Breakout session n°10: Joint use of Bio-Argo and Ocean Colour

Extending surface bio-optical properties to depth: a neural network for merging ocean color and Argo data

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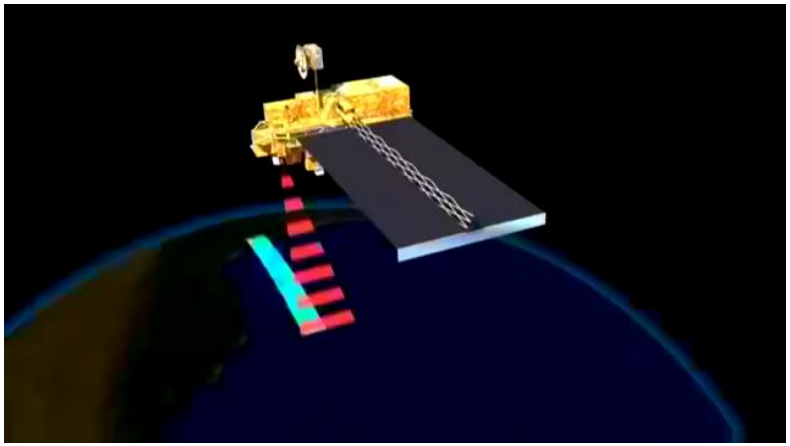
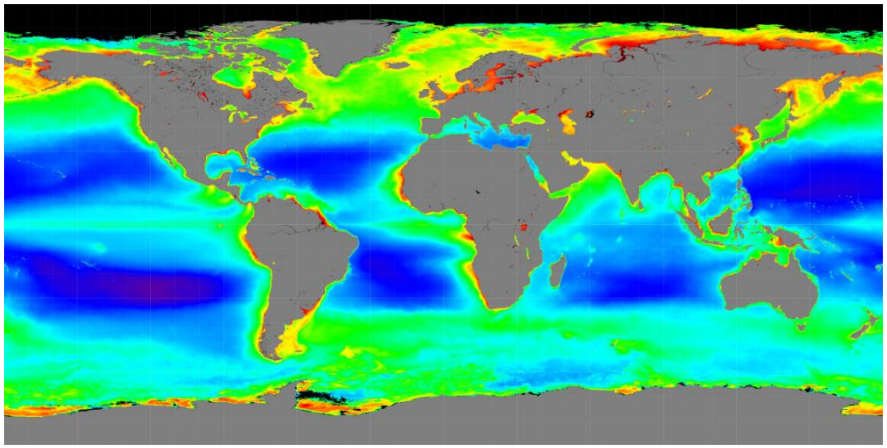
The 18th of June 2015, San Francisco, CA, USA

Surface distribution of several bio-optical parameters already well known with « ocean color » satellite data (Feldman *et al.,* 1989)



BUT only 1/5th of the productive zone
(Morel and Berthon, 1989)



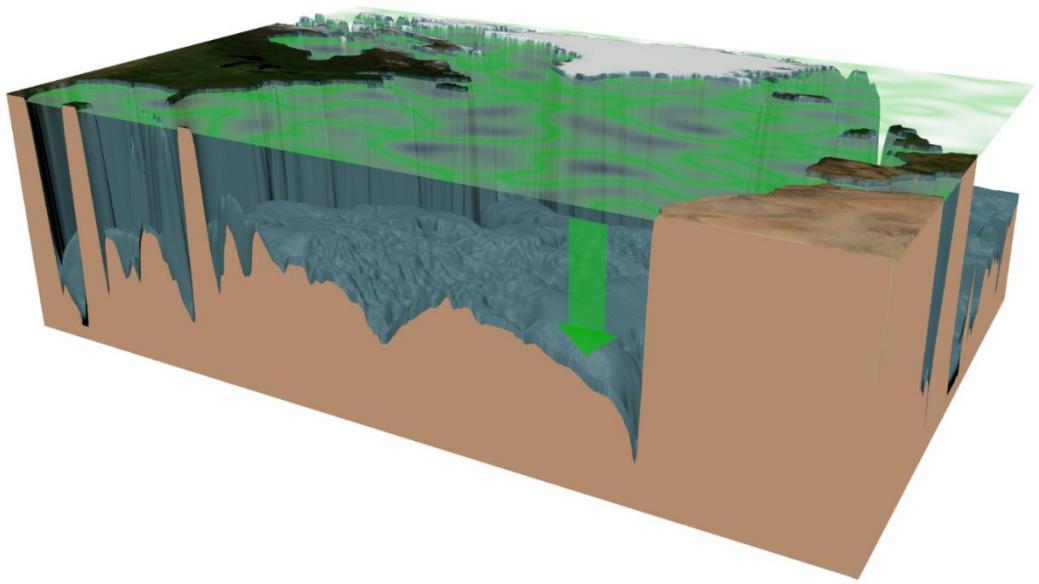
Surface [Chl] climatology by SeaWifs

Lack of information on the vertical

➔ surface estimations have to be extended to depth

OBJECTIVE

How to extend surface bio-optical properties to depth from ocean color data?



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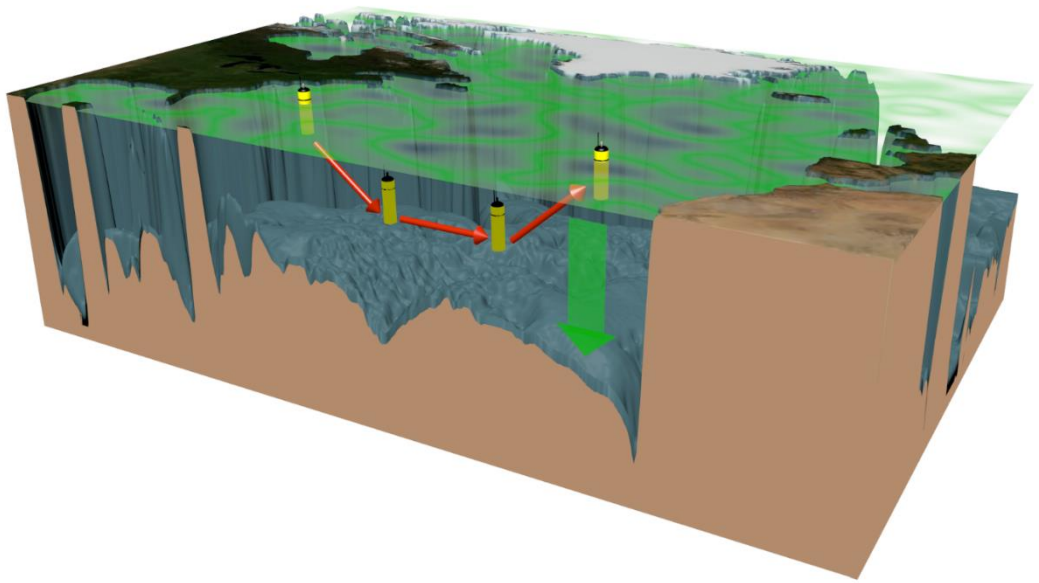

❑ **Physical state of the water column (from CTD profiles)**

- Influences nutrient and light availability for phytoplankton growth
- Available at high spatio-temporal frequency with Argo data

OBJECTIVE

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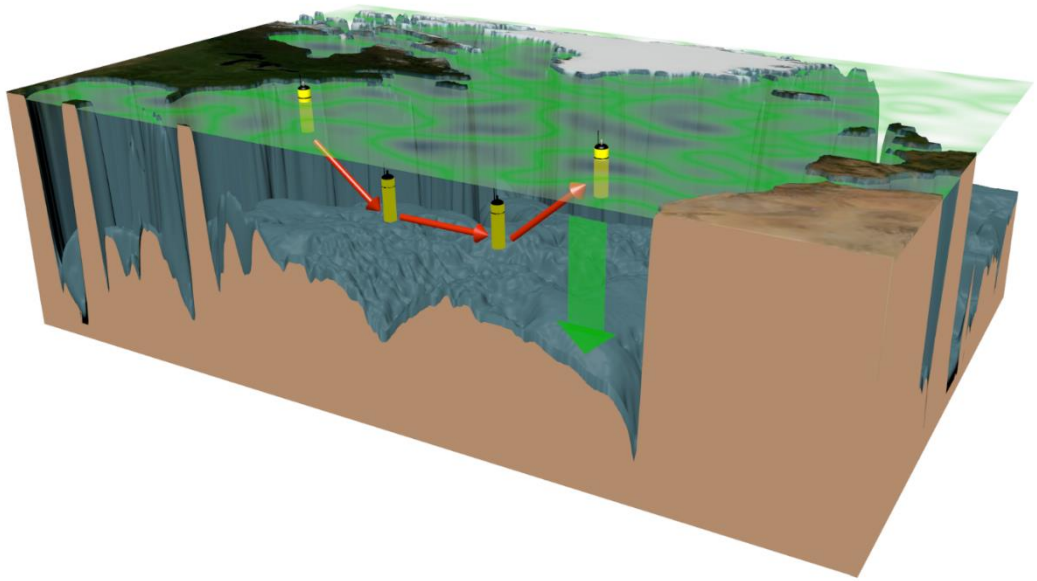

❑ **Physical state of the water column (from CTD profiles)**

- Influences nutrient and light availability for phytoplankton growth
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❑ **Methodology: MLP for Multi-Layered Perceptron (neural network) :**

- Iterative statistical method of learning
- Universal approximators
- Complex, noisy and non-linear distributions

OBJECTIVE

How to extend surface bio-optical properties to depth from ocean color data?

OBJECTIVE

To develop a neural network-based method using merged ocean color and Argo data to extend surface bio-optical properties to depth

Method after refer as **SOCA** (for Satellite Ocean Color and Argo data to vertical distribution of bio-optical properties)

- because production driven by nutrients avilability, driven by phisical properties
- Available at high spatio-temporal frequency with Argo data

- Iterative statistical method of learning
- Universal approximators
- Complex, noisy and non-linear distributions

Development of 2 neural networks :

- Optical particulate backscattering coefficient (b_{bp}) considered as a proxy of Particulate Organic Carbon (POC) (e.g. Loisel et al., 2002; Stramski et al., 2008) or phytoplankton carbon (e.g. Behrenfeld et al., 2005)

→ **SOCA-BBP:** MLP linking surface $b_{bp}(700)$ values with $b_{bp}(700)$ vertical distribution

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- Chlorophyll *a* concentration ([Chl]), proxy of the phytoplankton biomass (e.g. Cullen, 1982)

→ **SOCA-CHL:** MLP linking surface [Chl] values with vertical distributions of [Chl] associated to the total phytoplankton biomass and to 3 size classes (micro-, nano- and pico-phytoplankton; Uitz *et al.*, 2006)

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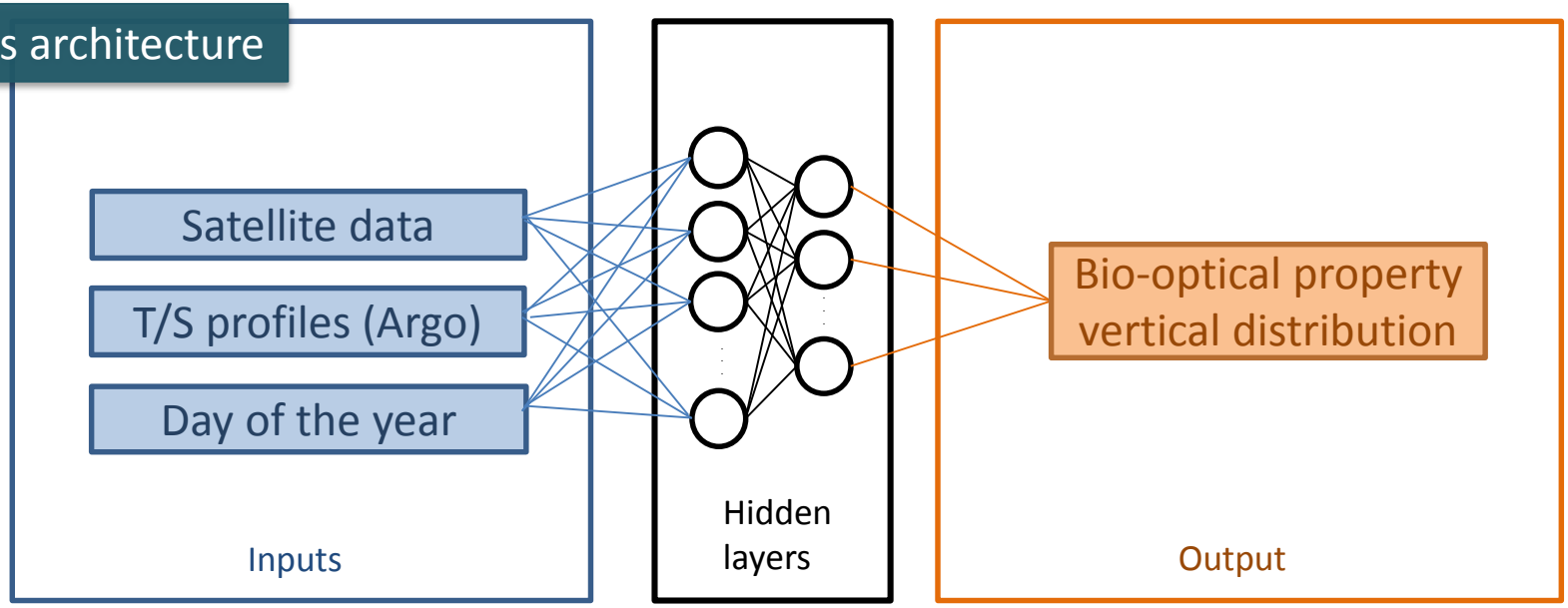
Argo T/S profiles and ocean color matchup
→ vertical profiles of b_{bp} and [Chl]

