PHYTOPLANKTON COMMUNITIES & BIO-OPTICAL PROPERTIES IN THE SOCLIM REGION – FIRST RESULTS

Julia Uitz, Christophe Penkerc'h, Hervé Claustre, Annick Bricaud, Céline Dimier, Joséphine Ras, Antoine Poteau & Edouard Leymarie

Laboratoire d'Océanographie de Villefranche, Villefranche-sur-Mer

Collin Roesler & Susan Drapeau

Bowdoin College, Brunswick, Maine, USA

OUTLINE

Phytoplankton communities

Biomass

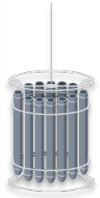
Composition

Bio-optical properties in the context of bio-optical anomalies

Absorption of phytoplankton

Absorption of Colored Dissolved Organic Matter (CDOM)

Particulate backscattering coefficient



HYDROCAST STATIONS

Vertical profiles of hyperspectral optical and biogeochemical properties within the water column

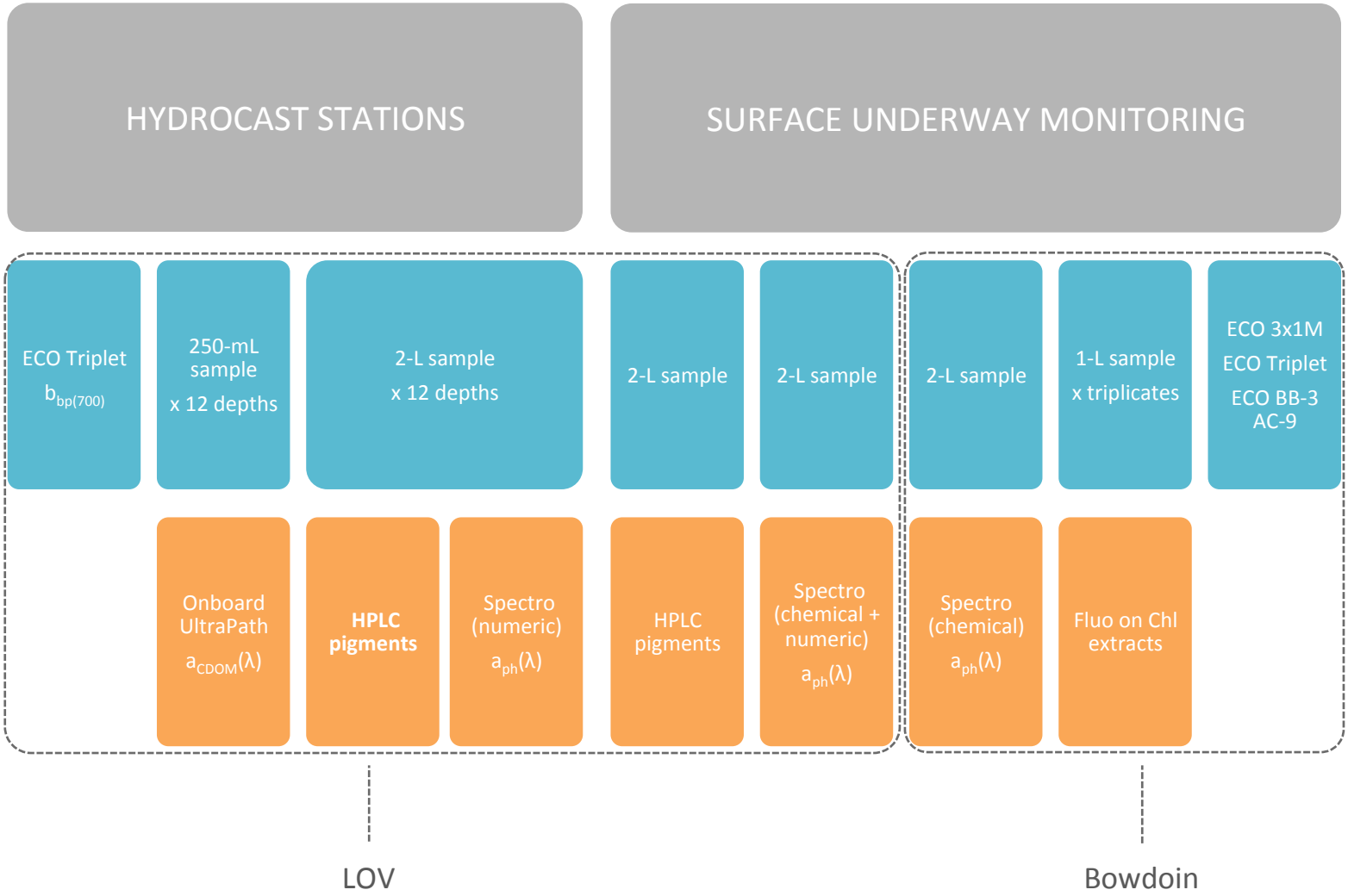
SURFACE UNDERWAY MONITORING

Acquisition of optical and biogeochemical properties using the vessel's surface flow through system

