Deciphering phytoplankton community dynamics from HPLC pigment variability

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Background

Phytoplankton pigments can provide insight into phytoplankton size classes, functional groups and taxonomy. High Performance Liquid Chromatography (HPLC) pigment analysis has been used worldwide for decades as it remains one of the fastest and easiest ways to characterize community composition. Changes in pigment ratios can be caused by changes in species composition, increased growth of certain groups, or photoacclimation, but this distinction is not always acknowledged.

Objectives

Since HPLC pigment data is often used to calibrate and validate satellite/optical algorithms and models of phytoplankton community composition, our goal was to characterize ranges of pigment variability and evaluate the role of photoacclimation.

Methods

- Compilation of all HPLC data (n=89,000) from 1988-2015 (fig. 1, 2).
- Select surface samples (<20m, n=43,500, fig. 1)
- 8 diagnostic pigments (table 1)
- 2 pigment ratios ~ pico/micro: chlb/fuco and zea/fuco
- Satellite monthly MODIS PAR matchups (fig. 5-11)
- Selected 17 regions (~5x5 degrees, boxes in fig. 1)

Quality control:
1. Level of detection $>10^{-4}$
2. Ratio of accessory pigments to chl a

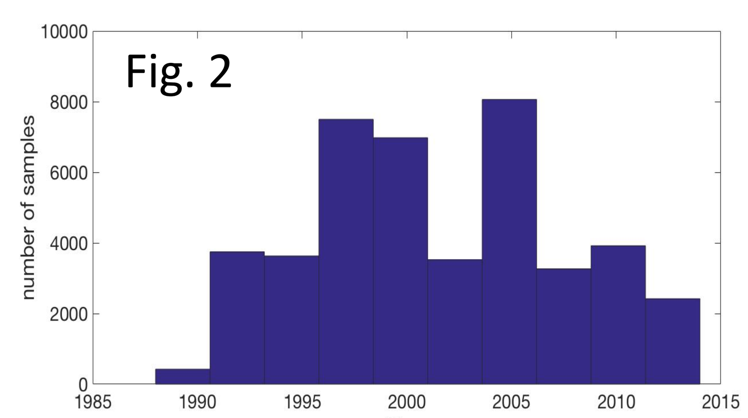


Figure 2. Temporal distribution of HPLC samples.

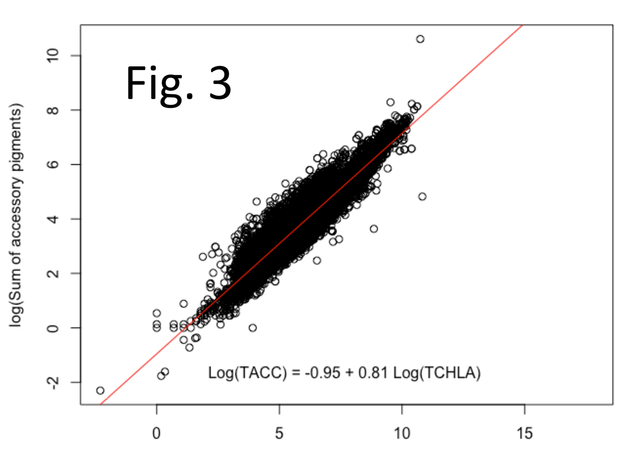
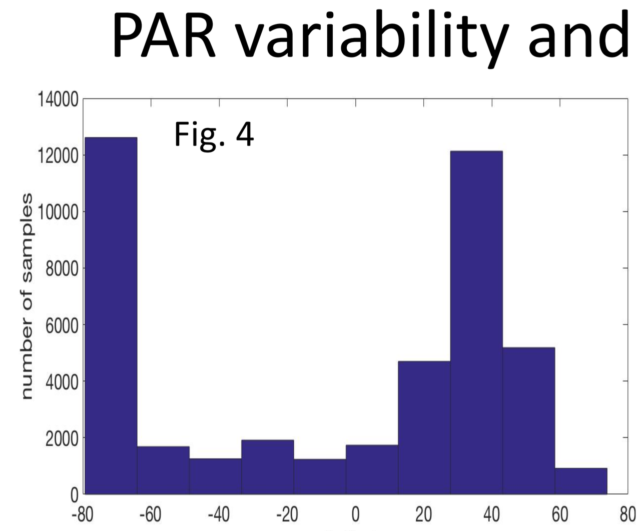