MLPs architecture



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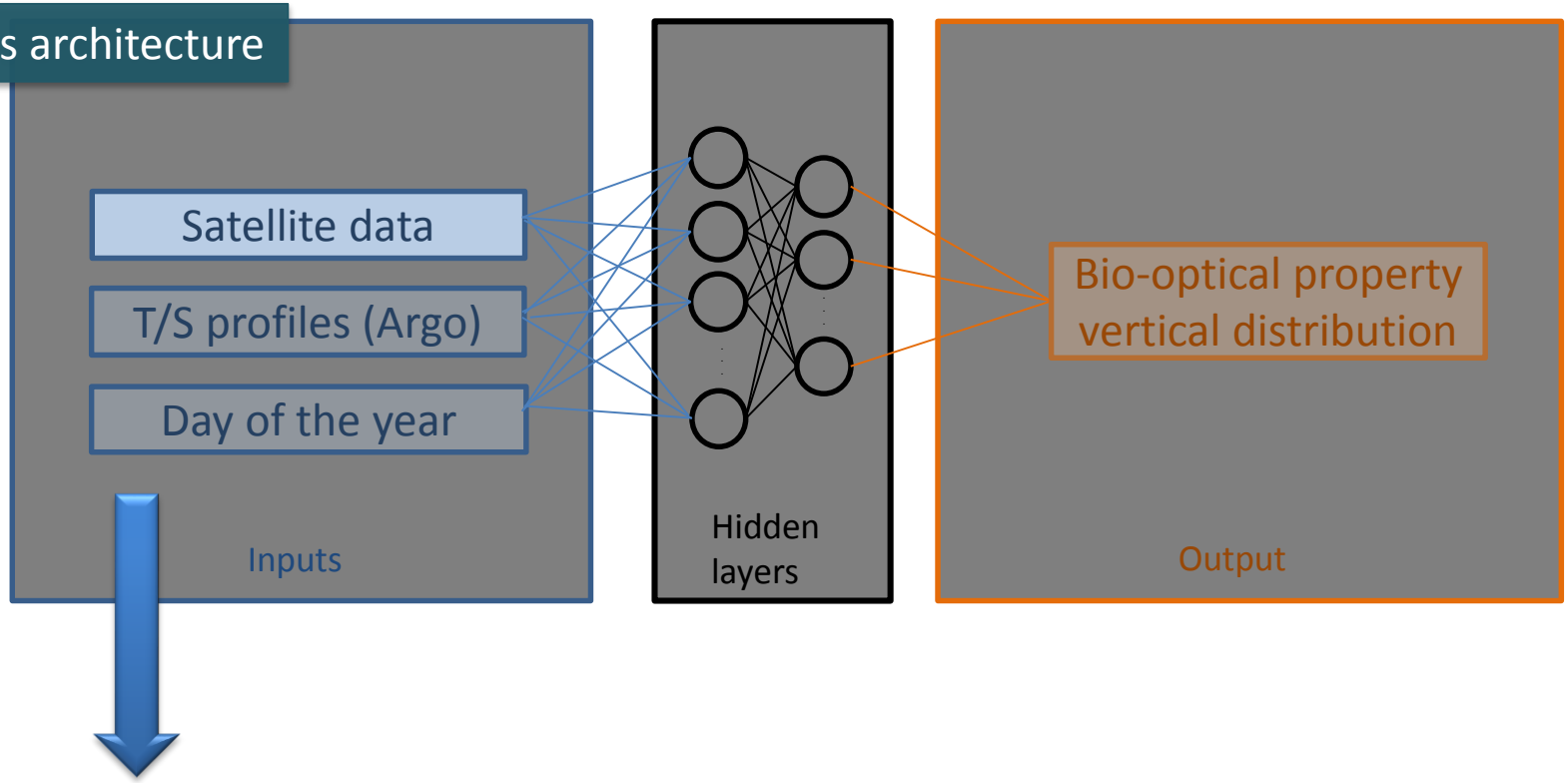
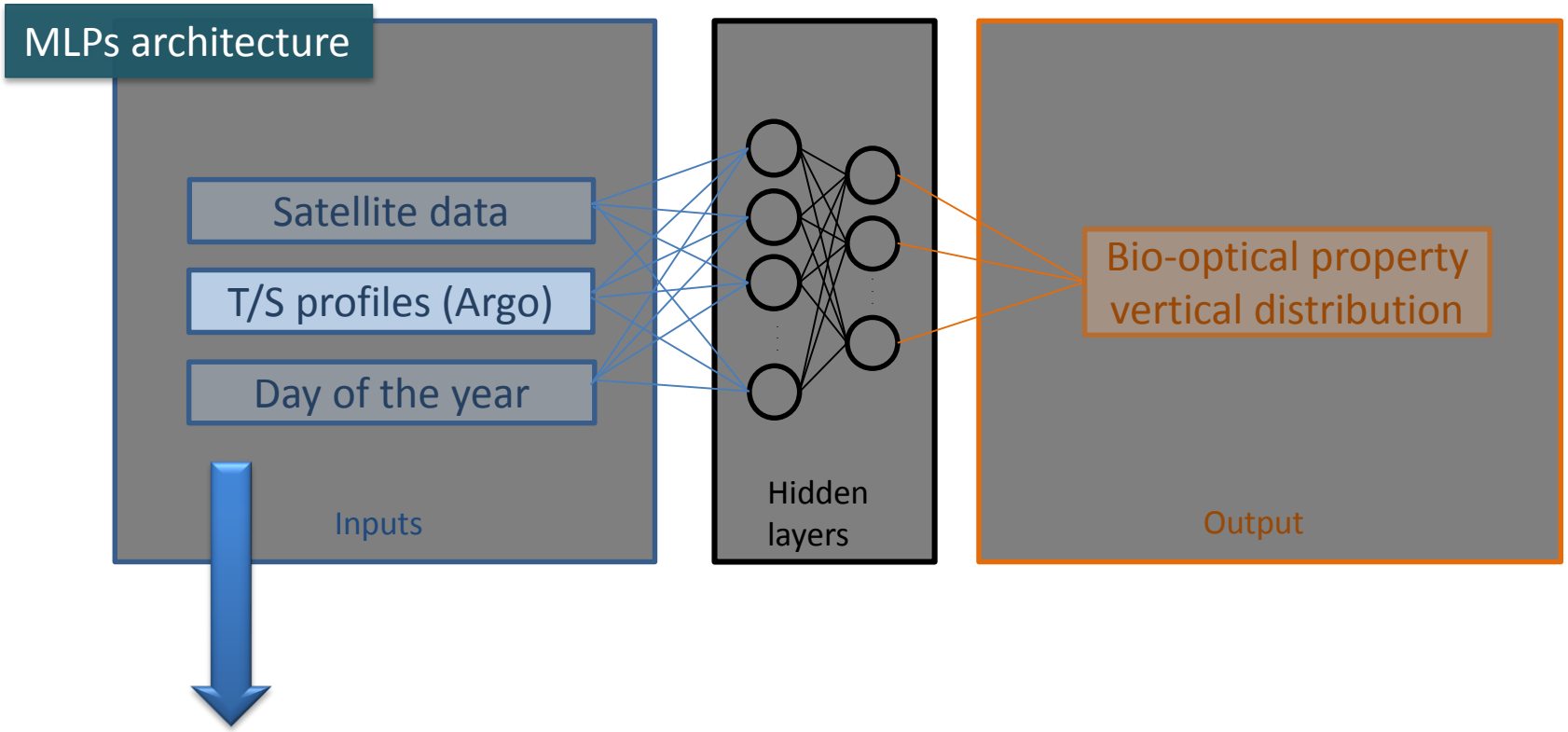


SOCA-BBP: log(**$b_{bp}(700)$**) derived from QAA (Lee et al., 2002,2009) and log(**$[Chl]_{sat}$**)

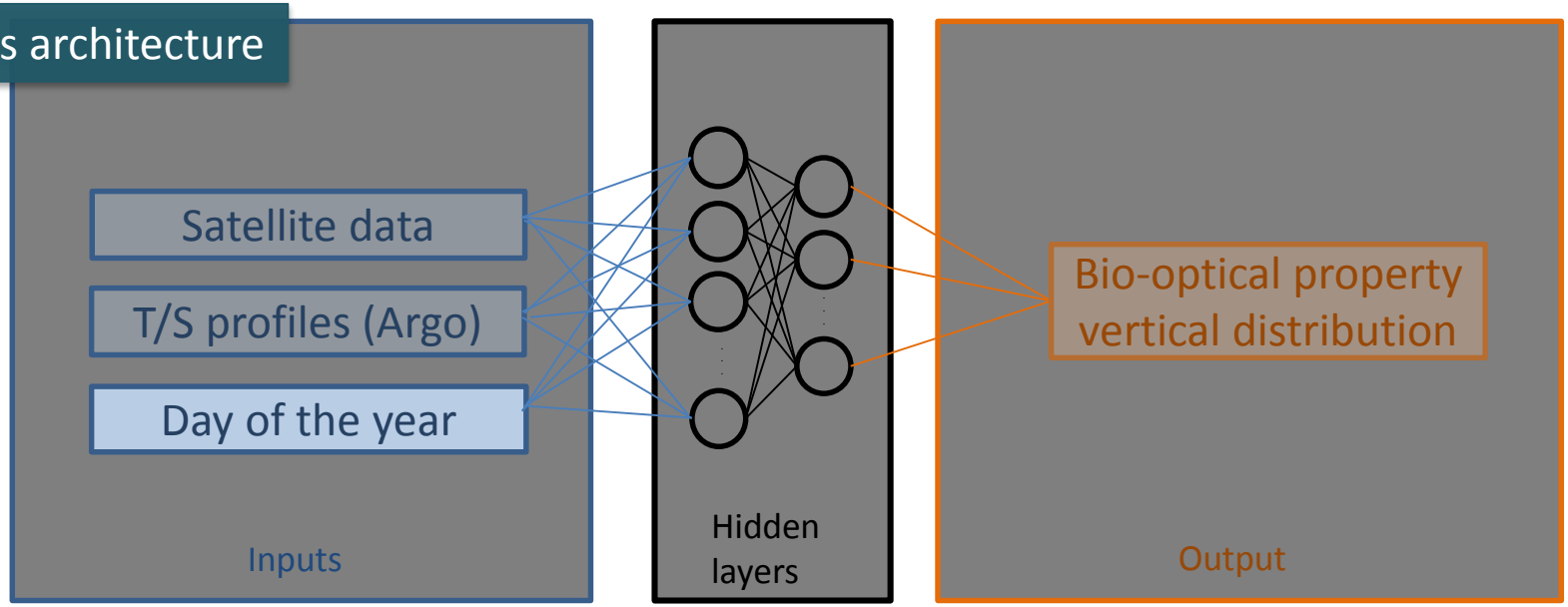
SOCA-CHL: log($[Chl]_{sat}$) and **PAR**