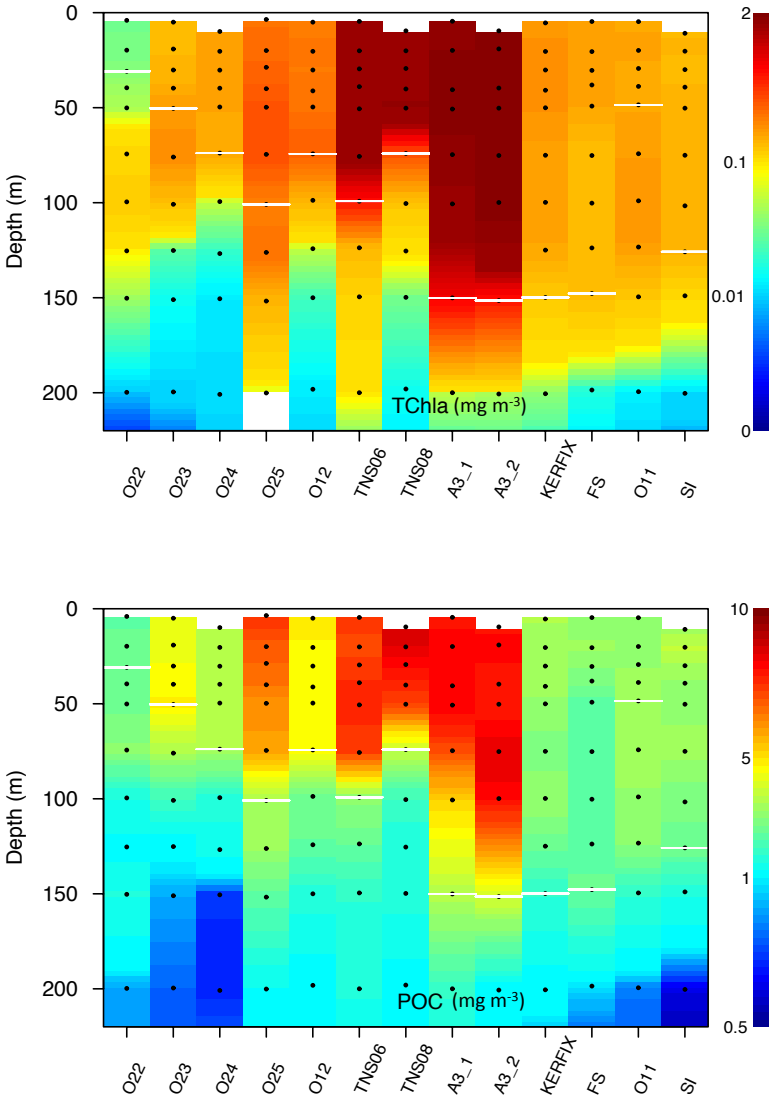
BGC-ARGO AND PROVAL FLOATS

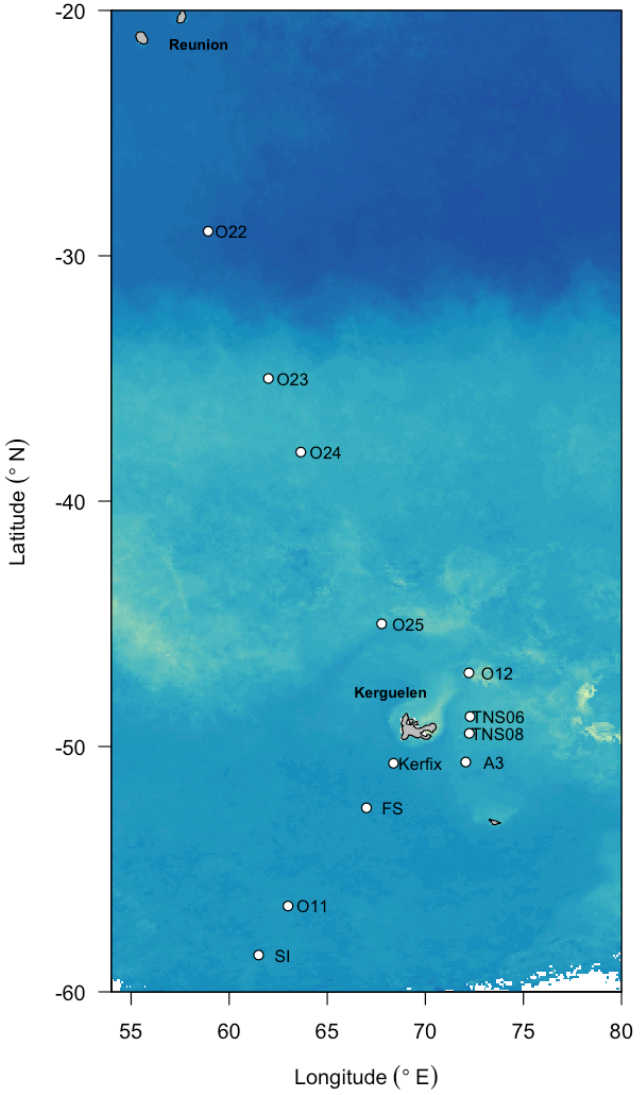
Bio-optical proxies within the water column for several years beyond the cruise