Figure 3. Log-linear relationship of the sum of all accessory pigments vs. chlorophyll a in HPLC samples.

pigment	Abbrev.	Taxonomic significance	size (µm)
zeaxanthin	zea	Cyanobacteria + prochlorophytes	< 2
Chlorophyll b	Chlb	Prochlorococcus + green flagellates	< 2
19'-hexanoyloxy-fucoxanthin	hex_fuco	Cromophytes + nanoflagellates	2-20
19'-butanoyloxy-fucoxanthin	but_fuco	Cromophytes + nanoflagellates	2-20
alloxanthin	allo	cryptophytes	2-20
fucoxanthin	fuco	Diatoms + haptophytes	2-20, >20
peridinin	peri	Dinoflagellates (type1)	>20

Table 1. Selected pigments and its associated taxonomy and size classification. Adapted from (Vidussi et al., 2000; Peloquin et al., 2013)

PAR variability and latitudinal ranges



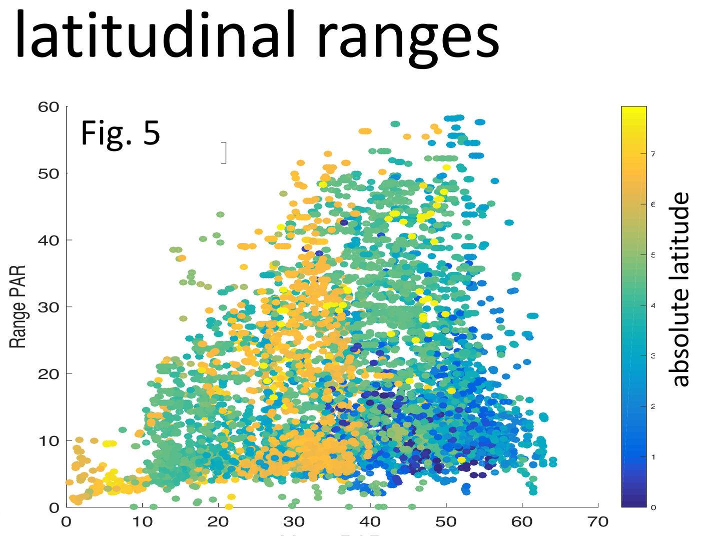


Figure 4. Histogram showing latitudinal distribution of samples.
Figure 5. Mean PAR vs. range of PAR variability within 1 degree bins for the location of each HPLC sample, colored by absolute latitude values. PAR units: E m^{-2} day^{-1}

