DEEP BIOMASS MAXIMA of phytoplankton

-

an approach with BGC-argo floats

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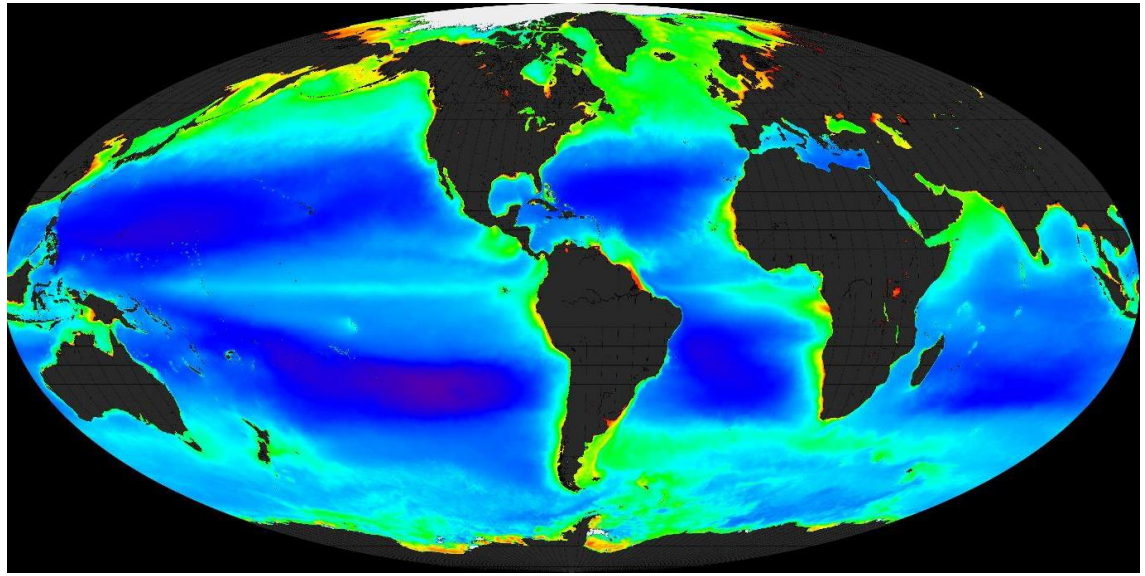
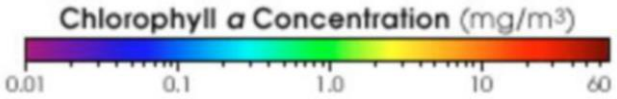
INTRODUCTION

- Strongly implied in the **C biogeochemical cycle** :
  Constitution of **organic matter** and potential **export** toward deep layers of ocean
- For the most monitored by **remote sensing**

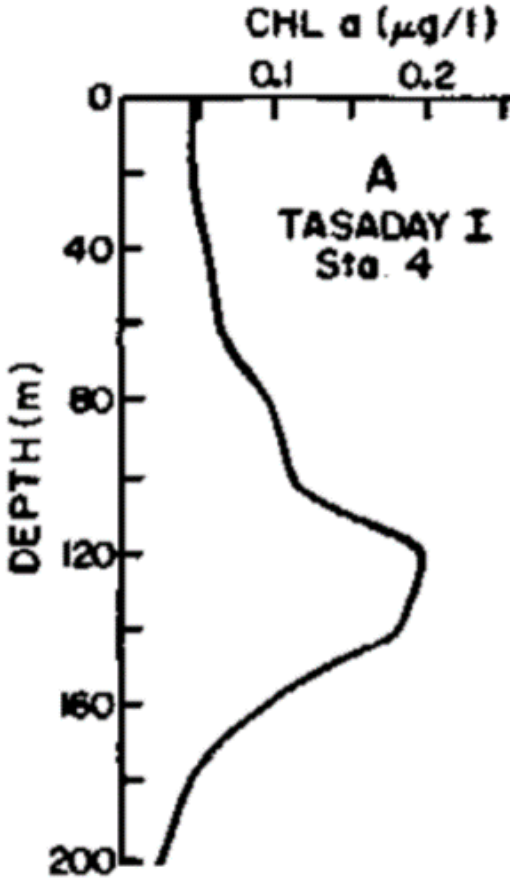




- → ***Subsurface dynamics still poorly understood***

INTRODUCTION

- Features of stratified system : **Deep Chlorophyll Maxima**
- Constrained by **light** and **nutrients** availability
- Contribution to the whole water column primary production ?



Example of vertical profile with DCM (North Pacific Gyre, Cullen et al., 1981)

INTRODUCTION

However, we distinguish 2 different type of maxima:

- → **DCM (Deep Chlorophyll Maxima)**
  True productive layer

  BUT also

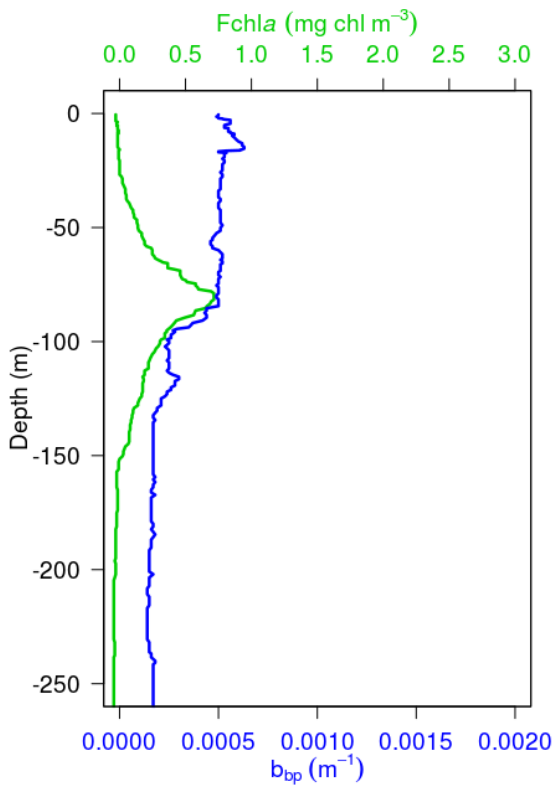
  Change in **Chl*a* content relative to organicC/ biomass**(Fennel & Boss 2003, Steele 1964), photoacclimation

- → **DBM (Deep Biomass Maxima)**
  Productive layers (Beckmann & Hense 2007)

INTRODUCTION

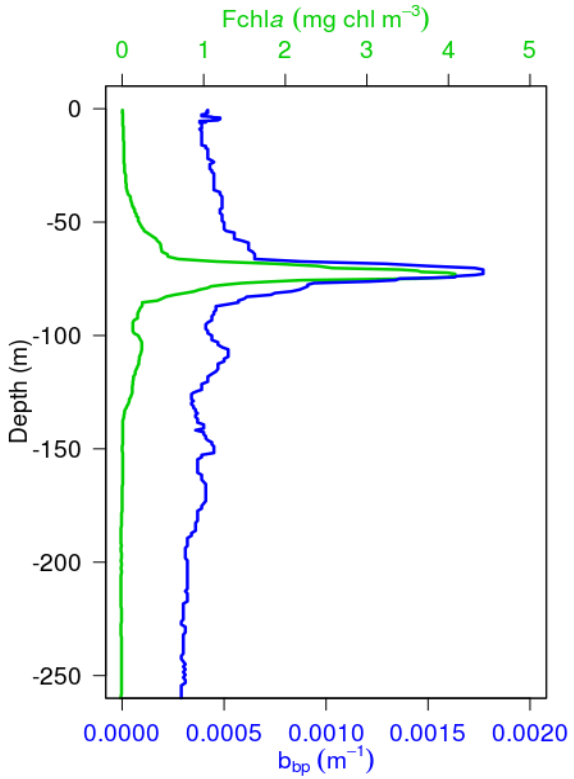
Fluorescence of the Chl*a* (Fchl*a*)
is a proxy of the **concentration of the Chl*a* ([Chl*a*])**

Backscattering coefficient (b_{bp})
is a proxy of the **Particulate Organic Carbon (POC)**



***DCM** only*
(photo-acclimation)

Profile showing peak of Fchl*a* (**DCM**) but no peak of b_{bp} (photoacclimation)



***DCM** associated*
*with local max of POC : **DBM***

Profile showing peak of Fchl*a* combined with a peak of b_{bp} (**DBM**)

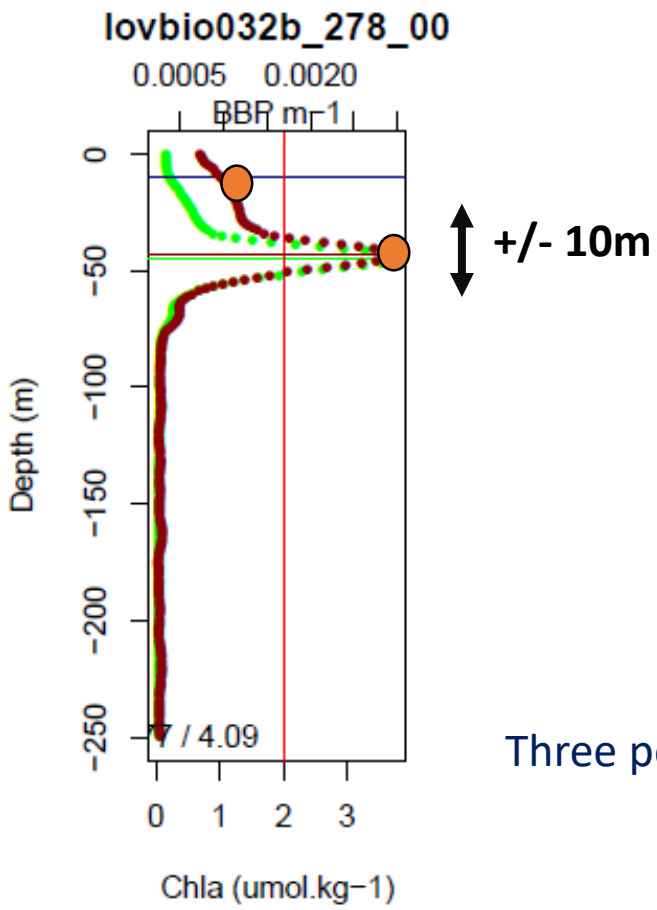
Objectives of the study :

→ **global DCM/DBM occurrence** (spatial and seasonal occurrence)

→ **global DCM/DBM properties** (biomass, depth, intensity)

→ **influence of abiotic forcing factors** (light and nutrients)

MAT/MET : **classification of bio-optical profiles → Method**



+/- 10m

1) Mean concentration in the 15 first meters

2) Filtering Median on vertical profile of b_{bp} et Fchl *a* depending on vertical resolution of sampling

3) Identification of **DCM** (>= 2X surface value) Lavigne *et al.,* 2015
→ Retrieval of closest value on raw profile

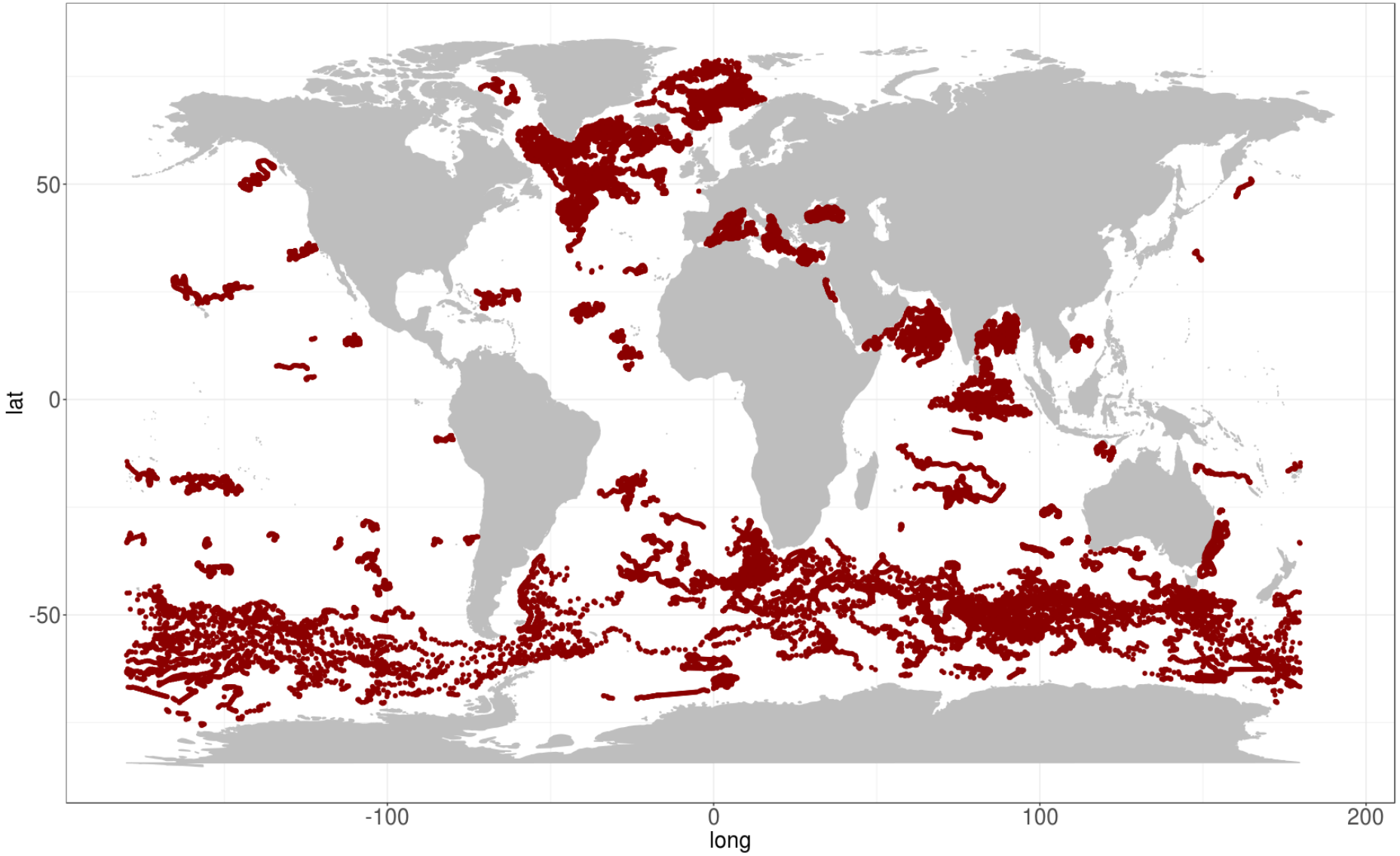
4) Max b_{bp} around DCM (±10m)
→ Retrieval of closest value on raw profile

