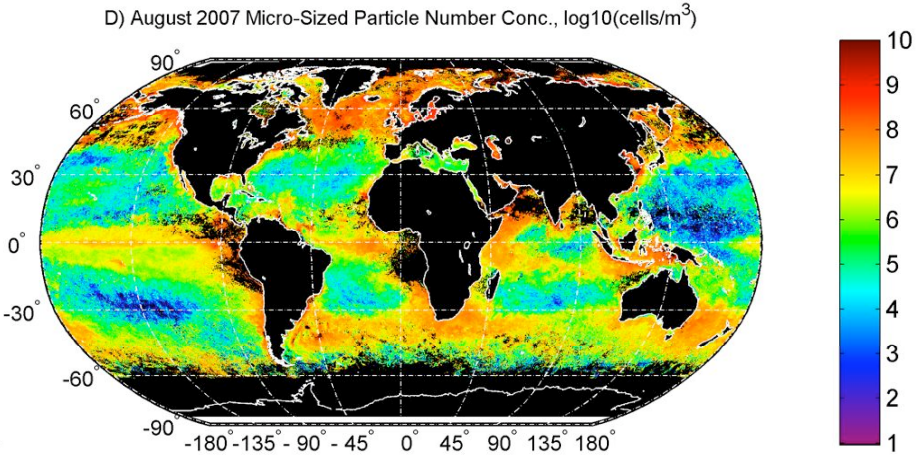
Pico's vary ~100 times

Nano's vary ~ 10,000 times

Micro's vary ~ 10^6 times

log10(particles/m^3)

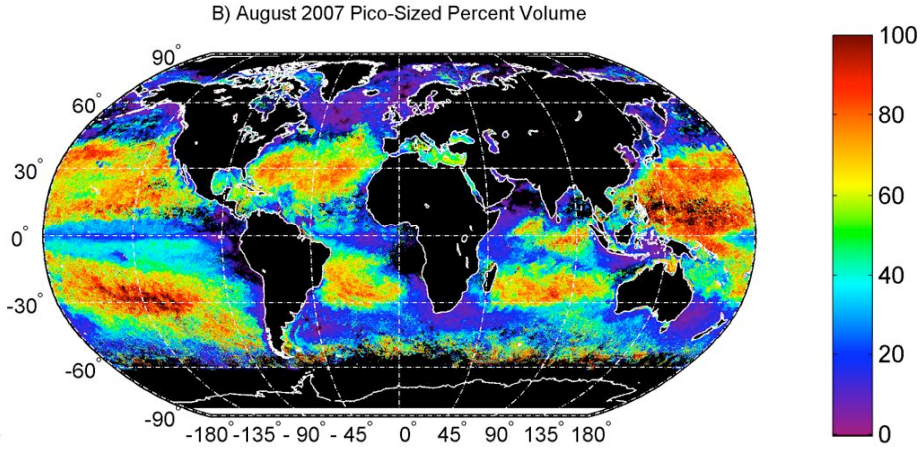
Micro-particles (20 μm to 50 μm)



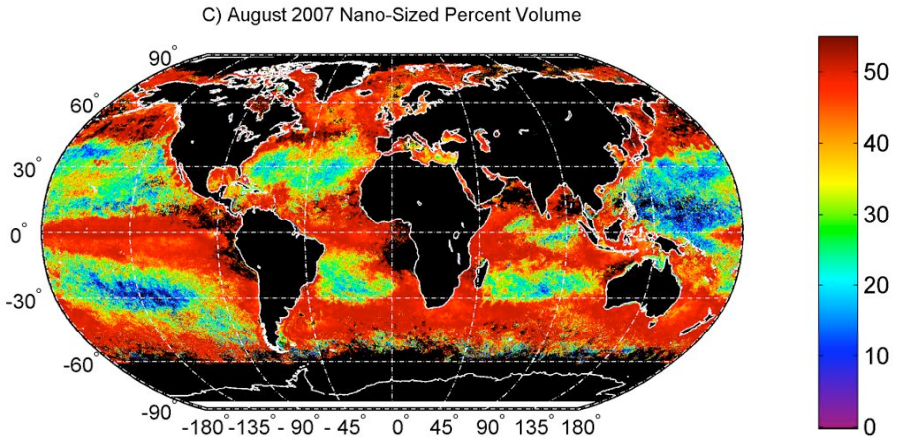
Kostadinov et al. [2009 - JGR]