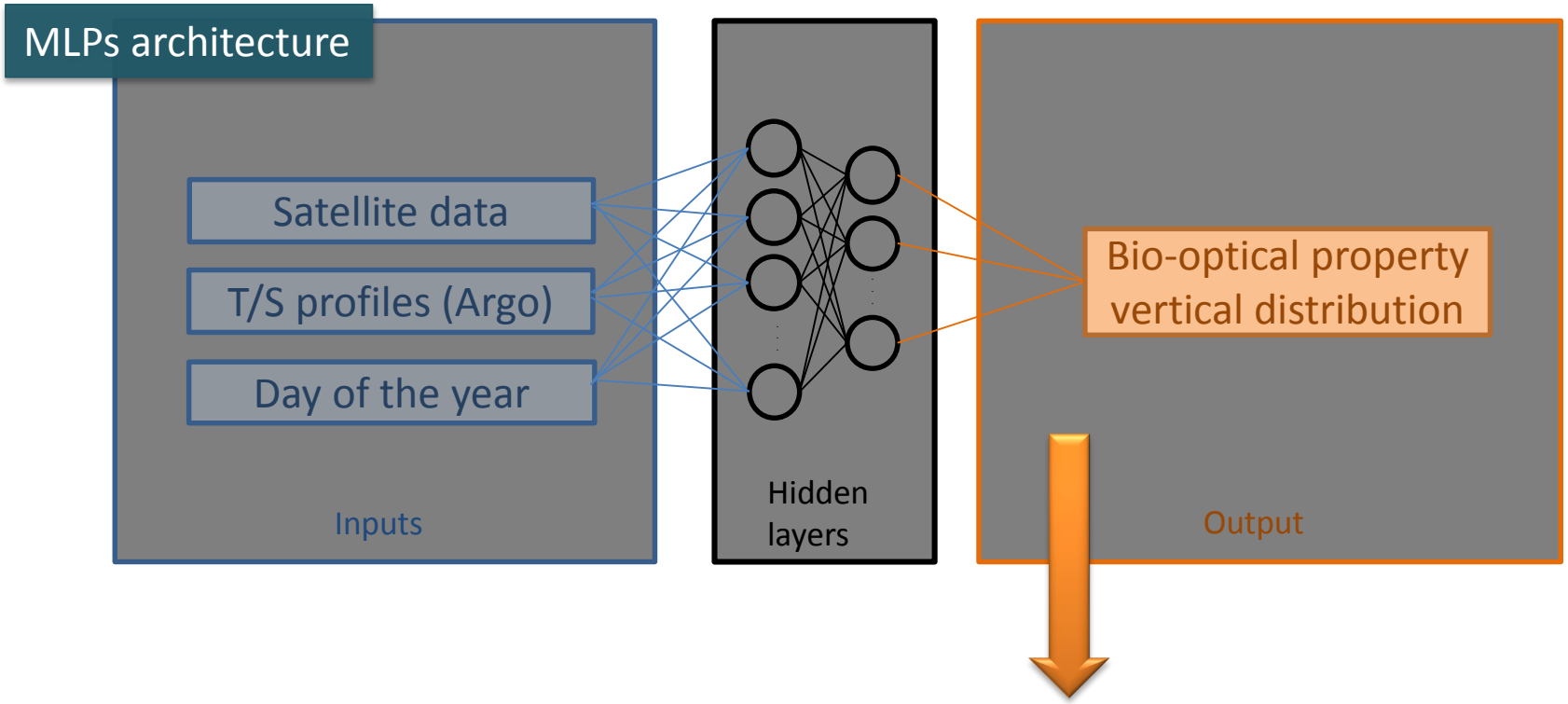


Vertically-resolved physical properties derived from the Argo T/S profiles:

- Mixed layer depth $\mathbf{Z_m}$ (de Boyer Montégut *et al.,* 2004)
- 4 **density** values
- $\mathbf{Z_{norm}}$ a normalization depth defined as the depth at which the Chl profile returns to a background value: computed empirically from Z_m and Z_e (the euphotic depth)

MLPs architecture



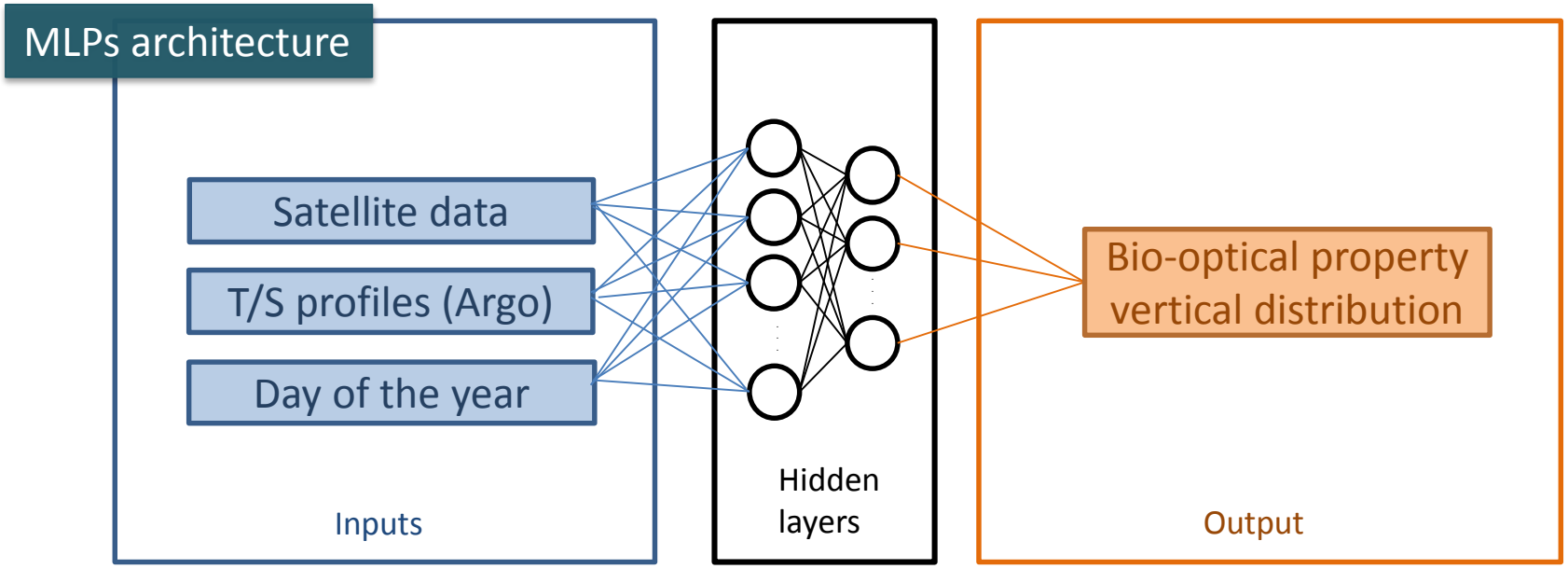


- **SOCA-BBP:**

→10 b_{bp} values for the water column simultaneously

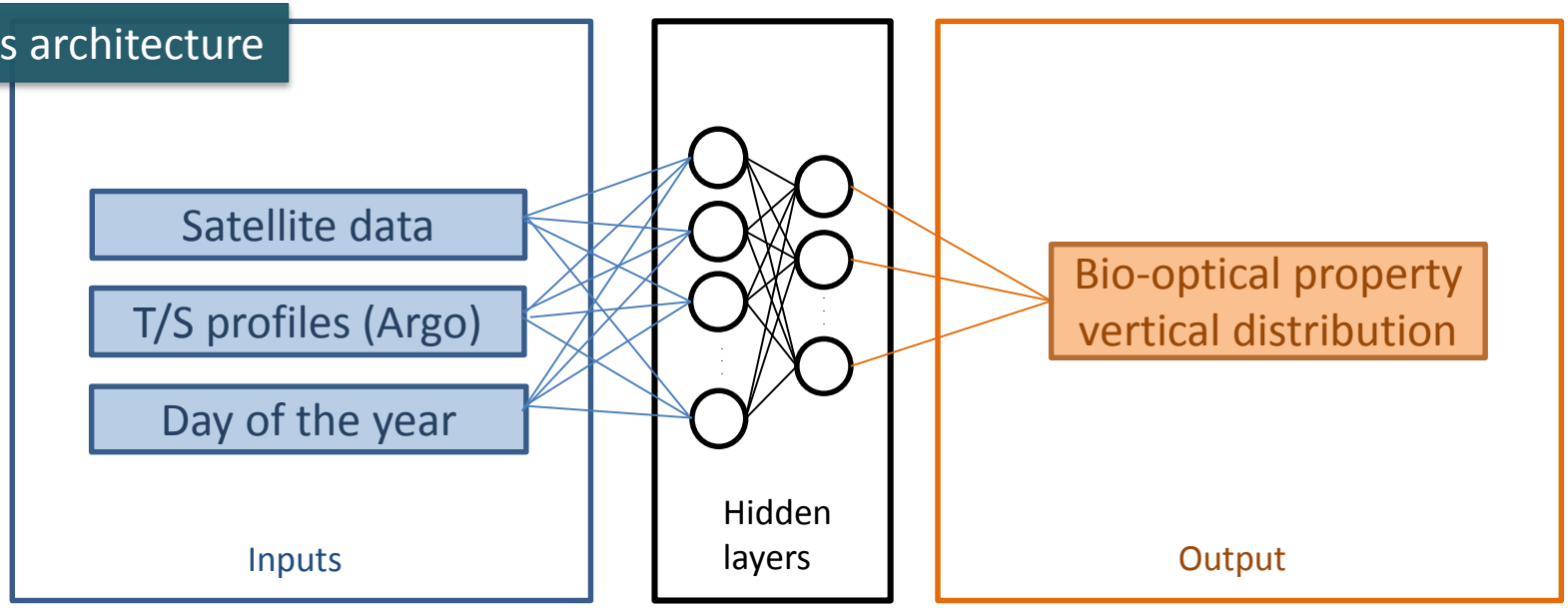
- **SOCA-CHL:**

→ Chl profile shape (10 normalized Chl values) used to retrieve the Chl and the assemblage of phytoplankton communities using FLAVOR method (Sauzède et al., 2015, JGR)



MLPs trained and validated using essentially Bio-Argo floats data.

MLPs architecture



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Be careful!

Argo data (only T/S) used as inputs.
Bio-Argo floats data are only used as reference values to train and validate the MLPs.

MLPs training and validation databases:

Concurrent profiles of density and bio-optical properties especially collected by **Bio-Argo floats**, concomitant with **satellite products** (i.e. matchups from 9-km/8-day MODIS Aqua)

MLPs **training** using 80% of the database and **validation** using 20% of the database