Results

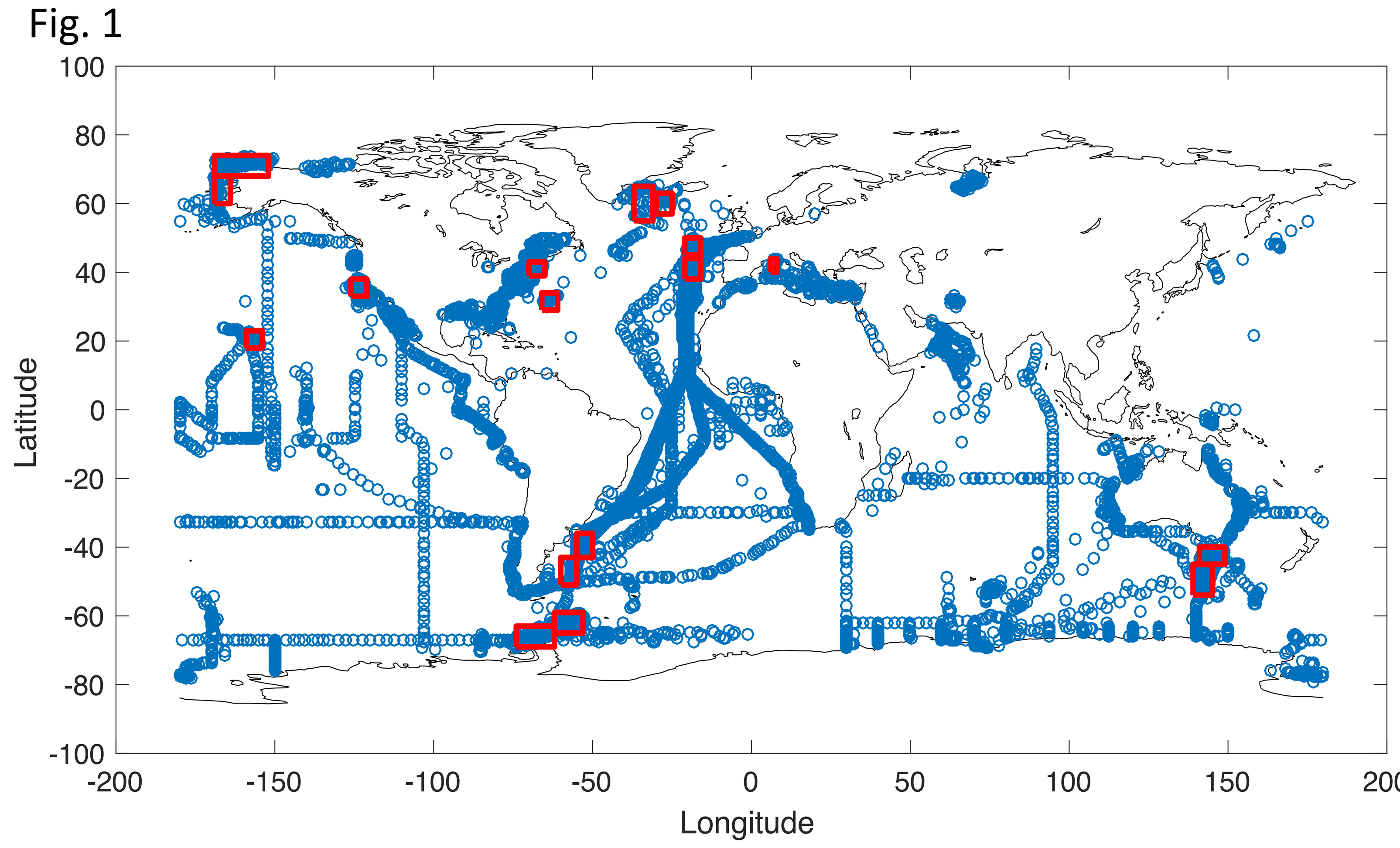


Figure 1. Distribution of surface HPLC samples (blue dots) and areas of study in figures 7-9 (red boxes).