Partitioning Particle Volumes

% Pico's (0.5 μm to 2 μm)



% Nano's (2 μm to 20 μm)

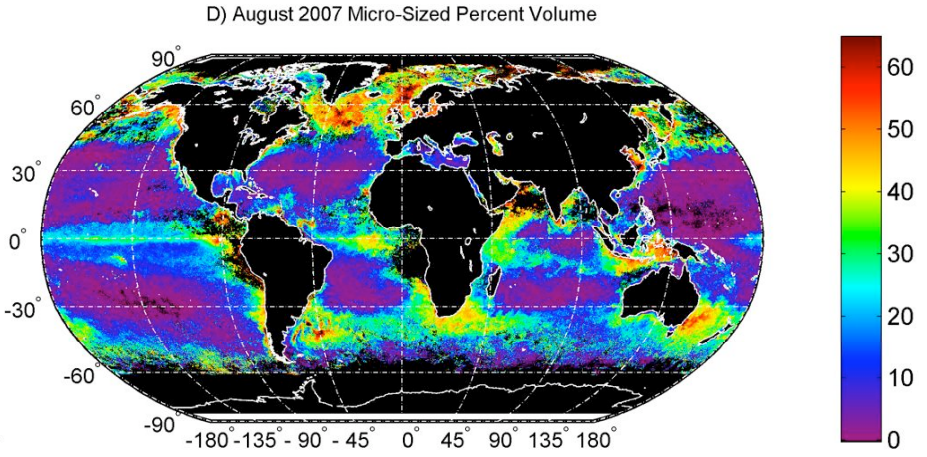


Pico's dominate oligotrophic ocean (>80%)

Nano's in transition regions (45%)

Micro's only found in upwelling zones & high latitudes (<40%)

% Micro's (20 μm to 50 μm)



Kostadinov et al. [2009 - JGR Oceans]