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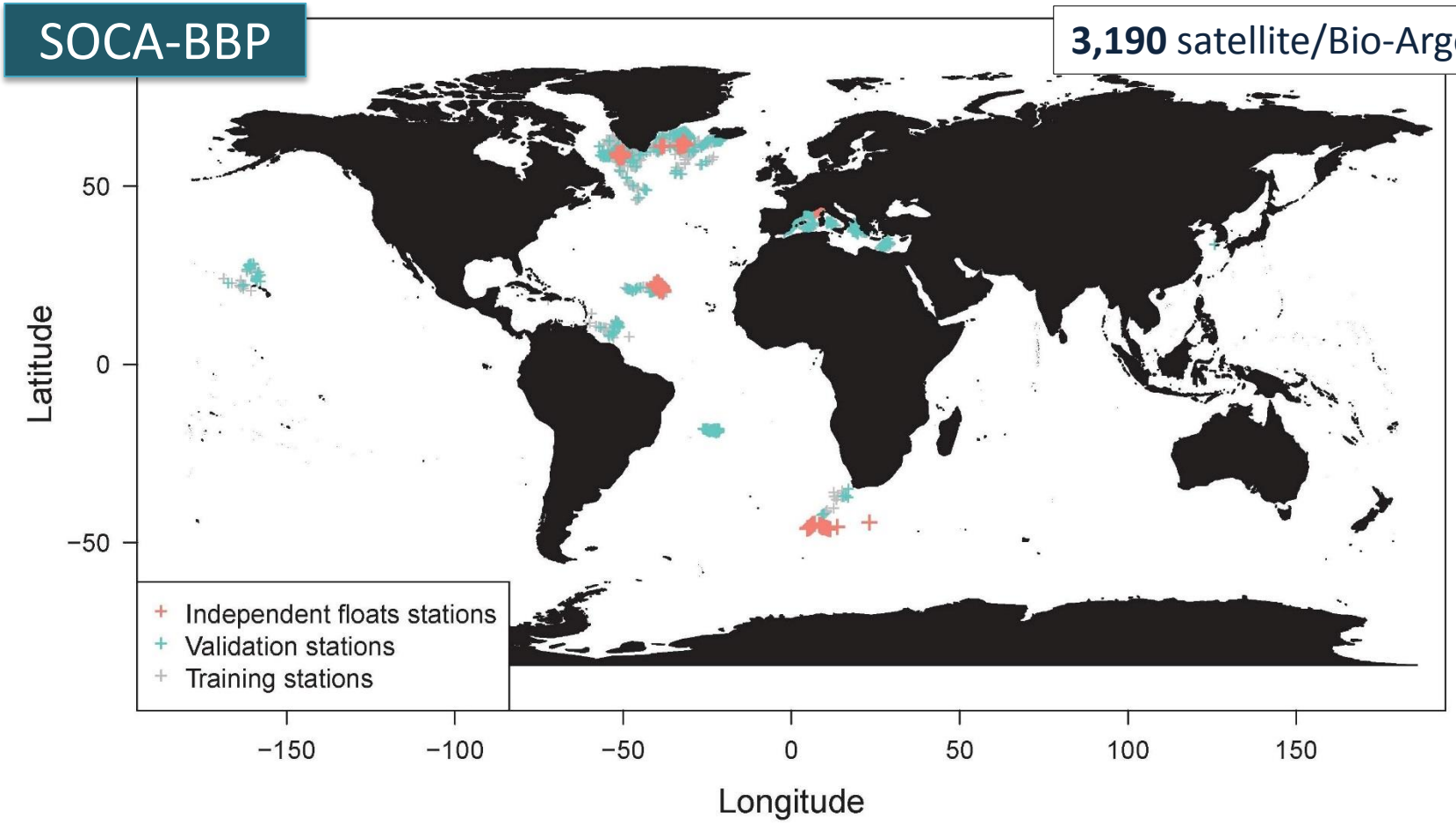
SOCA-BBP

3,190 satellite/Bio-Argo matchup



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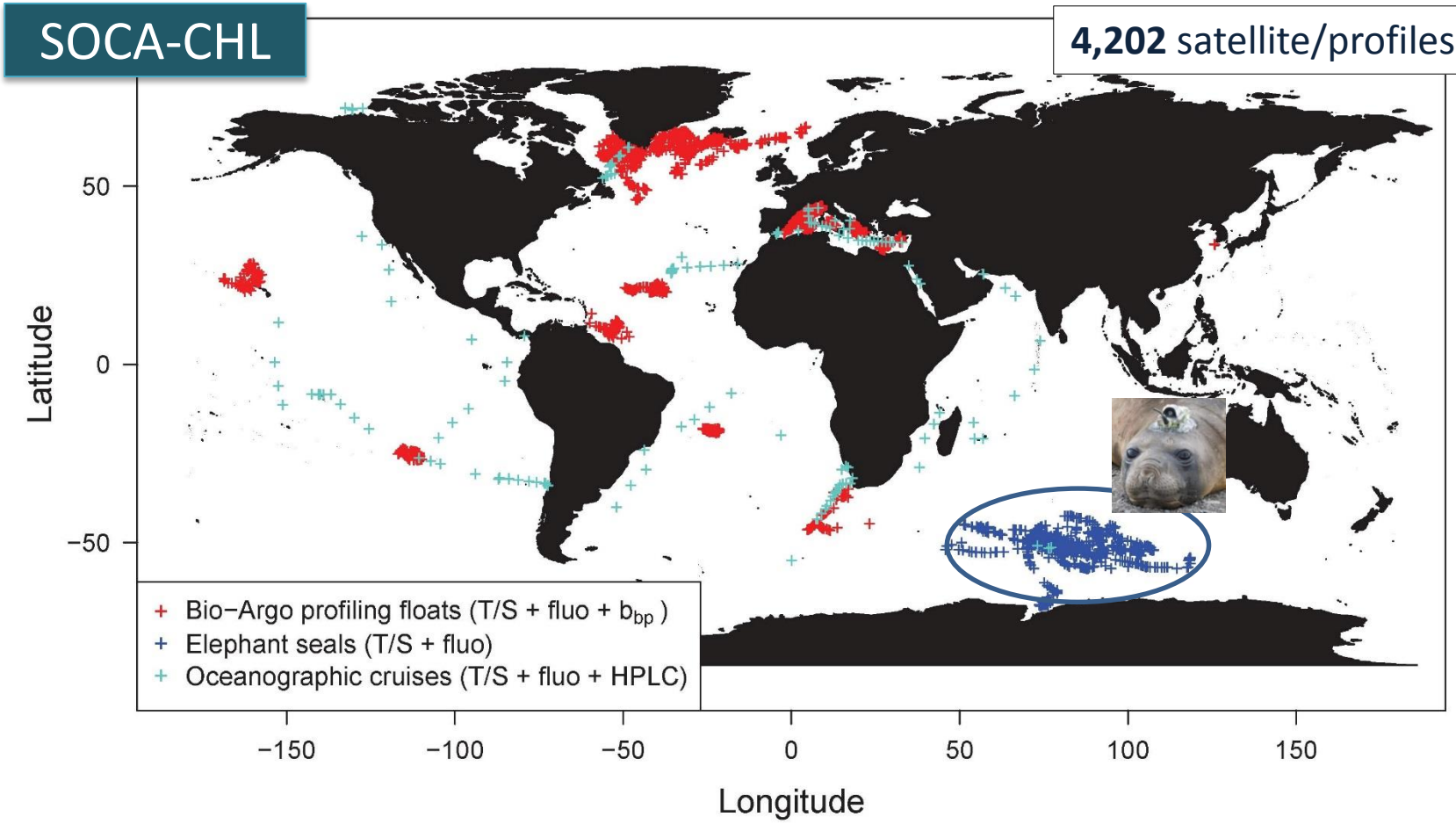
SOCA-CHL

4,202 satellite/profiles matchup



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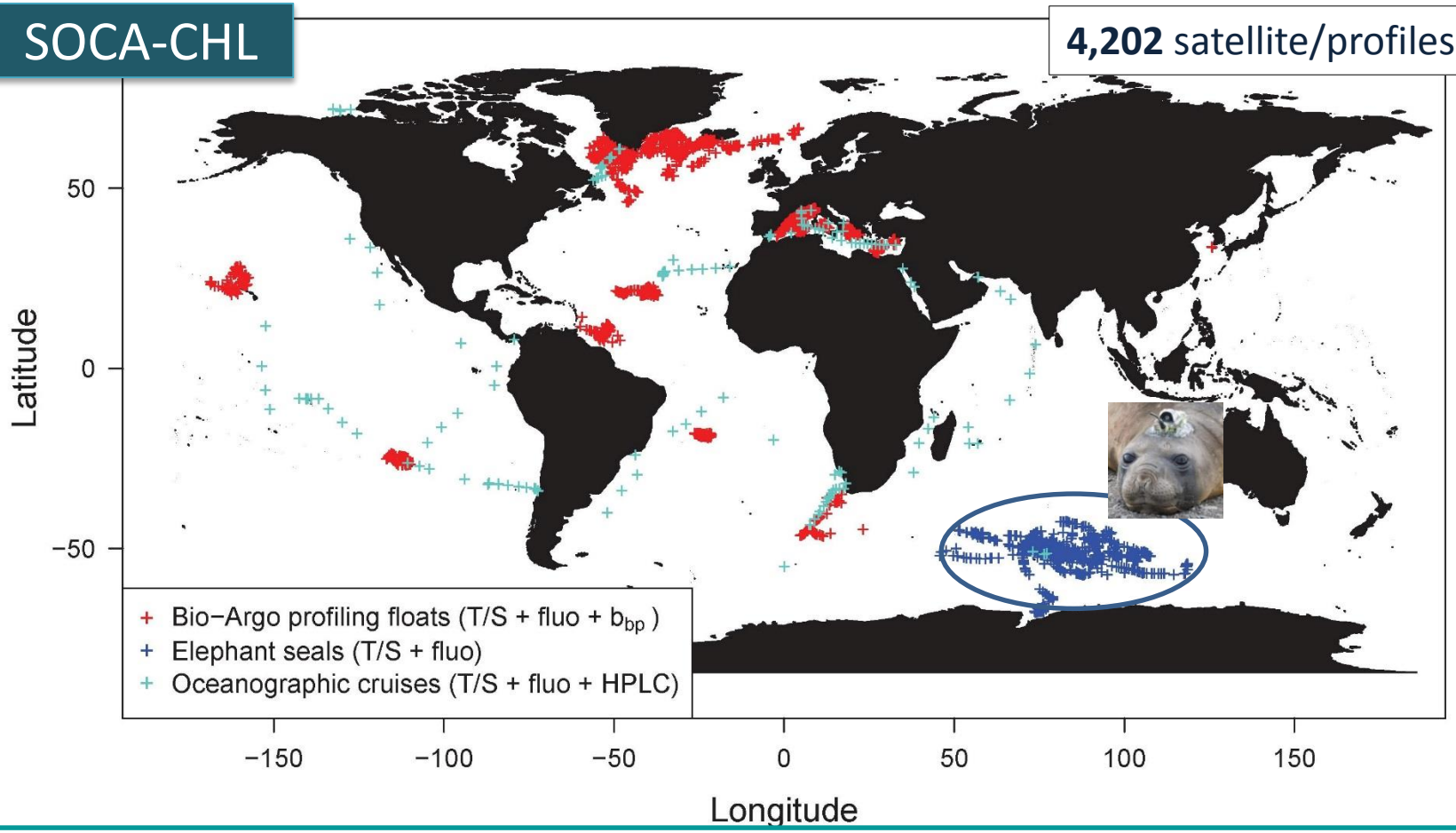
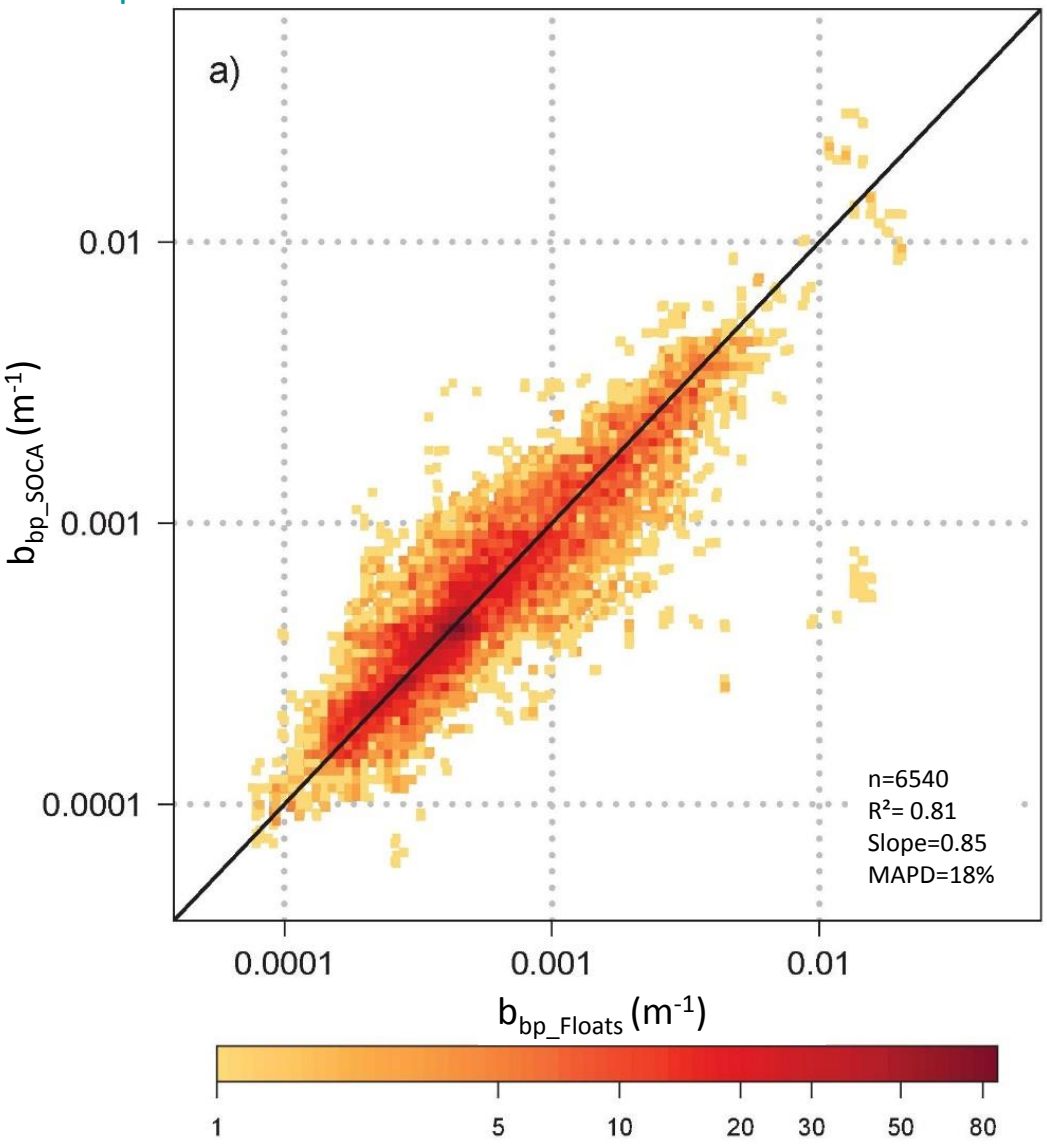


