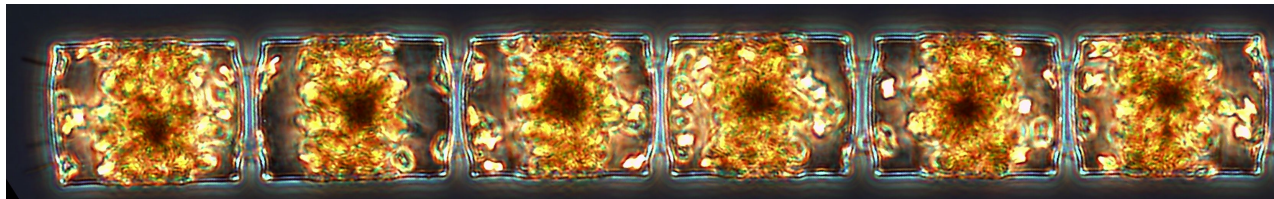
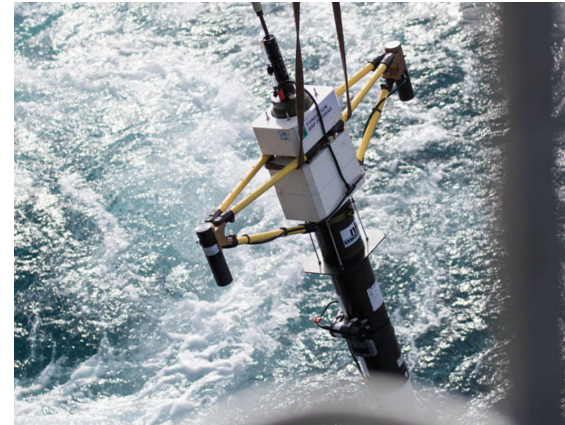


Plankton assemblage estimated from biogeochemical Argo floats in the Southern Ocean

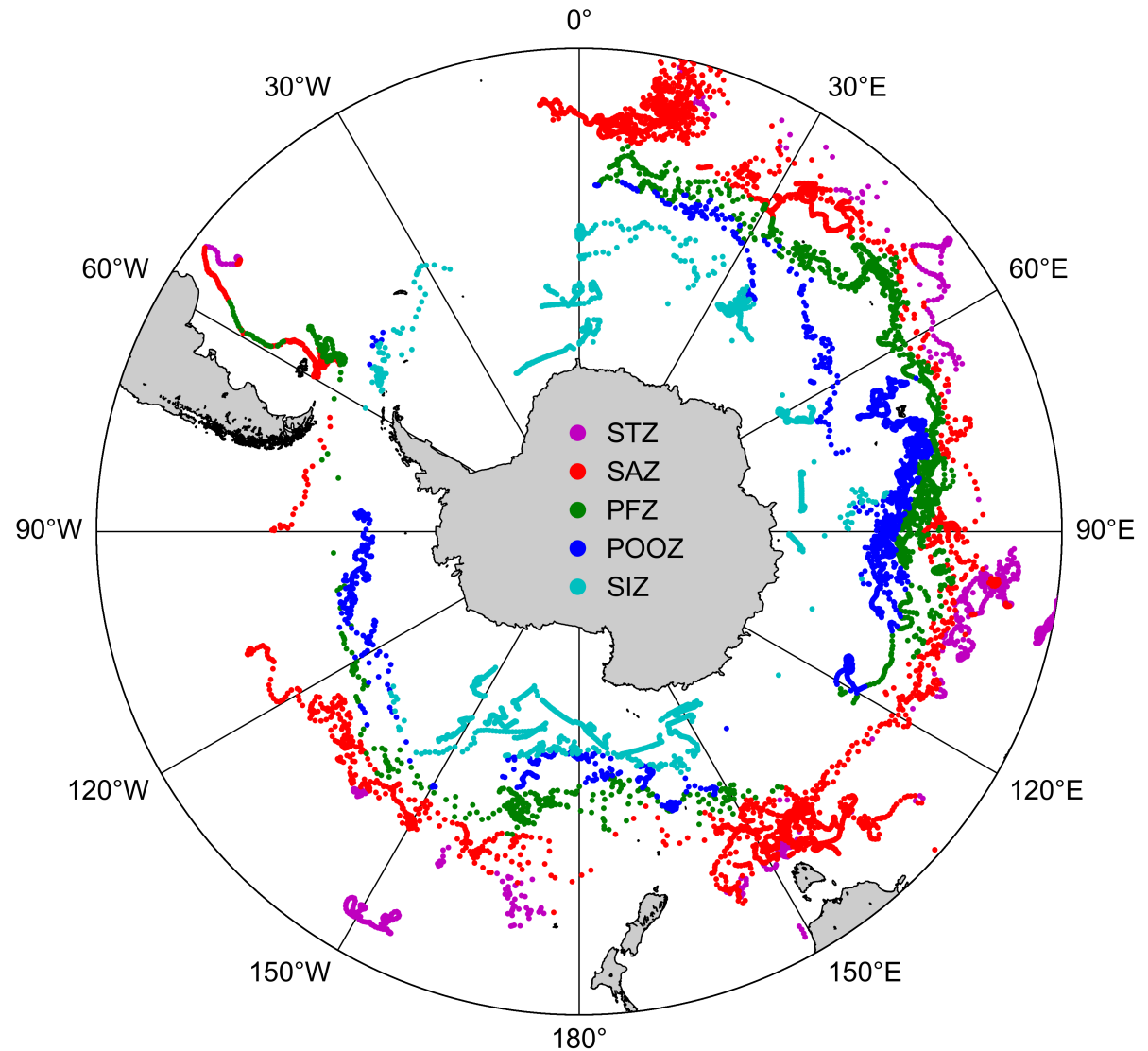


Mathieu Rembauville, Nathan Briggs, Mathieu Ardyna, Julia Uitz, Philippe Catala, Christophe Penkerc'ch, Antoine Poteau, Hervé Claustre, Stéphane Blain

Euro-Argo users meeting – 04 July 2017

The Southern Ocean

- Strong solubility CO₂ pump (40 % global ocean)
- Inefficient biological pump (present day)
- No annual phytoplankton time series (open ocean)
- Ship-based observations restricted in time and space
- Significant cloud cover



BGC-Argo floats coverage – June 2017

Aim : predict plankton assemblage from BGC-Argo data

Steps:

- (1) Estimate carbon partitioning among major plankton groups during the SOCLIM cruise
- (2) Build a statistical predictive model between hydrological/optical signals and the carbon partitioning
- (3) Apply the predictive model to BGC-Argo floats located in the vicinity of the calibration area

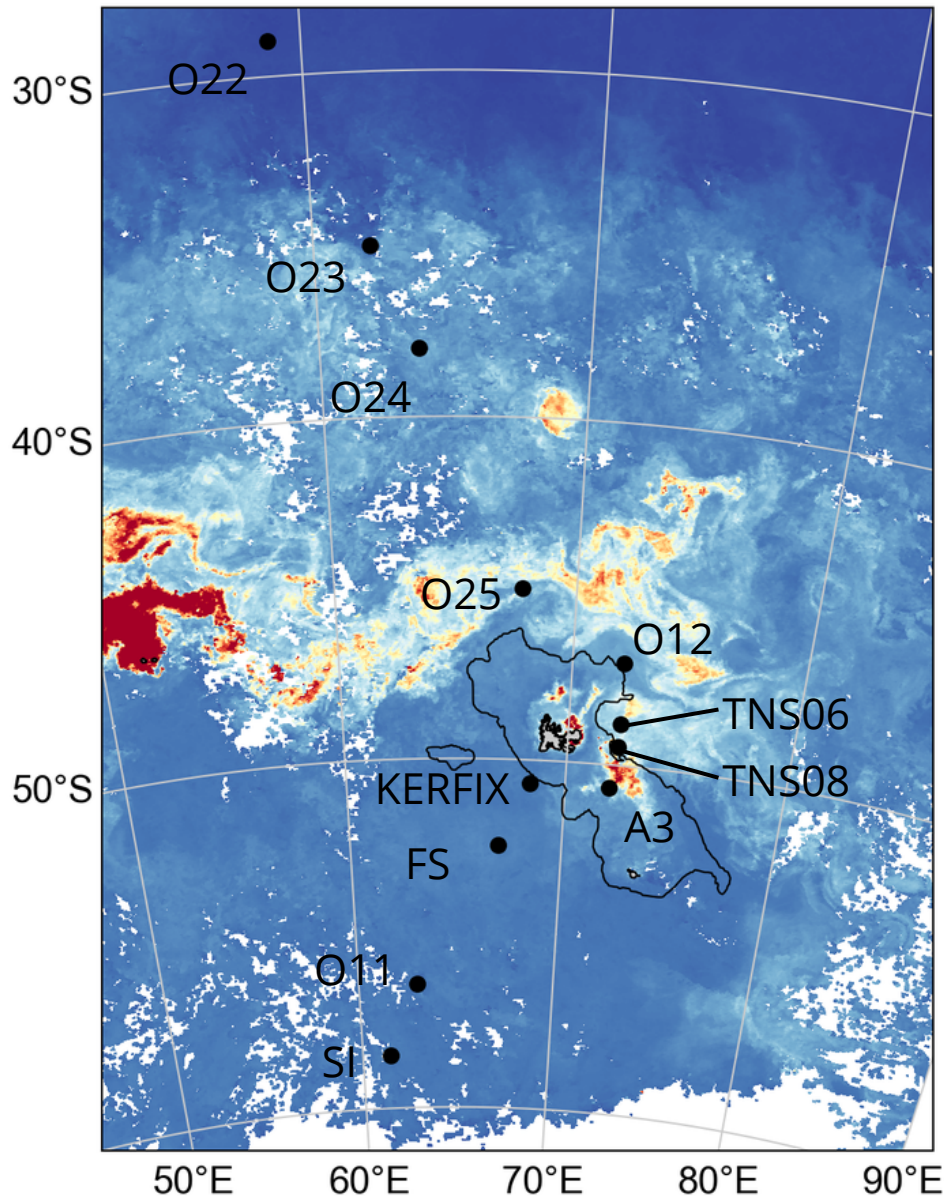
Microscopy + cytometry

$\%C_{\text{plank}} \sim [\text{CTD} + \text{opt}]$

cruise

$[\text{CTD} + \text{opt}] \rightarrow \%C_{\text{plank}}$

BGC-Argo float



The SOCLIM cruise

- October 2016
- 14 stations (28 °S – 58.5 °S)
- **CTD/O₂/Fluo/b_{bp}/c_p**
- **Phytoplankton (microscopy + cytometry)**
- Pigments/POC/PON/POP/BSi/LSi/PIC
- Nutrients/DOC/O₂/CDOM
- 8 BGC-Argo floats (2 proval)