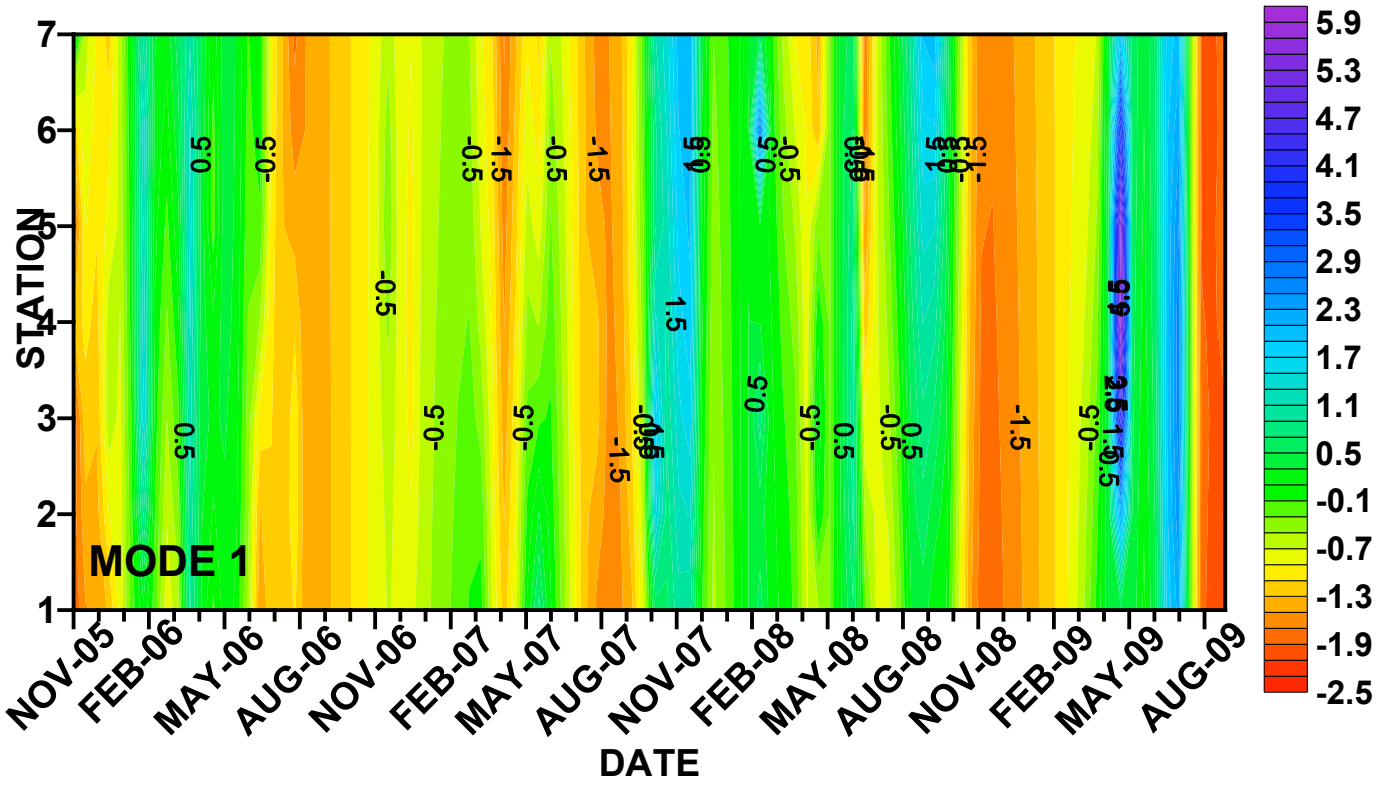
PSD Futures & Results

- PSD results makes sense ecologically…
- Validation is OK - but data are scarce
- PSD as global PFT's paper nearly submitted
- Work with in situ observations from PnB
  - Compare LISST N(D) & Hydroscat $b_b(\lambda)$ obs
  - Develop new statistical models of $Q_{bb}(\ldots)$??

$$b_{bp}(\lambda) = \int_{D_{\min}}^{D_{\max}} \frac{\pi D^2}{4} Q_{bb}(D, \lambda, m_r)\, N(D)\; dD$$