5) Identification of **DBM** (>= 1,3 X surface value) Cornec *et al., (in prep)*

Three possibility:

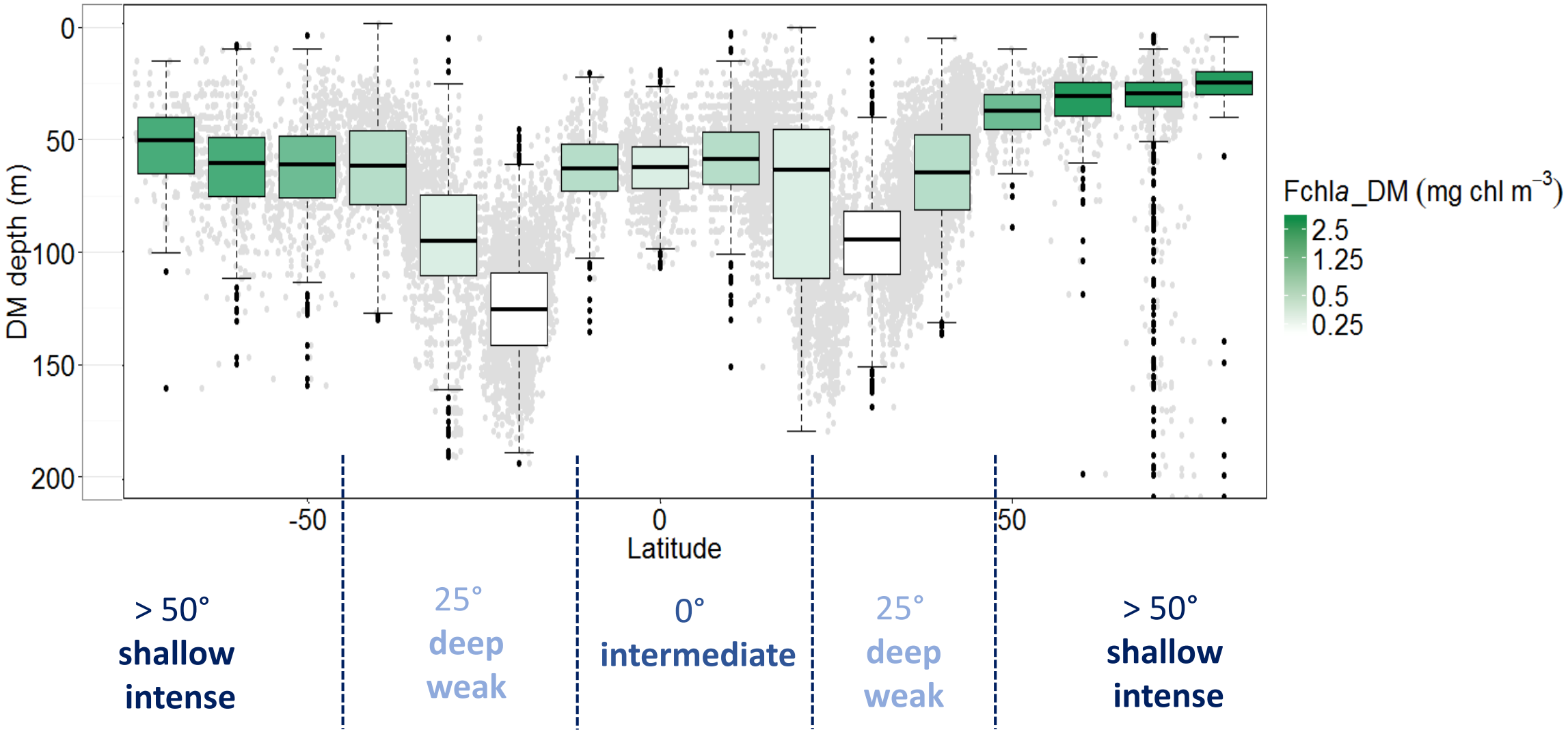
- **NO Maximum**
- **Only DCM (i.e. only max in Chl)**
- **DBM (i.e. max bbp and chl coincedent)**

MAT/MET : **55 082 BGC-Argo profiles with Fchla and BBP**



Results

RESULTS: **DCM DEPTH AND INTENSITY**

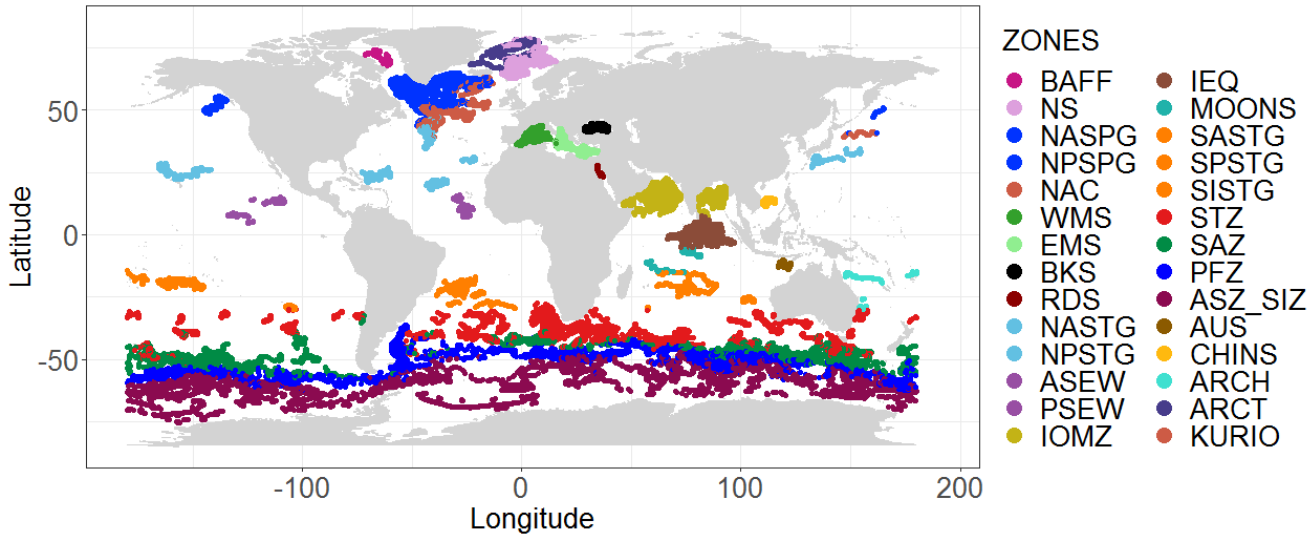


RESULTS: **DCM/DBM DEPTH AND INTENSITY**

Profiles characteristics are then grouped on the basis of a regional classification (28 regions)

For each region is calculated:

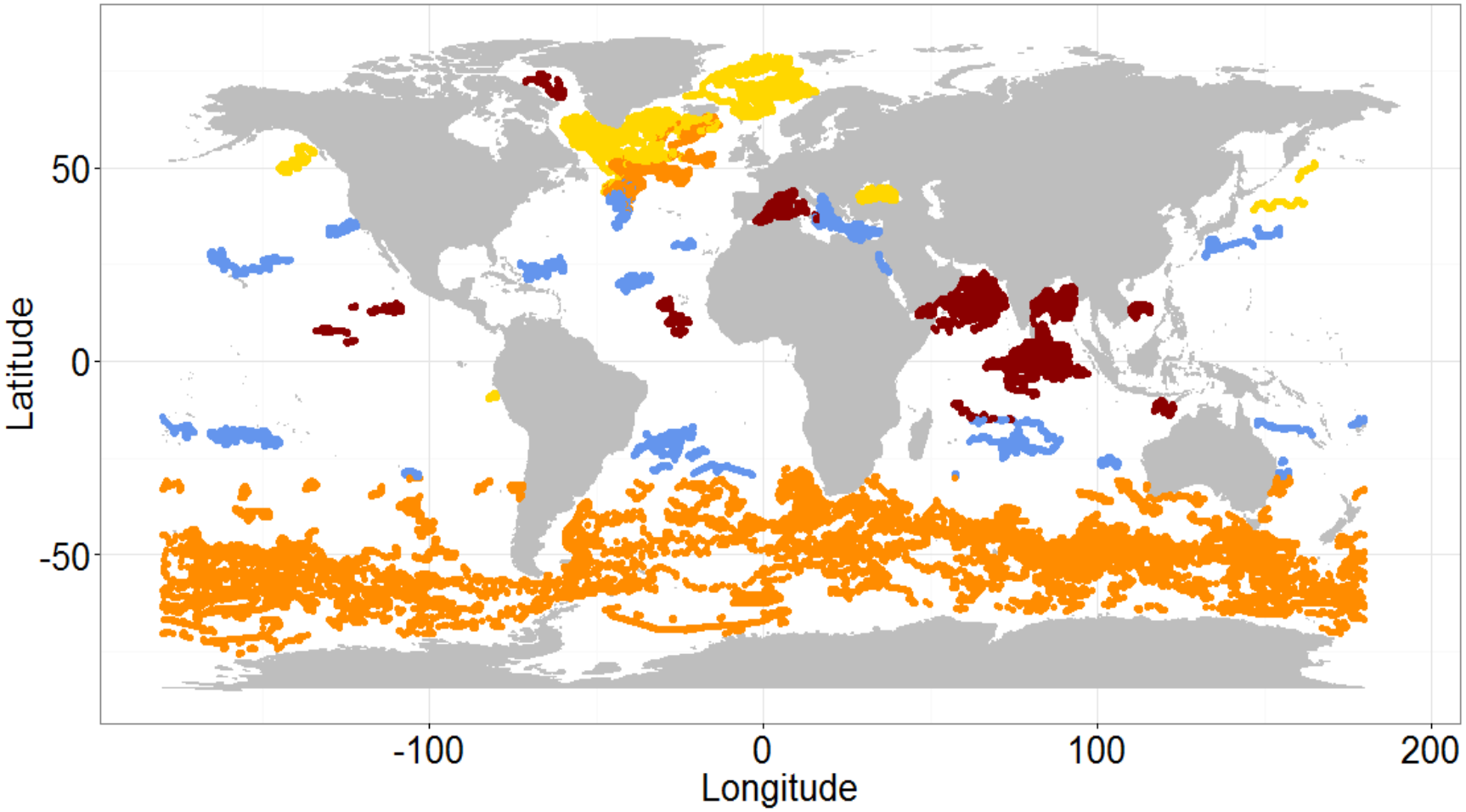
1. **DCM mean depth**
2. **Fchl*a* value at DCM depth**
3. **Number of DCM occurence**
4. **Number of DBM occurence**



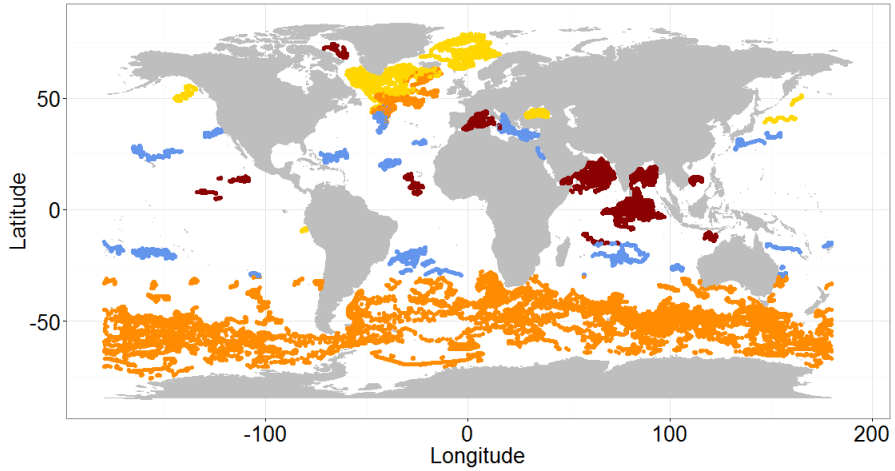
These 4 parameters are then clusterized **by K-means method**

RESULTS: **REGION CLASSIFICATION on the DM PROPERTIES**

K-Mean clustering on the DM depth, intensity, frequence of DBM and DCM : **4 groups of regions**