Databases representative of the global ocean → SOCA method applicable at a global scale

SOCA-BBP performance for b_{bp} retrieval

Validation:

→ 654 profiles from the 20% of the Bio-Argo database



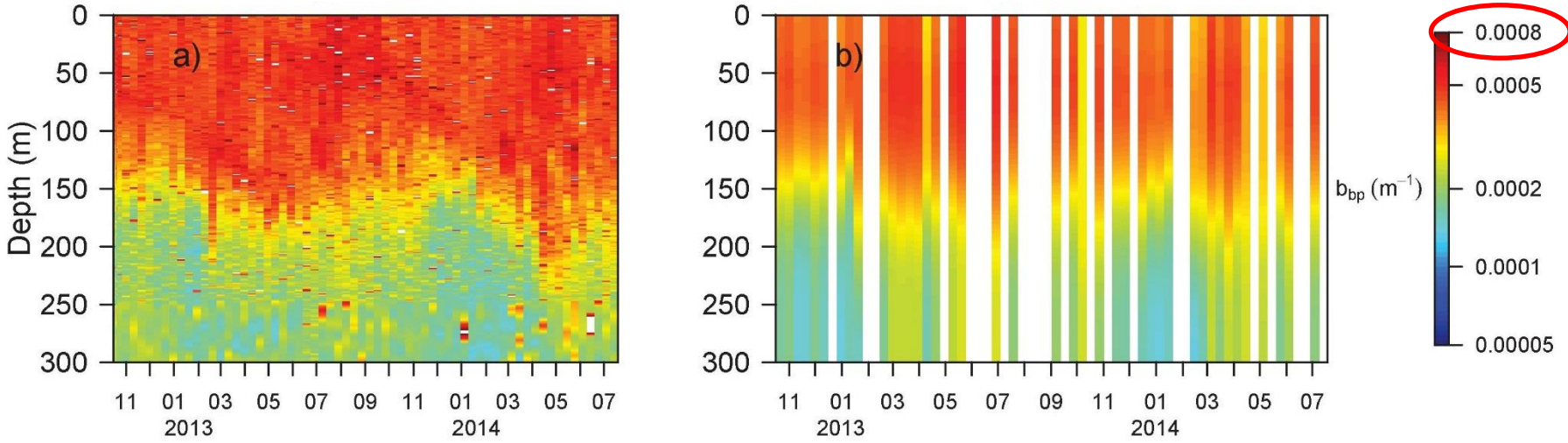
Sauzède *et al.*, In prep.

SOCA-BBP validation using 2 time series from the « independent » floats

b_{bp} from Bio-Argo floats

b_{bp} from SOCA: Satellite-Argo (only T/S) matchup

North Atlantic Subtropical Gyre



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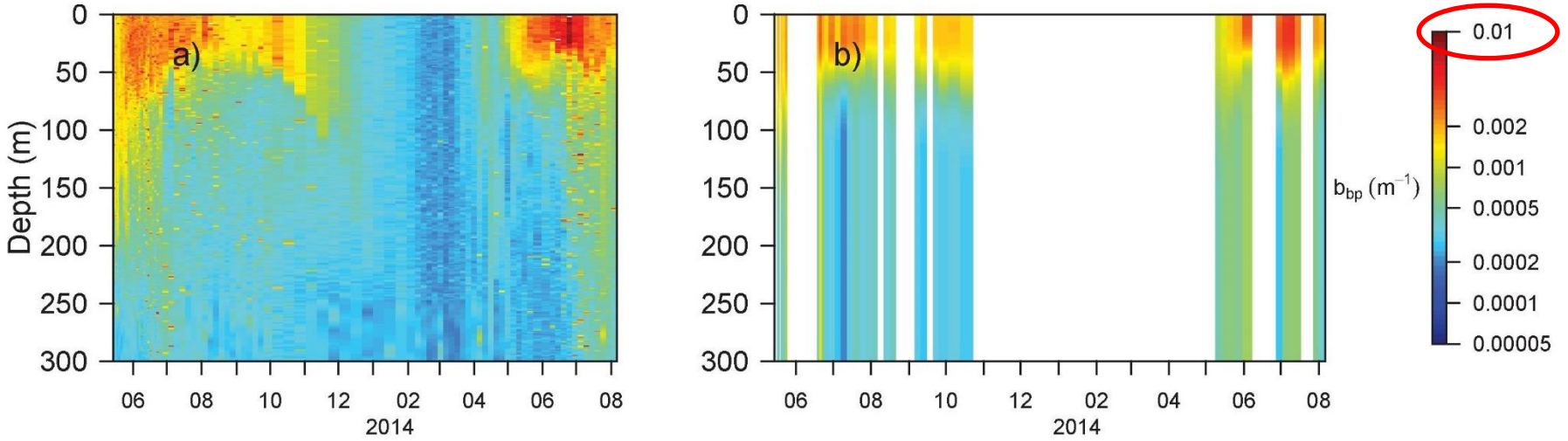

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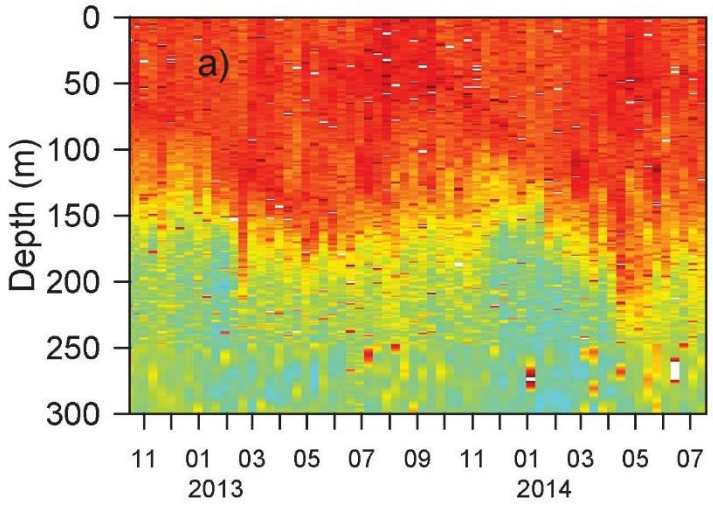
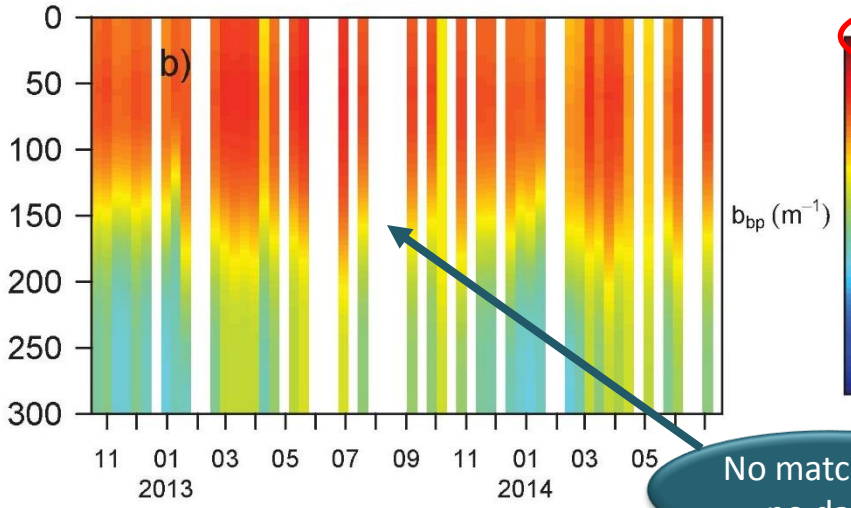
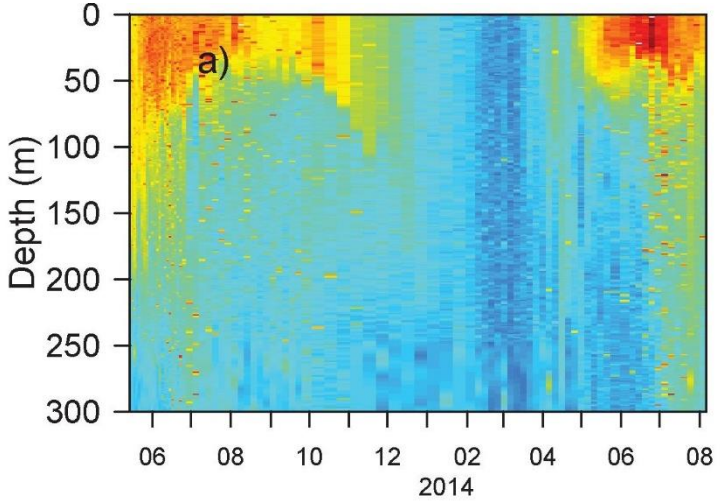
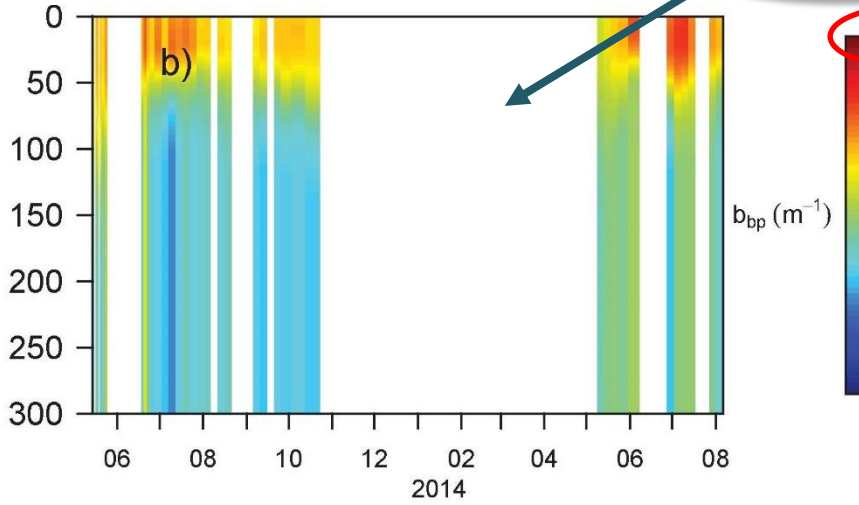




No matchup = no data!