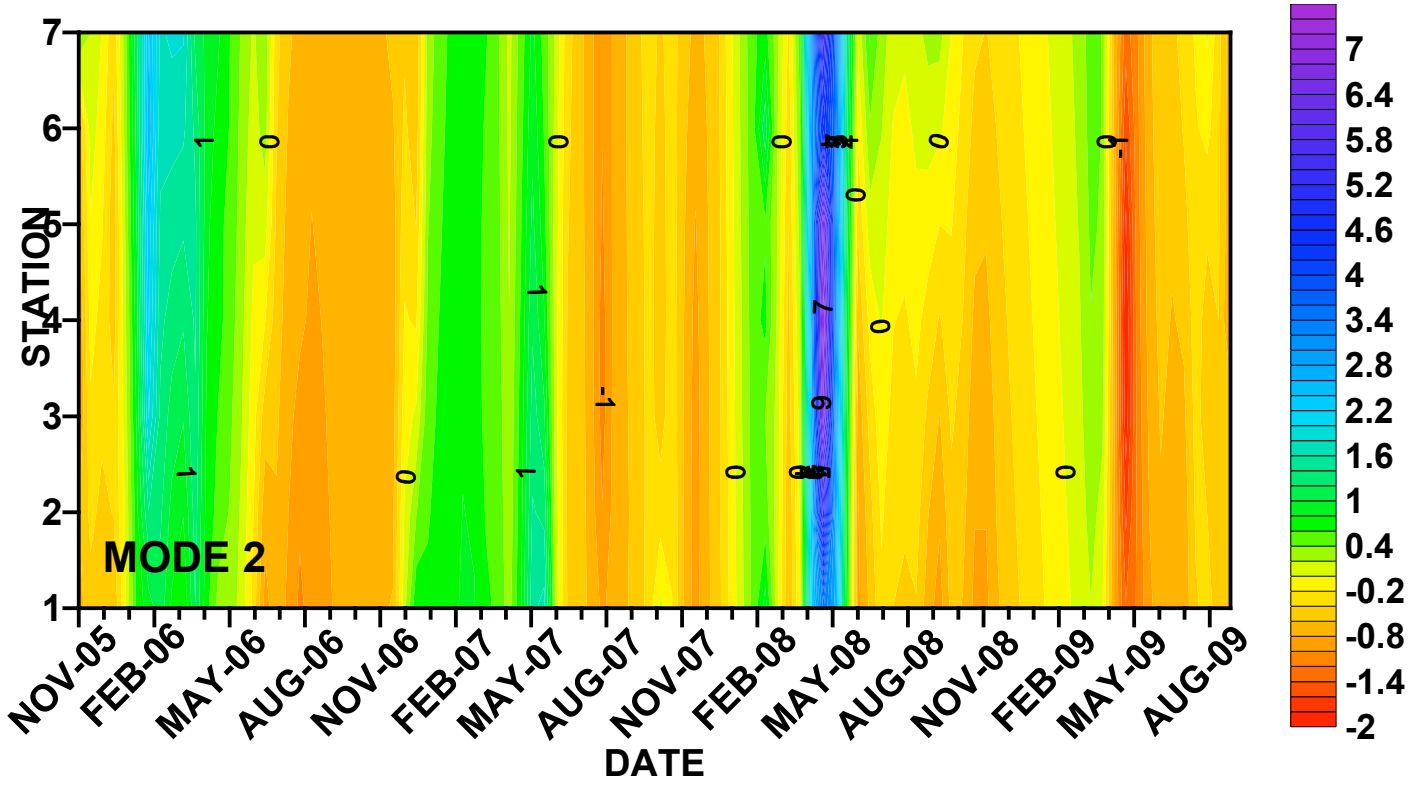

Thank You!!

Amplitude Functions for EOF modes in space and time



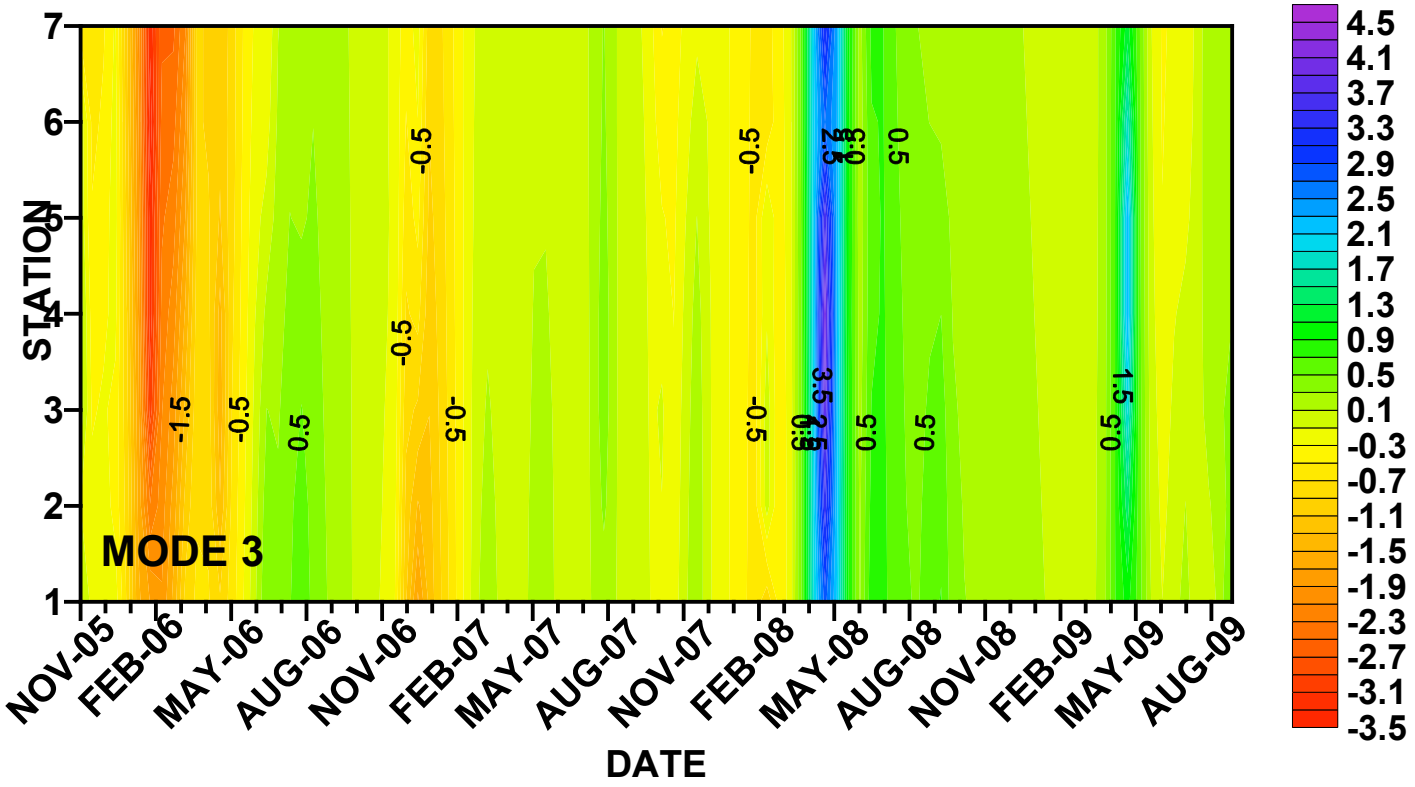
Mixed nanoplankton and picoplankton – microplankton have very low correlation with this mode