I - Partitioning carbon

Plankton group	Contains	Method	Volume (μm^3)	Carbon content (pgC)
Bact	Heterotrophic bacteria	Cytometry	0.25 ^a	0.015 ^a
Pico	Prochlorococcus	Cytometry	0.68 ^b	0.029 ^b
	Synechococcus		0.86 ^b	0.080 ^b
	Picoeukaryotes		2.76 ^b	0.73 ^b
Nano	Nanoplankton	Cytometry	284 ^c	15 ^c
Micro	Diatom (55 groups)	Optical microscopy	Shape-specific ^d	$C = 0.117 V^{0.881 e}$
	Dinoflagellate (14 groups)		Shape-specific ^d	$C = 0.670 V^{0.819 e}$
	Ciliate (4 groups)		Shape-specific ^d	$C = 0.216 V^{0.939 e}$
	Silicoflagellate (1 group)		3288	$C = 0.261 V^{0.860 e}$

^a Bratbak (1985)

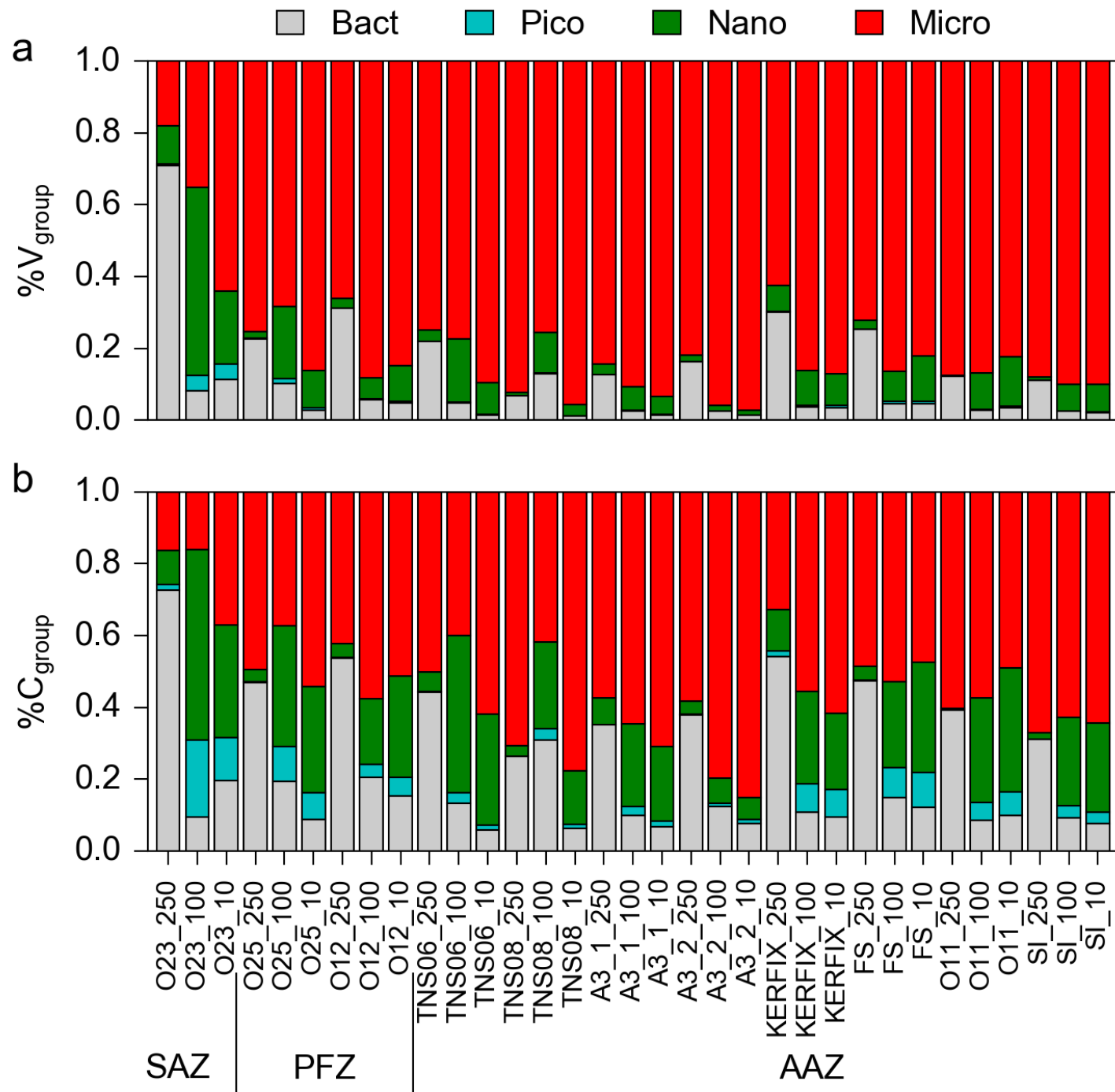
^b Grob et al. (2007)

^c Verity et al. (1992)

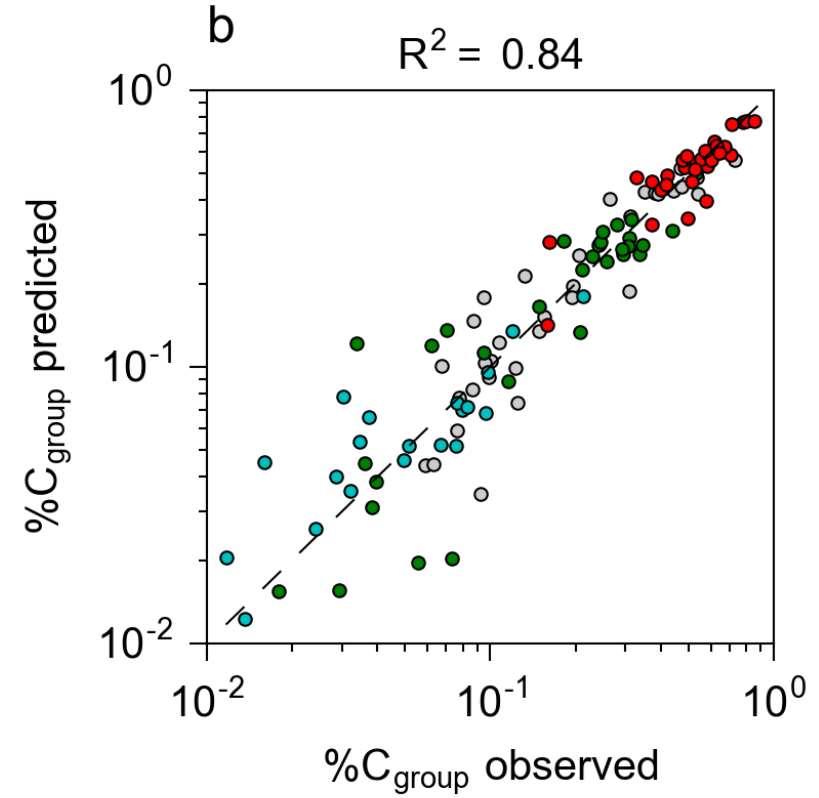
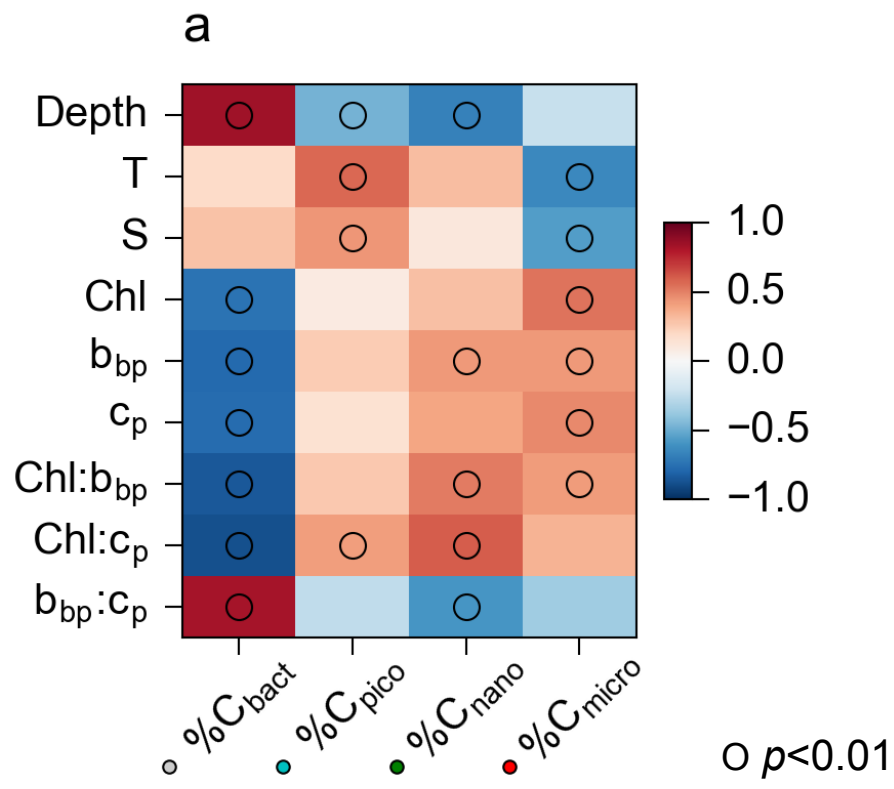
^d Hillebrand et al. (1999)

^e Menden-Deuer and Lessard (2000)

