Optimization of the PISCES biogeochemical model for global applications using *in situ* data assimilation — The LEFE/CYBER ASCOBIO project —

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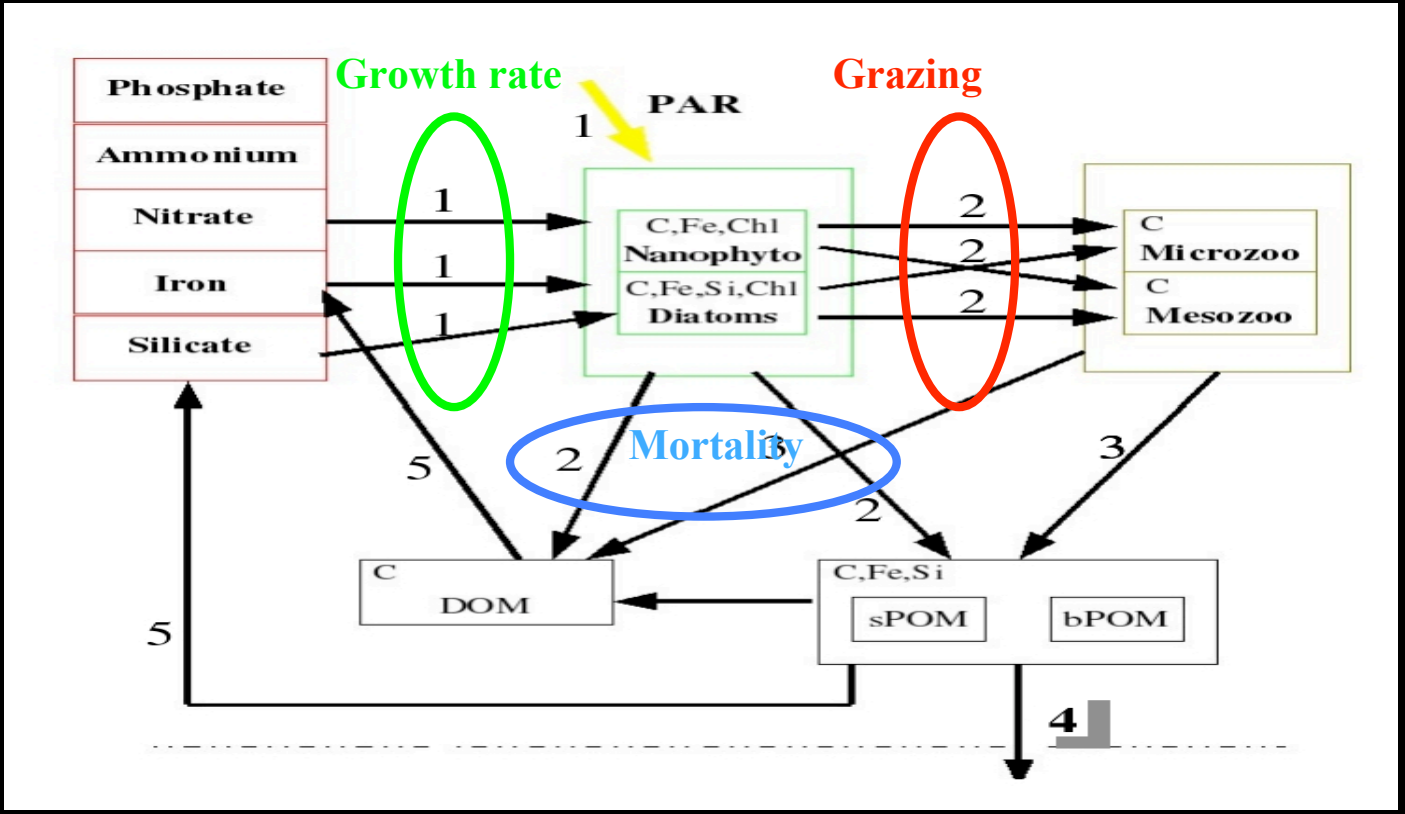
With the collaboration at LOCEAN of Mohamed Berrada, Luigi Nardi, Julien Brajard and Fouad Badran for the development of YAO and for the assimilation.