DATA & METHODS

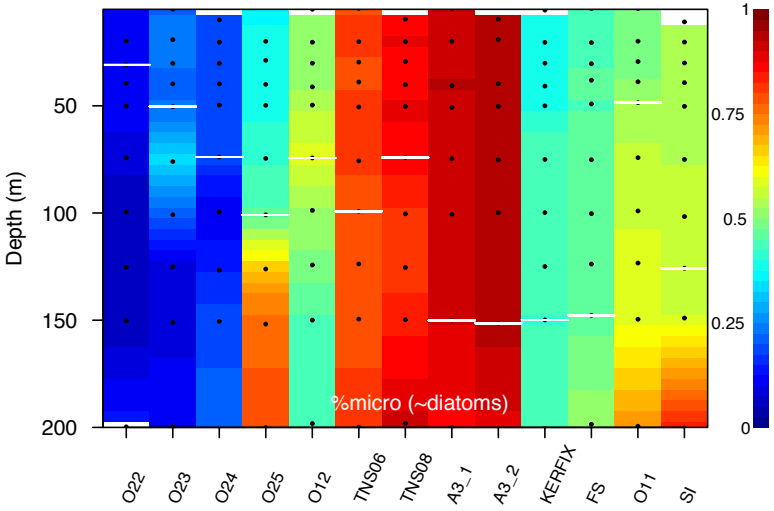


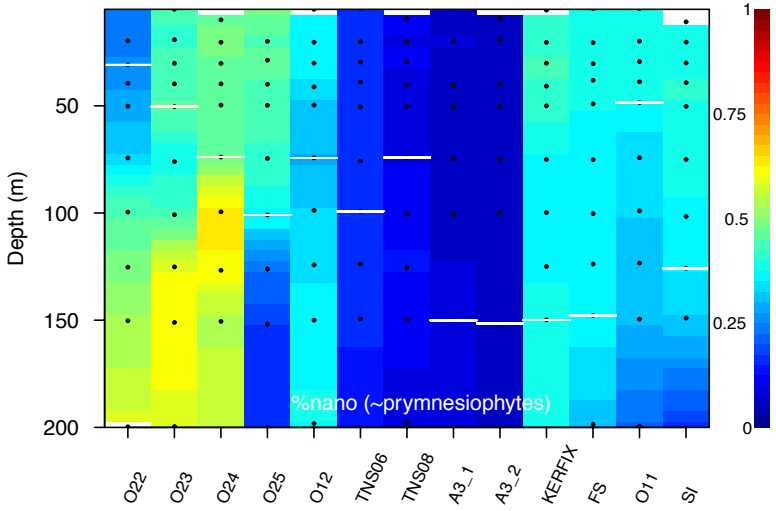
PHYTOPLANKTON BIOMASS AND COMPOSITION

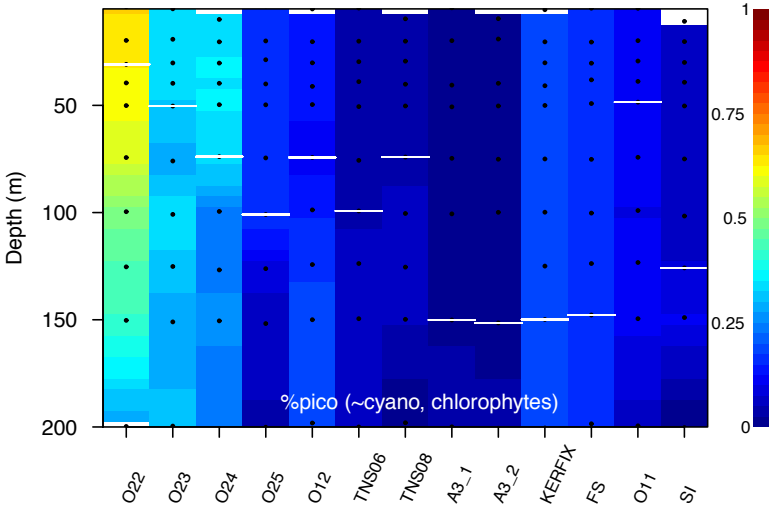




PHYTOPLANKTON BIOMASS AND COMPOSITION

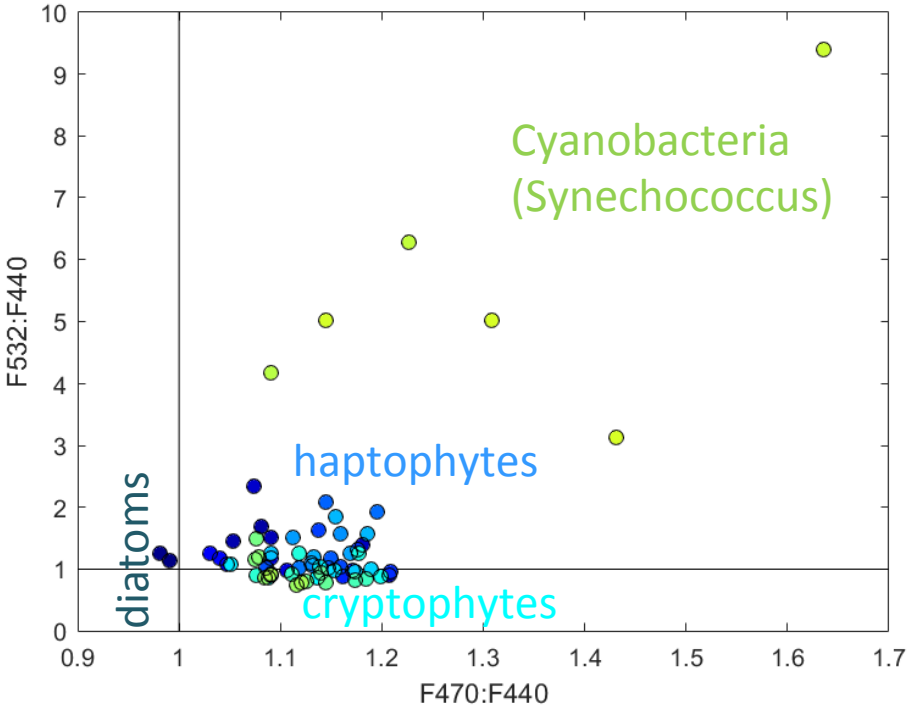


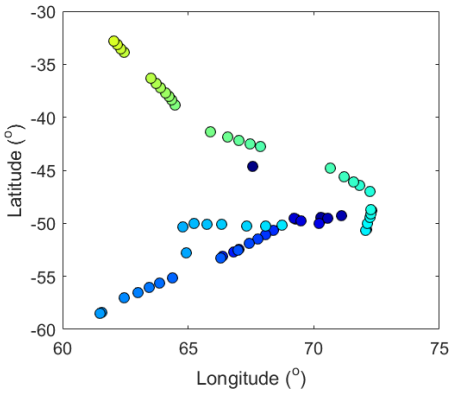




Phytoplankton composition from a multi-excitation Chl fluorometer for underway surface samples

- Excites chlorophyll fluorescence at 440 nm, 470 nm, 532 nm
- Ratio:ratio plot maps stations into taxonomic groupings based upon carotenoid presence or absence (independently validated in laboratory experiments)
- Without having seen the HPLC data, the predicted dominance is indicated
- Spatial patterns observed and dominance indicated by associated station color





Bio-optical relationships and anomalies

Some regions are subject to "bio-optical anomalies"

This is the case of the Southern Ocean

What is a bio-optical anomaly?

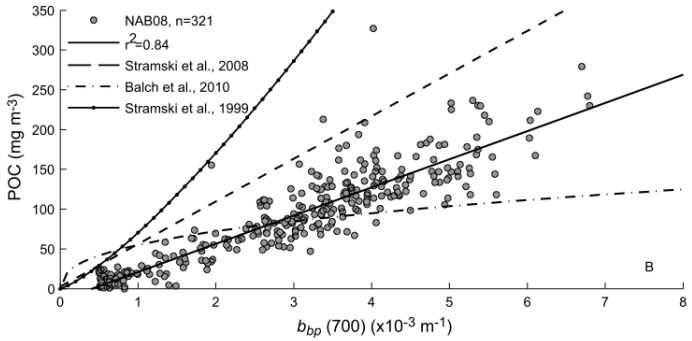
It is a deviation in a general bio-optical relationship

What is a bio-optical relationship?