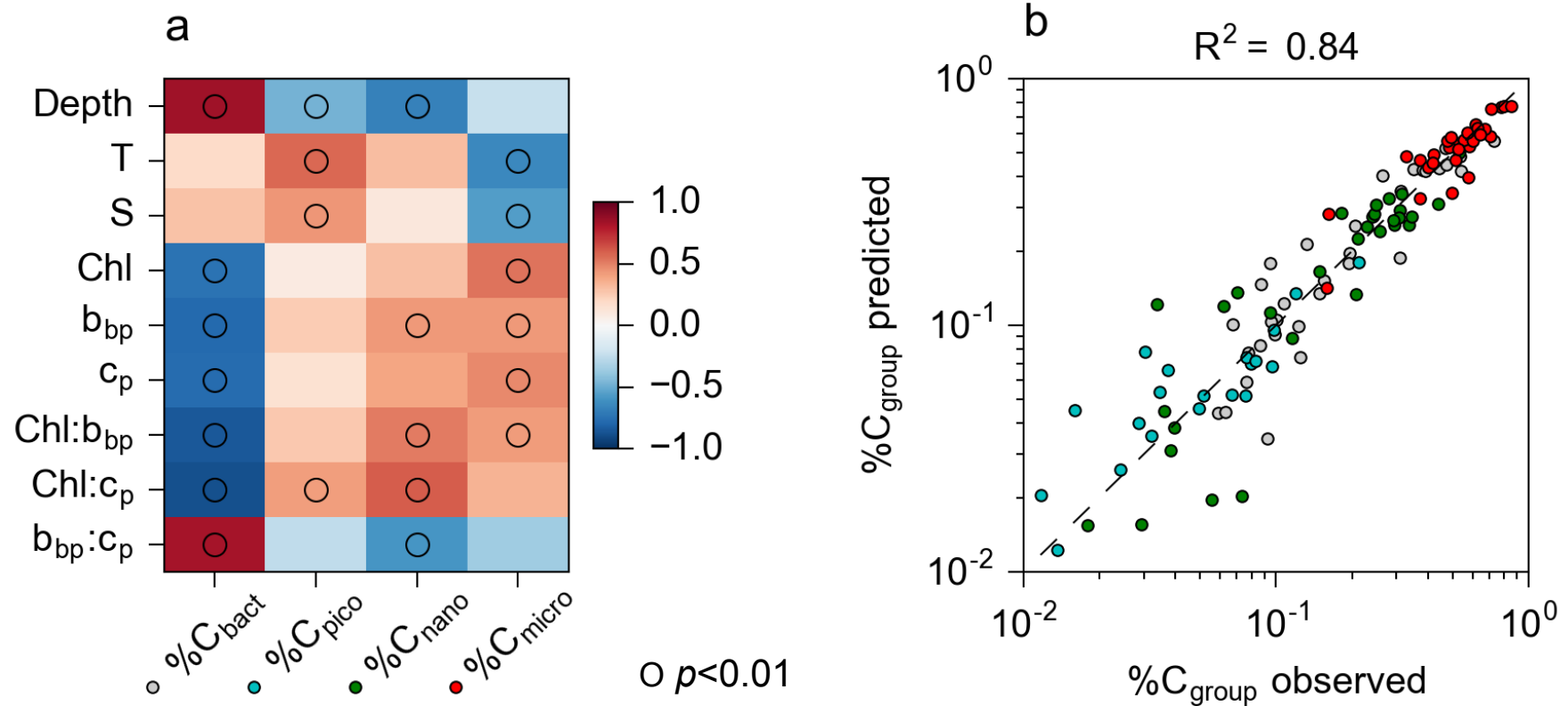
I - Partitioning carbon



II – Building a predictive model



II – Building a predictive model

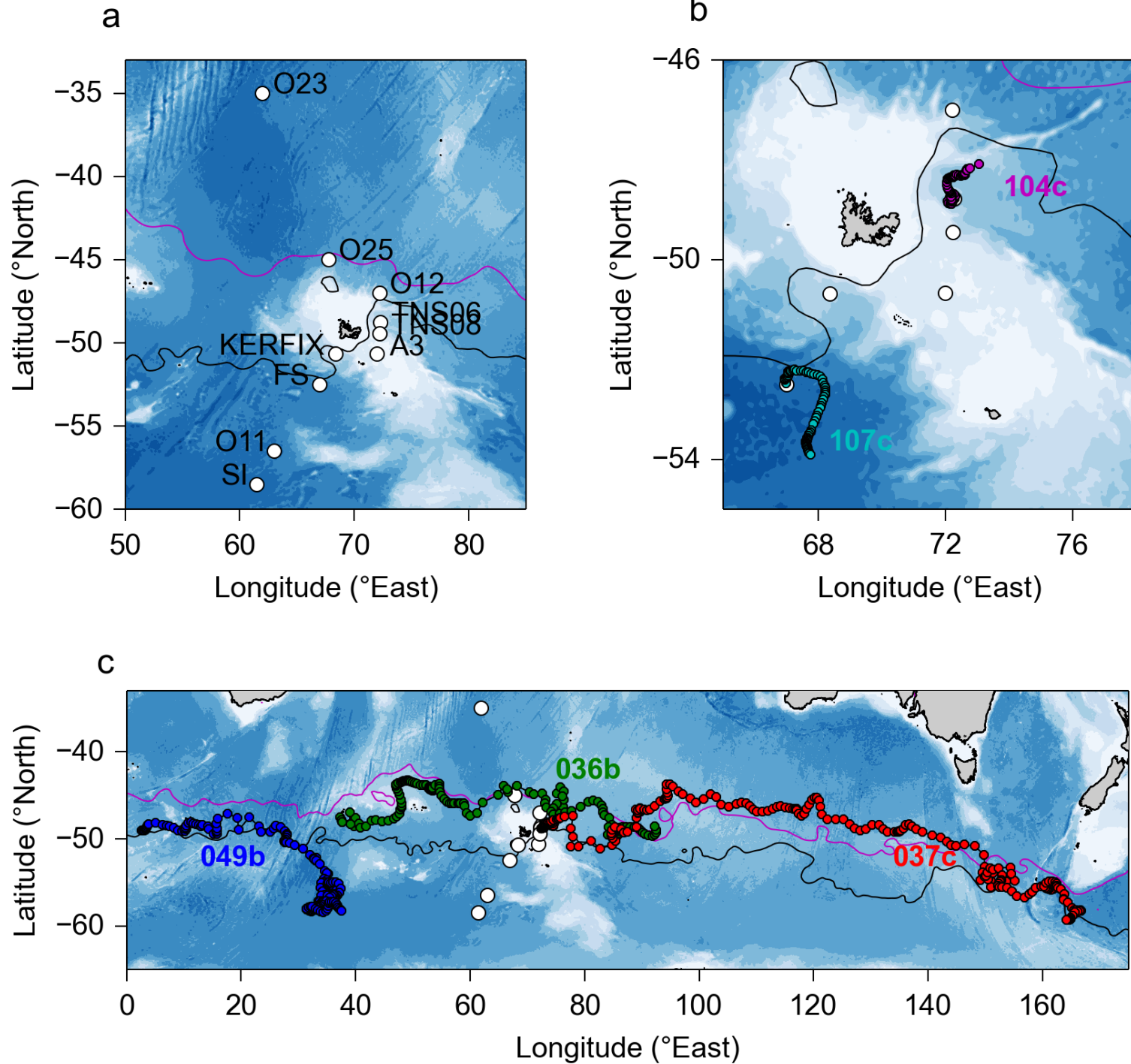


Bootstrap :

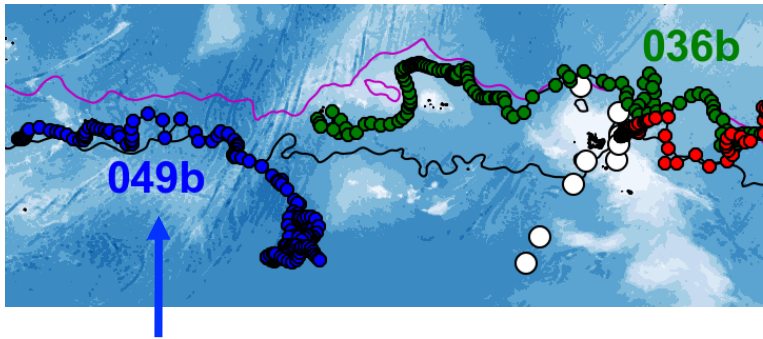
- 2/3 learning
- 1/3 testing
- 10 000 trials

Plankton group	R^2	RMSE (%)
Bacteria	0.71 ± 0.11	14 ± 4
Pico	0.61 ± 0.15	26 ± 2
Nano	0.65 ± 0.13	19 ± 6
Micro	0.59 ± 0.14	17 ± 5
Pooled	0.84 ± 0.06	6 ± 1