With the collaboration of Olivier Aumont (LPO) and Alessandro Tagliabue (LSCE) for PISCES validation and analysis.

Lsce- 2009

PISCES : the IPSL biogeochemical model used to study relationships between climate and marine carbon cycle



~ 50 parameters control the system evolution.

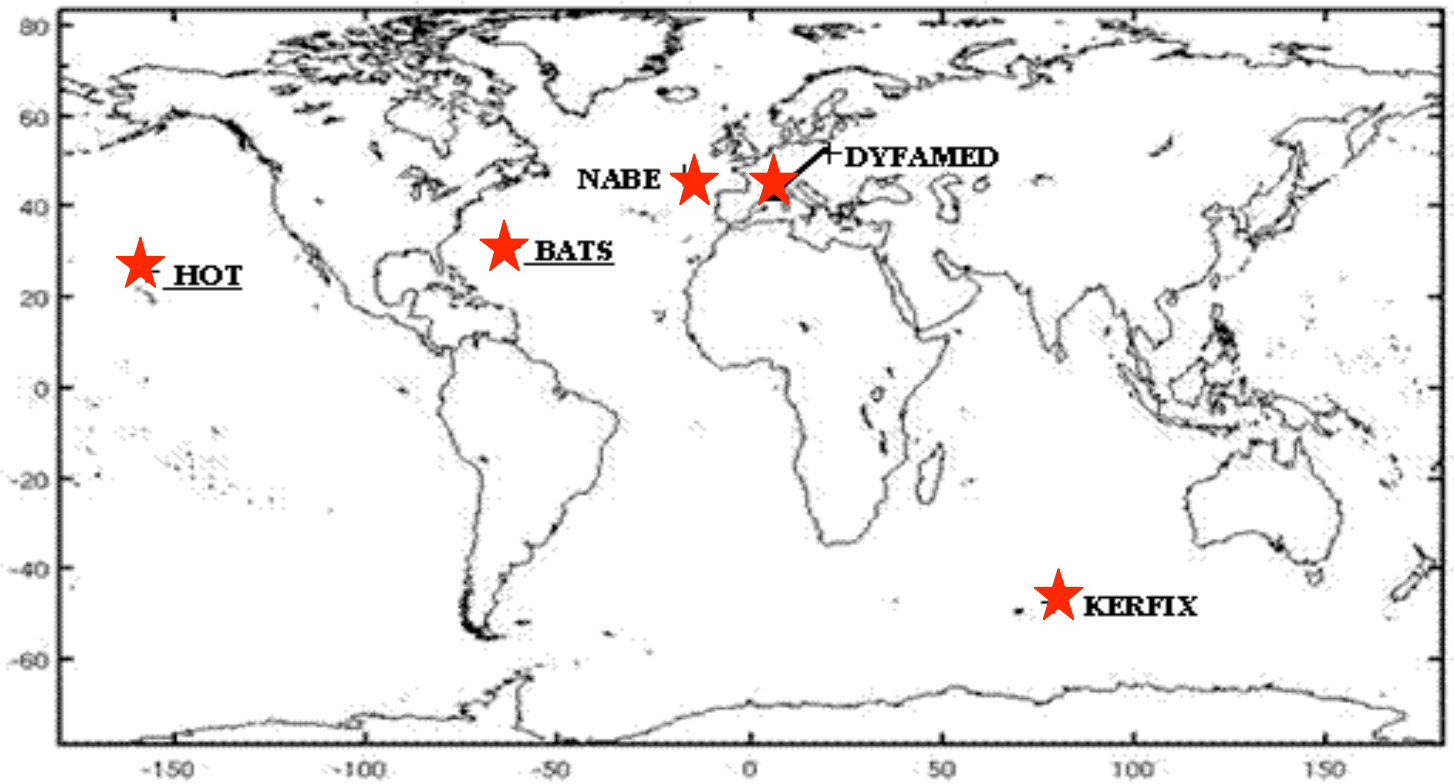
Most of these parameters are poorly constrained.

