Towards a 3D global Chlorophyll-a climatology based on merged historical and bio-Argo databases of in situ fluorescence profiles

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Motivations : Chlorophyll-a concentration ([Chl]) is the best proxy for the phytoplankton biomass at a global scale. The [Chl] can especially be estimated with the in vivo fluorescence. Currently, many vertical profiles of fluorescence (~50,000) are stored in historical databases. The number of these profiles will dramatically increase in the near future thanks to the advent of autonomous platforms (i.e. gliders, profiling floats, instrumented animals). Indeed, recent technological advances in oceanographic instrumentation, led to integrating fluorescence miniaturized sensors onto autonomous platforms. However, the variability of the [Chl]/fluorescence signal (linked to instrumental as well as physiological constraints) limits the utilization of these data for global applications (e.g. climatologies).

Objectives : 1) To develop a calibration method to convert raw fluorescence profiles into [Chl]. In order to be applicable to any profile, this method has to be based on the sole knowledge of the profile shape and has to be independent on any additional data. 2) Applying this method to a global database of fluorescence profiles. This database, calibrated into [Chl], could be considered as an initial phase in view of producing a 3D climatology of [Chl] for the global ocean.

Method : *Calibration of the fluorescence into [Chl] with a neural network (multilayered perceptron : MLP)*

The neural network was trained to return the [Chl] at 10 depths from 815 profiles of fluorescence and HPLC-determined [Chl], the method of reference. These profiles were acquired as part of 20 open ocean oceanographic cruises (Figure 1). The dataset is representative of the global ocean. The MLP developed in this study consists of four layers : one input layer, two hidden layers of 6 and 3 neurons on each and one output layer.

Inputs of the MLP :
1) 10 points of the normed fluorescence profile over the 0-1,3 ς interval
2) the depth Z0 (the depth at which the fluorescence begins to be constant with depth)
3) The dimensionless depth of one of the ten points of the normed fluorescence profile

Output of the MLP :
- the log10([Chl]) for the input depth defined in 3)

The MLP runs iteratively ten times (each run corresponding of a single dimensionless depth)

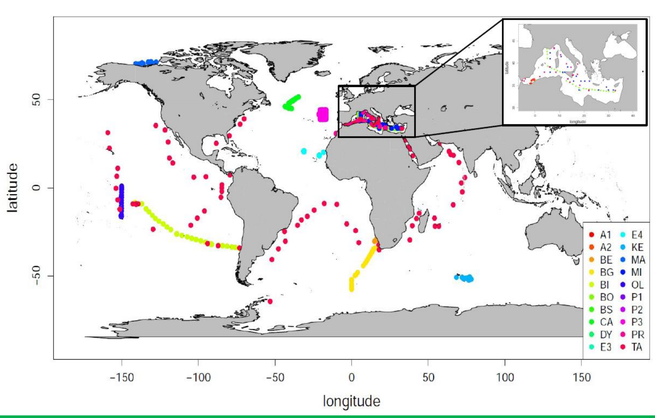

Figure 1 : Sampling stations of the 20 oceanographic cruises used for creating the training database for the MLP.