III – Testing on BGC-Argo data

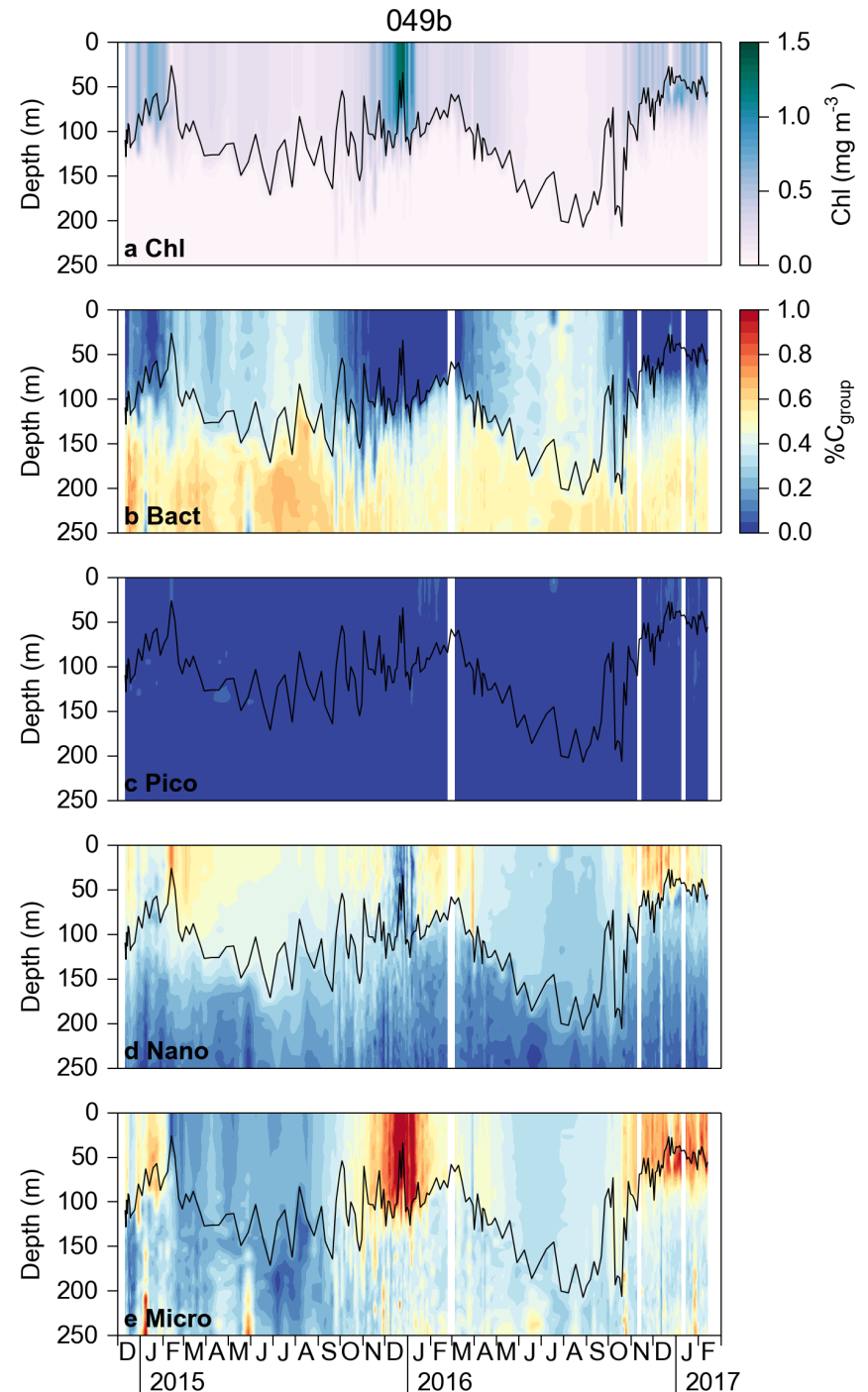


III – Testing on BGC-Argo data

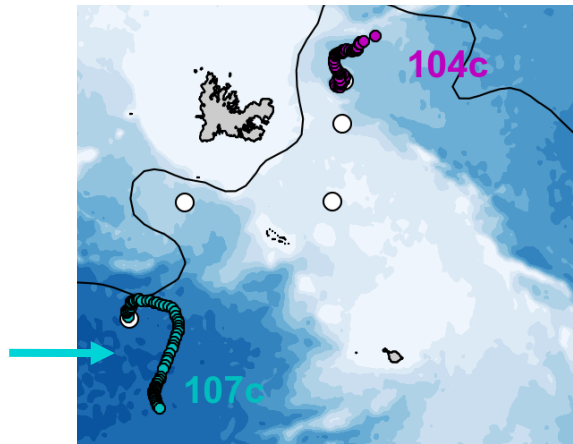


Float 049b

- Mainly HNLC AAZ
- Bacteria below MLD
 - No pico
 - Nano in winter
- Micro during blooms

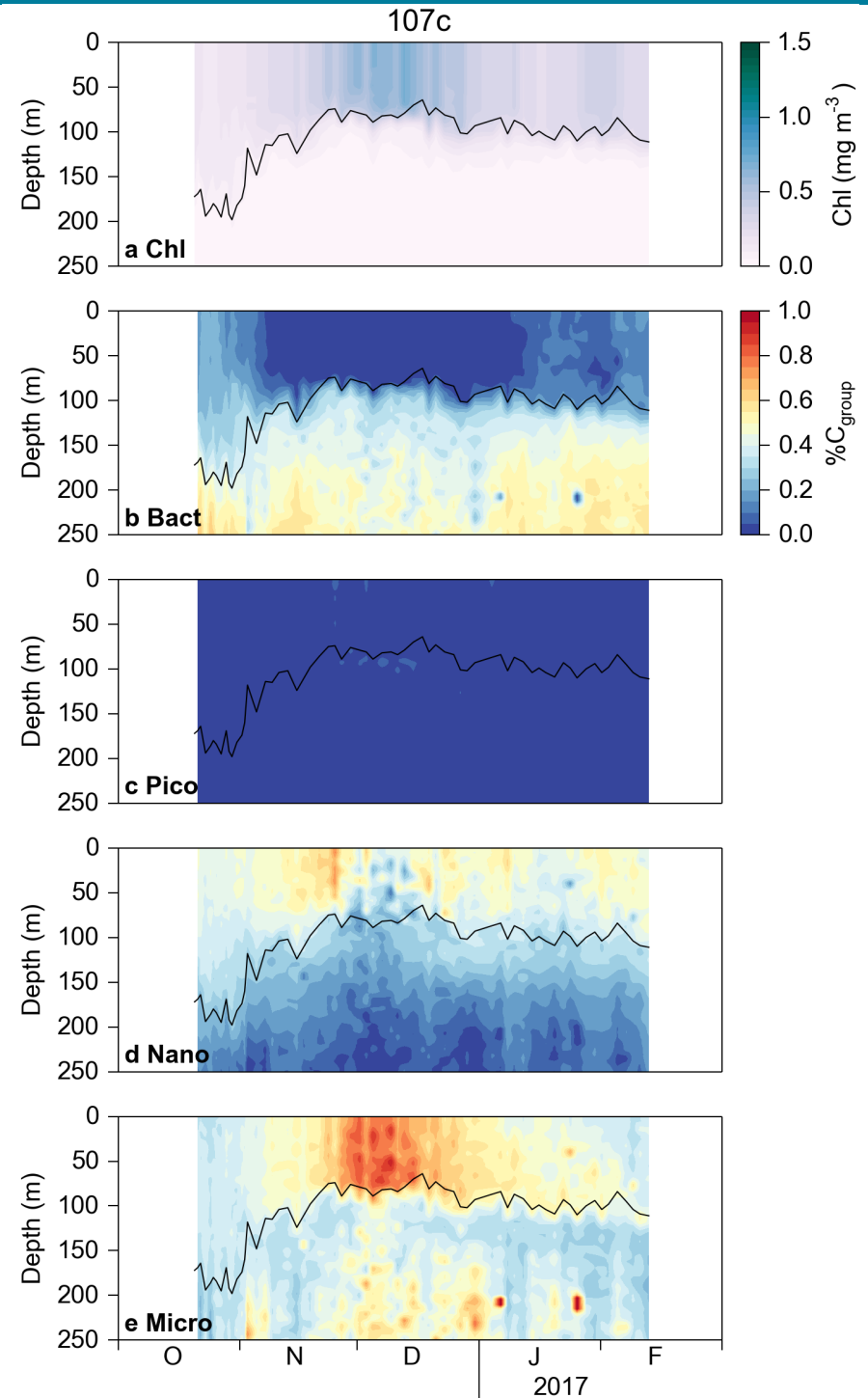


III – Testing on BGC-Argo data

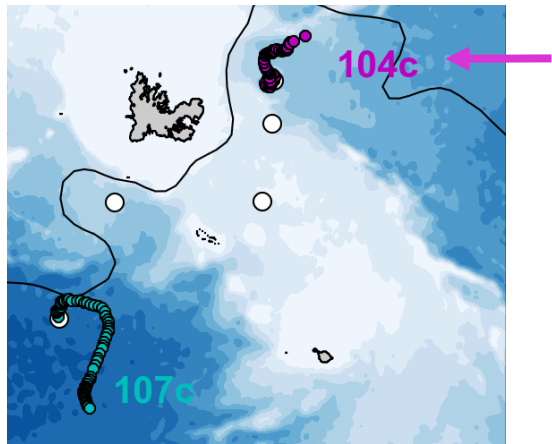


Float 107c

- Upstream KP plateau, HNLC
 - Low Chl $< 1 \text{ mg m}^{-3}$
 - Nano/Micro succession
 - Micro bloom