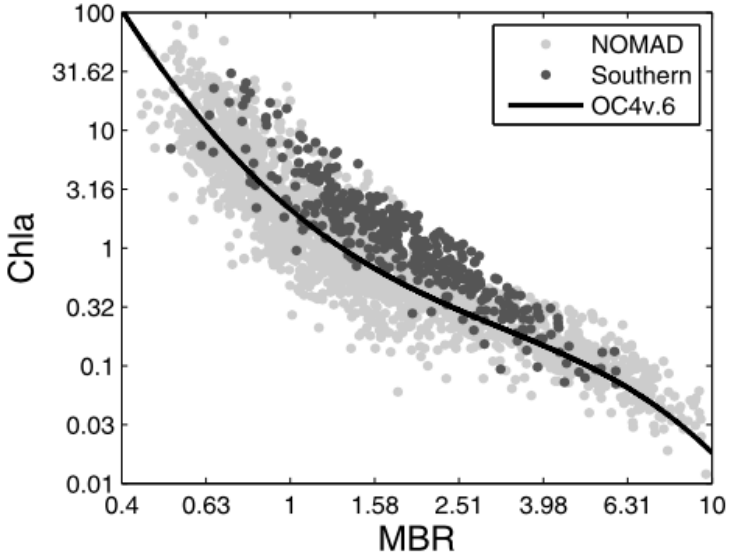
It is an empirical relationship between a biogeochemical quantity to an optical property

It enables to derive biogeochemical information from optical measurements acquired by autonomous platforms (ocean color satellites, floats, moorings…)

Advantages: space/time coverage, non-intrusive, relatively cheap…



Cetinic et al. (2012)



Szeto et al. (2011)

Bio-optical relationships and anomalies

Some regions are subject to "bio-optical anomalies"

This is the case of the Southern Ocean

What is a bio-optical anomaly?

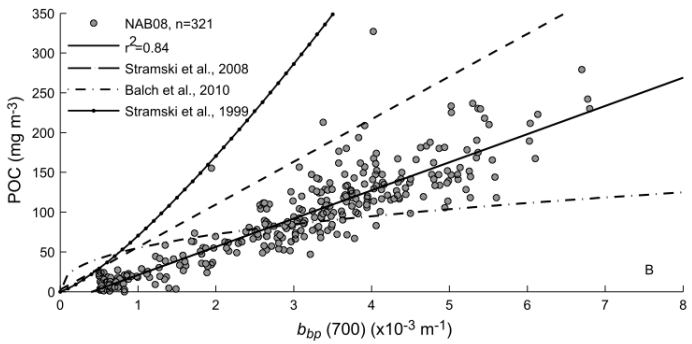
It is a deviation in a general bio-optical relationship

Why do we care?

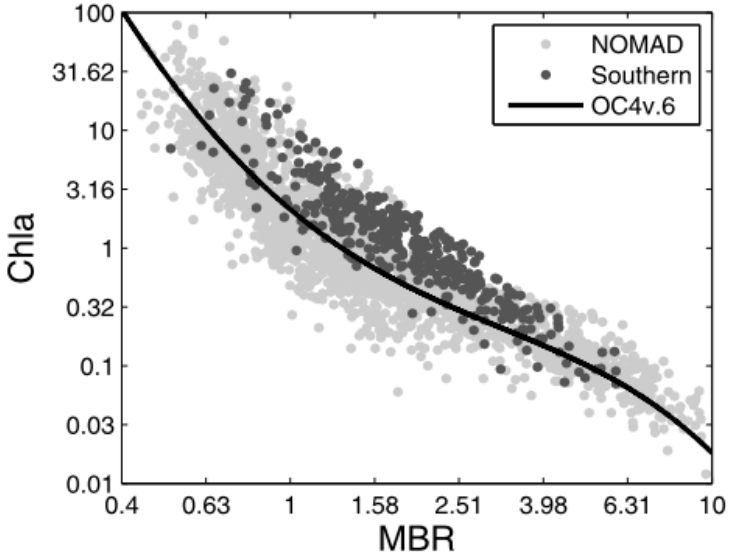
Bio-optical anomalies may induce large errors in optics-based biogeochemical quantities

In particular, standard ocean color algorithms underestimate surface Chl concentrations by up to >50% (Johnson et al. 2013)

The SO is bluer than it should considering the observed Chl levels!

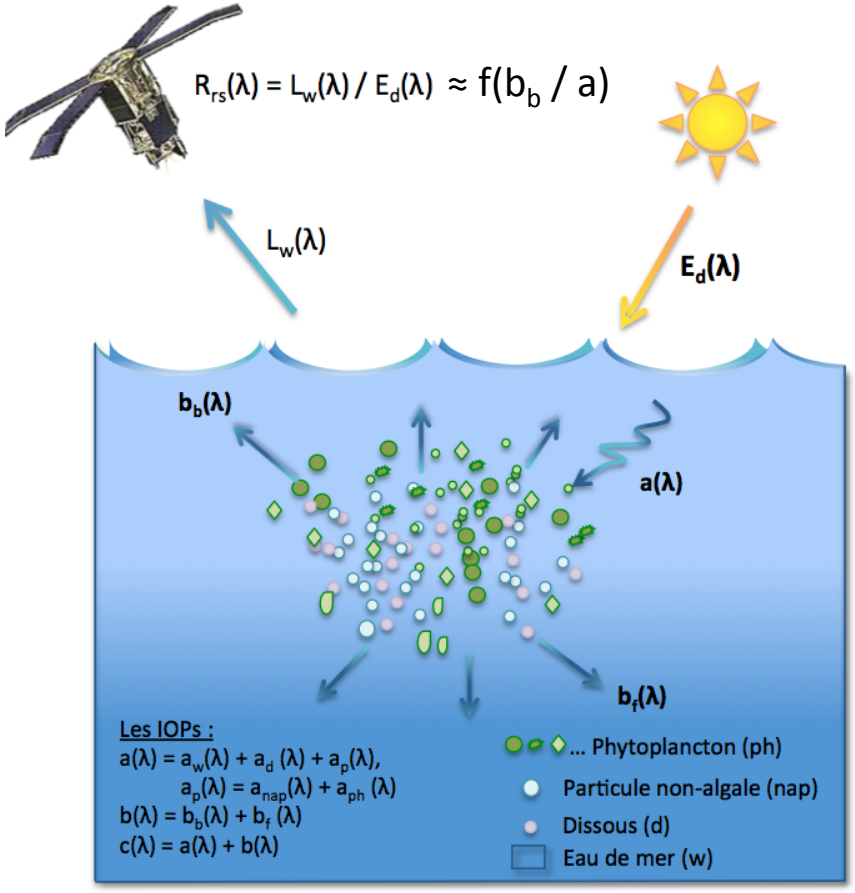


Cetinic et al. (2012)