Monthly PAR variability

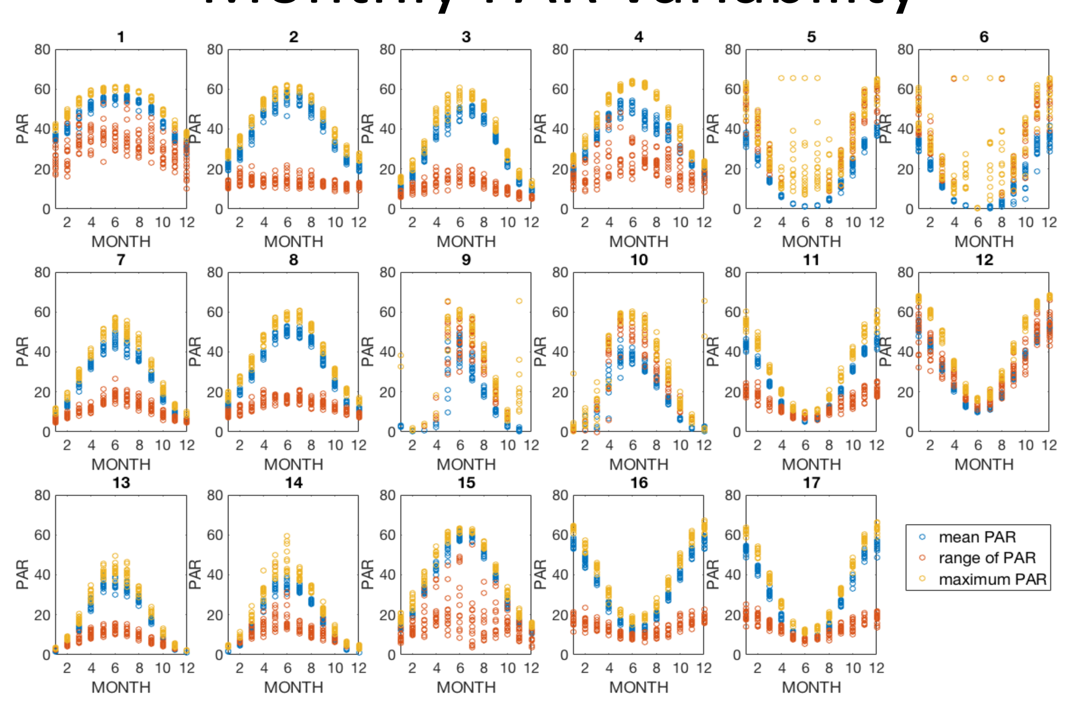
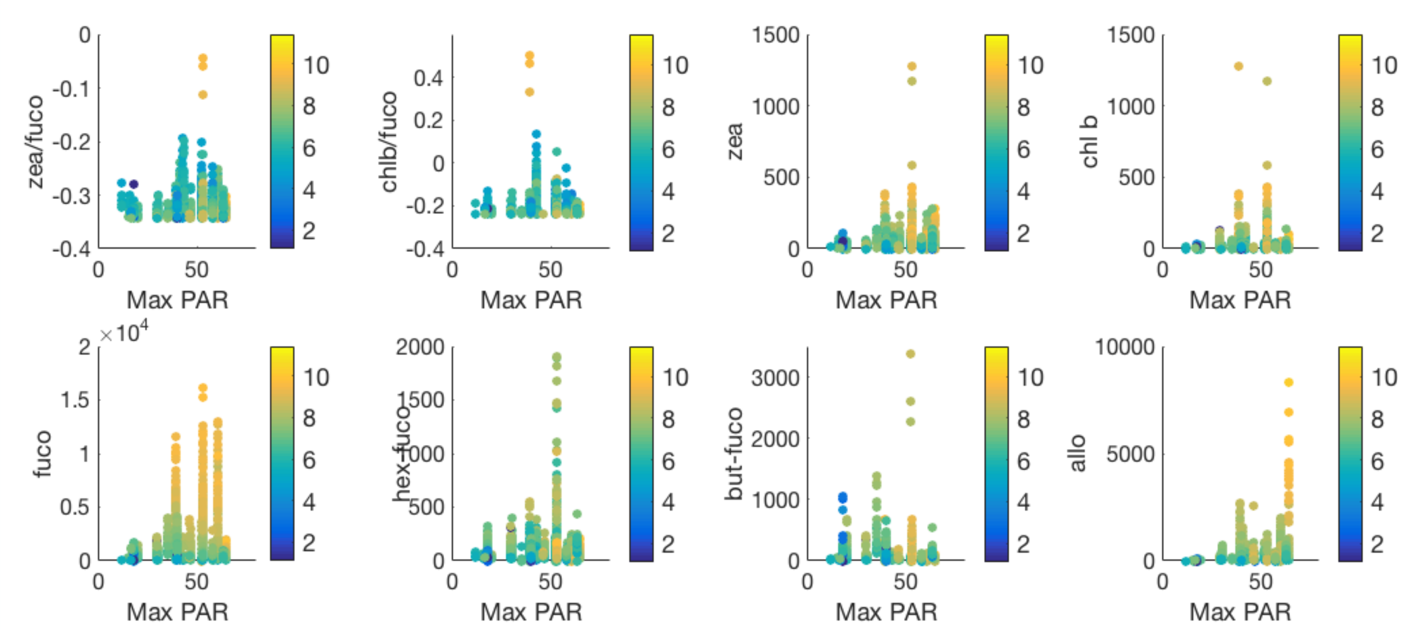


Figure 6. Satellite-derived monthly PAR variability (MODIS 4 km resolution) within each red box in figure 1. Mean, maximum and range of PAR (E m^{-2} day^{-1}) were calculated based on the pixels within each box for each given month.