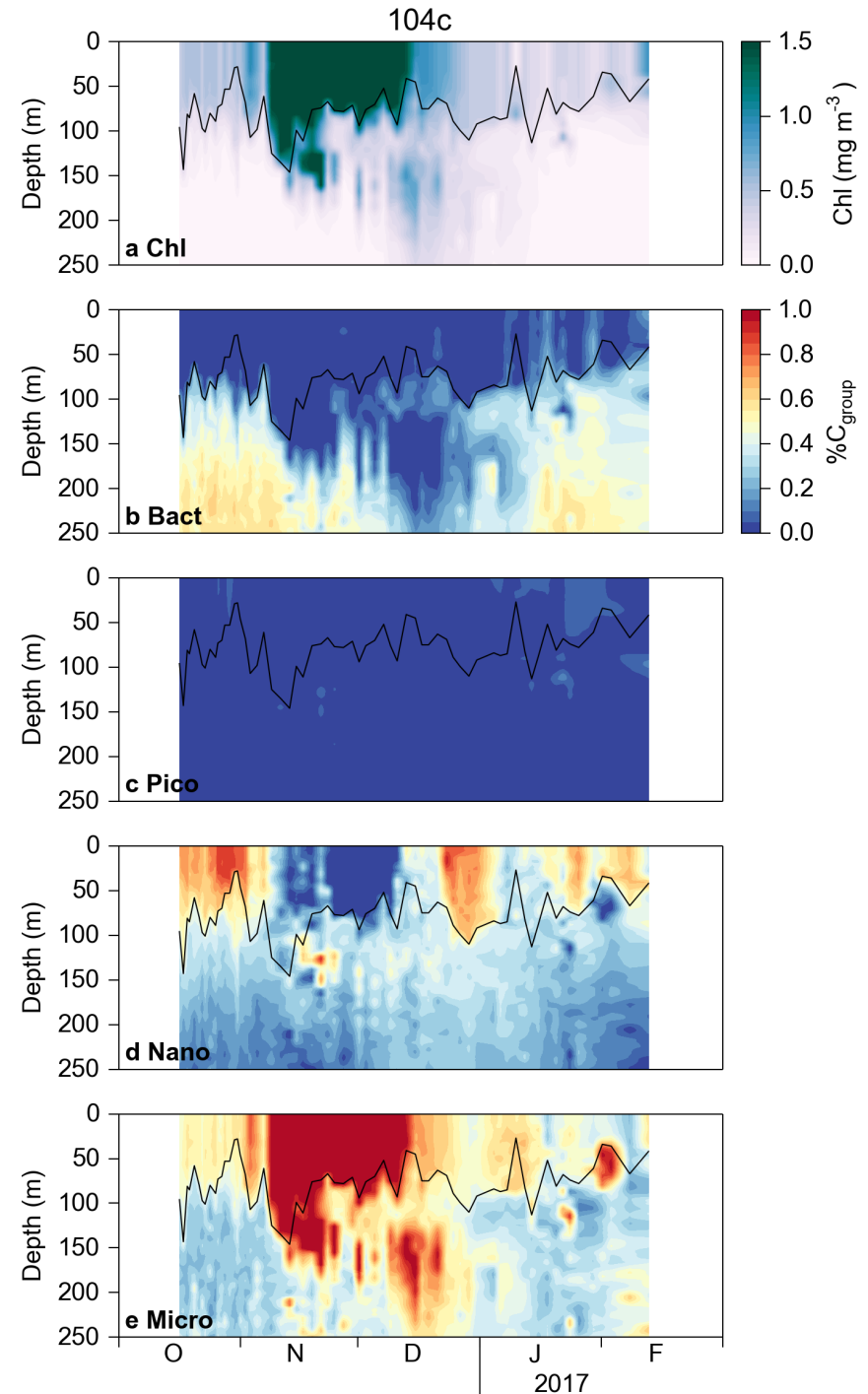


III – Testing on BGC-Argo data

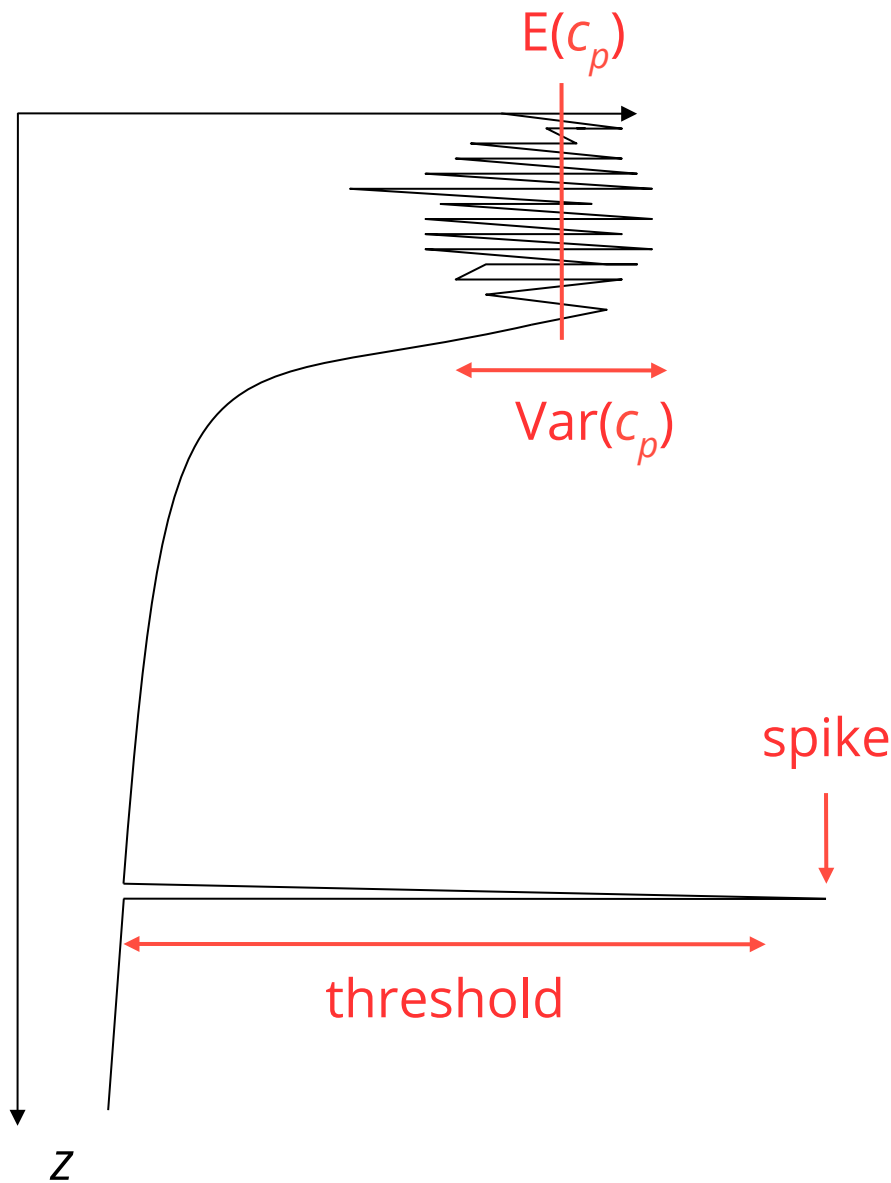


Float 104c

- Downstream KP plateau
 - Productive AAZ
 - High Chl $> 1.5 \text{ mg m}^{-3}$
 - Major micro bloom
- Detrainment of micro cells



III – Testing on BGC-Argo data



Particle diameter in the mixed layer

$$d_{\text{ML}} \sim \text{Var}(c_p) / E(c_p)$$

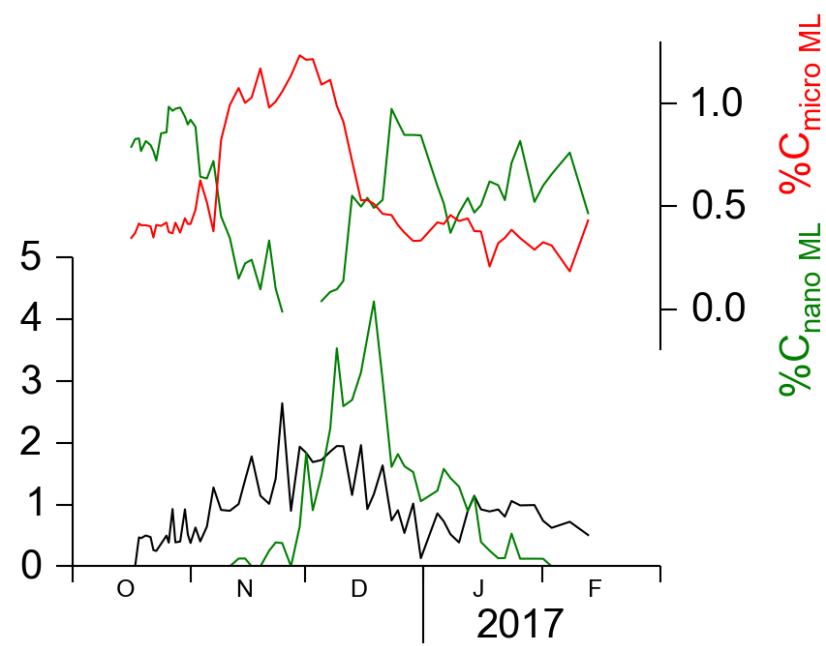
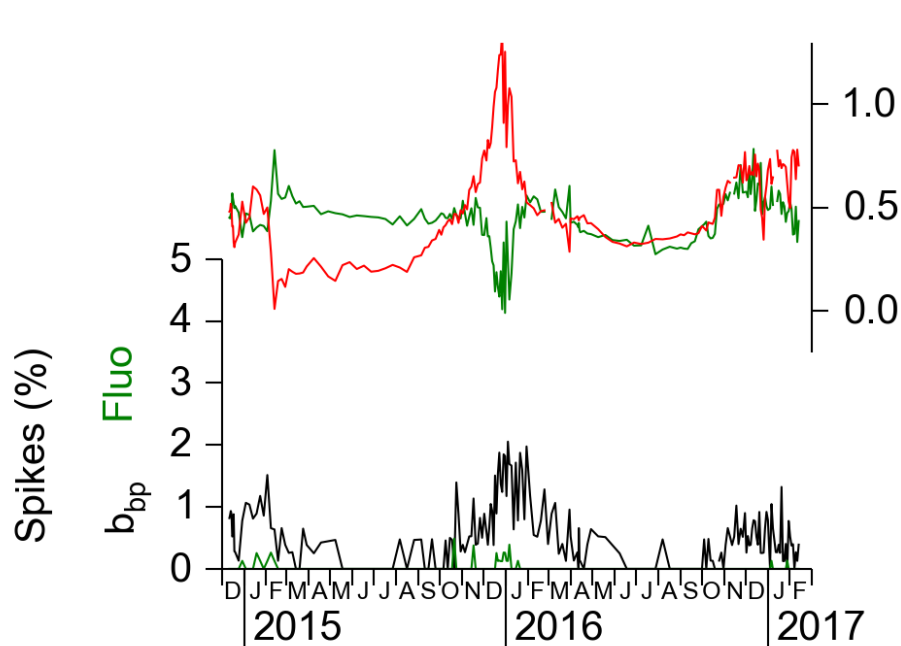
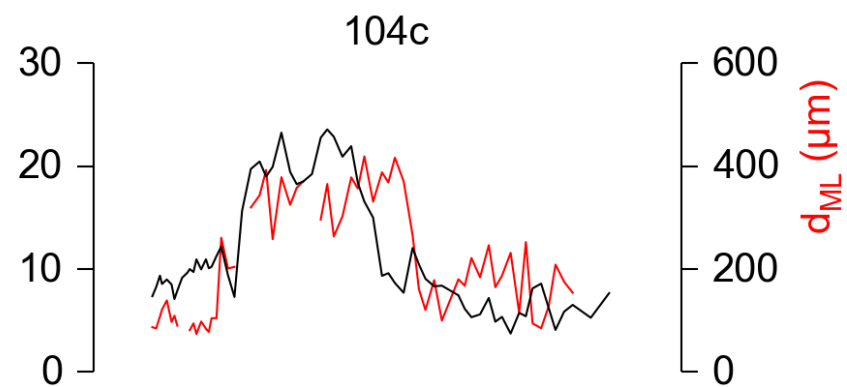
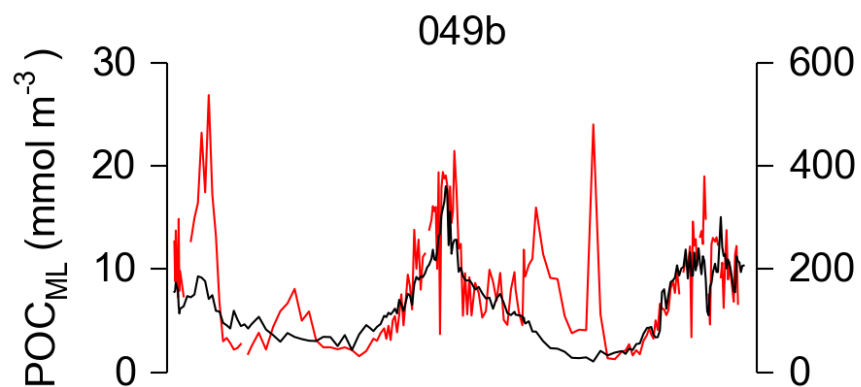
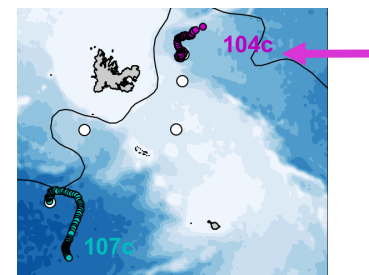
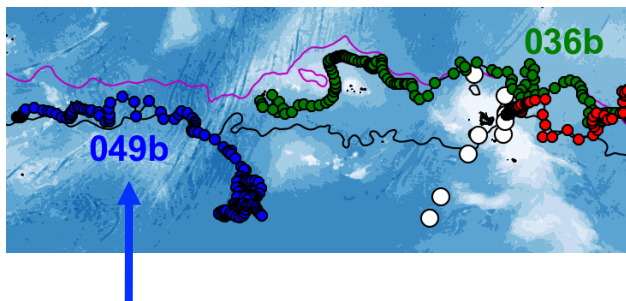
(Briggs et al. 2013)