Szeto et al. (2011)

BIO-OPTICAL RELATIONSHIPS AND ANOMALIES



Quick reminder of 'useful' optical properties

Phytoplankton absorption (a_{ph})

CDOM absorption (a_{CDOM})

Particulate backscattering (b_{bp})

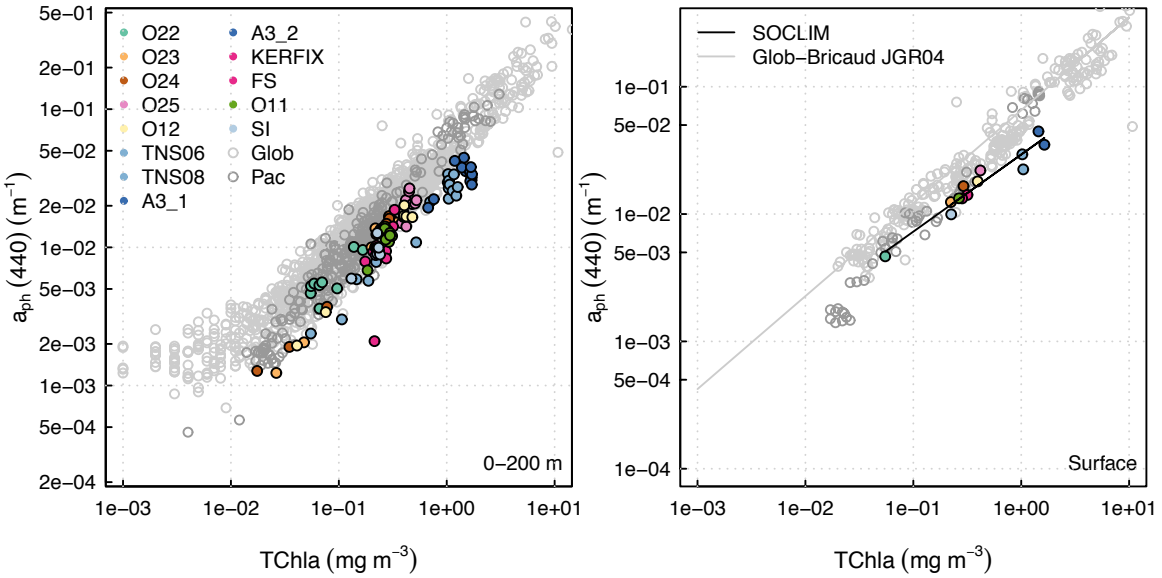
Several factors may explain bio-optical anomalies

Atypical phytoplankton community structure and/or photophysiology → Influences a_{ph}

Excess/Deficit of CDOM → Influences a_{CDOM}

Atypical 'backscatterers' → Influences b_{bp}

ABSORPTION VS CHLOROPHYLL A

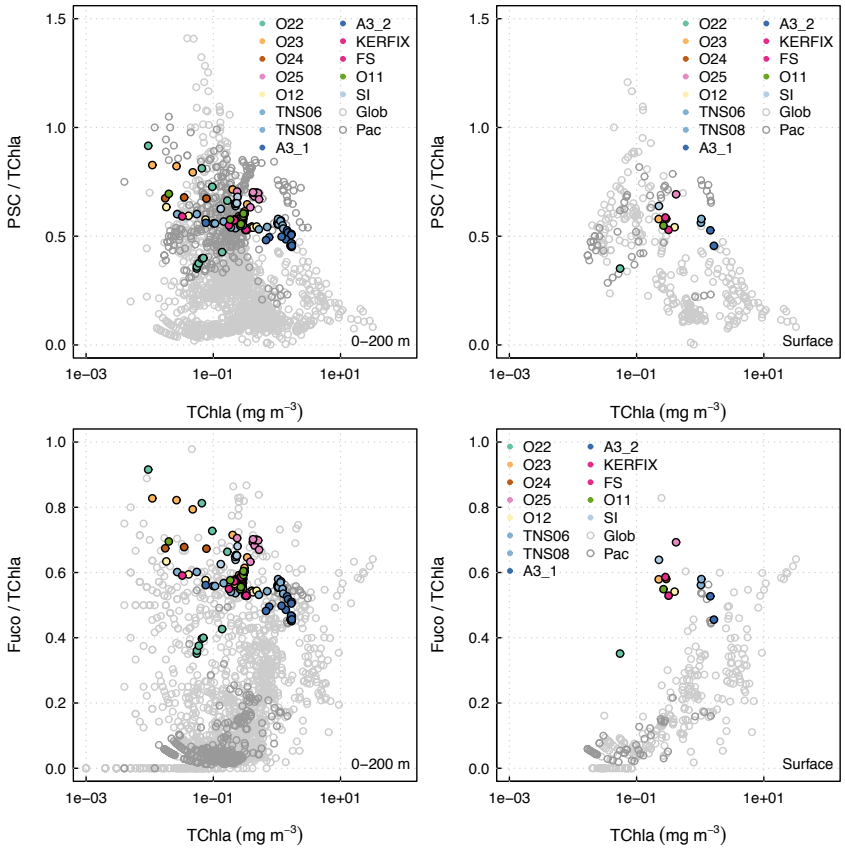


Glob: 'Global' Bricaud et al. JGR04 // Pac: South Pacific Bricaud et al. JGR10

Relatively lower absorption coefficient at comparable TChla levels

This results from pigment composition and/or package effect, itself induced by size and/or photophysiology

