Biogeochemical Proxies

Collin Roesler

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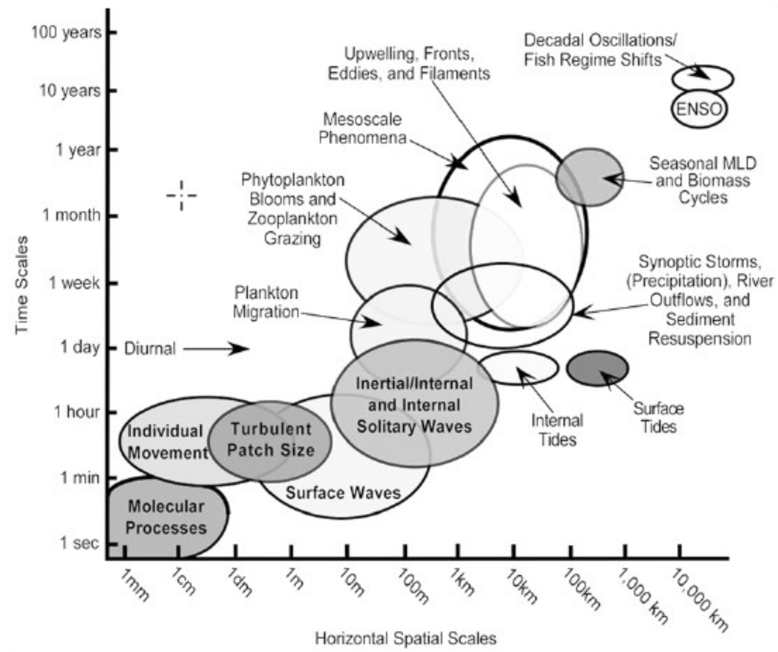
What are optically-based biogeochemical proxies

- Optical coefficients, parameters, indices that are related, either by empiricism or by mechanistic relationships, to biogeochemical parameters.

Why are *biogeochemical proxies* important

- Typically
  - We can measure optical properties on highly resolved, yet long-term time and broad space scales
  - Desired biogeochemical properties involve time consuming, expensive, and/or sample-dependent analyses which limit the temporal and spatial resolution and expanse
  - Optically-based proxies provide estimates of BGC properties on time and space scales that are relevant to their inherent processes, not afforded by discrete sampling



Theoretical or empirical basis for optical proxies for biogeochemical parameters

- *I know that optical property X varies with BGC property Y so perhaps I can derive a mechanistic relationship between them that should look like…*
- *vs*
- *I have a huge data set and I just plotted every optical property versus every BGC property to see which had high or the highest correlation coefficients*
- *Which is a "better" approach?*

Theoretical or empirical basis for optical proxies for biogeochemical parameters

- *The "best" approach depends upon what your ultimate desires or needs are*
- *Ask yourself the question "do I need an answer, or do I want to understand the mechanism"?*
- *Policy makers setting concentration limits for water quality parameters need an answer…*
- *Biogeochemical modelers often need to reveal and implement the underlying mechanisms to improve the robustness of their models*

No optical proxy for BGC parameter is perfect, what uncertainty are you willing to live with

Let’s do an exercise

- Build optical proxies for biogeochemical (and physical) parameters that are based upon your understanding of optical theory of IOPs
- Exercise 1 – sensor-based approach “*I have this sensor, what are the range of questions I can ask given the specific optical property measurements I can make?*”
- Exercise 2 – BGCP-based approach “*I am really interested in this particular BGCP process/cycle/dynamic, what optical tools can help me assess it mechanistically?*”

Mechanics

- Number off 1 through 6
- Merge two table together in a square
- Move to your assigned table (6 tables of 4 people)
- Sit around the table to maximize communication
- Assign a spokesperson who will report out your group's findings

Exercise 1 – sensor-based approach *"I have this sensor, what are the range of questions I can ask given the specific optical property measurements I can make?"*

- Select an IOP sensor from the list on the next slide
- You are invited on a collaborative cruise; you own this sensor.
- What can you contribute to the team in terms of optical proxies for BGCP parameters?