Particle export in the mesopelagic

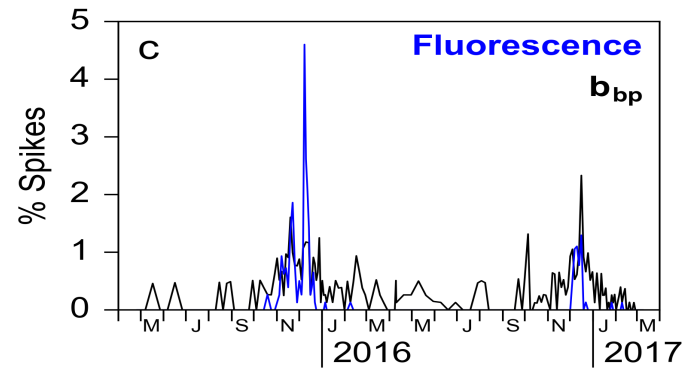
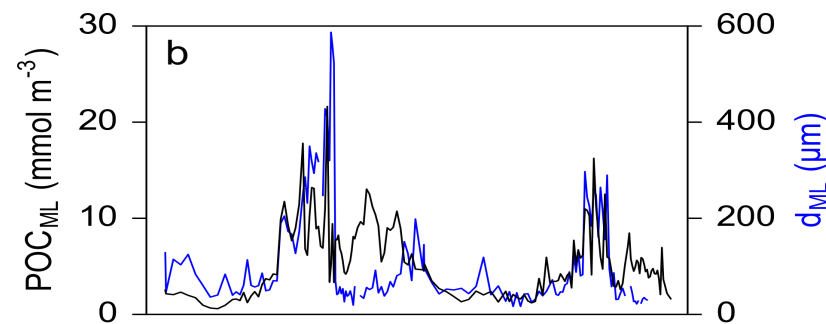
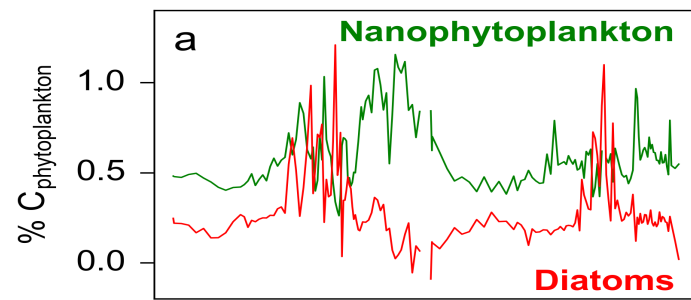
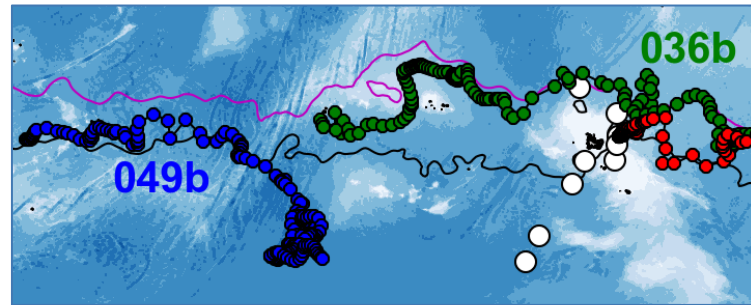
Spike when
signal - baseline > threshold

(Briggs et al. 2011)

III – Testing on BGC-Argo data



III – Testing on BGC-Argo data



Major results

- Robust carbon partitioning among plankton groups
- Consistent relationships with optical signals (Chl: b_{bp} ~ diatoms, b_{bp} : c_p ~ bacteria)
- $\%C_{group}$ predicted with 15-20% uncertainty
- Predicted seasonality and geographical distribution agree with literature
- $\%C_{micro}$ consistent with independent estimate of particle diameter
- High biomass, high $\%C_{micro}$ \rightarrow b_{bp} and fluo spikes (phytoagregates ?)

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- Not valid for very different communities (i.e. sea ice plankton assemblage)

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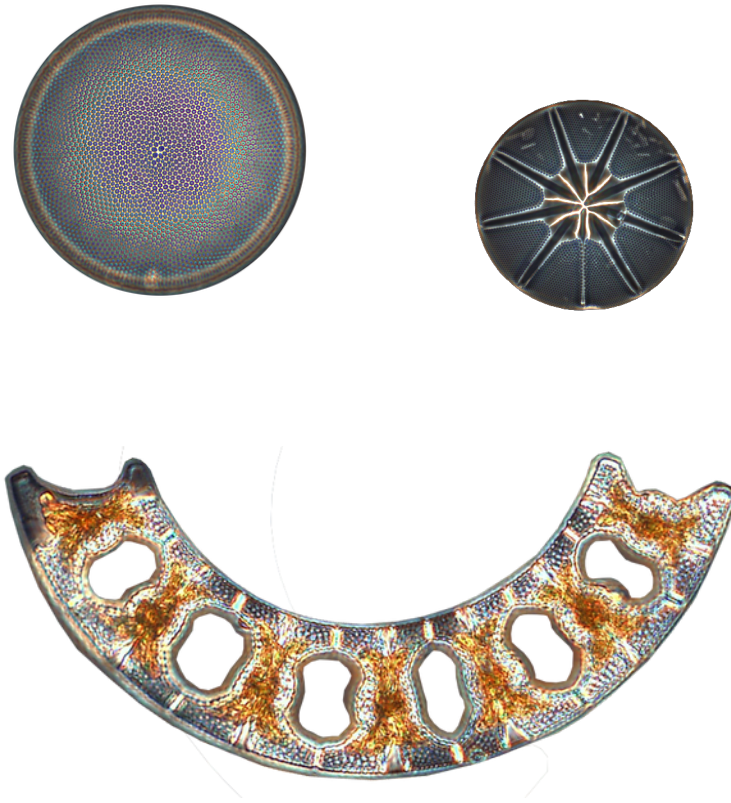
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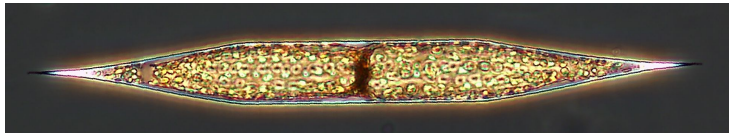
Perspectives

- Coupling plankton groups prediction and chemical variables prediction (CANYON, Sauzède et al. 2017)
- Relationship with export proxies or quantification ?

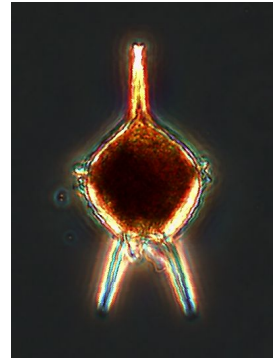
Thank you for your attention



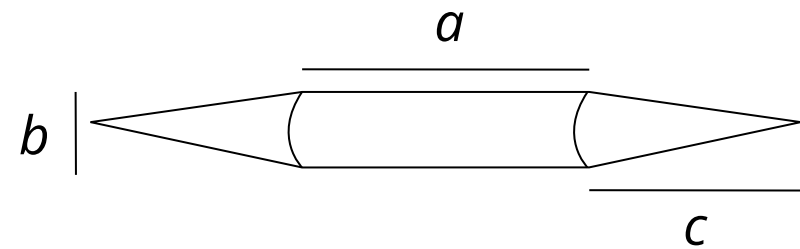
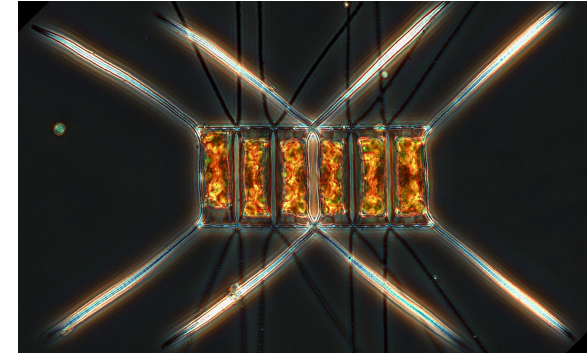
Rhizosolenia