Absorption vs chlorophyll a

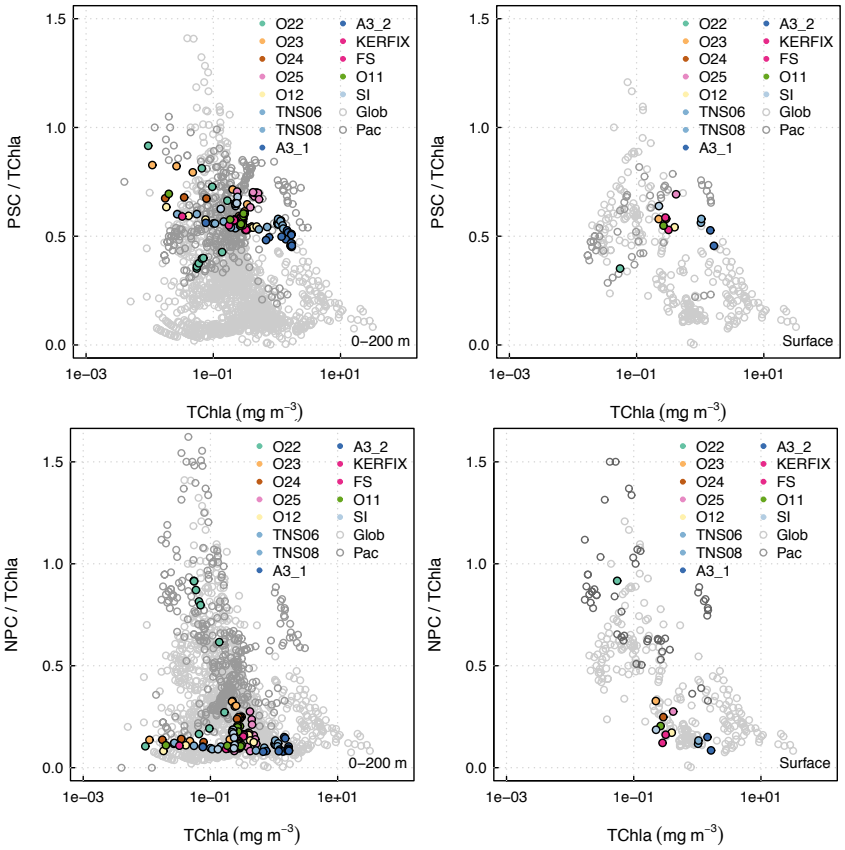


Pigment composition (determined by taxonomy and physiology)

Relatively larger contribution of PSC, especially fucoxanthin, at comparable TChla levels

PSC: Photosynthetic Carotenoids (fucoxanthin, peridinin, 19-Hex, 19-But)

Absorption vs chlorophyll a

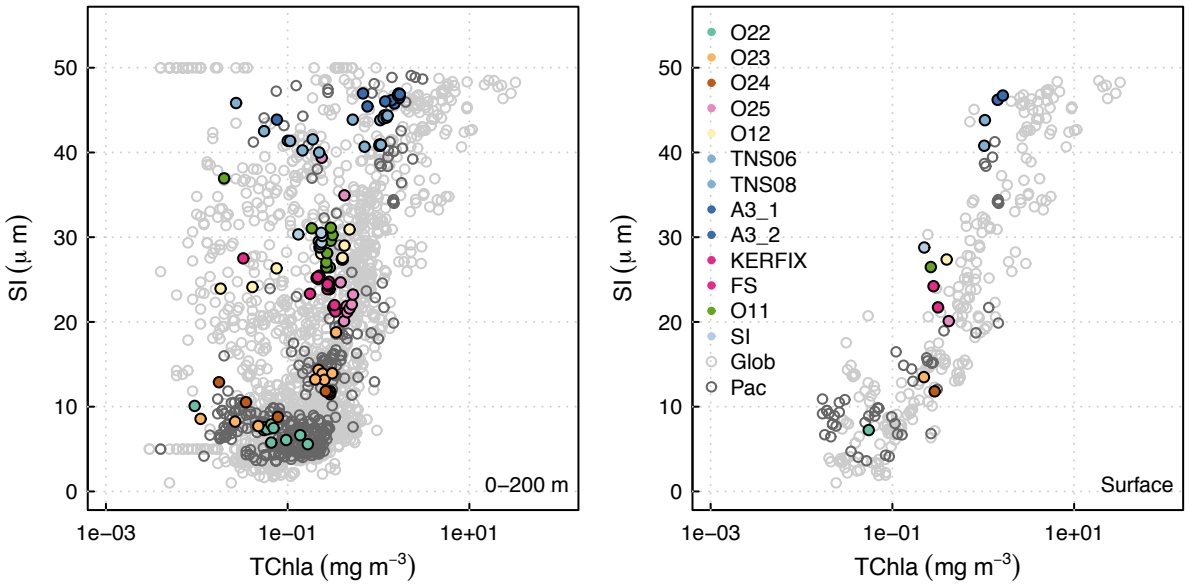


Pigment composition (determined by taxonomy and physiology)

Relatively lower contribution of NPC at comparable TChla levels

NPC: Non Photosynthetic Carotenoids (Zea, Diato, Diadino, α- and β-Carotens)

Absorption vs chlorophyll a



Size index

Similar or maybe larger average size of phytoplankton cells at comparable TChla levels

→ Both size and physiology (contribution of PSC, especially fucoxanthin) could explain relatively low phytoplankton absorption coefficient

Consistent with previous studies (Johnson et al. 2013; Organelli et al. 2016; Ferreira et al. 2017)