North Atlantic





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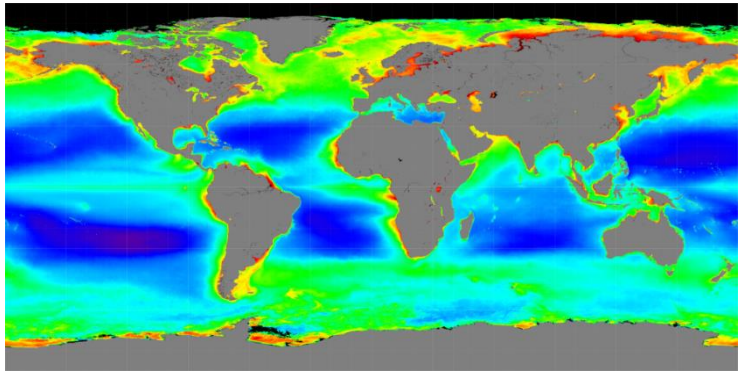
SOCA-BBP Application: climatology of b_{bp} for June at a global scale



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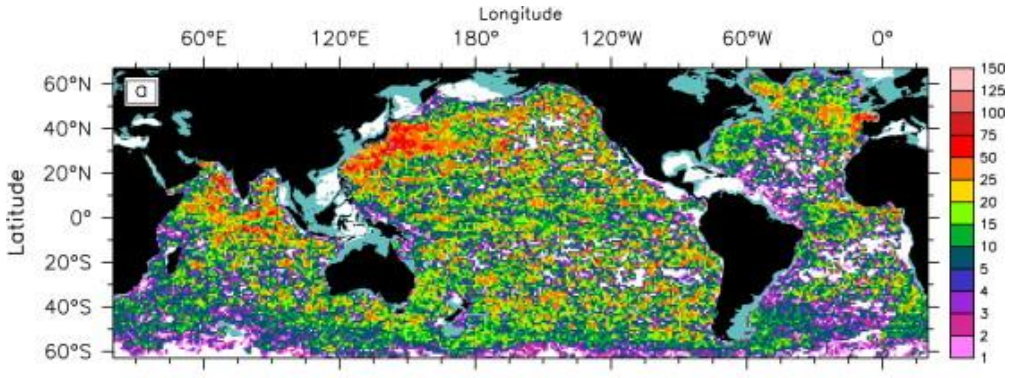
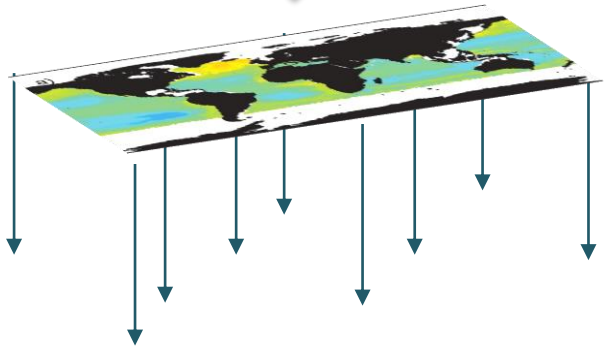


Surface ocean color climatologies

Argo T/S climatology (Roemmich and Gilson ,2009)

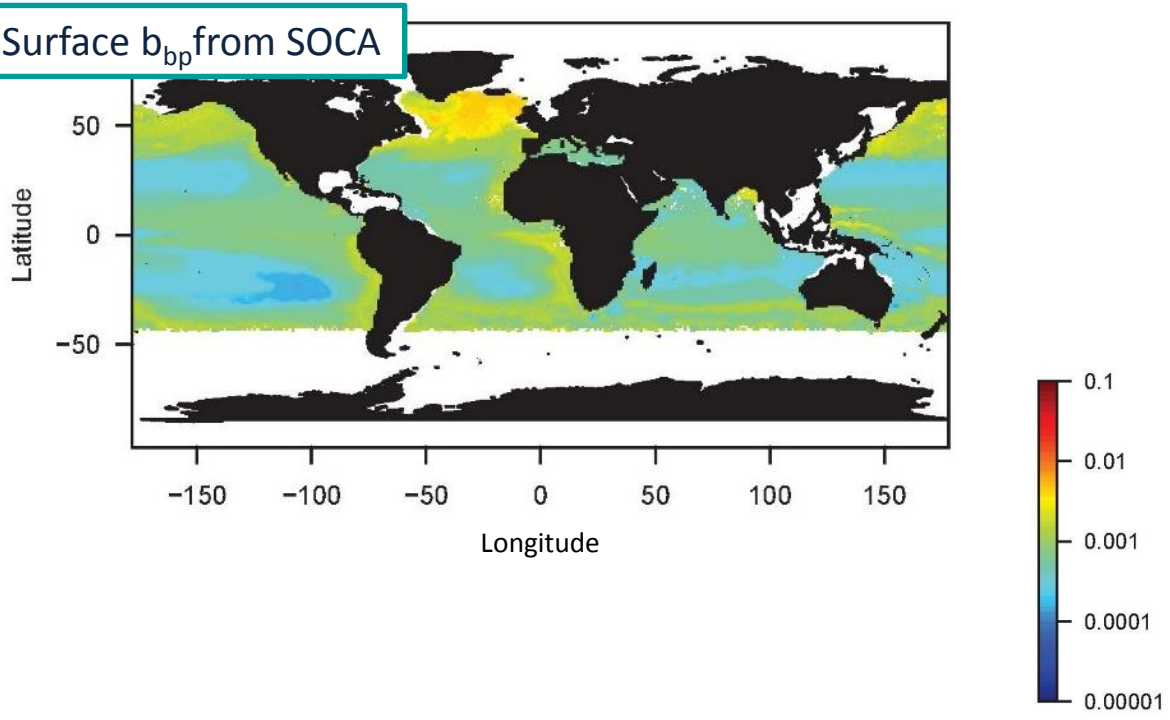
SOCA



3D global climatology of b_{bp}

SOCA-BBP Application: climatology of b_{bp} for June at a global scale

Surface b_{bp} from SOCA



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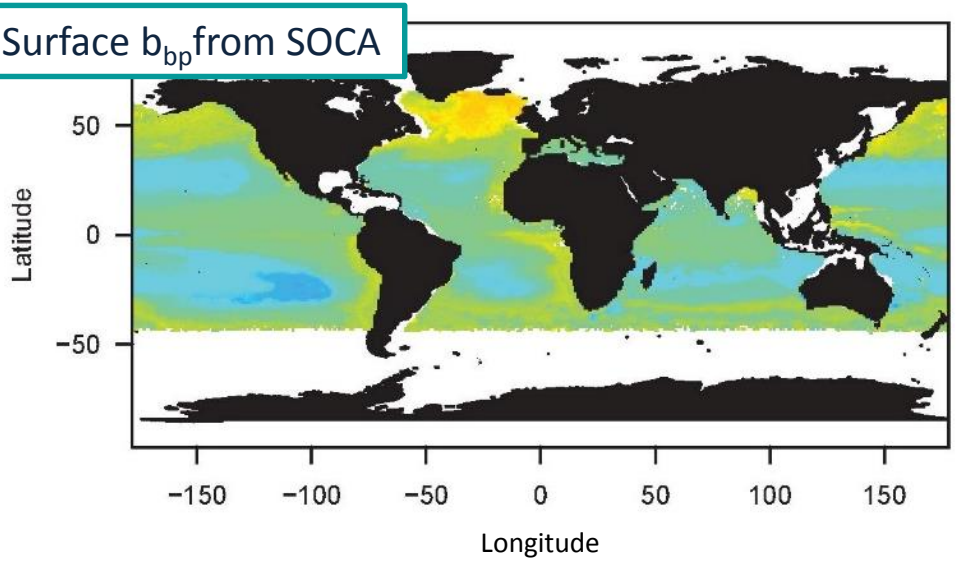
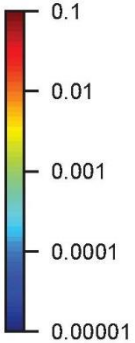
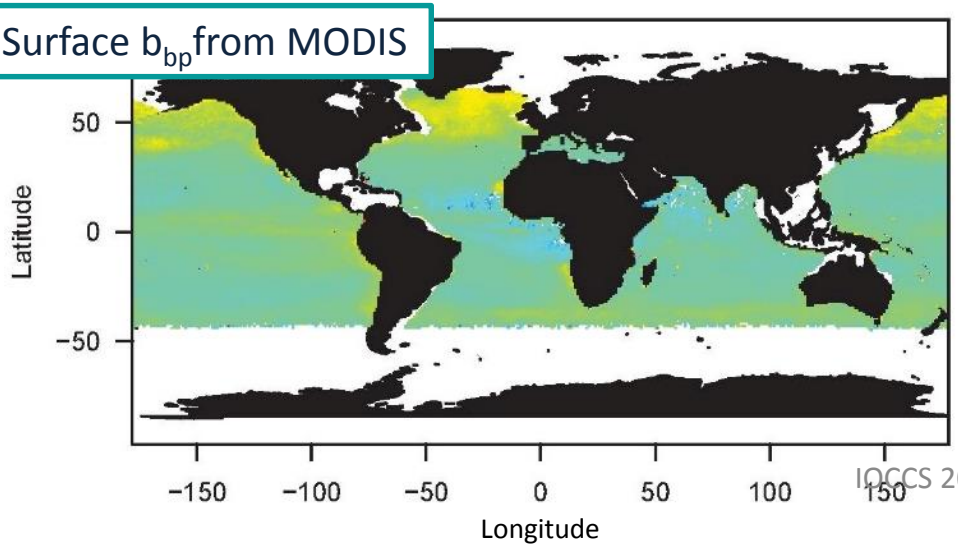




Surface b_{bp} from MODIS



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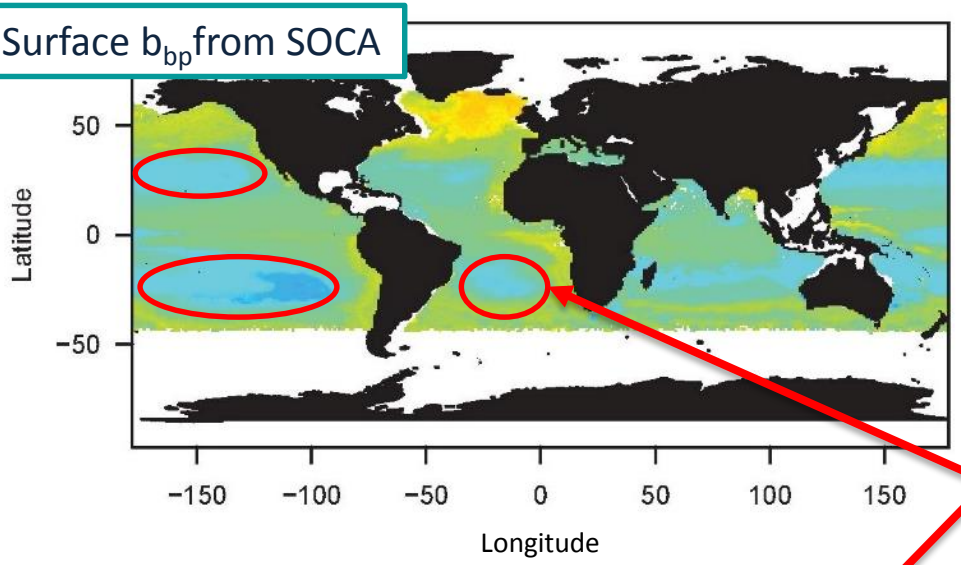