Protoperidinium

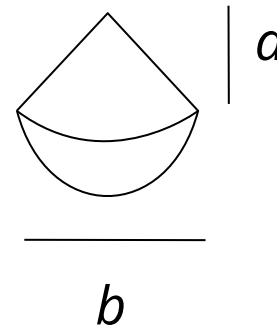


Chaetoceros



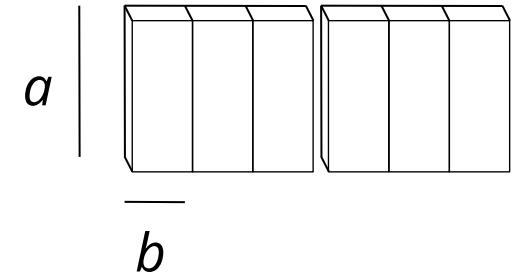
Cylinder + 2 cones

$$V = \frac{\pi}{4} b^2 a + 2 \frac{\pi}{12} b^2 c$$



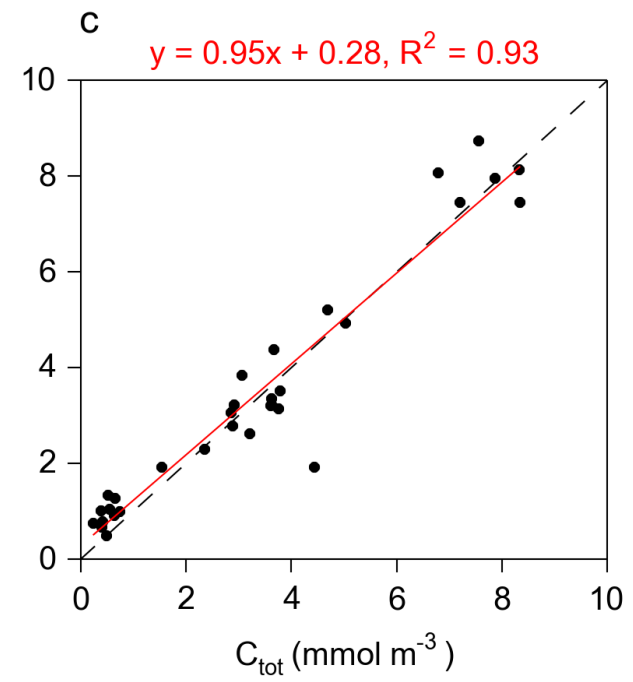
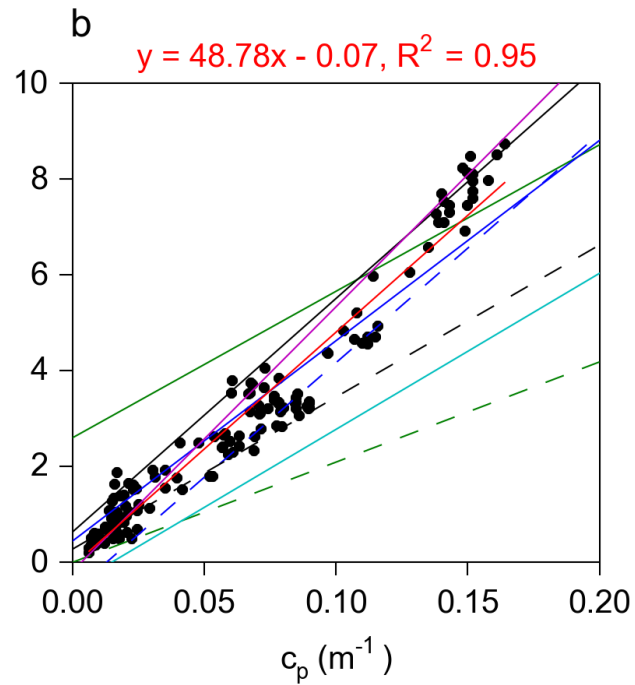
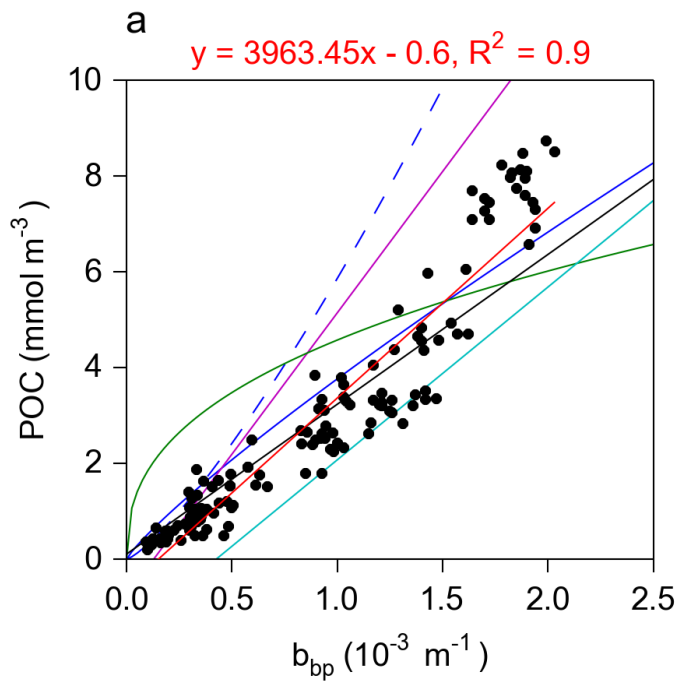
Cone + half sphere

$$V = \frac{\pi}{12} b^2 (a + b)$$



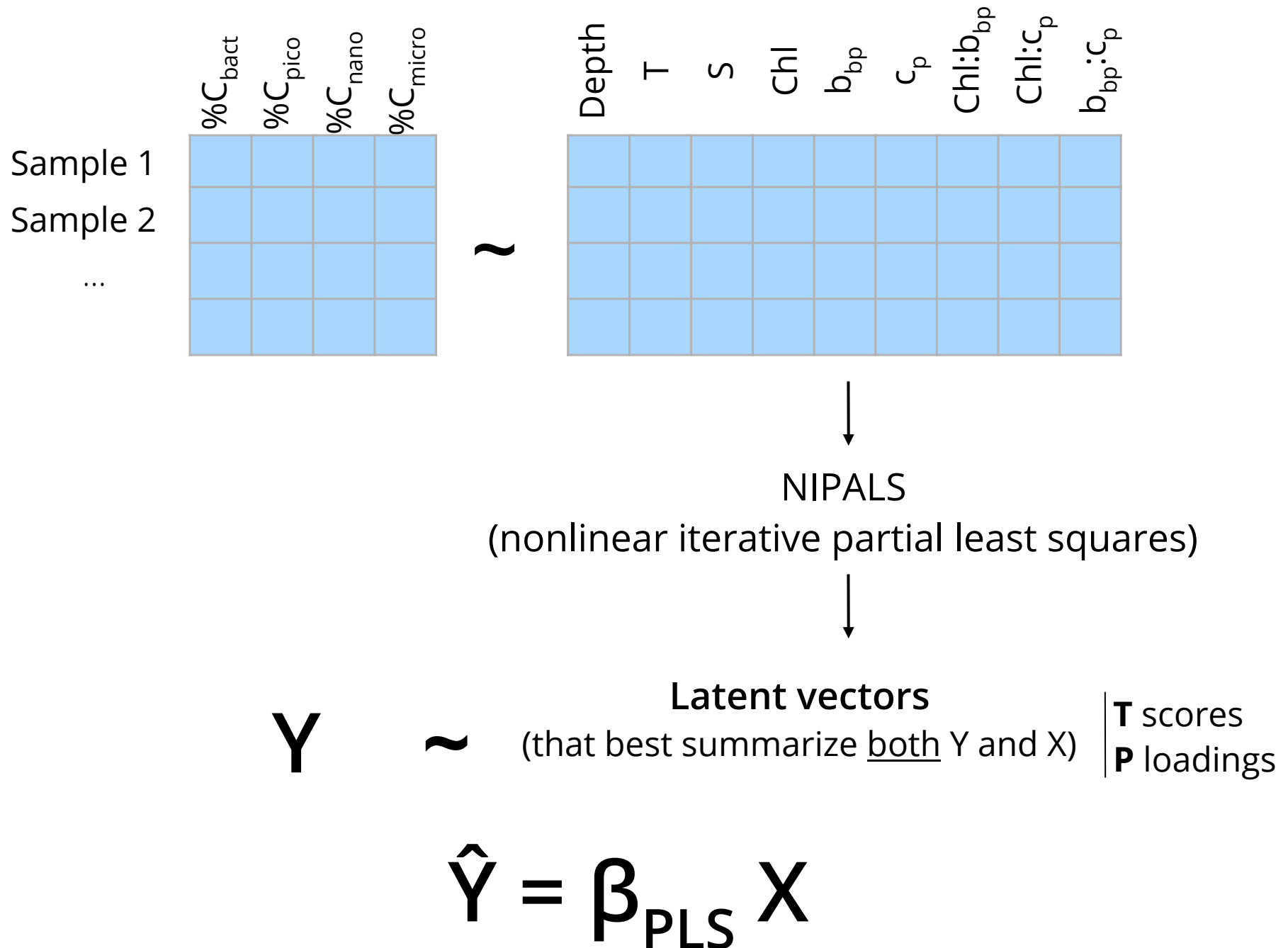
Parallelepiped

$$V = a b^2$$



- This study
- Stramski et al. [1999] PFZ
- - Stramski et al. [1999] Ross
- Loisel et al. [2001]
- Stramski et al. [2008]
- Balch et al. [2010]
- Cetinic et al. [2012]

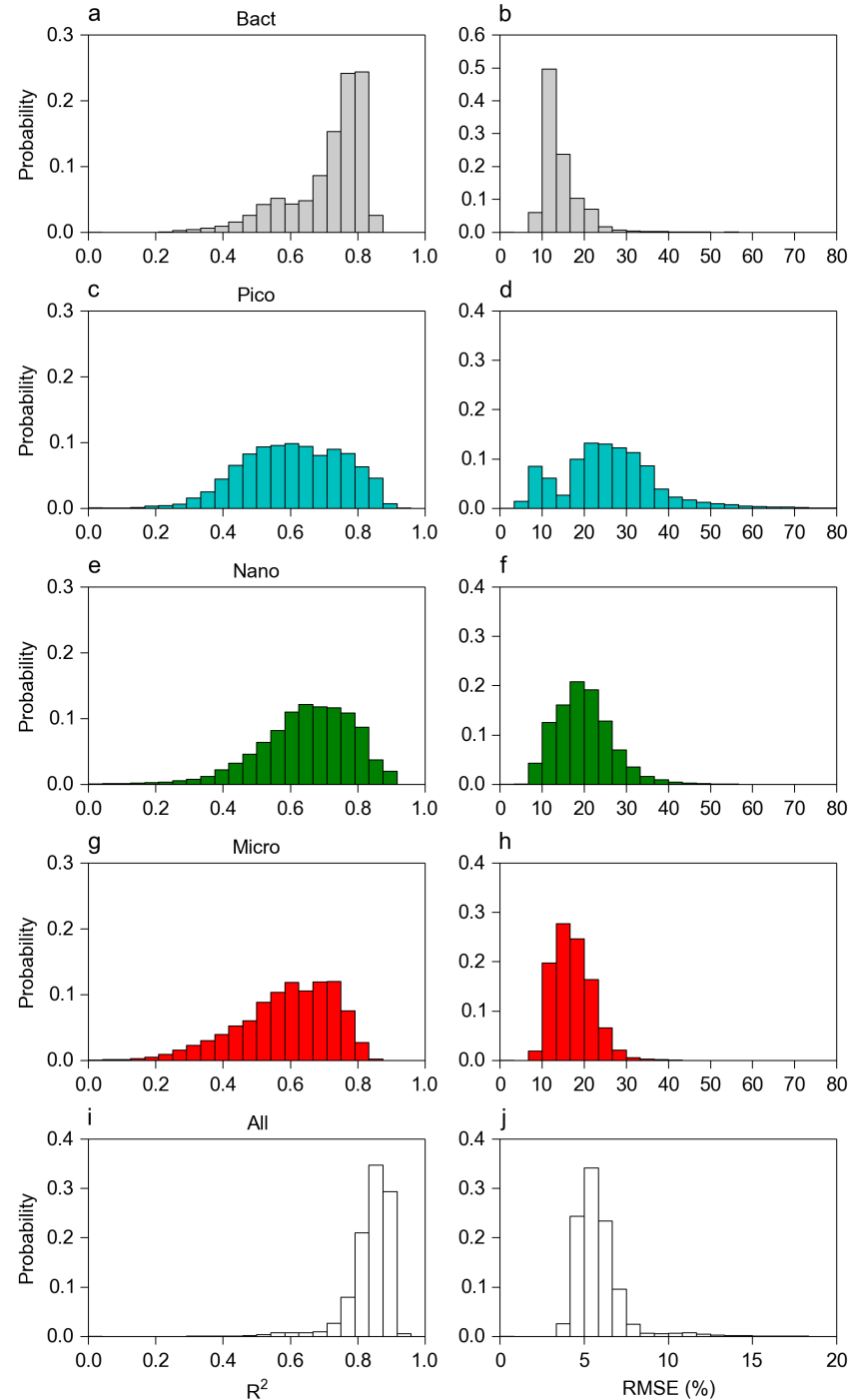
- This study
- Marra et al. [1995]
- - Bishop et al. [1999]
- Claustre et al. [1999]
- - Oubelkheir et al. [2005]
- Behrenfeld and Boss [2006]
- - Gardner et al. [2006]
- Stramski et al. [2008]
- Cetinic et al. [2012]