Absorption coefficients for underway surface samples

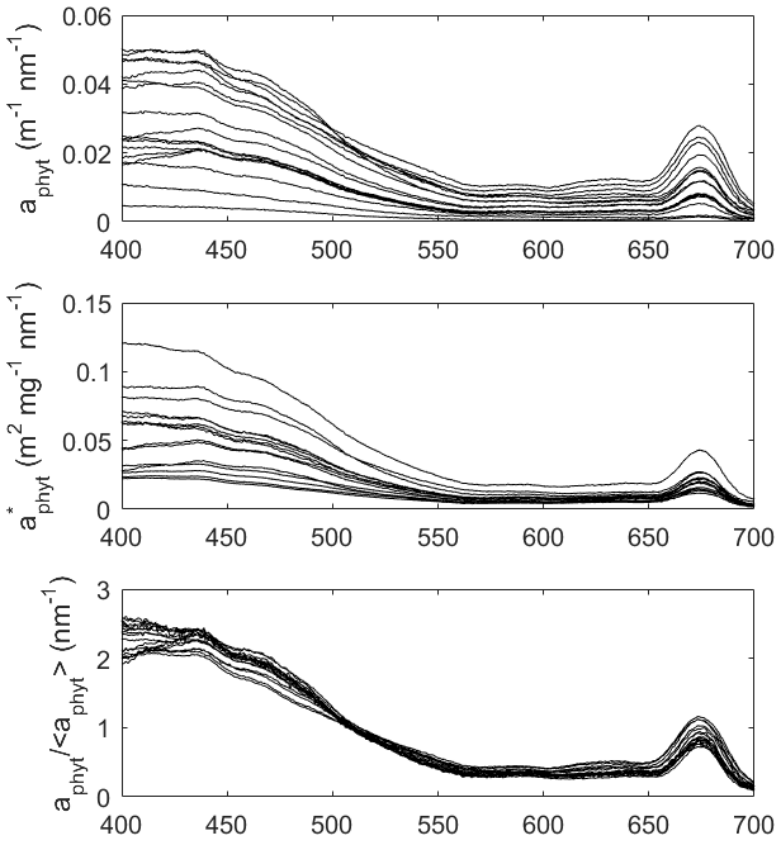
Phytoplankton absorption in VIS wavelengths measured at Bowdoin for flow through samples

- 0.005 to 0.05 m^{-1} at 400nm
- Chlorophyll-specific absorption, m^2 mg^{-1}
  - 0.0116-0.0422
  - Mean = 0.0216
  - No bio-optical anomaly
- Variability in spectral shape of absorption in blue-green carotenoid waveband

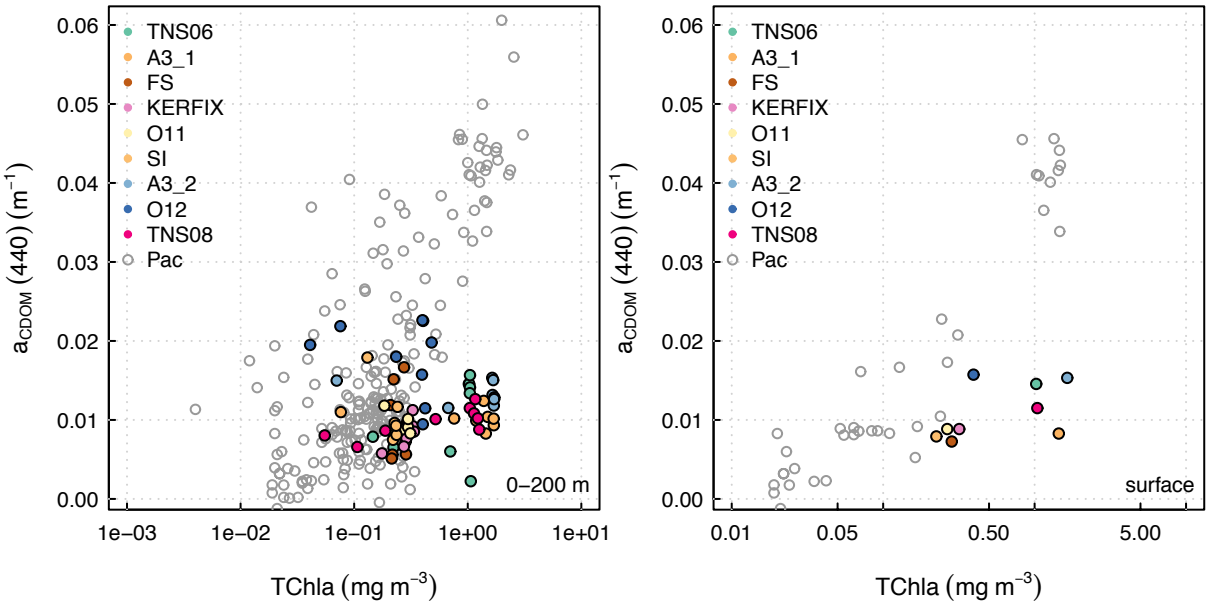
In comparison, $a^*_{ph}(400)$ measured at LOV for surface CTD stations samples

0.0145–0.0521

Mean = 0.027



CDOM ABSORPTION VS CHLOROPHYLL A



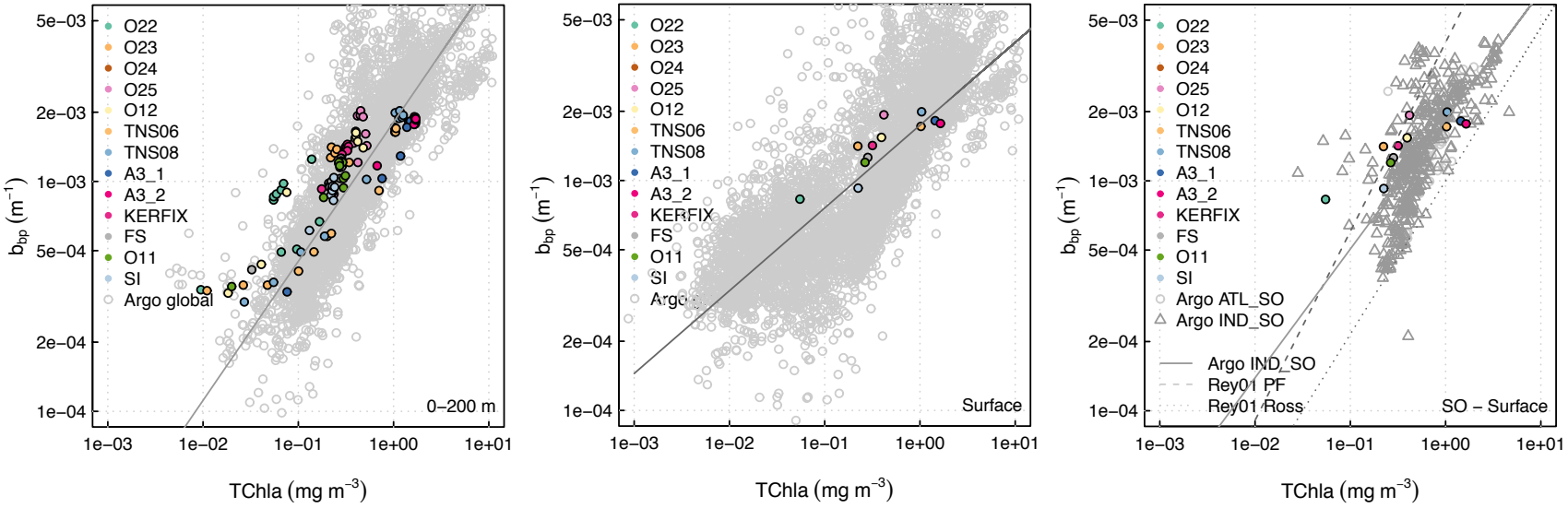
Relatively lower CDOM absorption at comparable TChla levels

Limited dataset of a_{CDOM} measured with UltraPath available for comparison!