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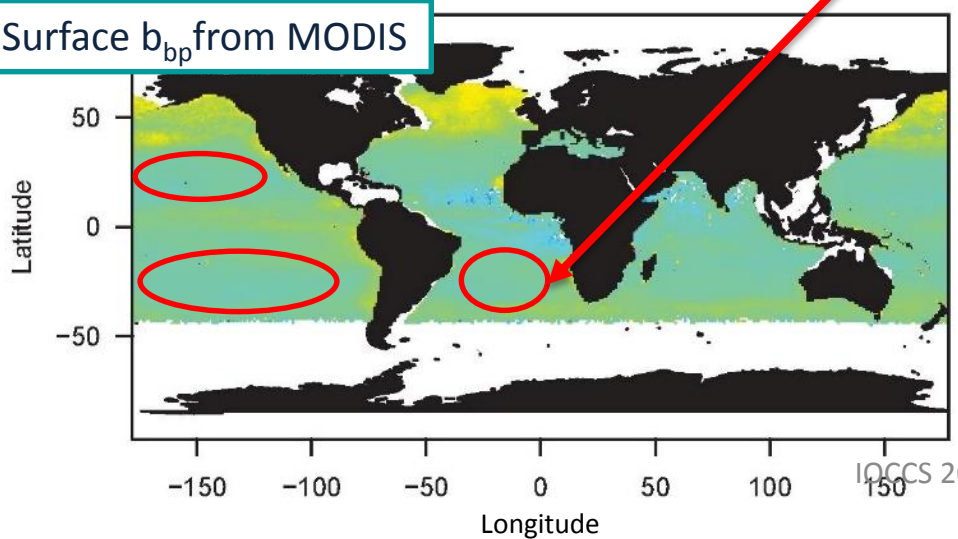
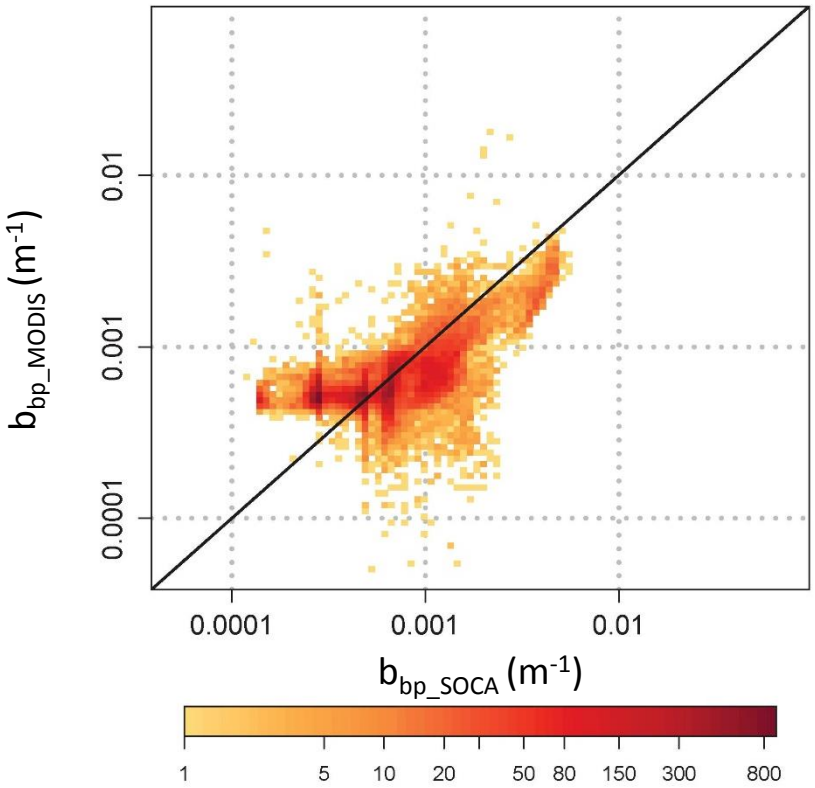
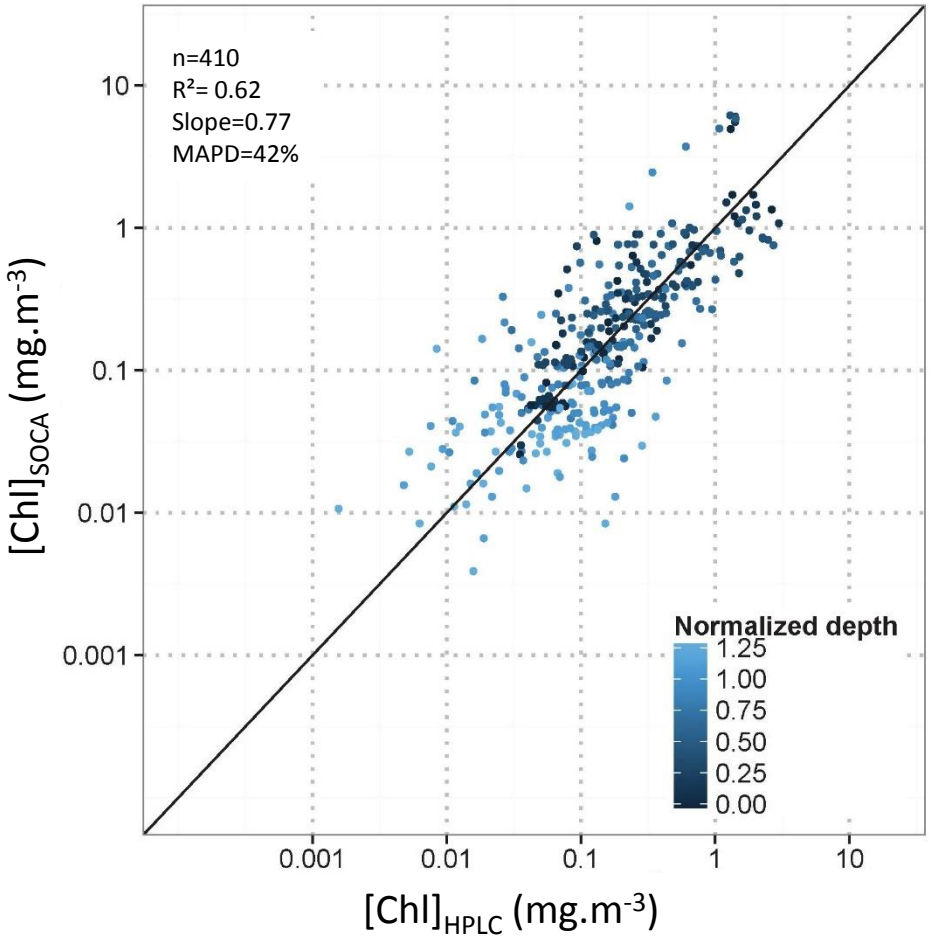


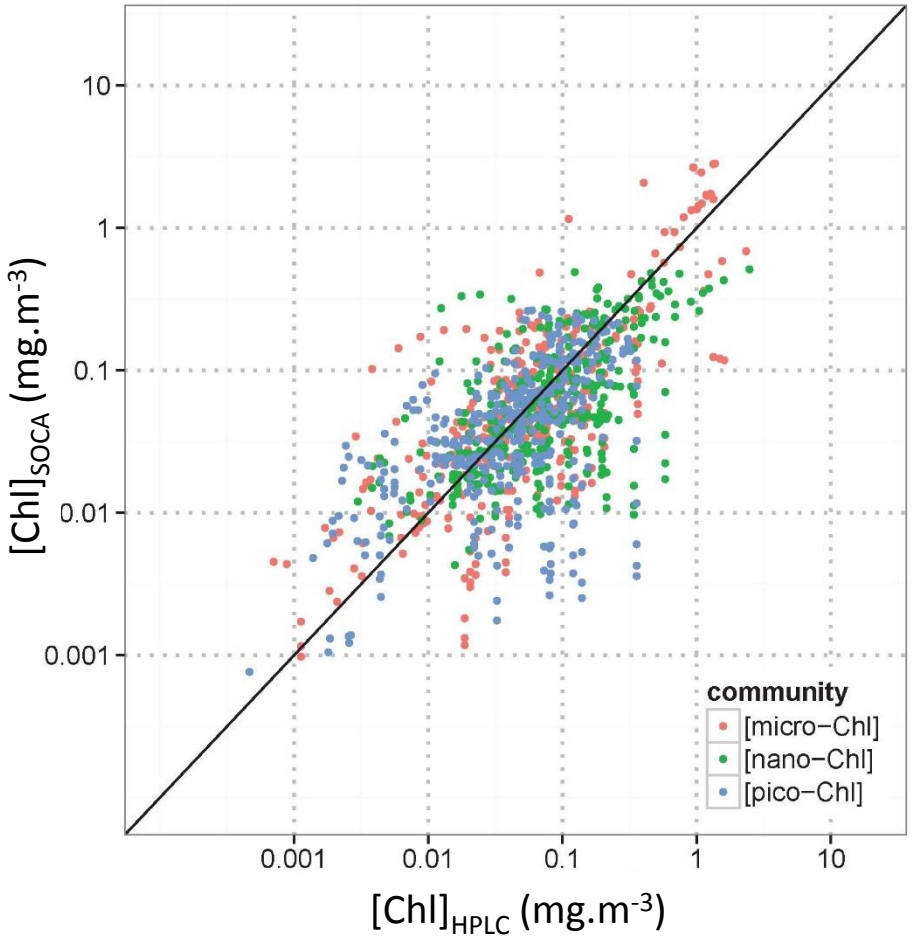


Sauzède *et al.*, In prep.

SOCA-CHL performance for [Chl] and assemblage of phytoplankton communities retrievals

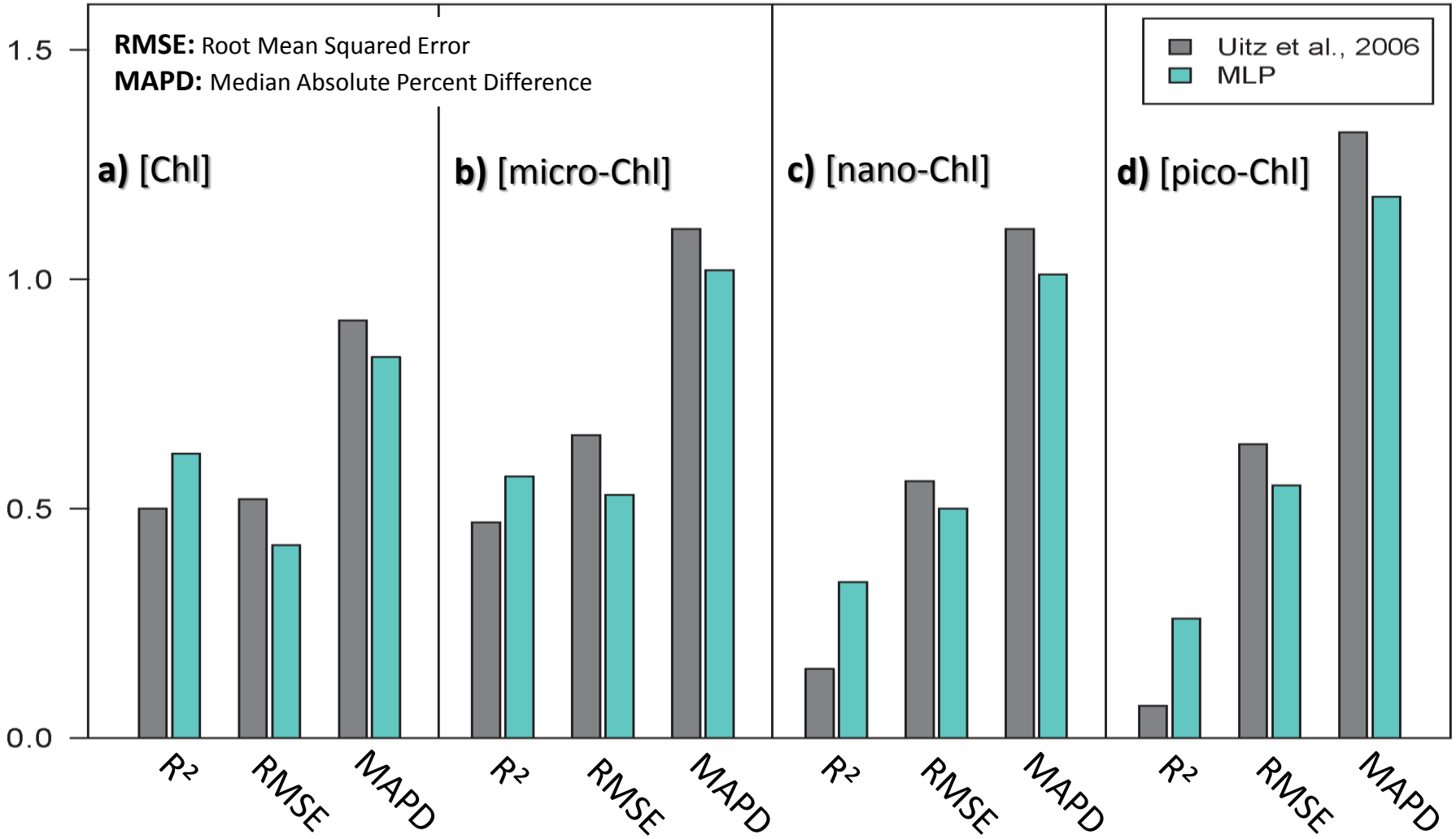
Validation of final results with cruises data (HPLC)
→ finally, 41 profiles to validate SOCA-CHL





SOCA-CHL performance for [Chl] and assemblage of phytoplankton communities

→ Comparison with the parameterization of Uitz *et al.* (2006)