RESULTS: **GROUP PROPERTIES**



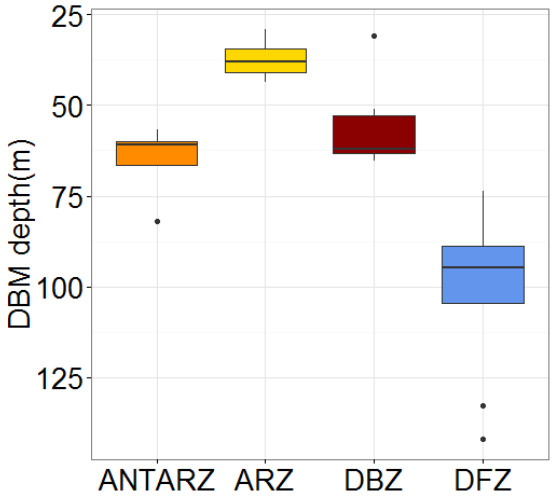
Acronyms:

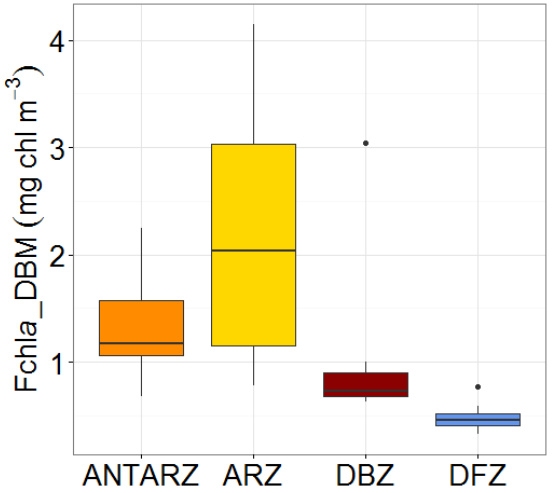
ANTARZ: Antarctic Zones

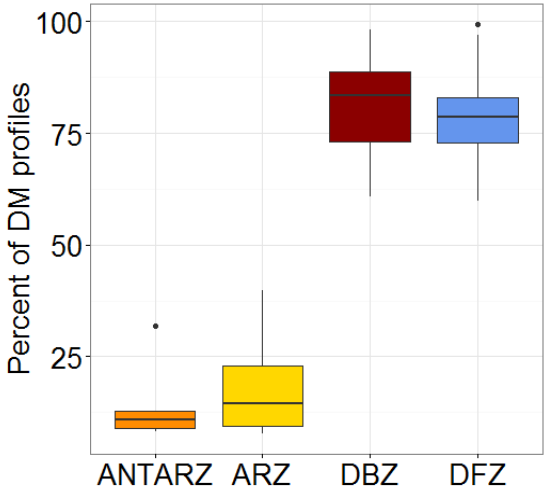
DFZ: Deep Fluorescence Zones

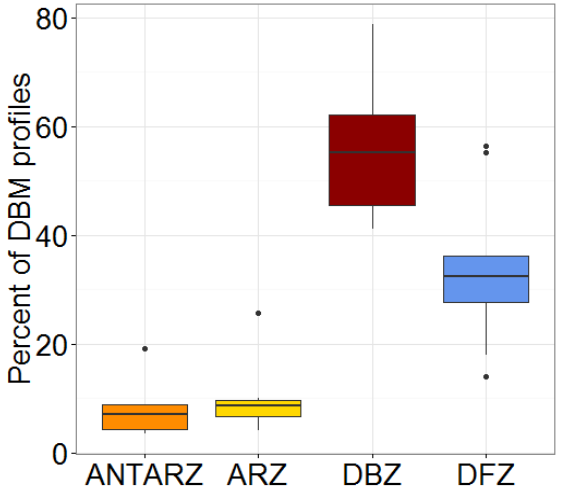
DBZ: Deep Biomass Zones

ARZ: Arctic Zones









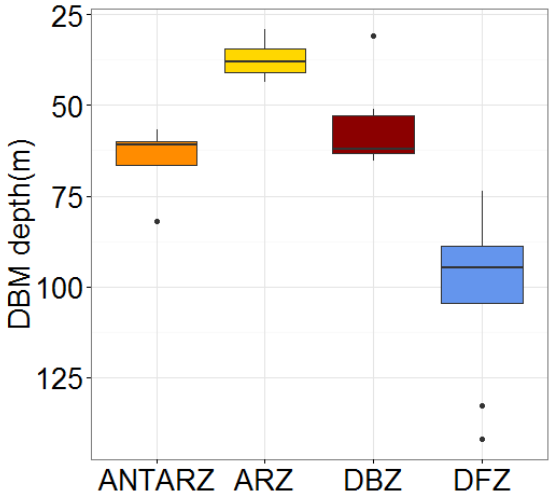
RESULTS: **GROUP PROPERTIES**

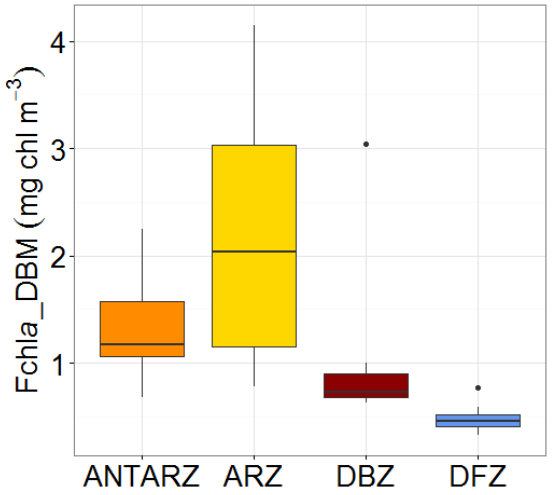
ANTARZ: **shallow** and **intense** DCM/DBM, but **parse**

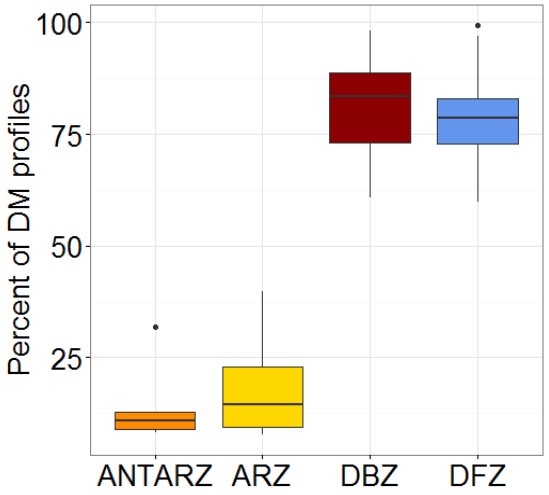
ARZ: **shallowest** and **most intense** DCM/DBM, but **parse**

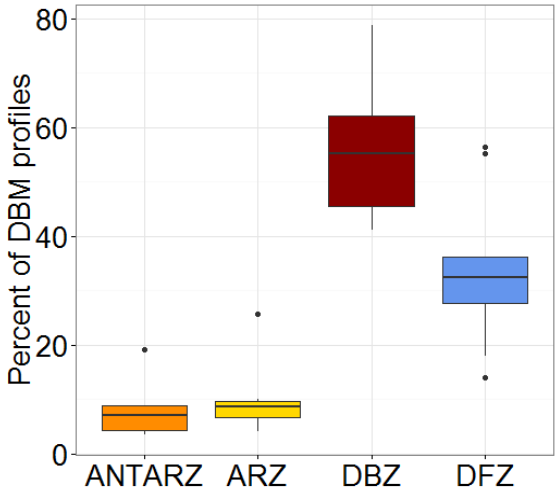
DFZ: **deepest** and **weakest** DCM/DBM. High occurence of DCM, but **low occurence of DBM**: mostly **photoacclimation**

DBZ: **shallow** and **high occurring DBM**





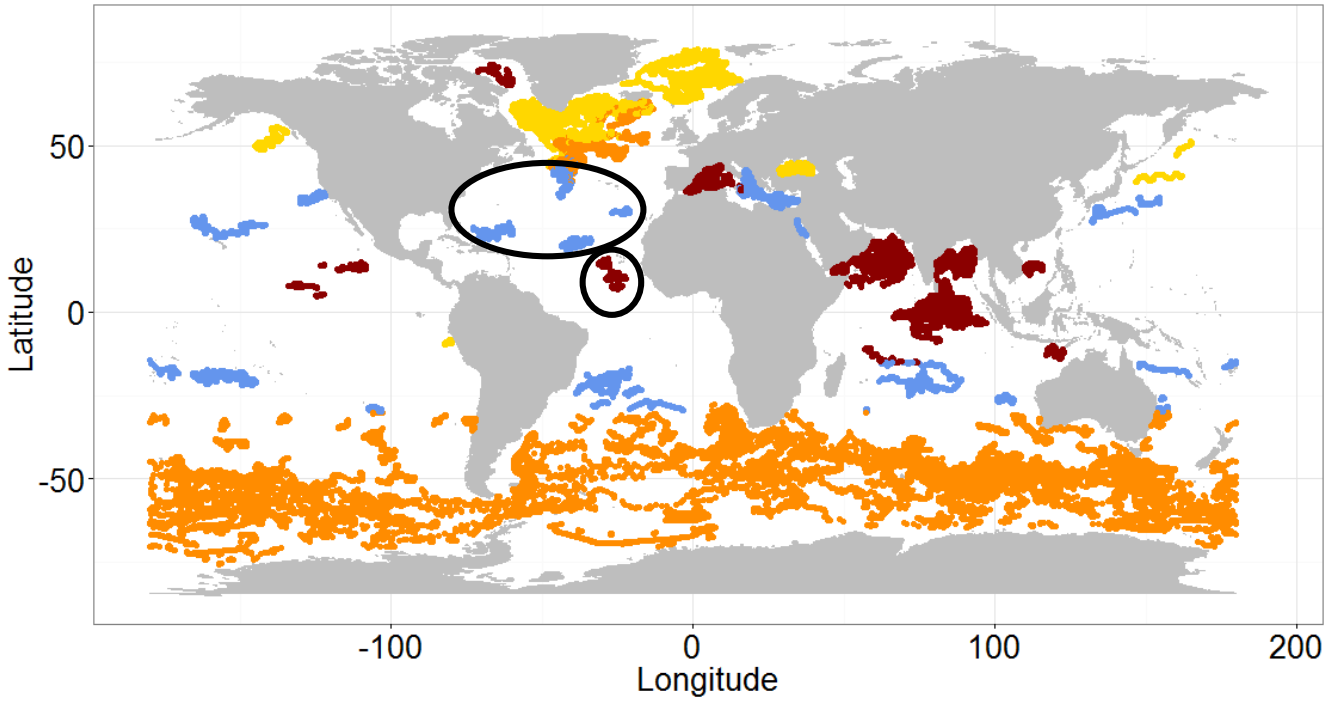




ANTARZ: Antarctic Zones. DFZ: Deep Fluorescence Zones. DBZ: Deep Biomass Zones. ARZ: Arctic Zones

RESULTS: **FOCUS ON STRATIFIED SYSTEMS (ASEW AND NASTG)**

Climatologies of 6 floats data in the ASEW and NASTG



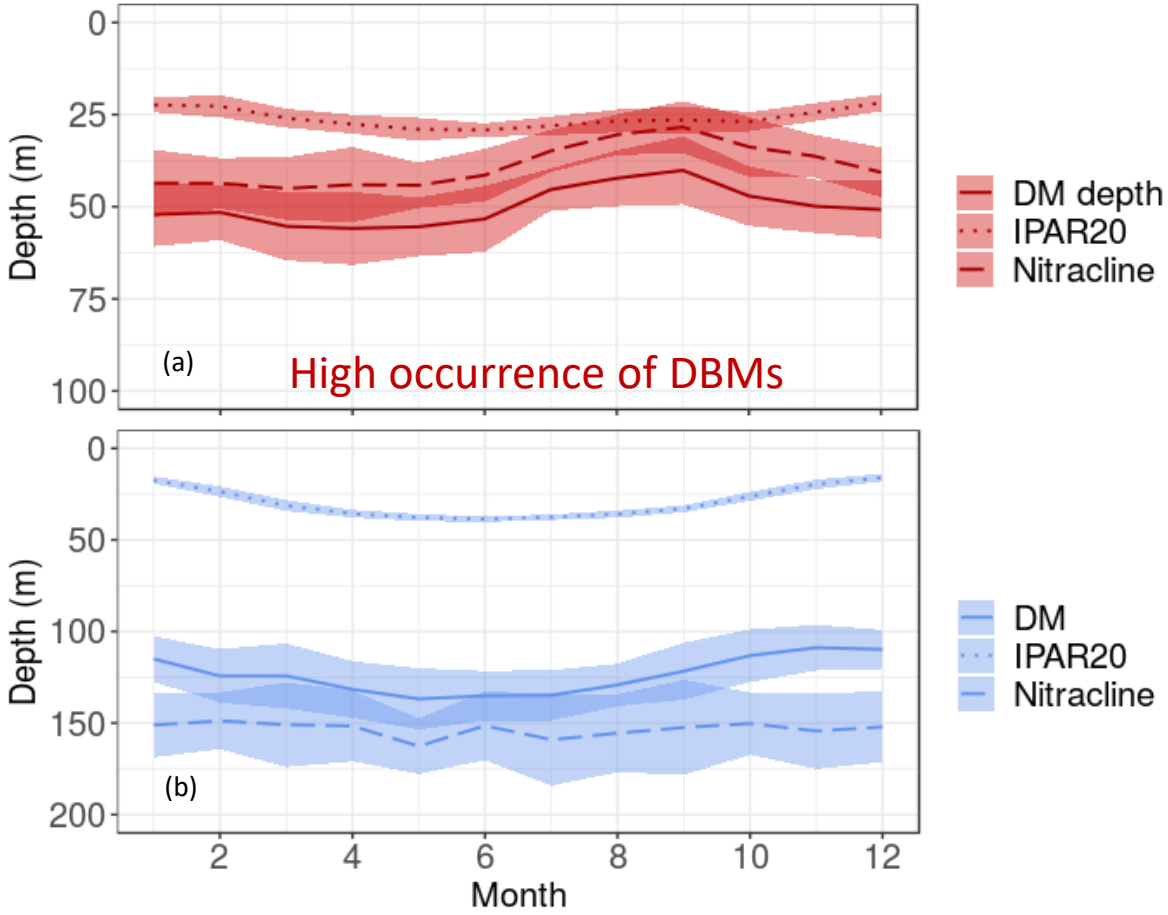
We focused on 2 regions from two stratified groups from the **same oceanic basin** but showing **different DBM characteristics**:

Low occorrence of DBMs
High occurrence of DBMs

What **environmental parameters** are implied in those distinct deep dynamics ?