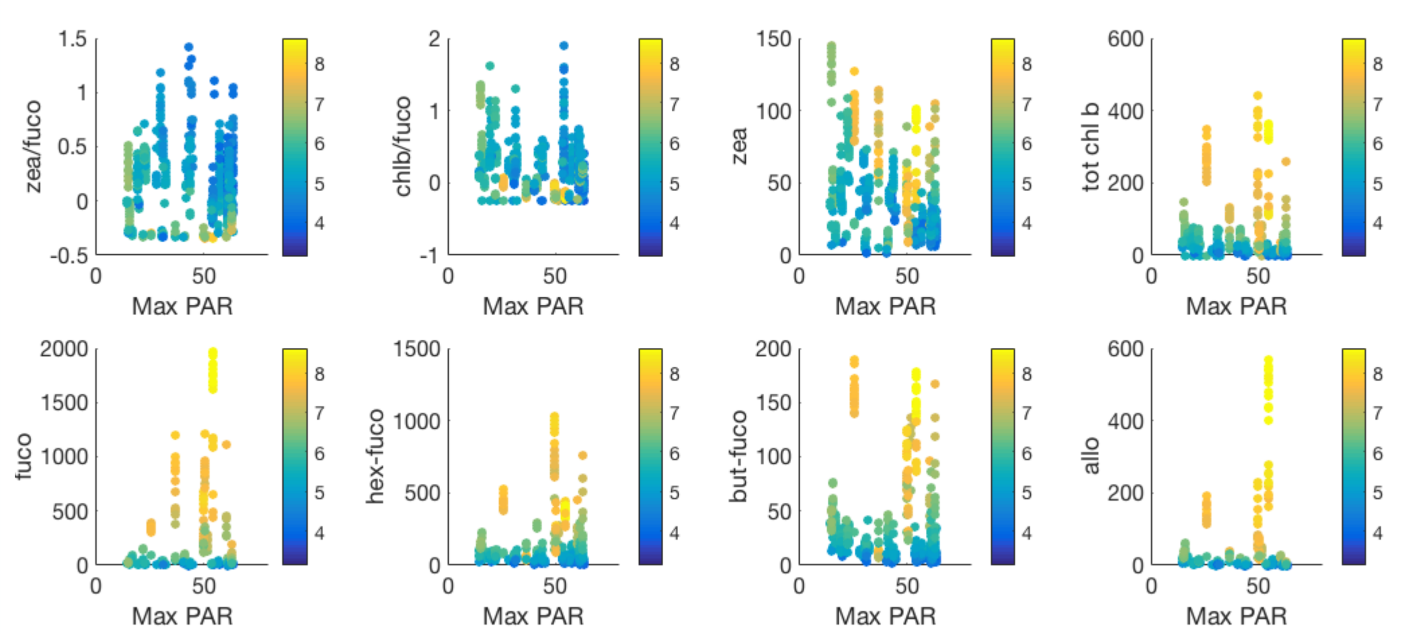
Regional Variability

Figures 7-9. Relationship between pigment ratios or concentrations and its corresponding monthly mean satellite PAR (E m^{-2} day^{-1}) per region: polar, temperate (Mediterranean) or subtropical. Markers colored by the logarithm of chlorophyll a concentrations (ng/l).