Exercise 1

Sensor-based

- c(660)
- bb(660)
- vsf, $\beta(\theta)$
- acs, $a(\lambda)$, $c(\lambda)$
- $a_{spectrophotometric}$
- $F_{chl\ (single\ excitation)}$
- $F_{chl\ (multiple\ excitation)}$
- F_{CDOM}

- Select 1 sensor
- Briefly review the theory of the measurement
- Describe how the optical property depends on characteristics of the particulate and dissolved matter and/or the seawater medium
- Propose how you would use it as a proxy for some biogeochemical or physical parameter
- Take ~5-10 minutes

Single channel beam attenuation, c(660)

- Raise you hand if you chose this sensor
- Lingering questions on measurement
- List of Proxies and why justified

Single channel backscattering, bb(660)

- Raise you hand if you chose this sensor
- Lingering questions on measurement
- List of Proxies and why justified

Volume scattering function, VSF

- Raise you hand if you chose this sensor
- Lingering questions on measurement
- List of Proxies and why justified

ac meter, a(λ), c(λ), b(λ)

- Raise you hand if you chose this sensor
- Lingering questions on measurement
- List of Proxies and why justified

spectrophotometer, $a(\lambda)$ for particulate and dissolved matter

- Raise you hand if you chose this sensor
- Lingering questions on measurement
- List of Proxies and why justified

Fchl, single excitation chlorophyll fluorometer

- Raise you hand if you chose this sensor
- Lingering questions on measurement
- List of Proxies and why justified

Fchl, multiple excitation chlorophyll fluorometer

- Raise you hand if you chose this sensor
- Lingering questions on measurement
- List of Proxies and why justified

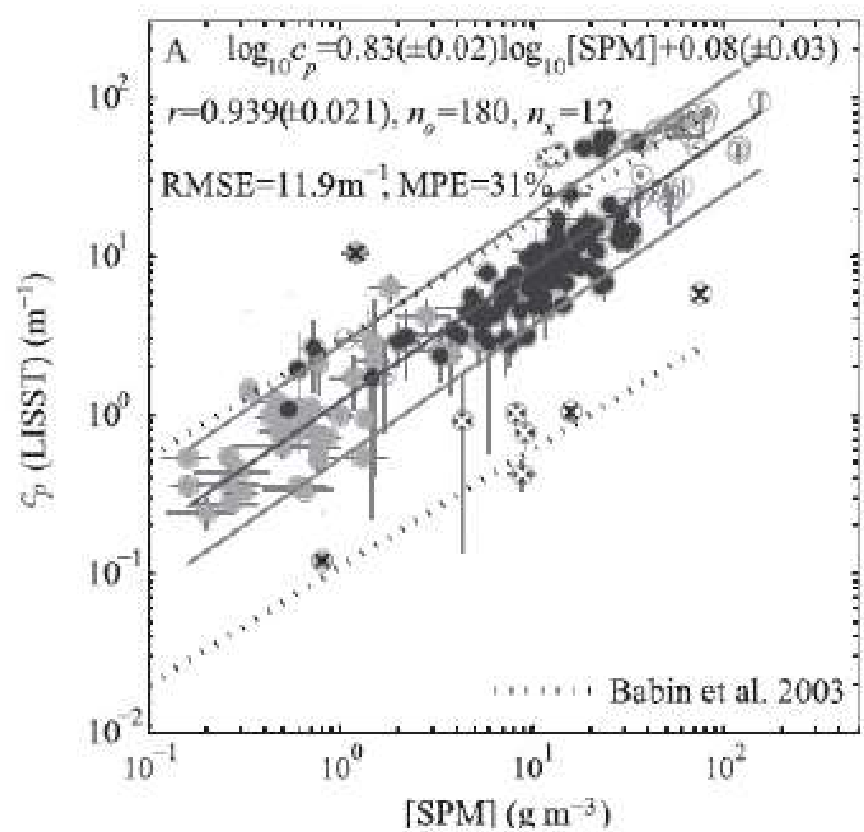
Fcdom, single excitation cdom fluorometer

- Raise you hand if you chose this sensor
- Lingering questions on measurement
- List of Proxies and why justified

Questions?

Yesterday Emmanuel raised the point that many proxies are driven by biomass

- Essentially when there is more phytoplankton biomass in the ocean, there is more of *everything*, meaning there is a lack of independence in the BGC properties and their respective optical proxies
- The "relationships" are due to the ~4 orders of dynamic range in biomass
- Assessing the real robustness of the proxies lies in the "noise" (typically factor of 10)
- We encourage you to think critically about underlying mechanisms for proxies and to consider whether you are driven by the biomass relationship or the mechanism giving rise to the noise



Extrinsic versus intrinsic proxies

- Most optical properties are related to the mass of material in the ocean, for example
  - IOPs vs Chl
  - IOPs vs TSS
  - IOPs vs POC
  - IOPs vs DOC
- These are extrinsic proxies
- Optical proxies that are not sensitive to biomass (essentially scaled by biomass) are sensitive to intrinsic properties of materials, for example
  - Backscattering ratio $\frac{b_{bp}}{b_p}$ sensitive to particle composition
  - Power spectral slope of beam attenuation, γ, size slope proxy
  - Chlorophyll-specific absorption, $a^*_{chl} = \frac{a}{[Chl]}$, pigment packaging proxy
  - Exponential spectral slope of CDOM absorption, S_{CDOM}, proxy for DOM composition