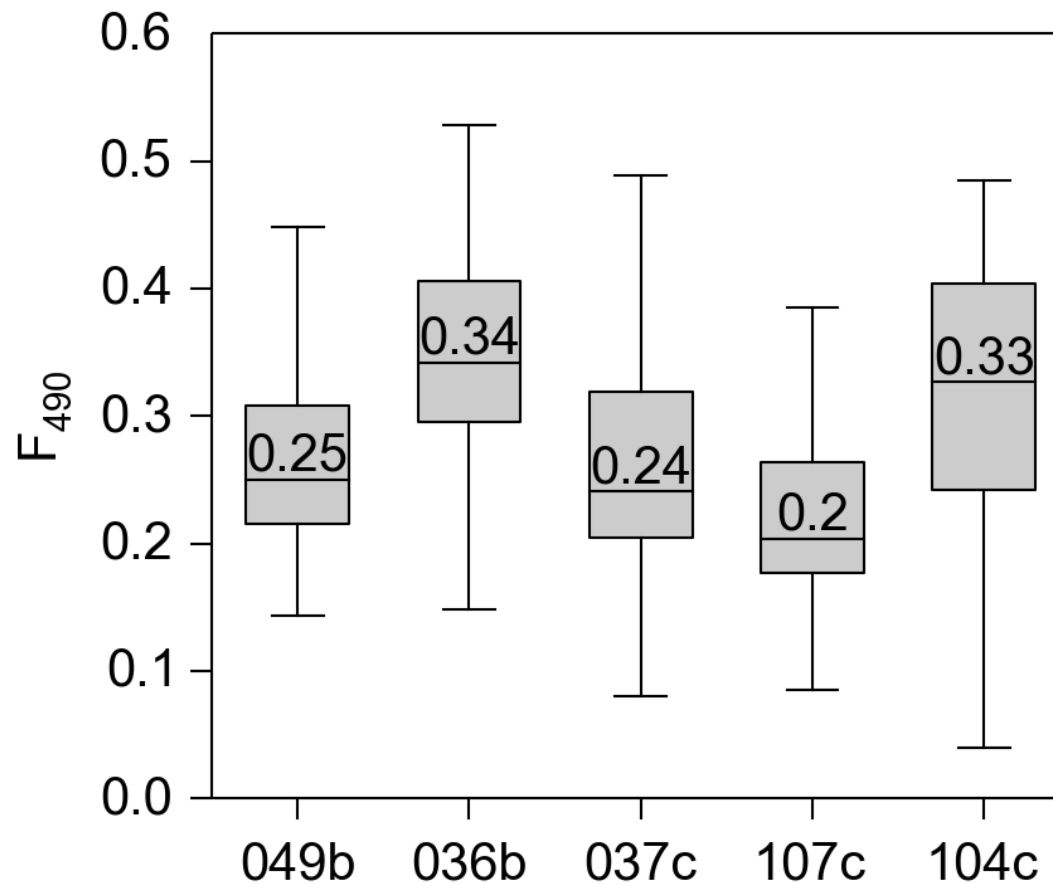


	PLSR	MARS	MLR
R ² global	0.84	0.78	0.81
R ² range	0.78 - 0.86	0.69 - 0.85	0.72 - 0.85
RMSE global	5.4 %	6.7 %	6 %
RMSE range	1.6 - 7.2 %	2.2 - 8.6 %	1.8 - 8.1 %

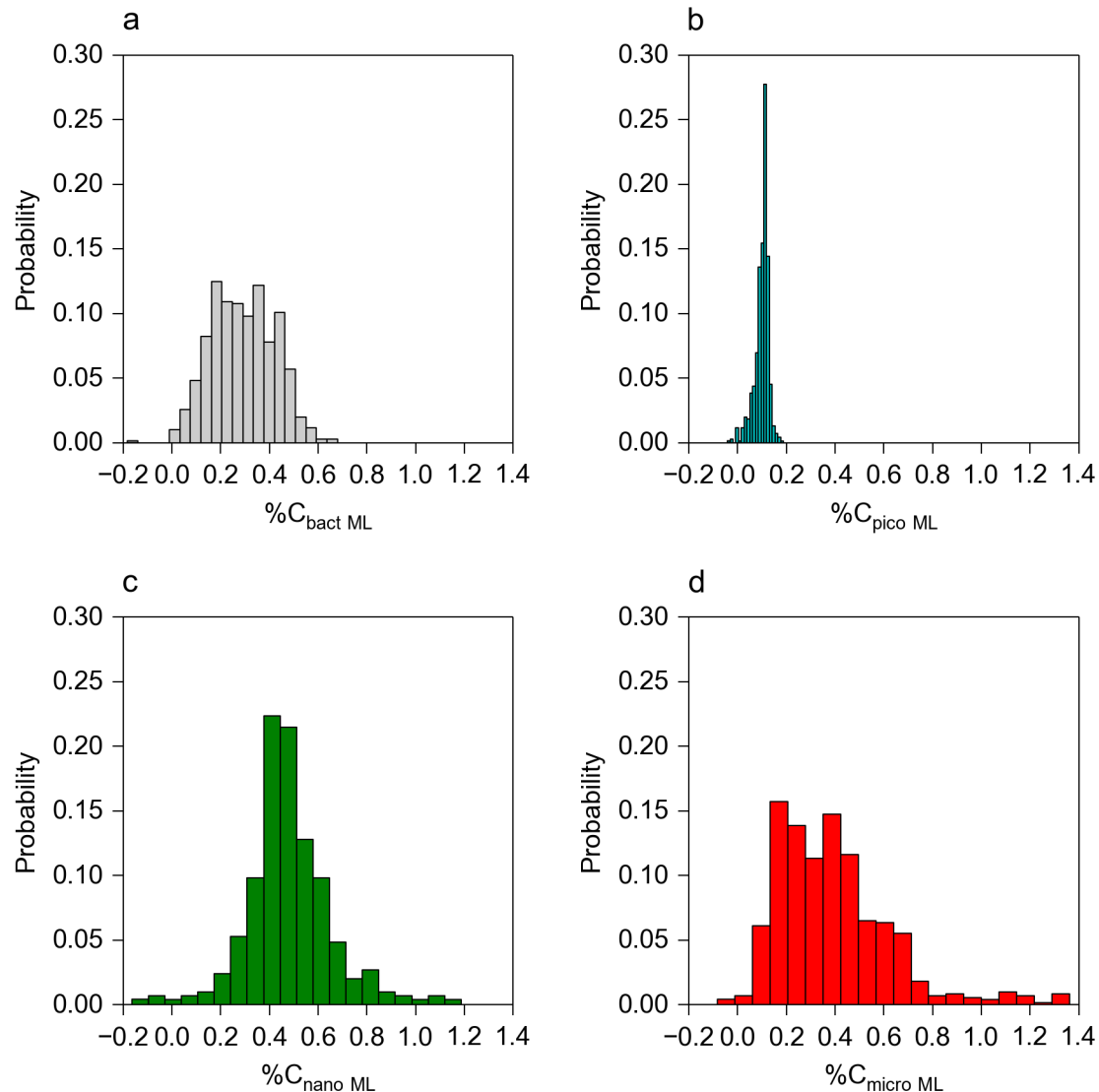
Probability histograms of the results from the bootstrapping used to estimate the quality of the PLSR prediction.

The dataset was randomly split into 2/3 learning set, 1/3 validation set, and prediction was repeated 10 000 times.

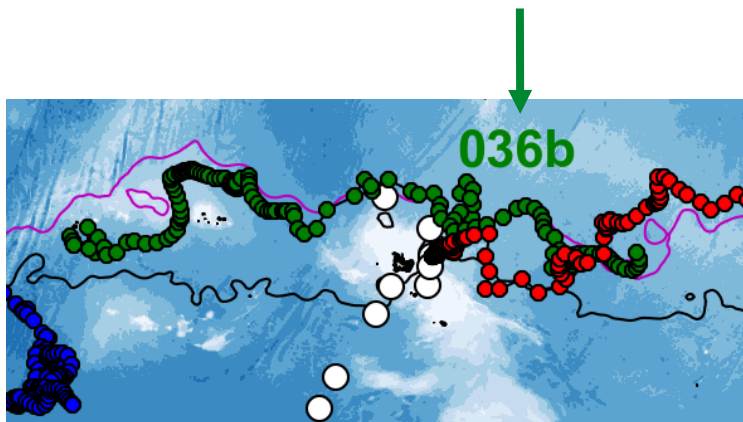




Box and whisker plots of the F_{490} factor calculated for each float. The median value is specified.



Probability histograms of the mean $\%C_{\text{group}}$ in the mixed layer predicted from the float data (n = 758 profiles).



Float 036b

- North Crozet/Kerguelen PFZ
- End North Crozet bloom : nano
- *Phaeocystis* ? (Poulton et al. 2007)
- Episodic micro around fronts