RESULTS: **FOCUS ON STRATIFIED SYSTEMS (ASEW AND NASTG)**

Climatologies of 6 floats data in the ASEW and NASTG



Low occorrence of DBMs

DM depth: depth of the DCM

Nitracline:

depth of the nitracline

Nitrate profiles were calculated from neural network CANYON B (Sauzède *et al.*, 2017, Bittig *et al.*, 2018). Nitracline was estimated as described in Pasqueron de Fommervault *et al.*, 2017.)

IPAR 20:

isoline of the daily photon flux at a value of 20 E m^{-2} j^{-1}

PAR profiles were retrieved from a solar irradiance model and an empirical bio-optical relationship between spectral the diffuse attenuation coefficients (K_d) and Fchl*a* from the float profiles (Xing *et al.*, 2018).
PAR profiles were then integrated over the day length (Lacour *et al.*, 2017).

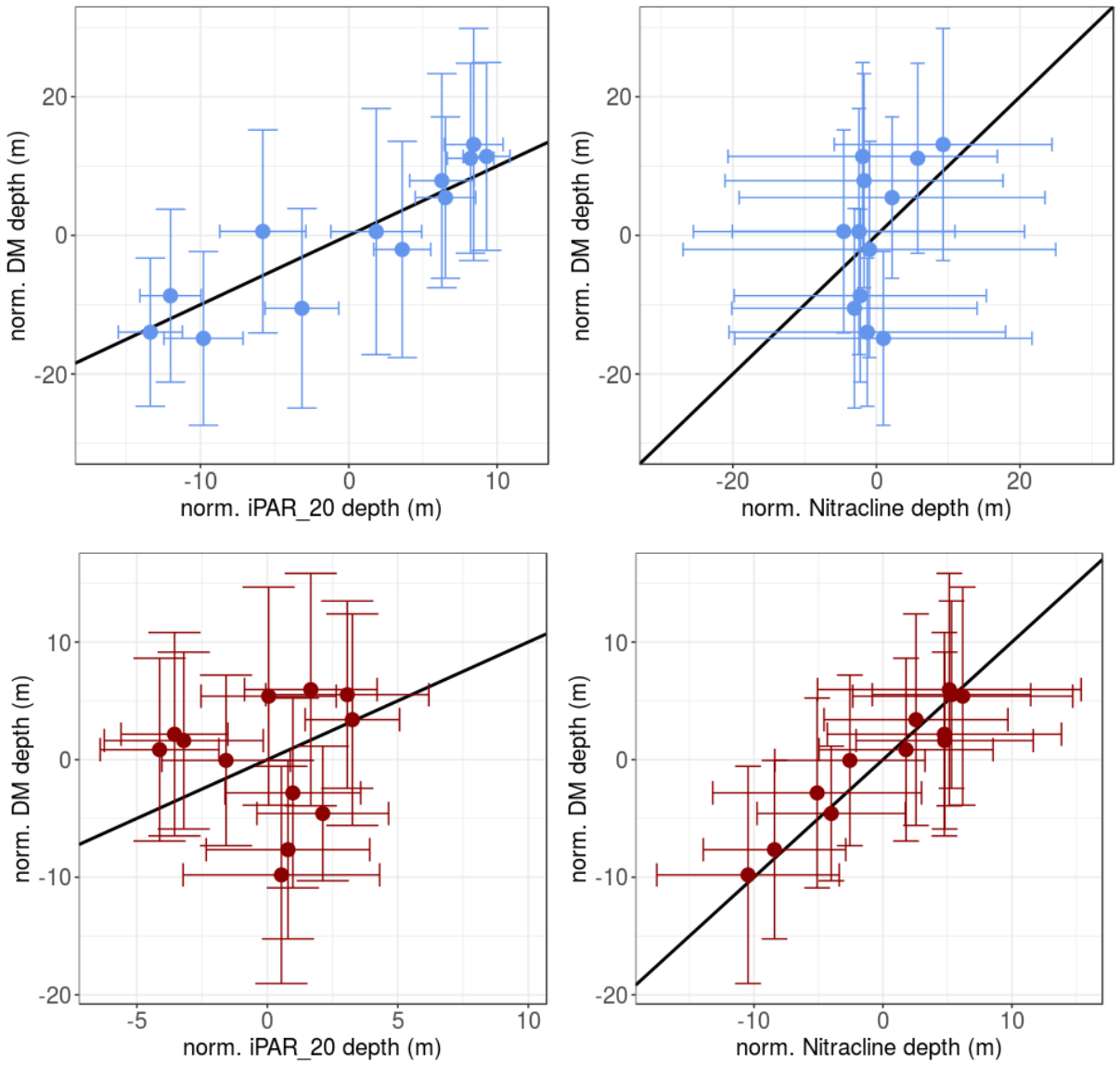
RESULTS: **FOCUS ON STRATIFIED SYSTEMS (ASEW AND NASTG)**

In the NASTG: Low occurrence of DBMs

The DCM/DBM depth
covaries with the **IPAR 20**.

In the ASEW: High occurrence of DBMs

the DCM/DBM depth
covaries with the **nitracline**.



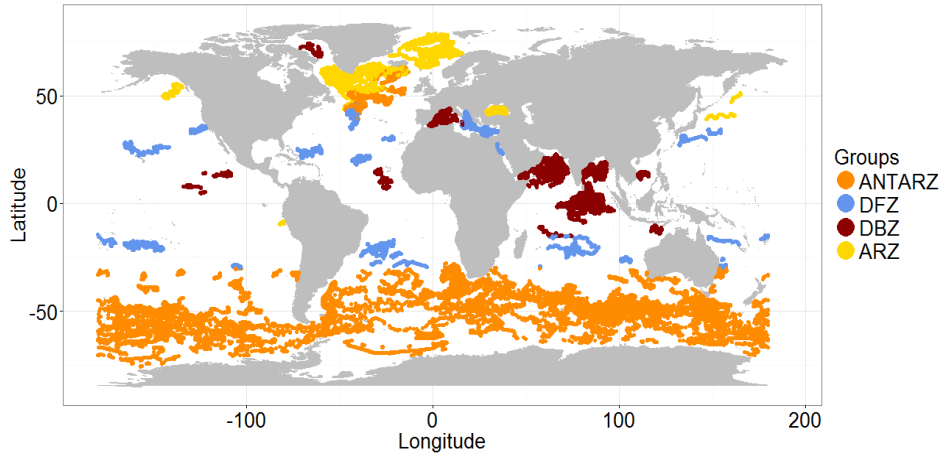
Conclusion

DMB/DCM spatio_temporal variability was analysed at global scale

The bioregionalisation approach provides also insights of the DCM/DMB abiotic forcing factors

Latitudinal gradient of occurrence of DCM/DBM:
permanent and frequent (equatorial) -> spring/summer and parse (high latitudes)

ASEW (example of DBZ) : -> DBM/DCM covaries with nutricline dynamic
NSTG (example of DFZ) : -> DBM/DCM covaries with light field



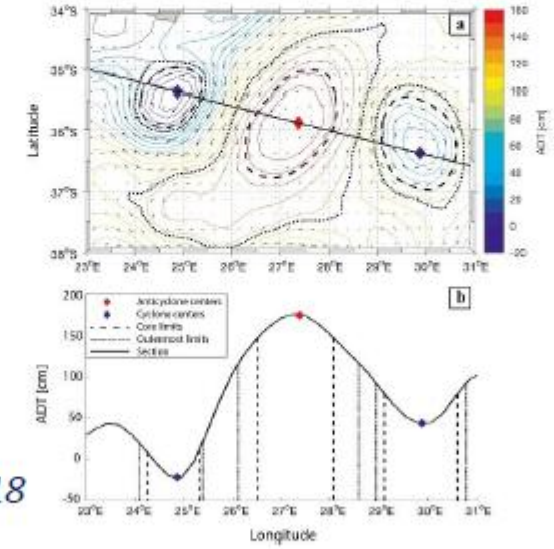
THANK YOU FOR YOUR ATTENTION !

Perspective: mesoscale impacts on DCM/DBM

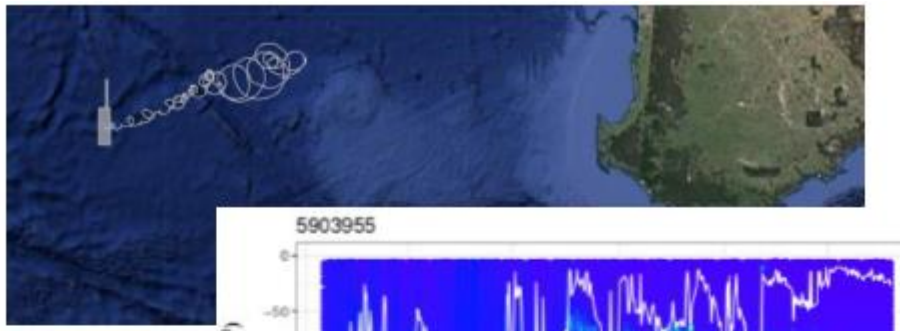
Ocean mesoscale dynamics :

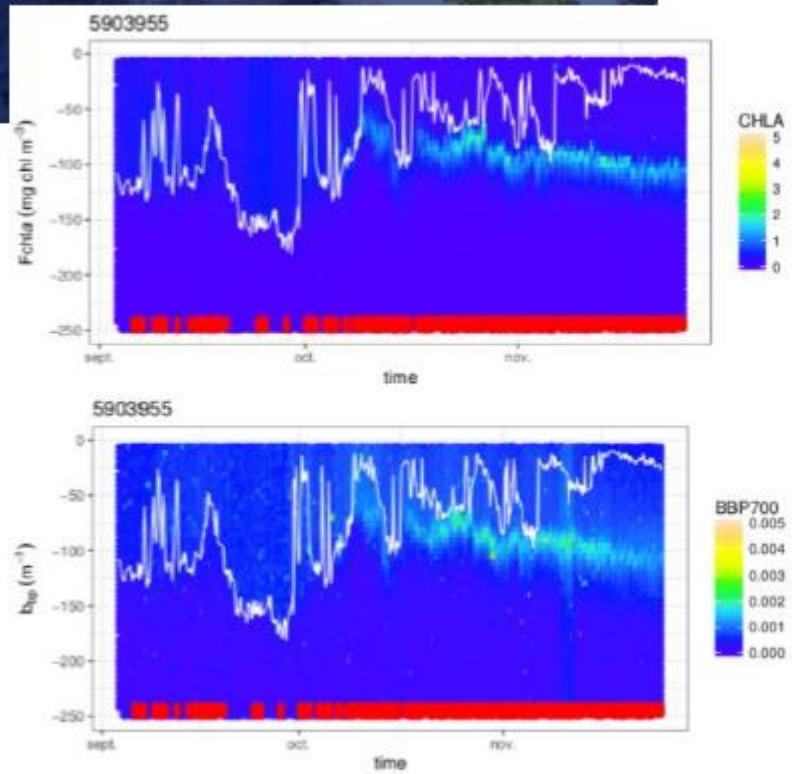
→ Influence of mesoscale features (eddies, fronts) (McGilliguddy *et al.*, 2007 , Levy *et al.*, 2018)