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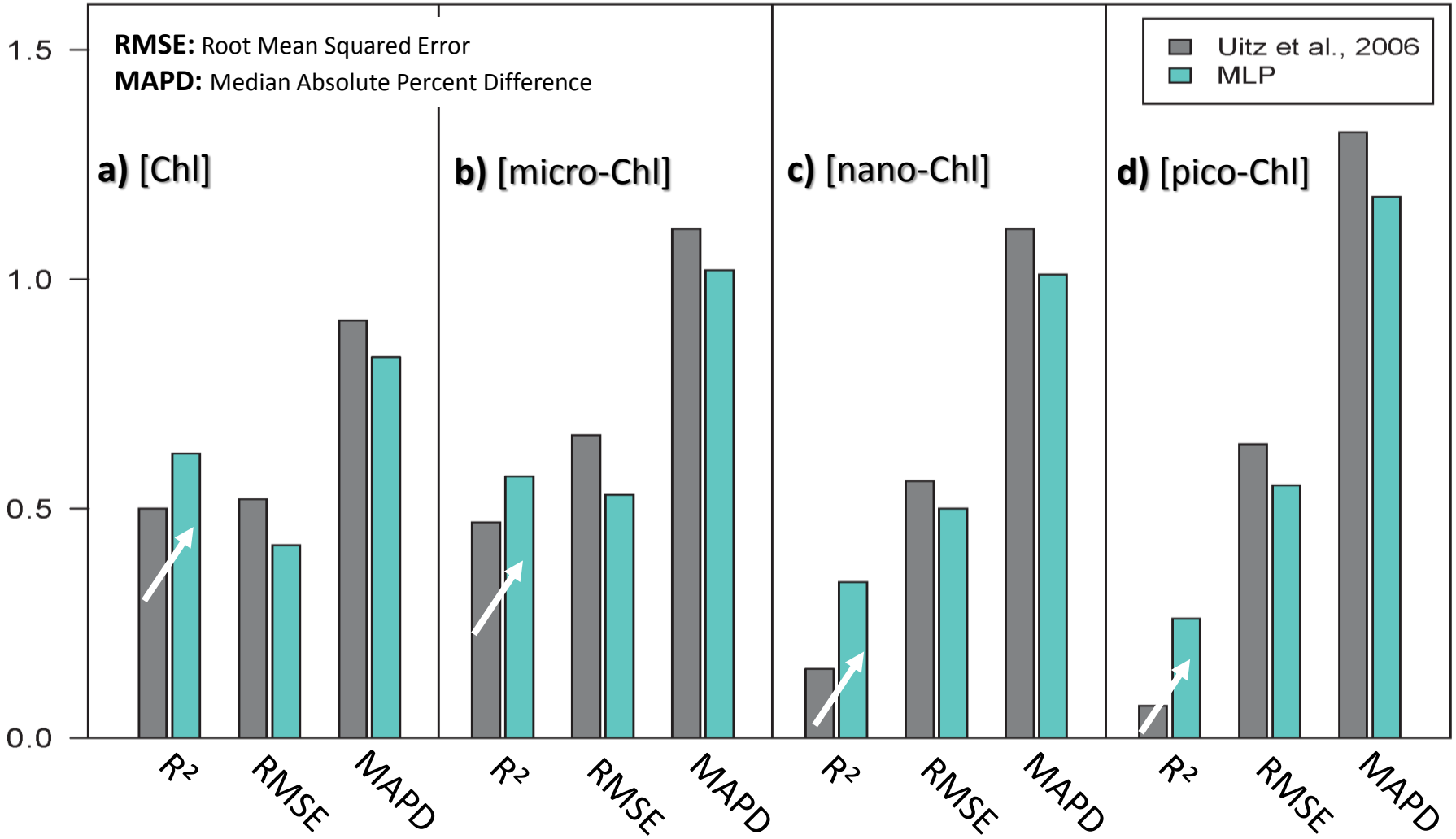

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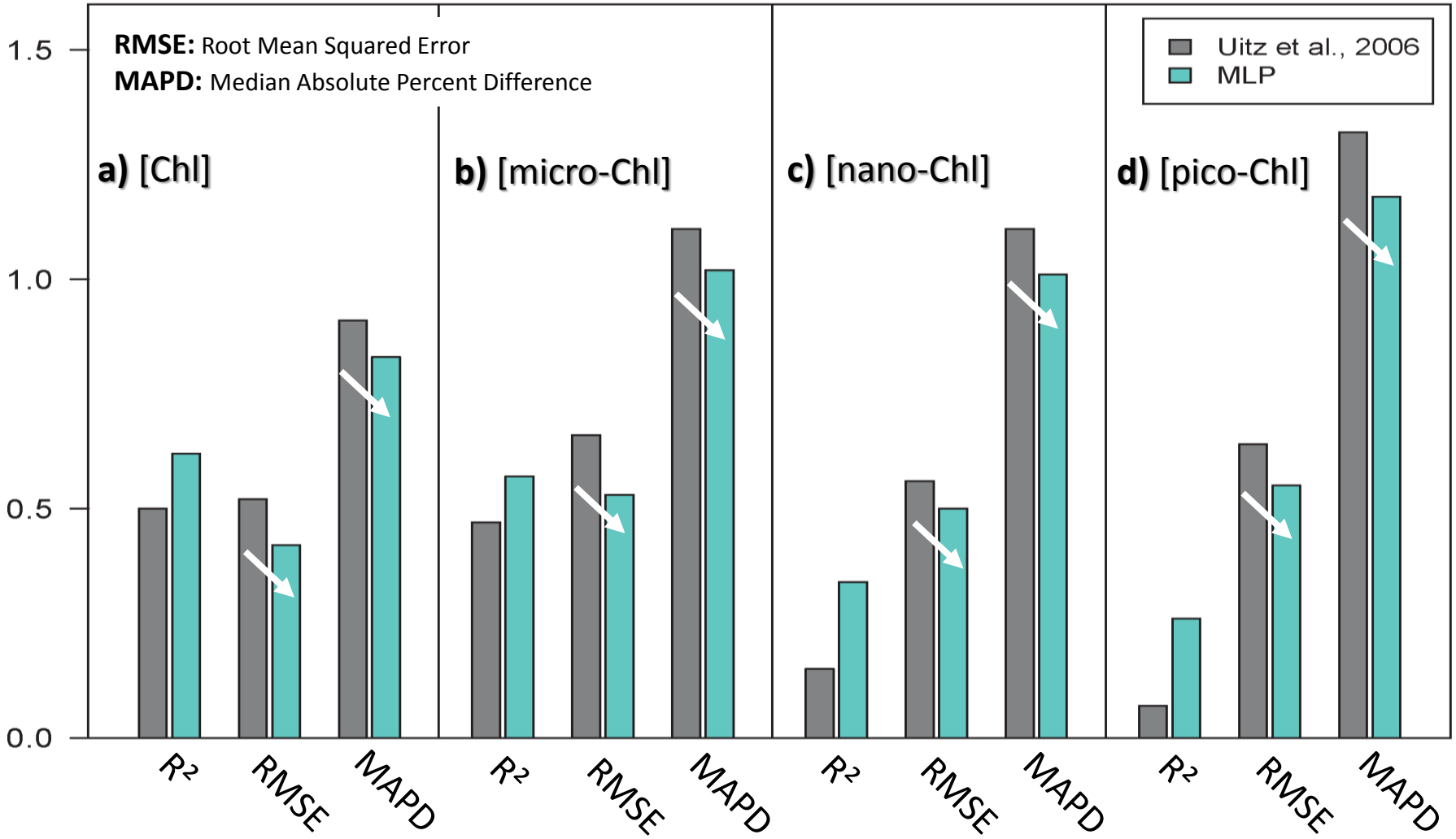
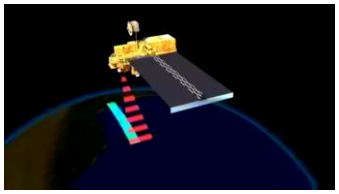


Conclusion and perspectives :



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[Chl] +
[micro-Chl] +[nano-Chl] +[pico-Chl] +
b_{bp}

Argo T/S profiles + satellite matchup
→ Profiles of b_{bp} + [Chl] + phytoplankton communities

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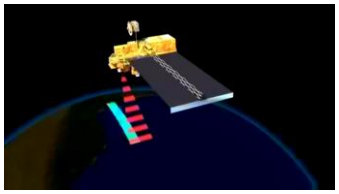

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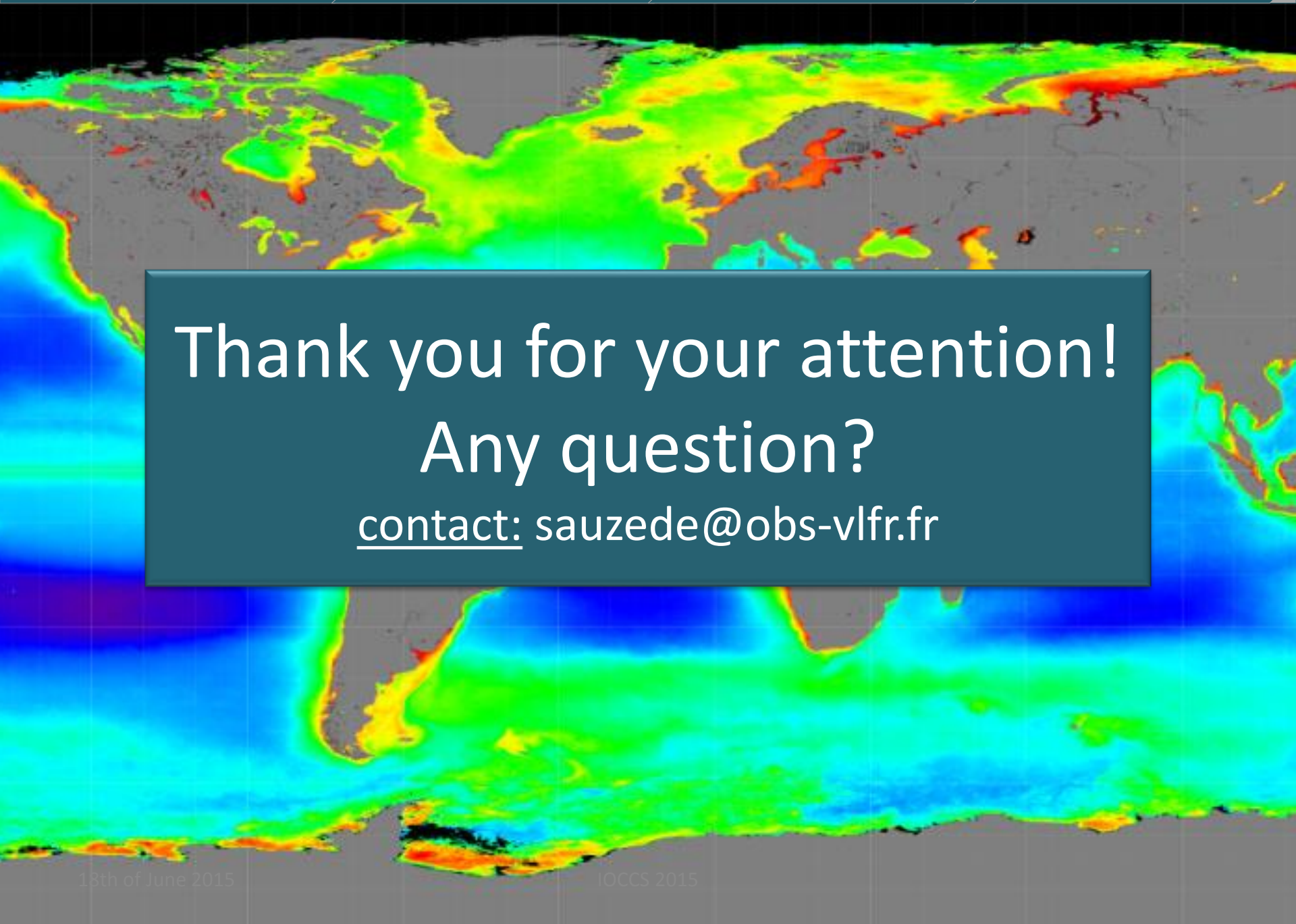
Argo T/S profiles + satellite matchup
→ Profiles of b_{bp} + [Chl] + phytoplankton communities

- SOCA-BBP: first results of the application of SOCA-BBP at the regional and global scales are very promising. SOCA-BBP suggests an overestimation of b_{bp} by satellite in the subtropical gyres.
- SOCA-CHL: improvement of the retrieval of the [Chl] associated with the total phytoplankton biomass and with the three size classes compared to the model of Uitz *et al.* (2006).
- SOCA method have multiple potential applications such as the initialisation/validation of biogeochemical models, the retrieval of POC from b_{bp} …
- Improvement of SOCA performance using more Bio-Argo profiles (available soon)



Thank you for your attention!
Any question?

contact: sauzede@obs-vlfr.fr