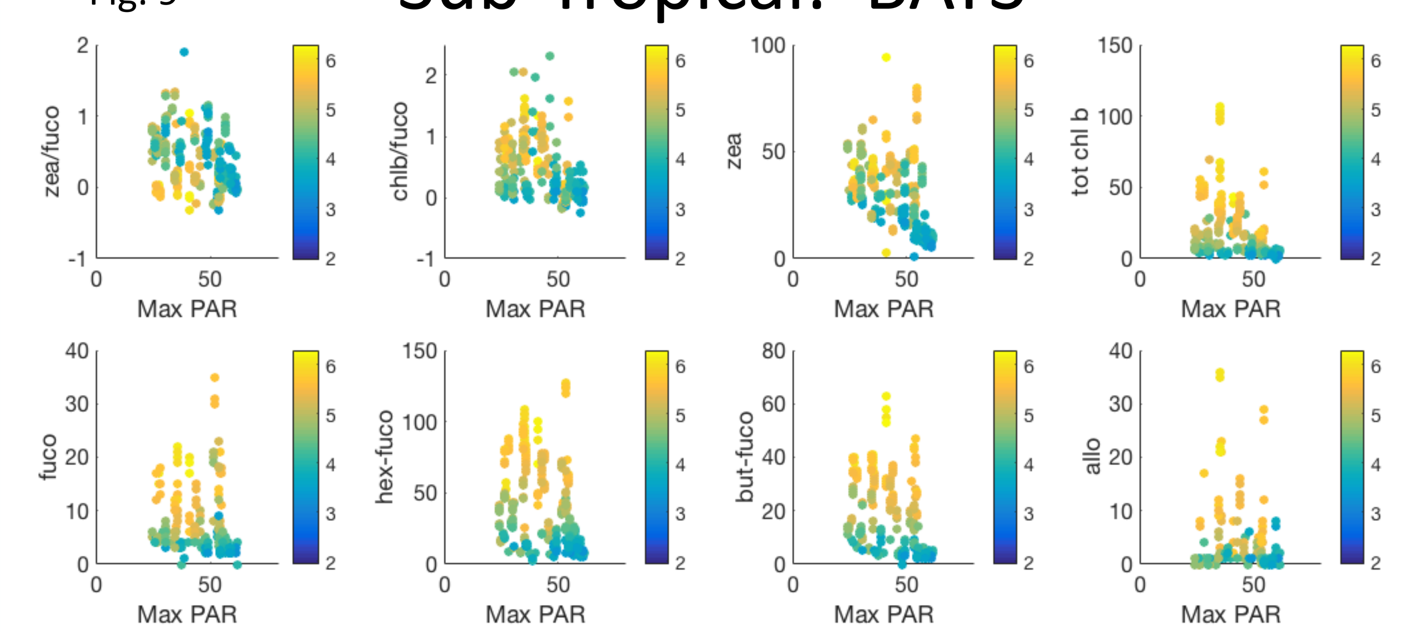
Polar: Palmer



Temperate: Boussole



Sub-Tropical: BATS



Pigments, PAR and latitude

Figure 10: Relationship between pigment ratios and monthly mean PAR (left panels) or range of PAR variability (right panels). Markers colored by the logarithm of chlorophyll a concentrations (in ng/l). PAR (E m^{-2} day^{-1}) calculated from pixels within 1 degree to the location of each HPLC sample.