R. Laxenaire : detection and tracking of eddies at a global scale



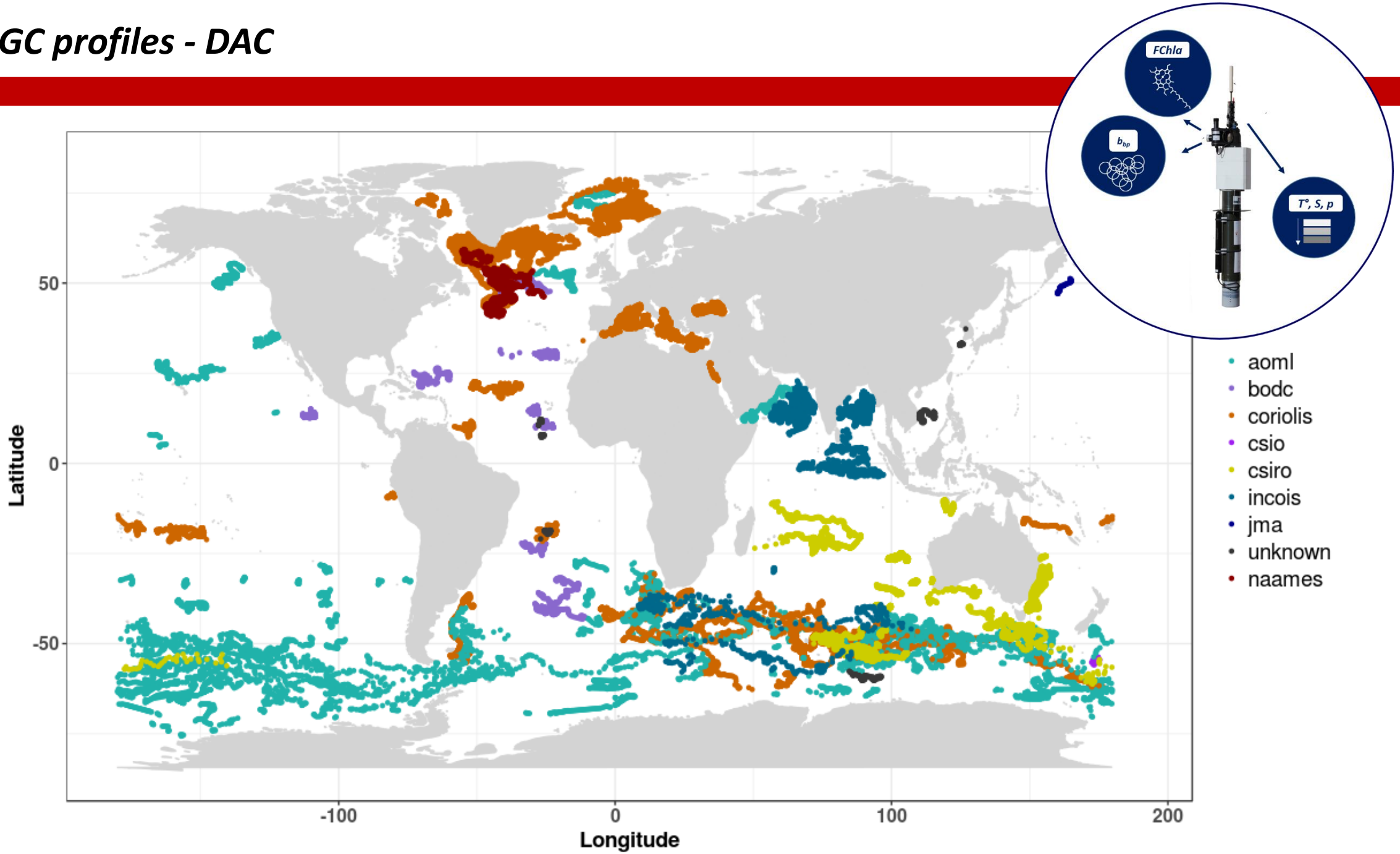
Laxenaire et al. 2018





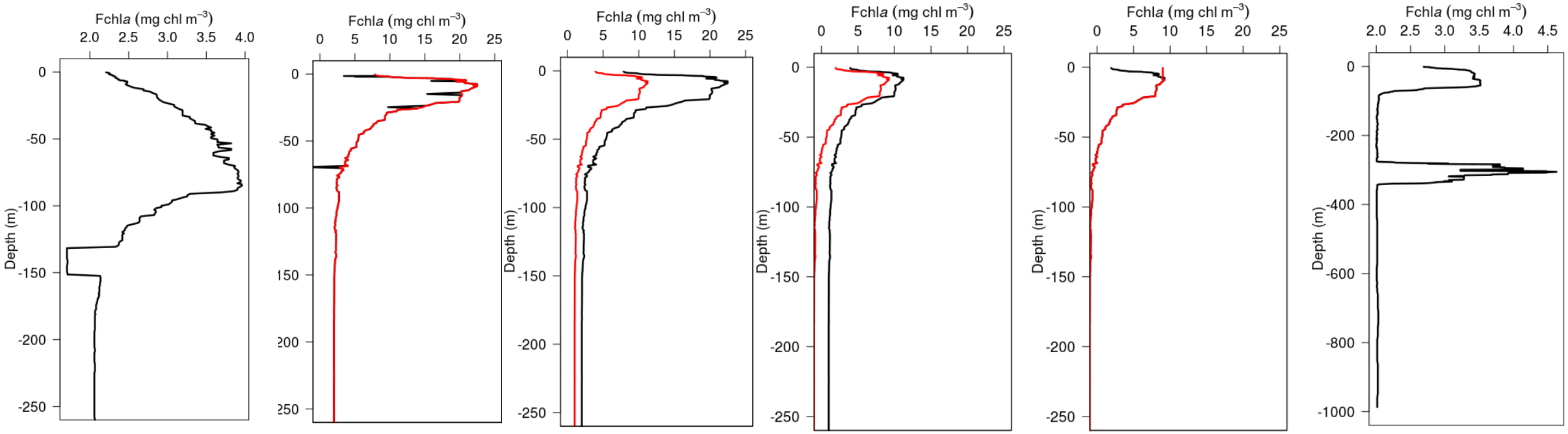
→ Horizontal features : subduction, isopycnal inputs (Yentsch 1980, Jenkins and Doney 2003)

extra: ***BGC profiles - DAC***



extra : ***CORRECTION PROCESS OF THE FCHLA PROFILEs***

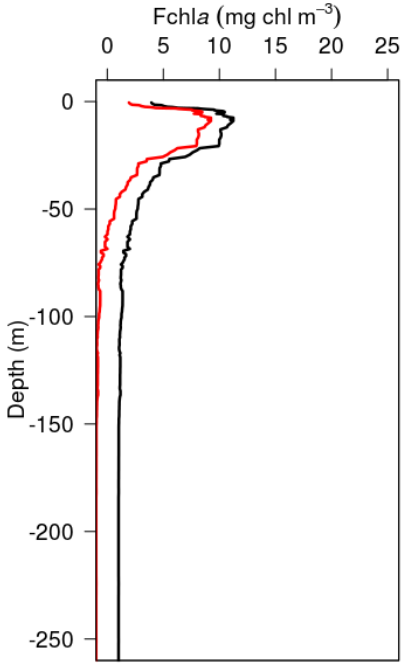
DATA QUALITY CONTROL → DESPIKE → F2 → DARK OFFSET → NPQ → PROFILES REMOVAL (ZOO, COASTAL, *ETC…*)



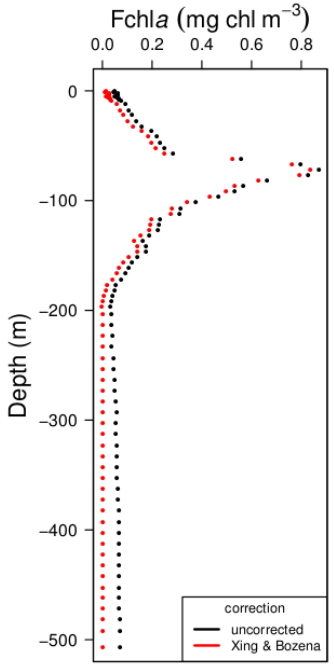
extra: ***Fchla profiles dark correction***

Correct the profile of **an offset** between the factory calibration and the real dark values

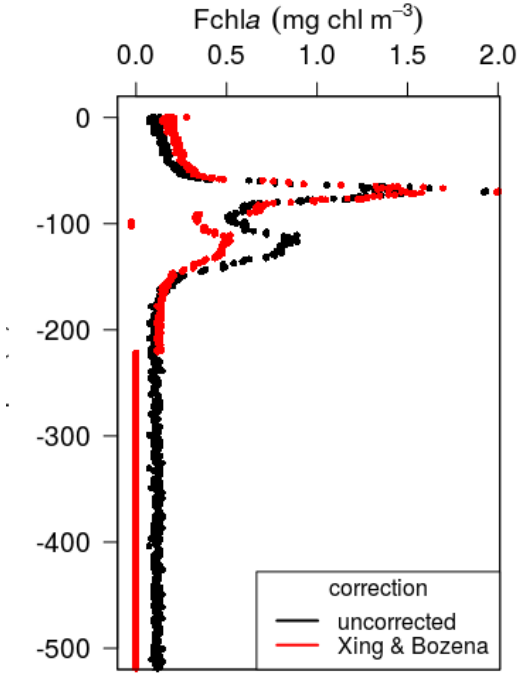
USUAL CORRECTION
Schmechtig *et al*, 2014



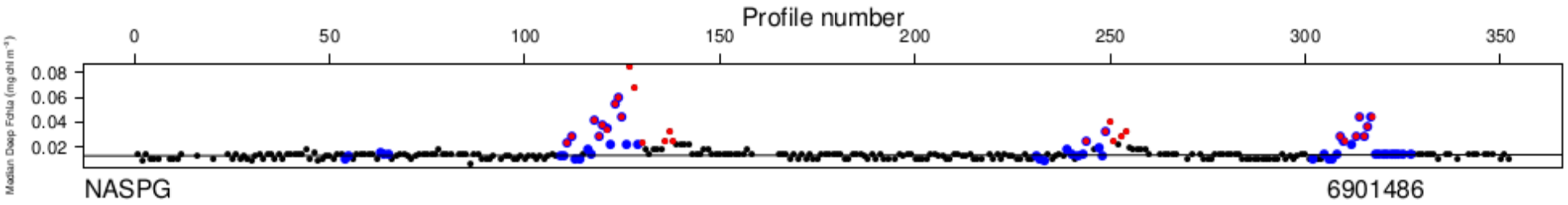
OLIGOTROPHIC WATERS
Xing *et al*, 2017



OMZ WATERS
Bozena *et al*, 2018

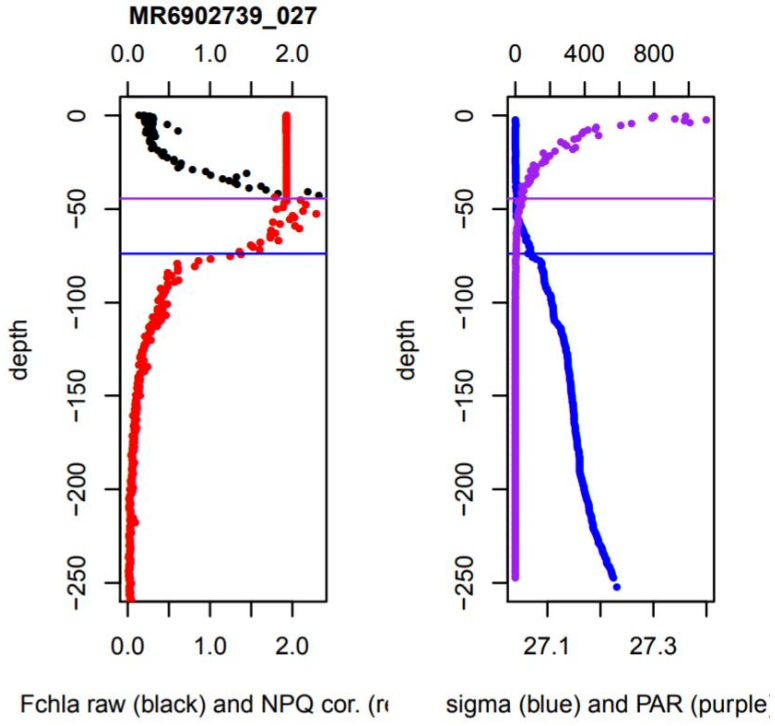


CASE OF
DEEP MIXING



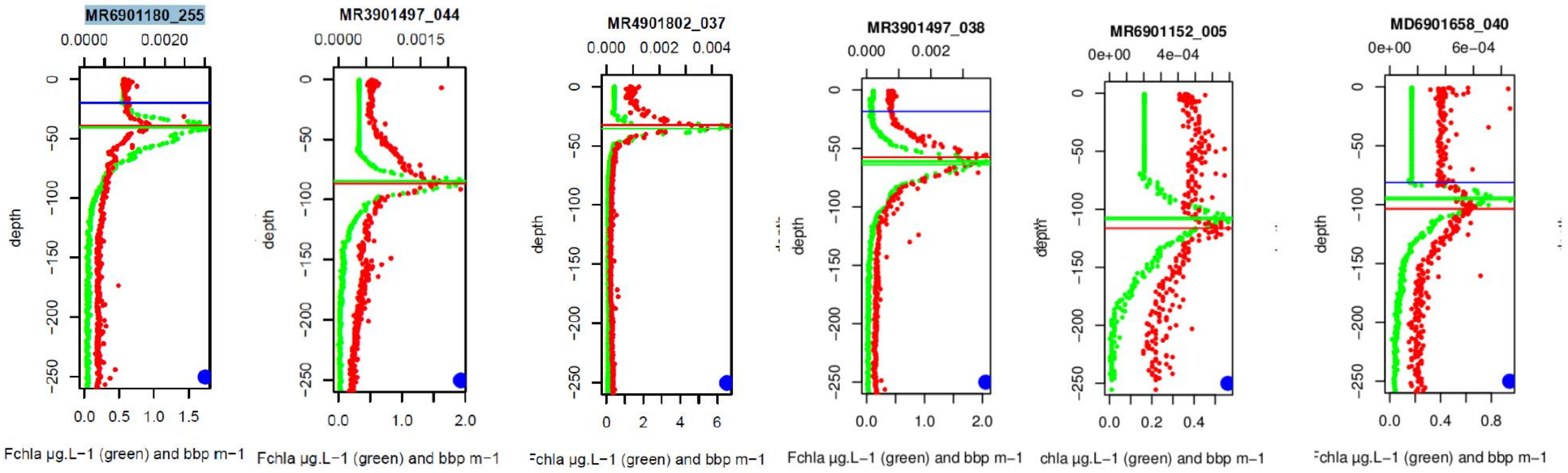
extra: ***npq correction***

Correction for **Non Photochemical Quenching**
(Light and MLD tresholds)
Xing *et al*., 2018