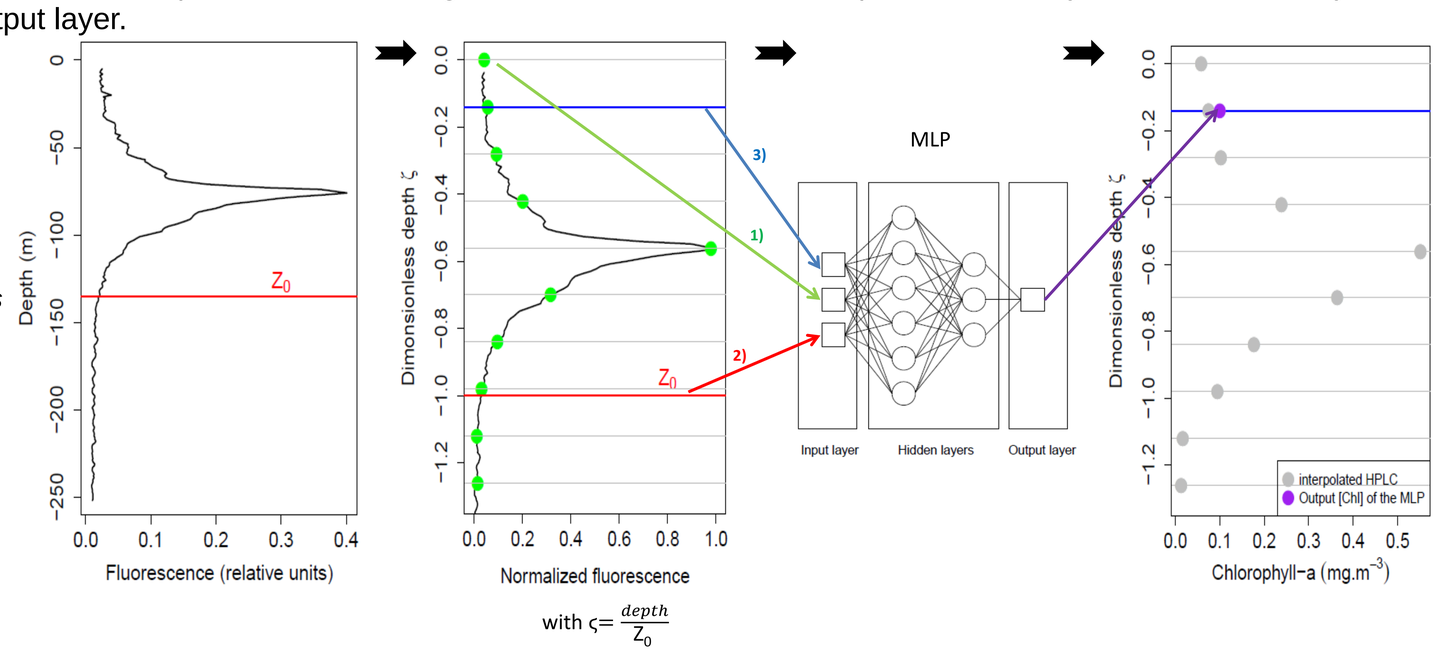

Figure 2 : Schematic overview of the functioning of the MLP.

Method performance:

The prediction error of the MLP is evaluated with the linear model between the calibrated [Chl] and the [Chl] of reference (HPLC) (i.e. R^2 and slope of the Fluo=a.HPLC+b model) and with the MAPD (Median Absolute Percent Difference).

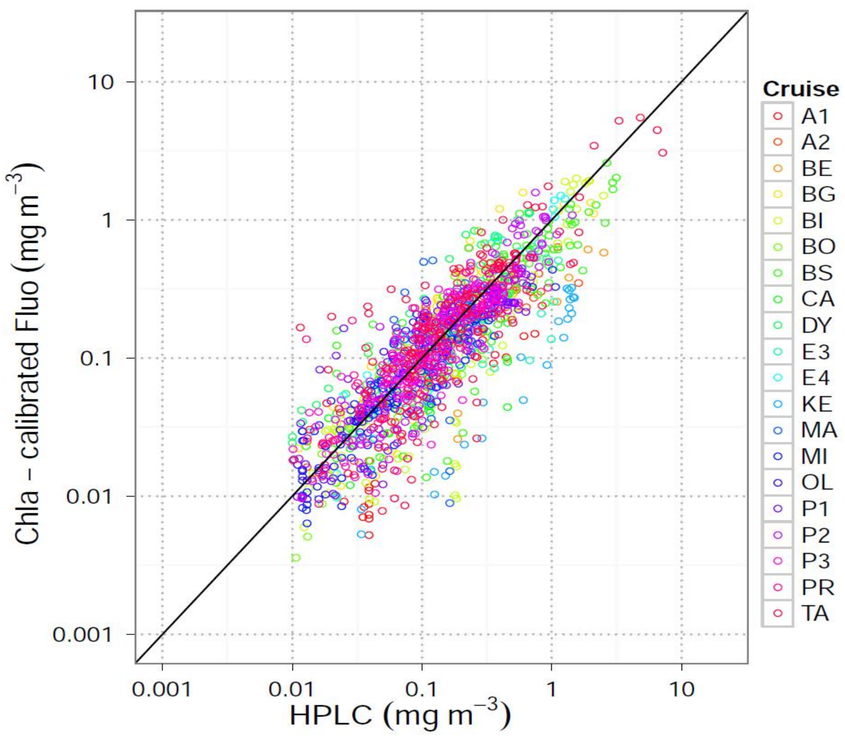

Figure 3 : Scatter plot between the [Chl] predicted by the MLP and the reference values of HPLC in function of the 20 oceanographic cruises used in this study.

Table 1 : Prediction errors and limits of application of the MLP method and of the three other methods developped at LOV.

Method	R^2	a	MAPD (%)	additional input data
MLP method	0.71	0.85	34	none
Lavigne *et al.* (2012)	0.67	0.75	31	surface [Chl] from satellite data
Mignot *et al.* (2011)	0.72	0.85	33	profile shape (i.e. stratified or mixed)
Xing *et al.* (2011)	0.76	0.87	29	downwelling irradiance profile

Towards a 3D global [Chl] climatology :

Global database of [Chl] :
After a quality process of the fluorescence profiles retrieved from national and international databases, and the application of the calibration method, a database of 39,817 profiles of [Chl] was created.

NAOS and remOcean projects :
Deployment objective : 60 bio-Argo floats deployed between 2012 and 2015.
About 15,000 fluorescence profiles are expected (corresponding to more than a third of the current database).