Amplitude Functions for EOF modes in space and time



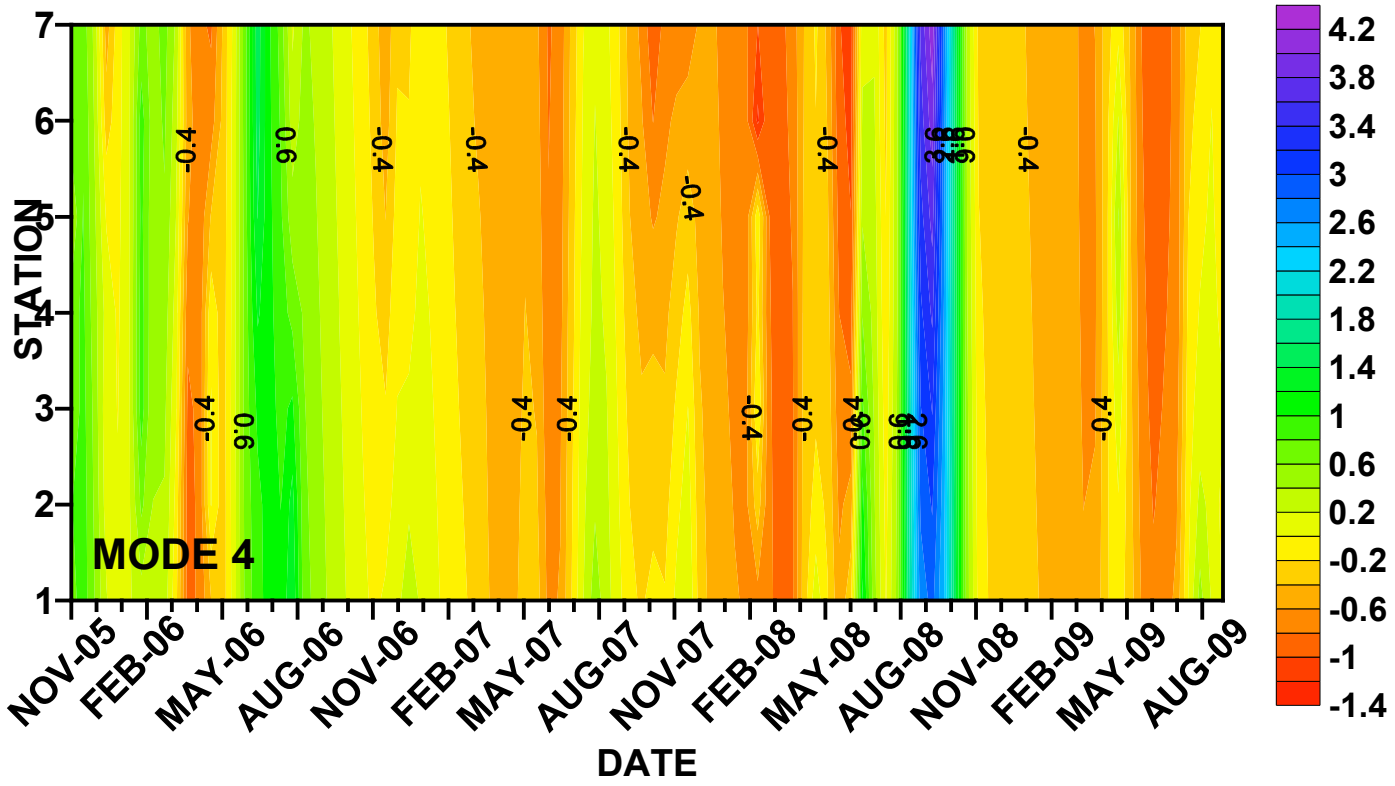
Mixed microplankton – Diatoms dominate this mode while dinoflagellates and cryptophytes are also present