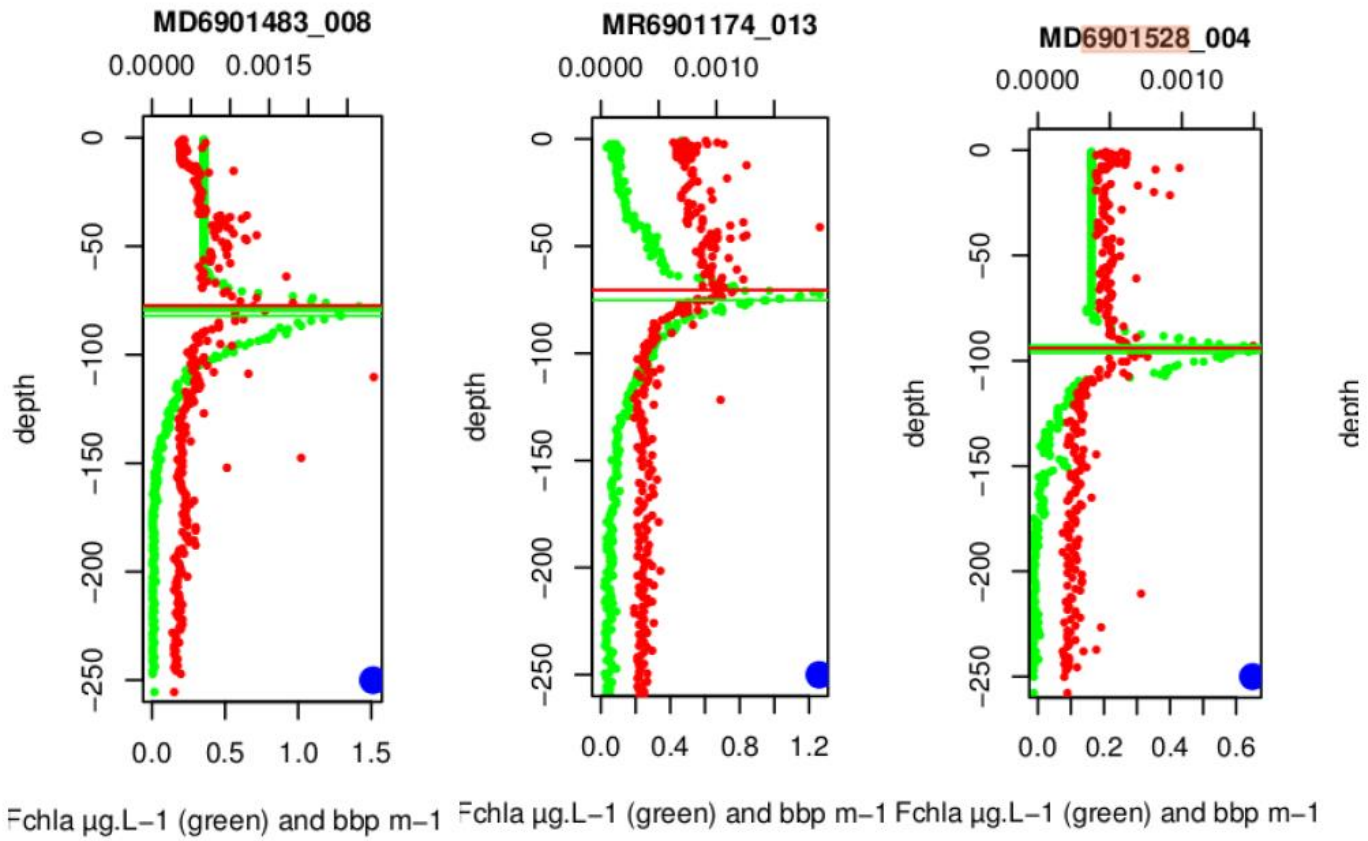
extra : ***profiles examples dbm***

Atlantique Nord | Océan Austral | Mer de Baffin | Gyre Nord Atlantique | Gyre Sud Atlantique | Gyre Sud Pacifique

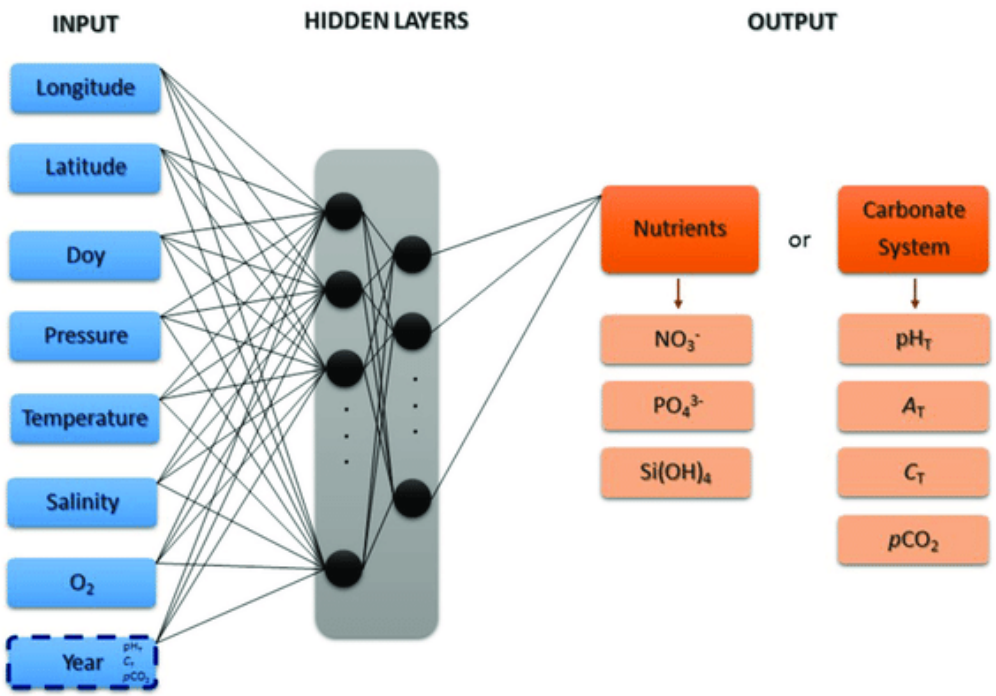


extra : ***profiles examples dbm***

Med Ouest Dôme de Guinée Med Est

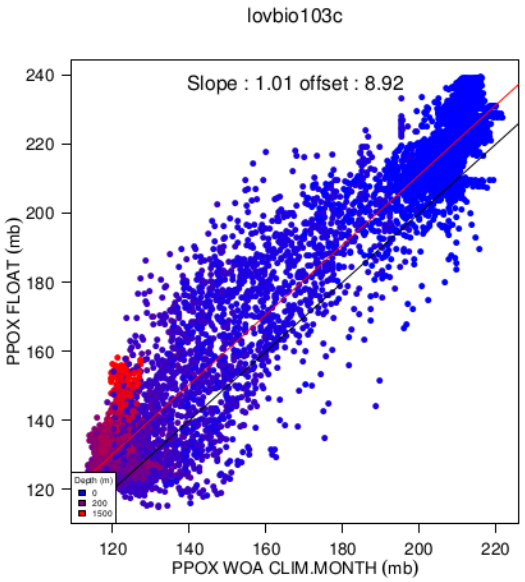


extra: ***nitrates estimation from neural network CANYON B***



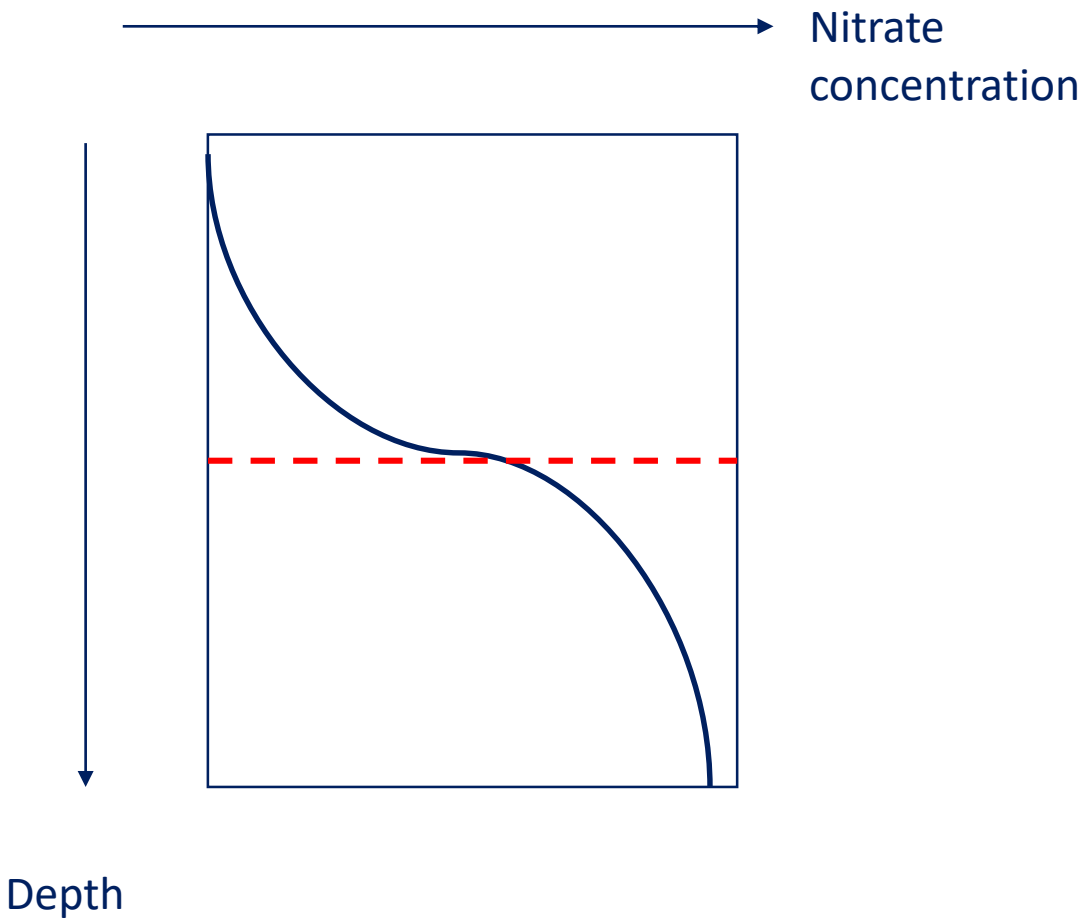
Sauzède *et al.*, 2017
Bittig *et al.*, 2018