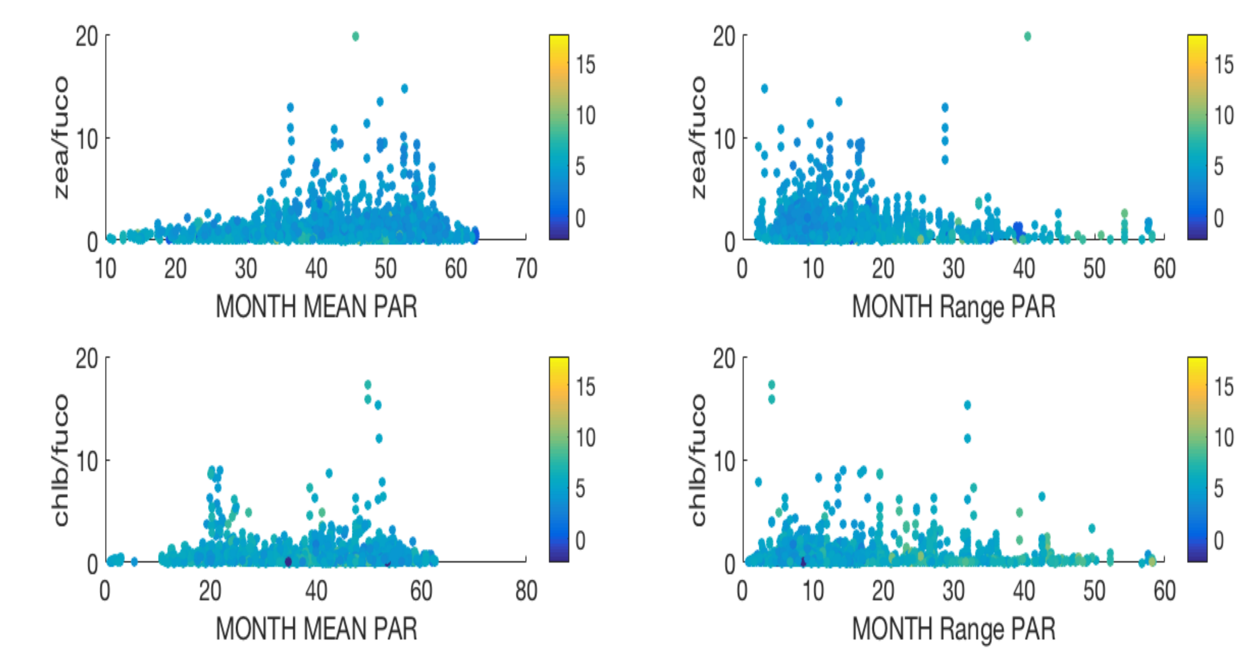
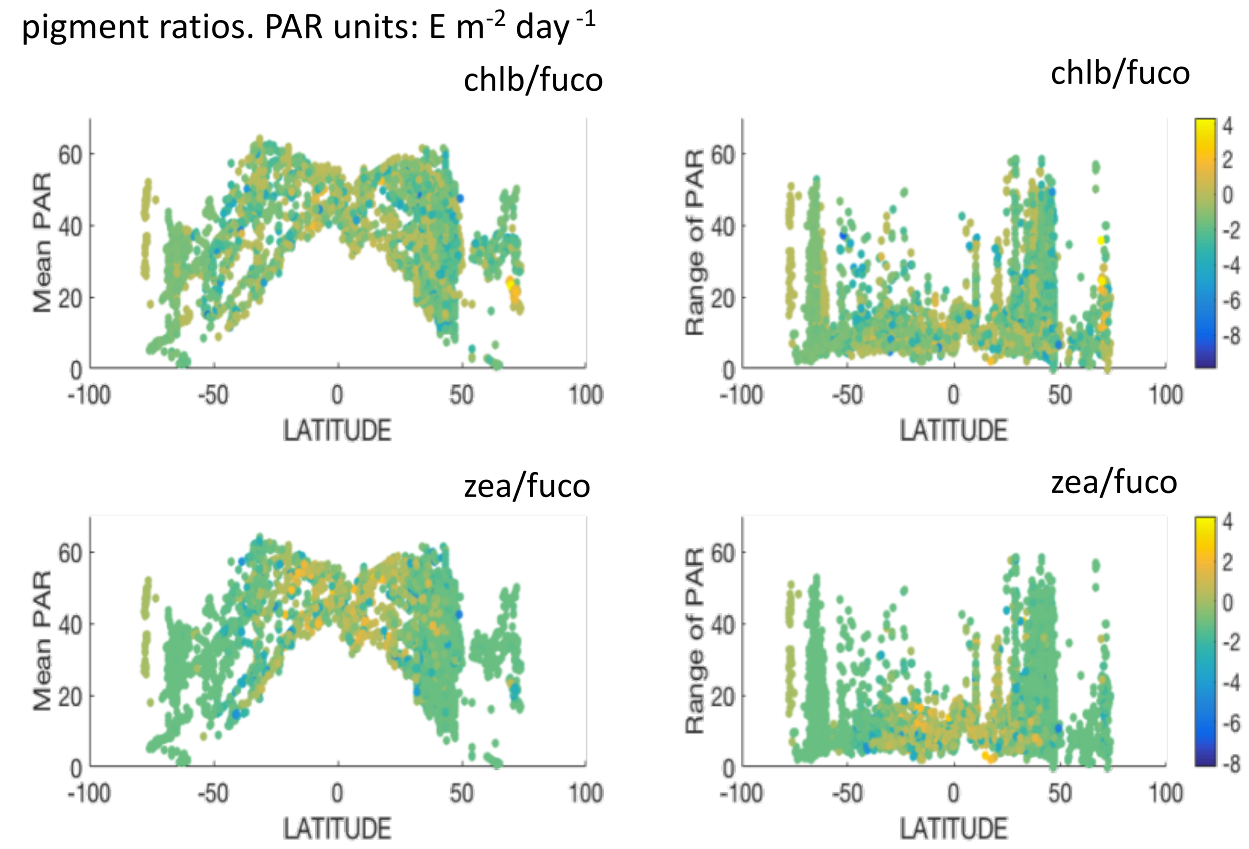


Figure 11: Relationship between sample latitude and corresponding monthly mean PAR (left panels) or range of PAR variability (right panels) within 1 degree of the location of each HPLC sample. Markers colored by the logarithm of pigment ratios. PAR units: E m^{-2} day^{-1}



Conclusions

- Within regions, the relationship between individual pigment and PAR suggest photoacclimation responses. For pigment ratios, this trend might be driven by community composition and biogeography.
- On a global basis, trends in pigment ratios reproduce expected biogeographical patterns BUT exactly how similar (or different) is the variability in pigment ratios to the variability in phytoplankton size fractions?

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