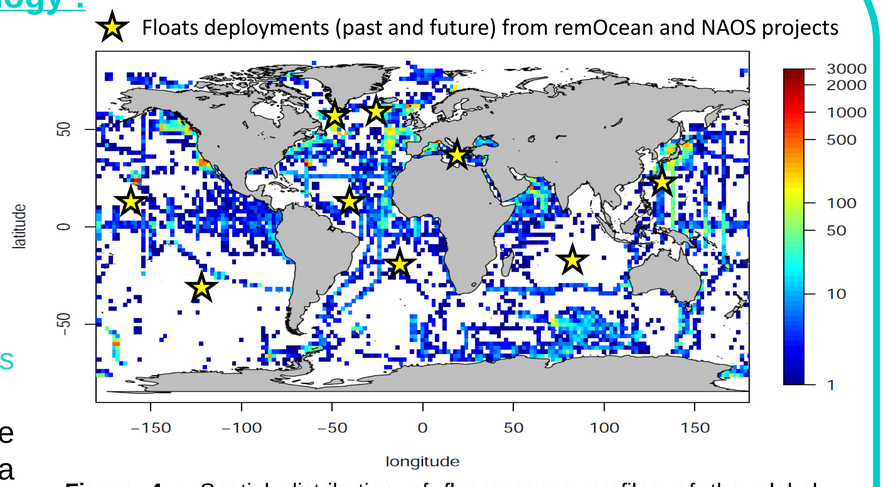

Figure 4 : Spatial distribution of fluorescence profiles of the global database (color refers to the number of profiles in boxes of 3°x3° by side)

Irregular spatial grid : utilization of the 56 ecological provinces described by Longhurst (2006) for creating some initial monthly climatologies of [Chl].

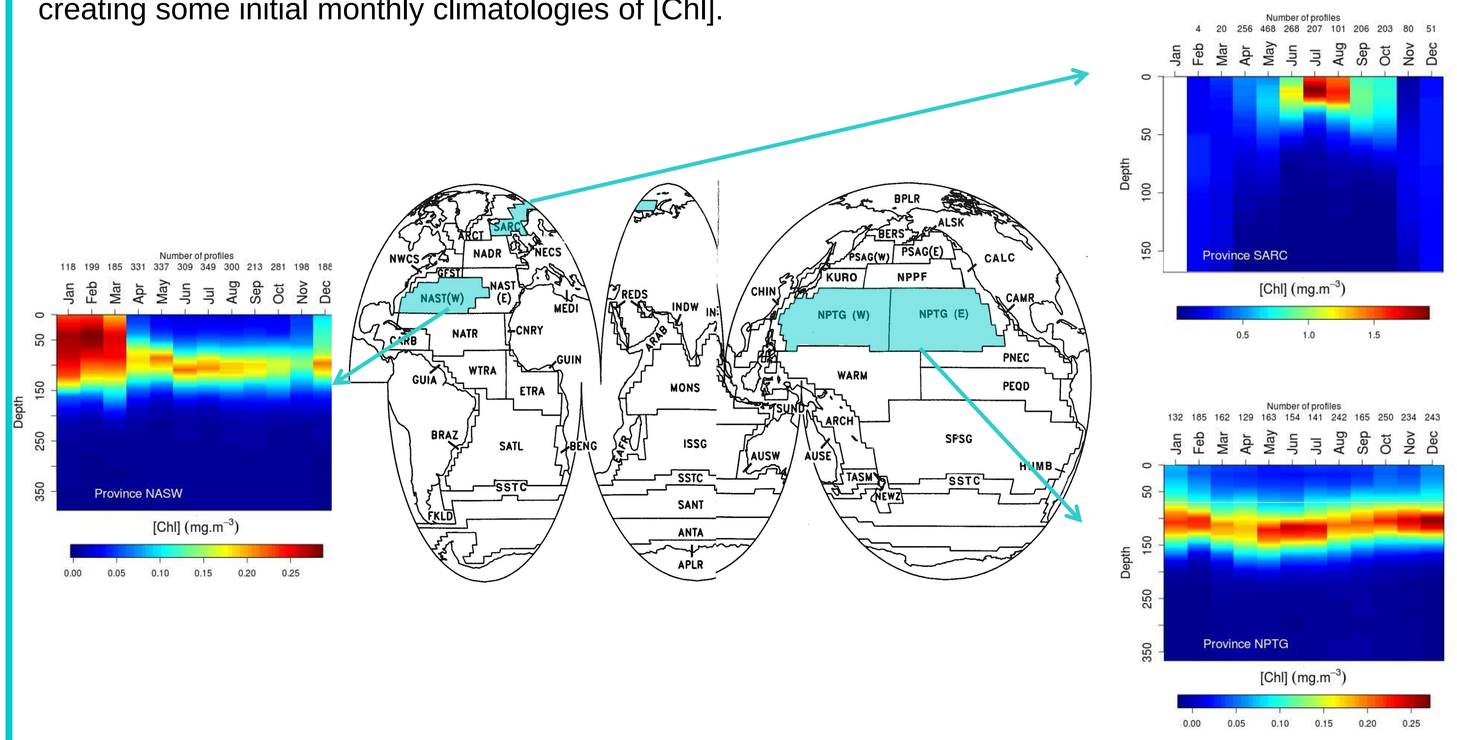

Figure 5 : monthly climatologies of [Chl] for the SARC (Atlantic Subarctic Province), NASW (North Atlantic Subtropical Gyral Province West) et NPTG (North PacificTropical Gyre Province) provinces.

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