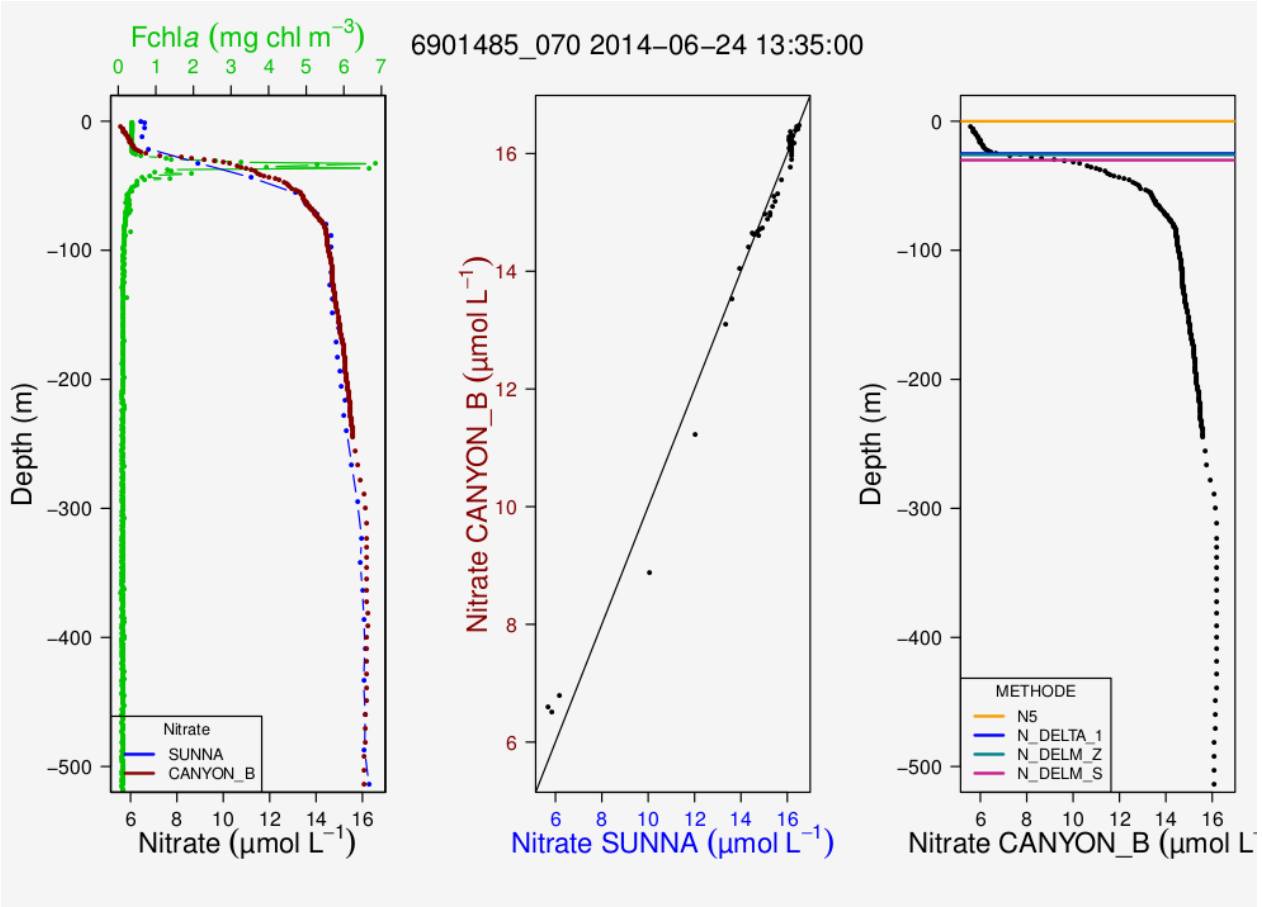
Optode calibration



extra : ***nitracline depth calculation***

NITRACLINE DEPTH

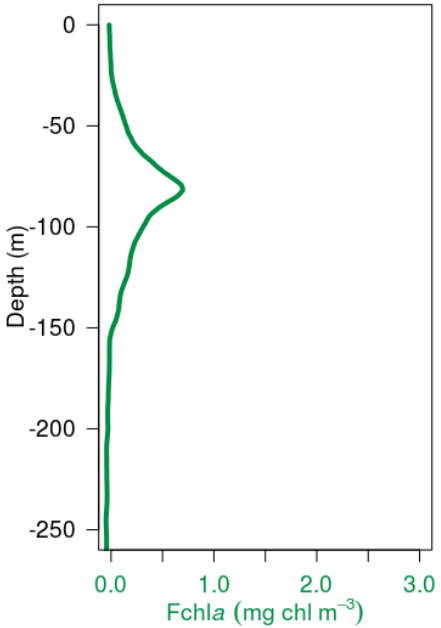


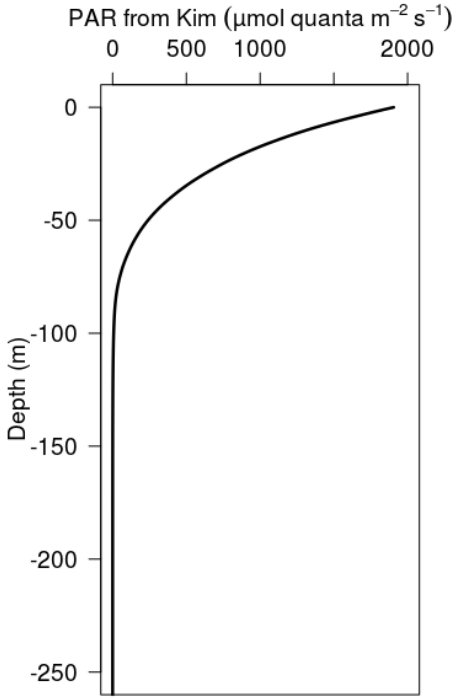


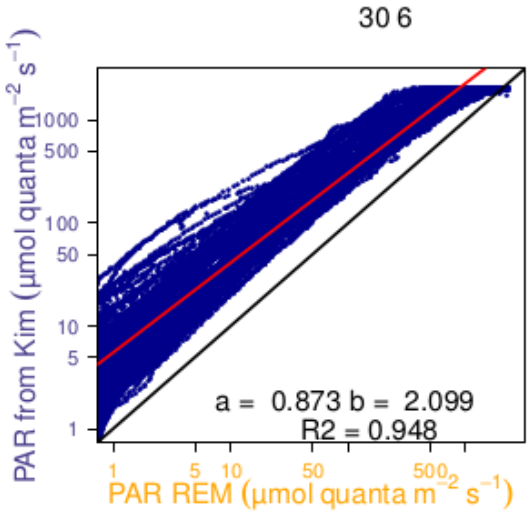
extra: ***Par estimation from Fchla profiles***

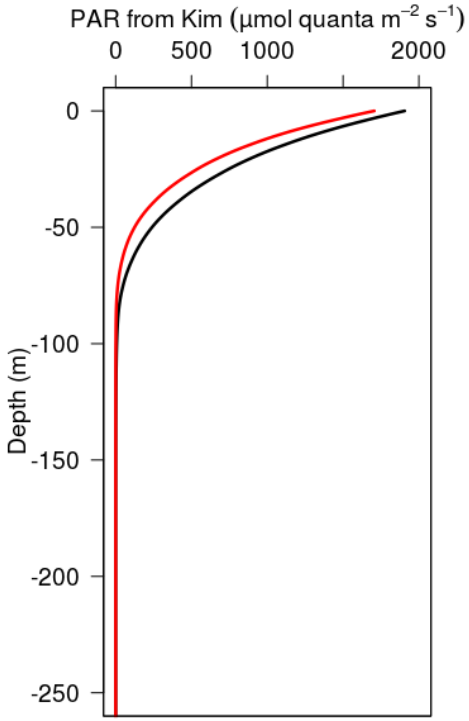
Kd(PAR) ~ Fchl *a* relationship
Kim *et al,* 2005

Correction of cloud cover
(monthly and latitudinal comparisons
with PAR profiles)