Amplitude Functions for EOF modes in space and time



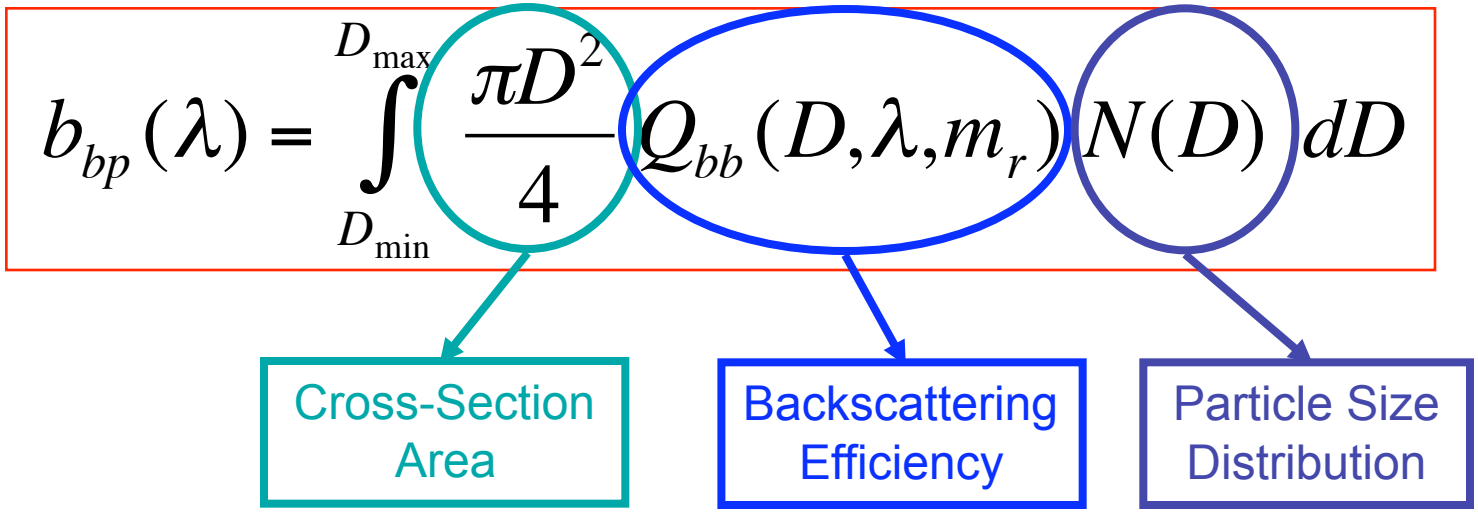
Alternating microplankton dominance – Negative values indicate dinoflagellate dominance and positive values indicate diatom dominance

Amplitude Functions for EOF modes in space and time



Picoplankton dominance – cyanobacteria DP and photoprotective DP have the strongest correlations (positive) with this mode.

Linking Particles & Backscattering



- Common assumptions are known to be poor

  $Q_{bb}(\ldots)$ from Mie theory for homogeneous sphere

  N(D) following power-law formulation ($N_o\ (D/D_o)^{-\xi}$)