Not clear a_{CDOM} to-TChla trend (a_{CDOM} driven by combined effects of biology and hydrology)

Results suggest a 'deficit' in CDOM that would reinforce the effect of relatively lower a_{ph}

PARTICULATE BACKSCATTERING VS CHLOROPHYLL A



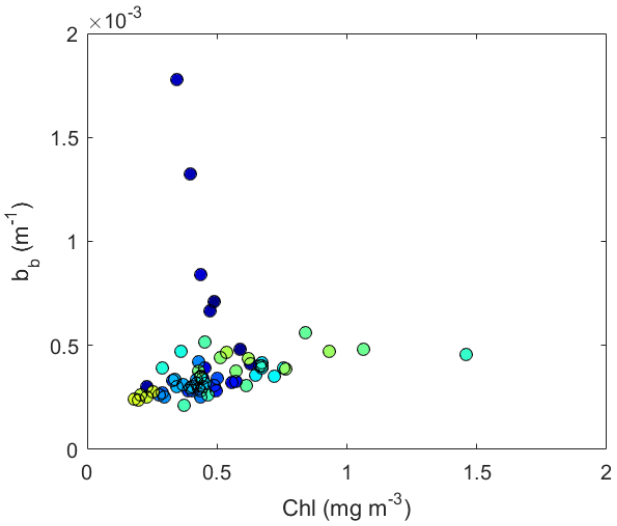
Argo global : Global BGC-Argo database // ATL_SO: Atlantic Sector // IND_SO: Indian Sector – Barbieux et al. in rev
PF: Antarctic Polar Front Zone // RS : Ross Sea – Reynolds et al. JGR01

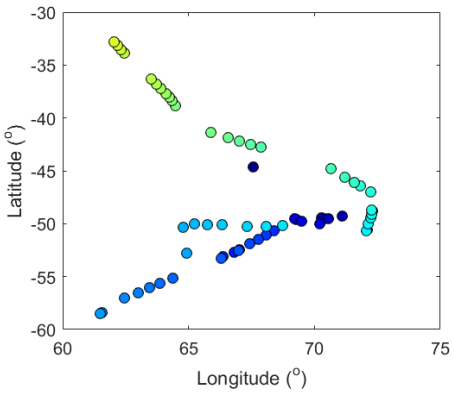
Particulate backscattering coefficient comparable to global

Not likely responsible for anomalies

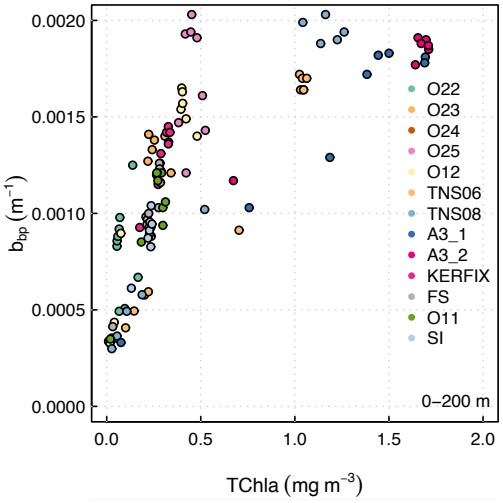
Particulate backscattering vs chl from an eco triplet and chl extracts for underway surface samples

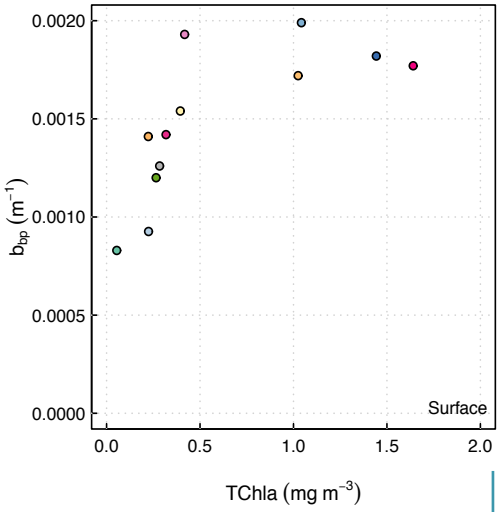
- Linear relationship (on linear scale)
- Symbols color-coded by station
- Enhanced non-algal particle backscattering near Kerguelen





In comparison, $b_{bp}(700)$ values measured by the sensor attached to CTD-rosette much higher





WHAT'S NEXT?

Phytoplankton community composition

- Comparison/validation of SI determined from pigments vs microscopy-flow cytometry
- Work on coefficients associated with diagnostic pigments using the combined KEOPS 1&2 and SOCLIM dataset for estimation of %micro, %nano and %pico
- Comparison HPLC-based and 3x1M composition for flow through samples

Phytoplankton absorption

- More work needed to compare absorption coefficients measured at LOV and Bowdoin
- Do Bowdoin samples actually show an anomaly in the $a_{ph}(440)$ vs Tchla relationship

CDOM absorption

- Work needed to clean and QC the profiles
- Comparison with PEACETIME and GreenEdge UltraPath data
- Will help to invalidate/confirm the trend to somewhat "lower than expected" a_{CDOM} values

b_{bp} coefficients

Explain discrepancies between CTD (LOV) and flowthrough (Bowdoin) values

Reflectance

- Can we identify anomalies in R_{rs} data acquired by ProVal floats / on-deck HyperSAS (UConn) / ocean color satellite in the Soclim region?
- Does it coincide with anomalies in bio-optical relationships?

THANK YOU!