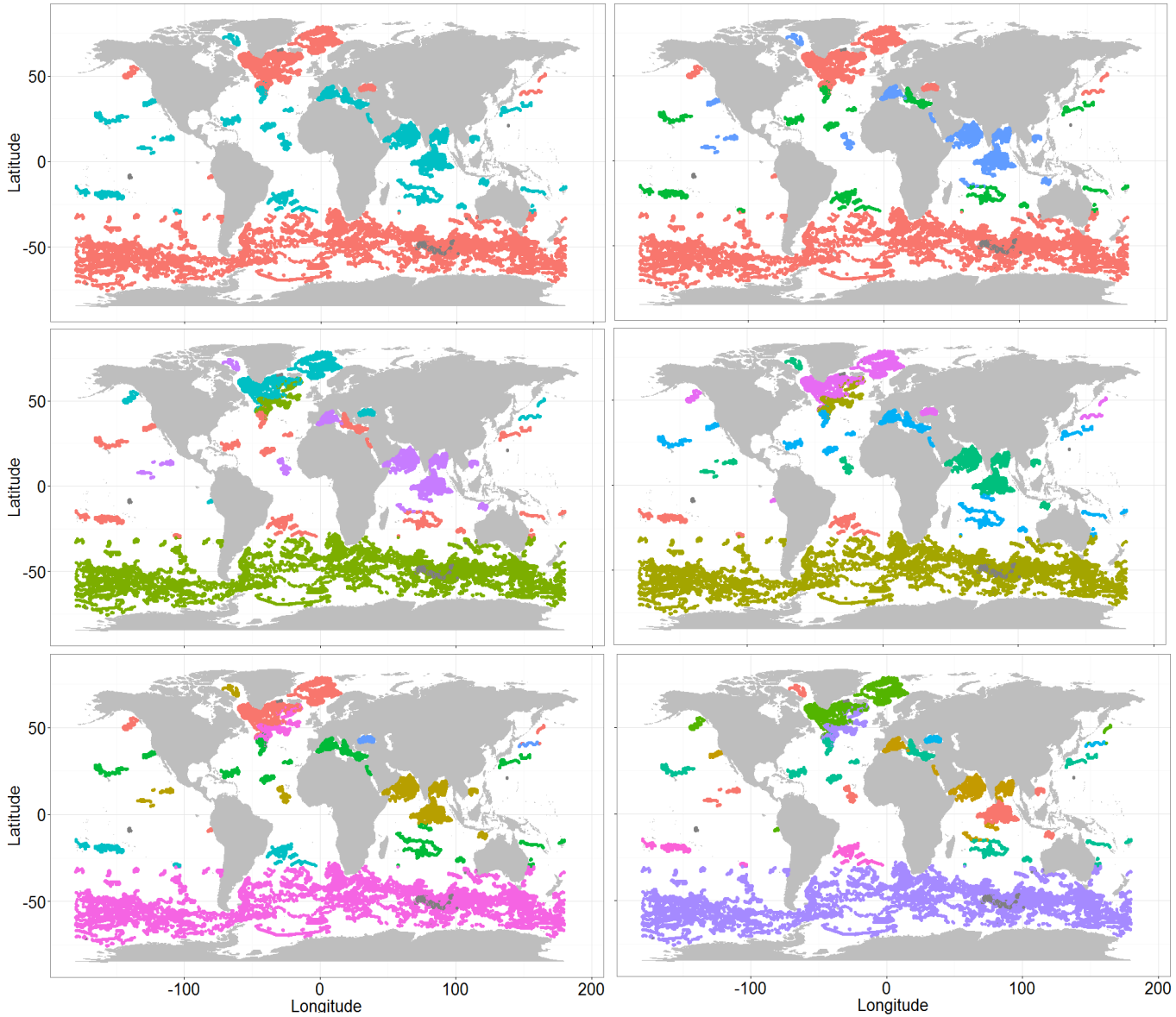




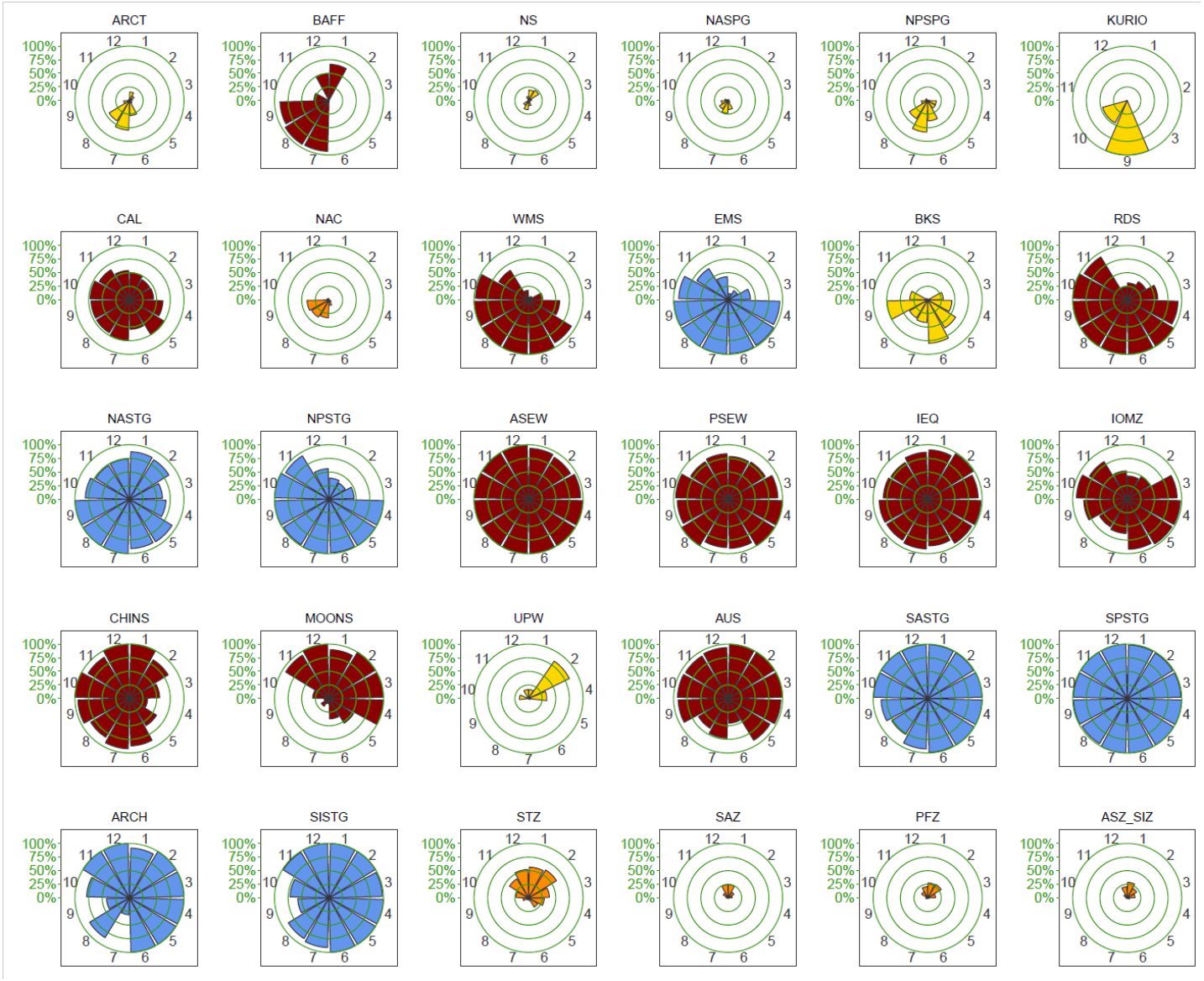




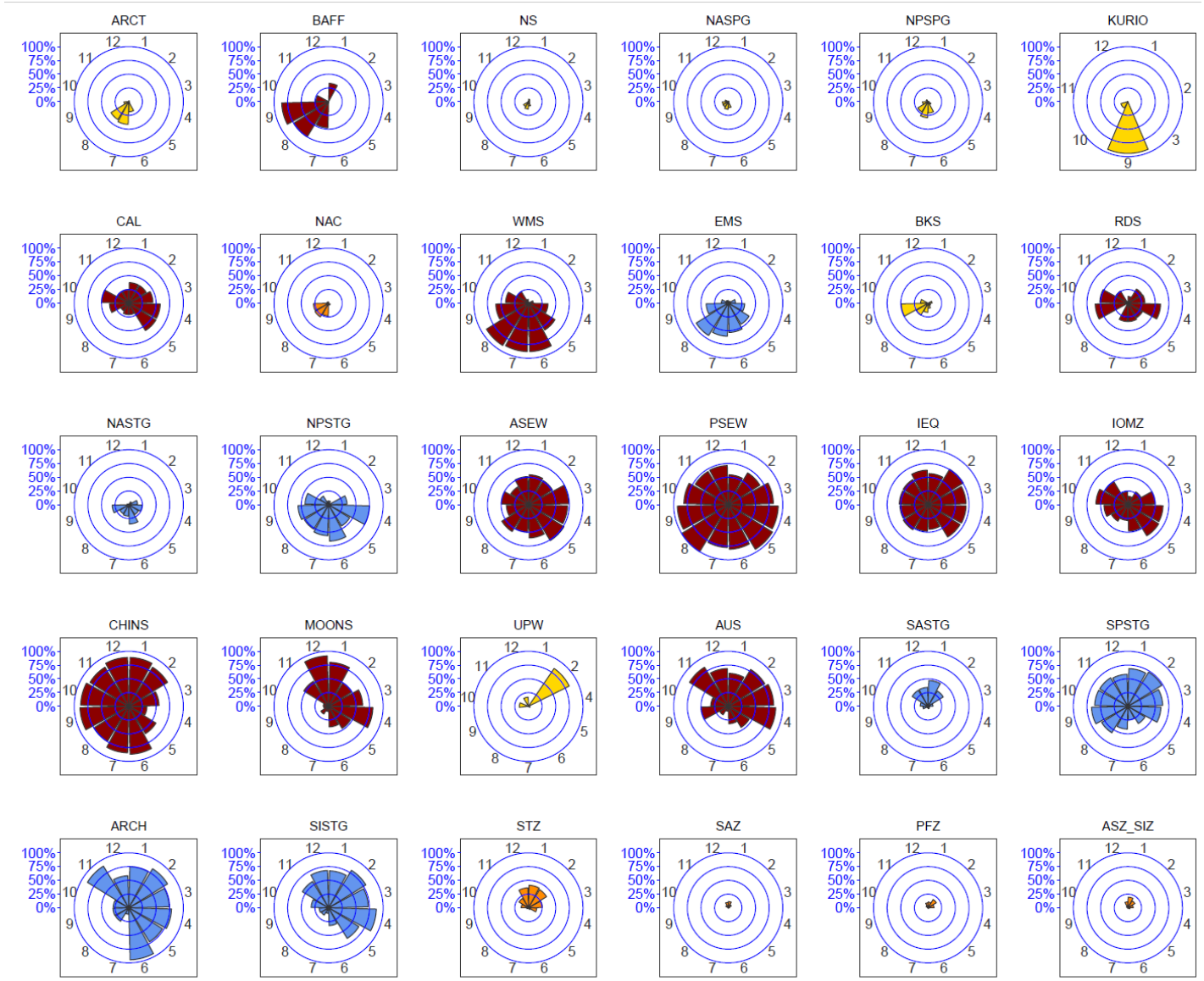
extra : ***clustering test***



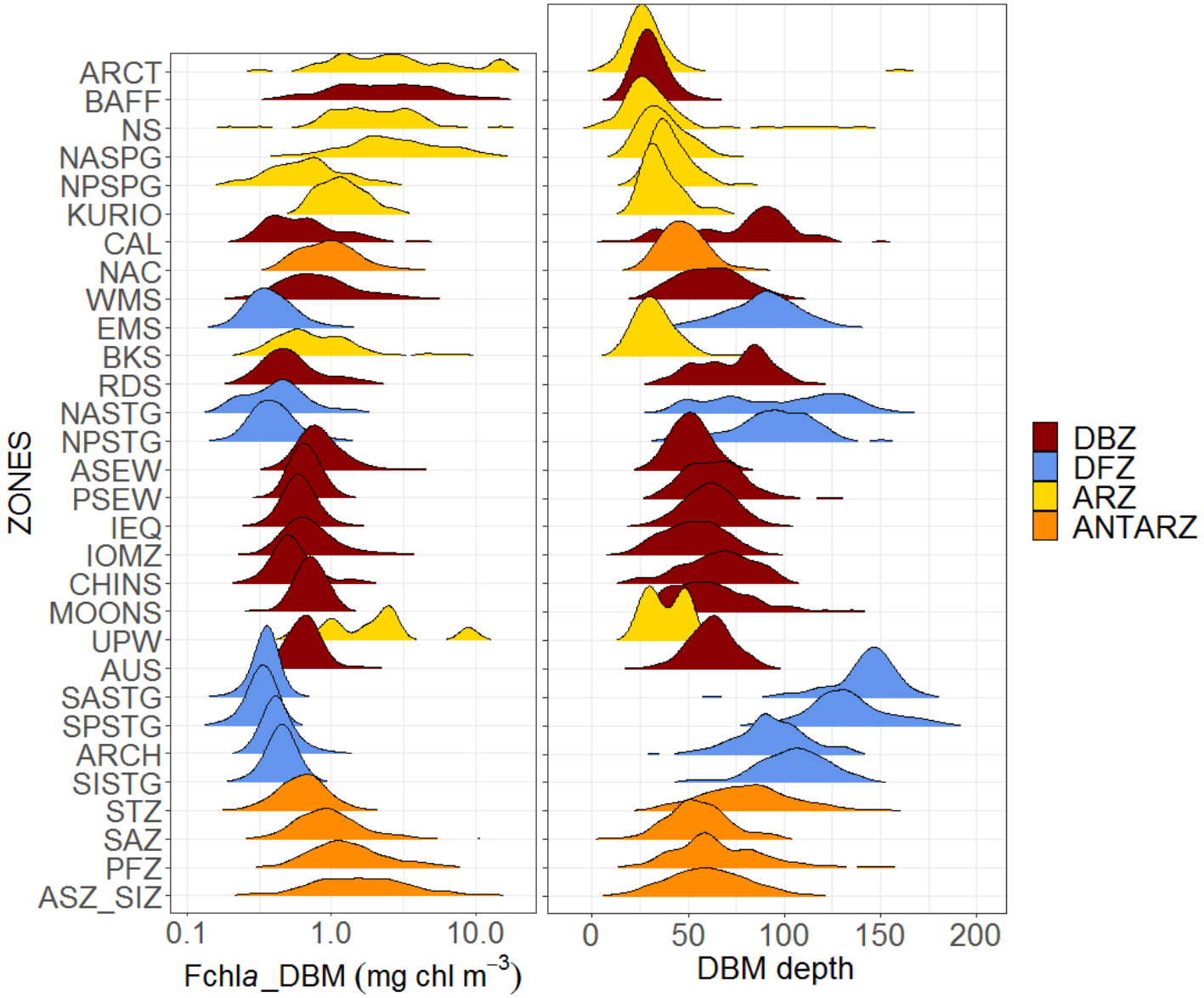
extra : ***DCM OCCURENCE***



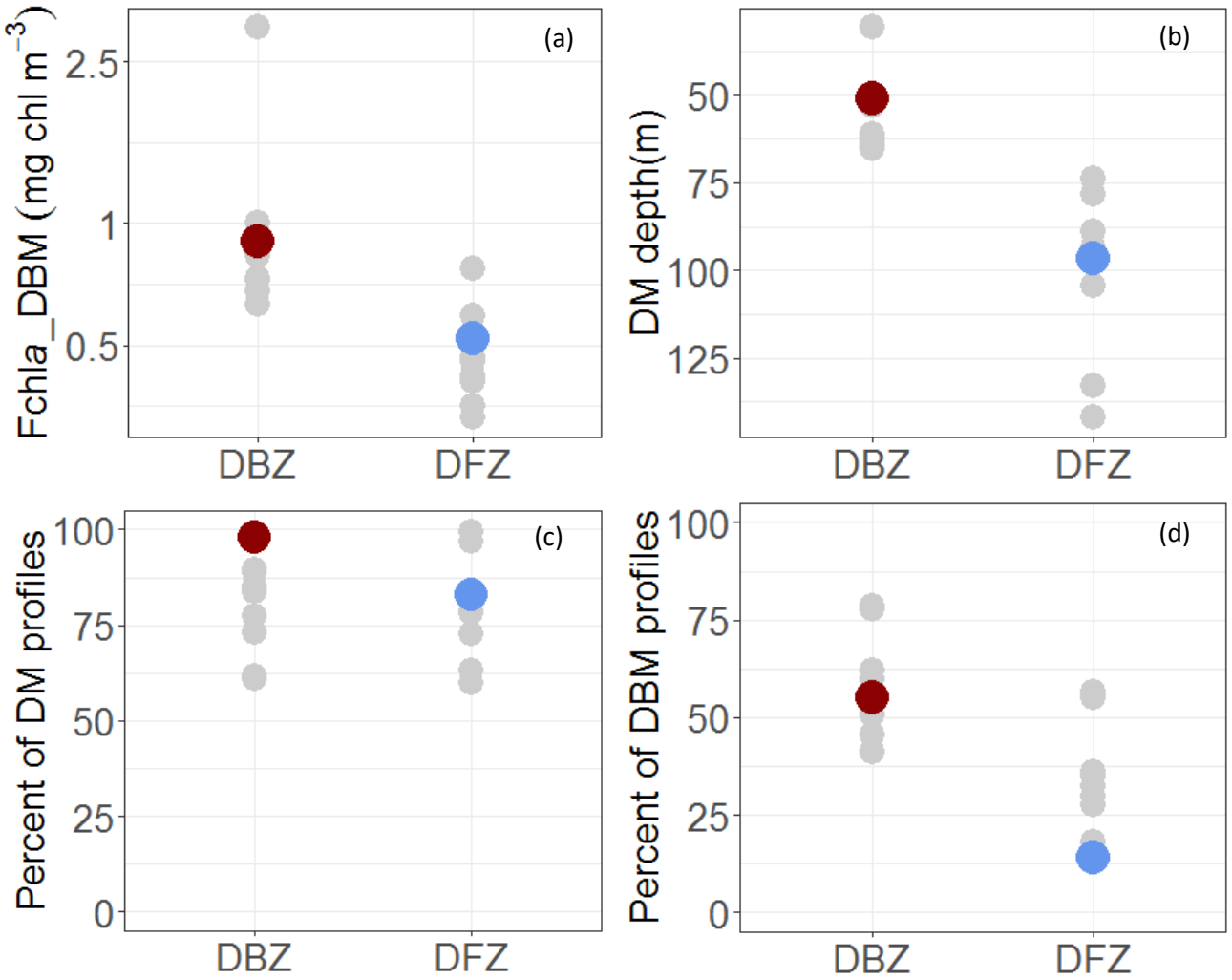
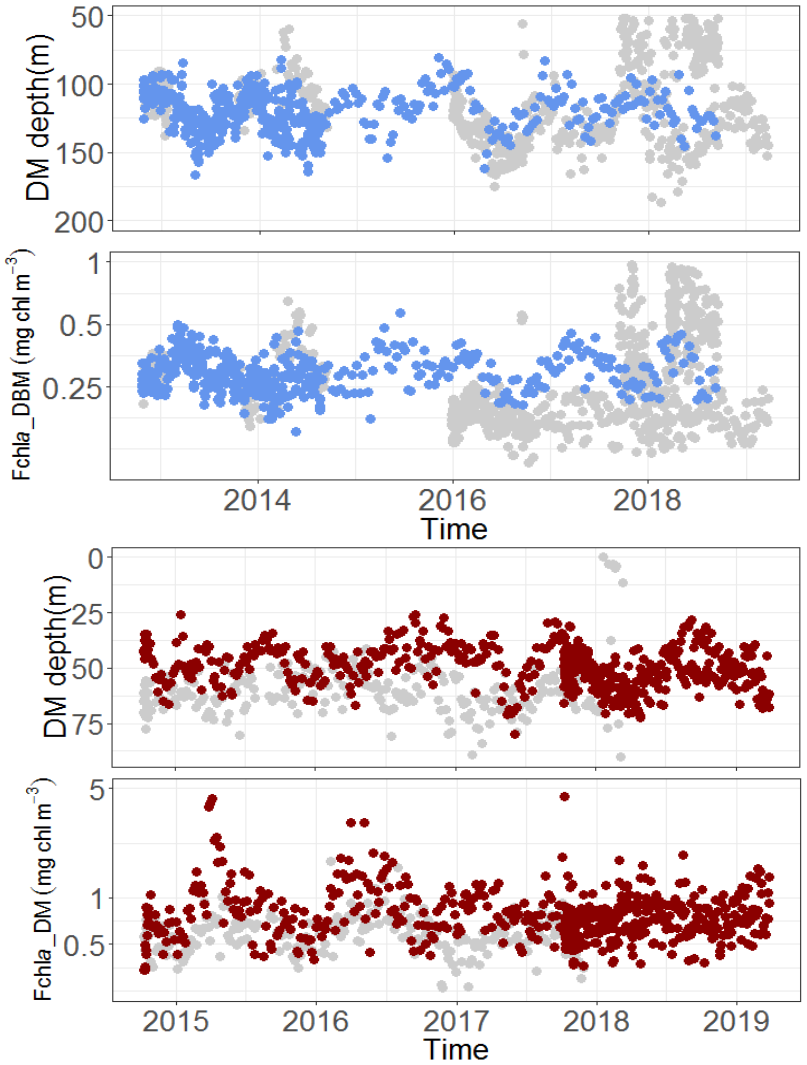
extra : ***DBM OCCURENCE***



extra : ***DCM/DBM INTENSITY DEPTH DISTRIBUTION***



extra : ***REGION SELECTION***



extra : ***FLOAT SELECTION***