Our goal is to use *in situ* data available at a limited set of oceanographic stations to optimize PISCES parameters

In situ data : JGOFS Stations

+ : vertical profiles, large variety of data (Chl, NO_3, Si)

- : 1D Information , monthly frequency



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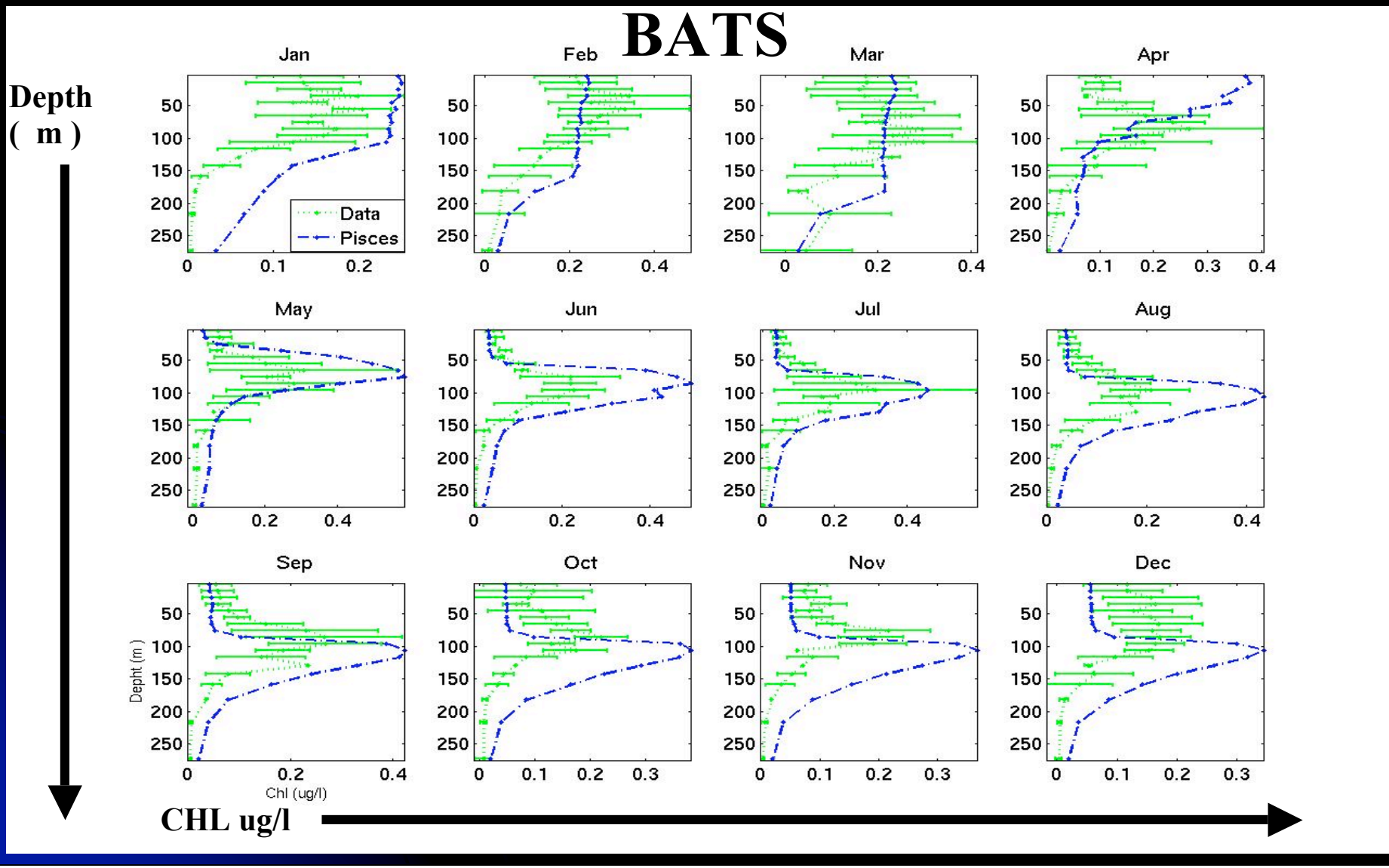
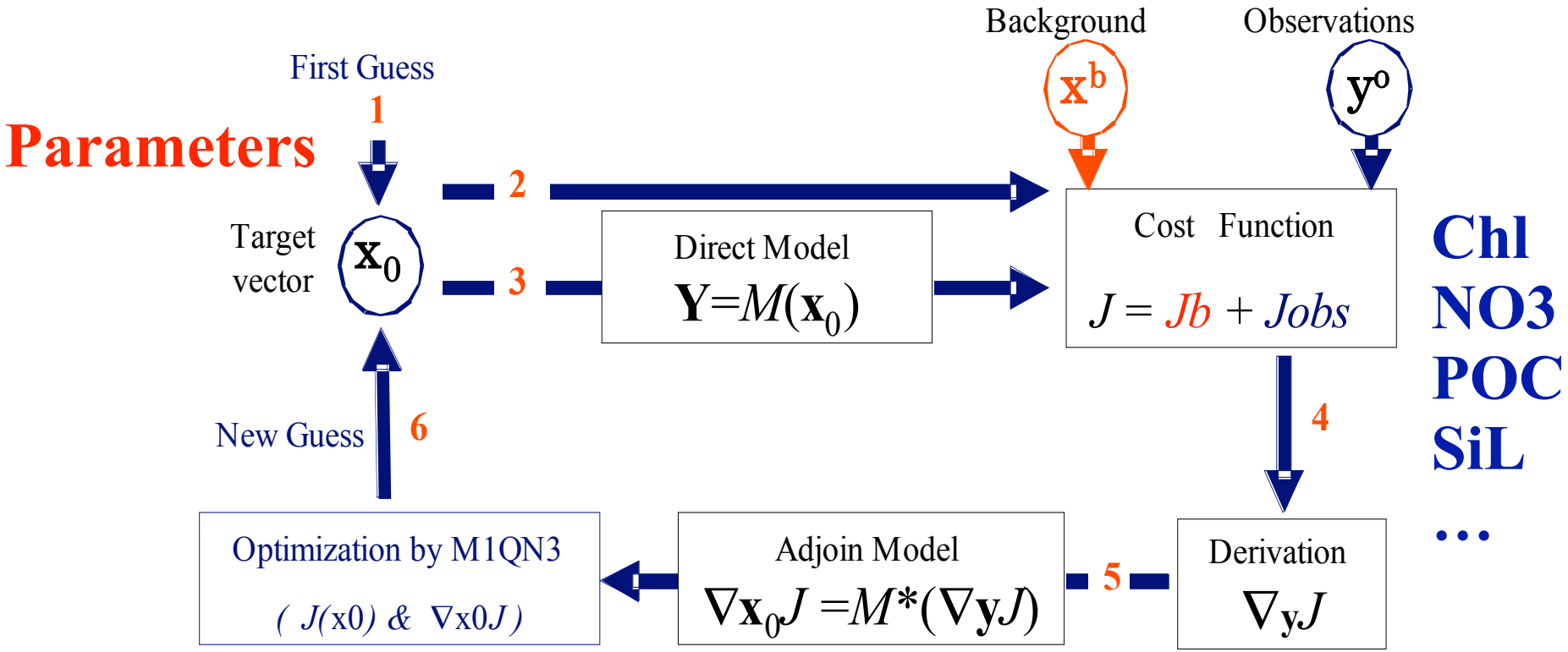


GOAL : Combine model and data in a non-subjective manner to get the best set of parameters

Assimilation : YAO Software (LOCEAN, Thiria et al)



→ **Cost function to minimize by adjusting the models parameters (Xo) :**

$$J(x_0) = (x_0 - x^b)^T B^{-1} (x_0 - x^b) + (M(x_0) - y^o)^T R^{-1} (M(x_0) - y^o)$$

What we have done so far (since 2007)

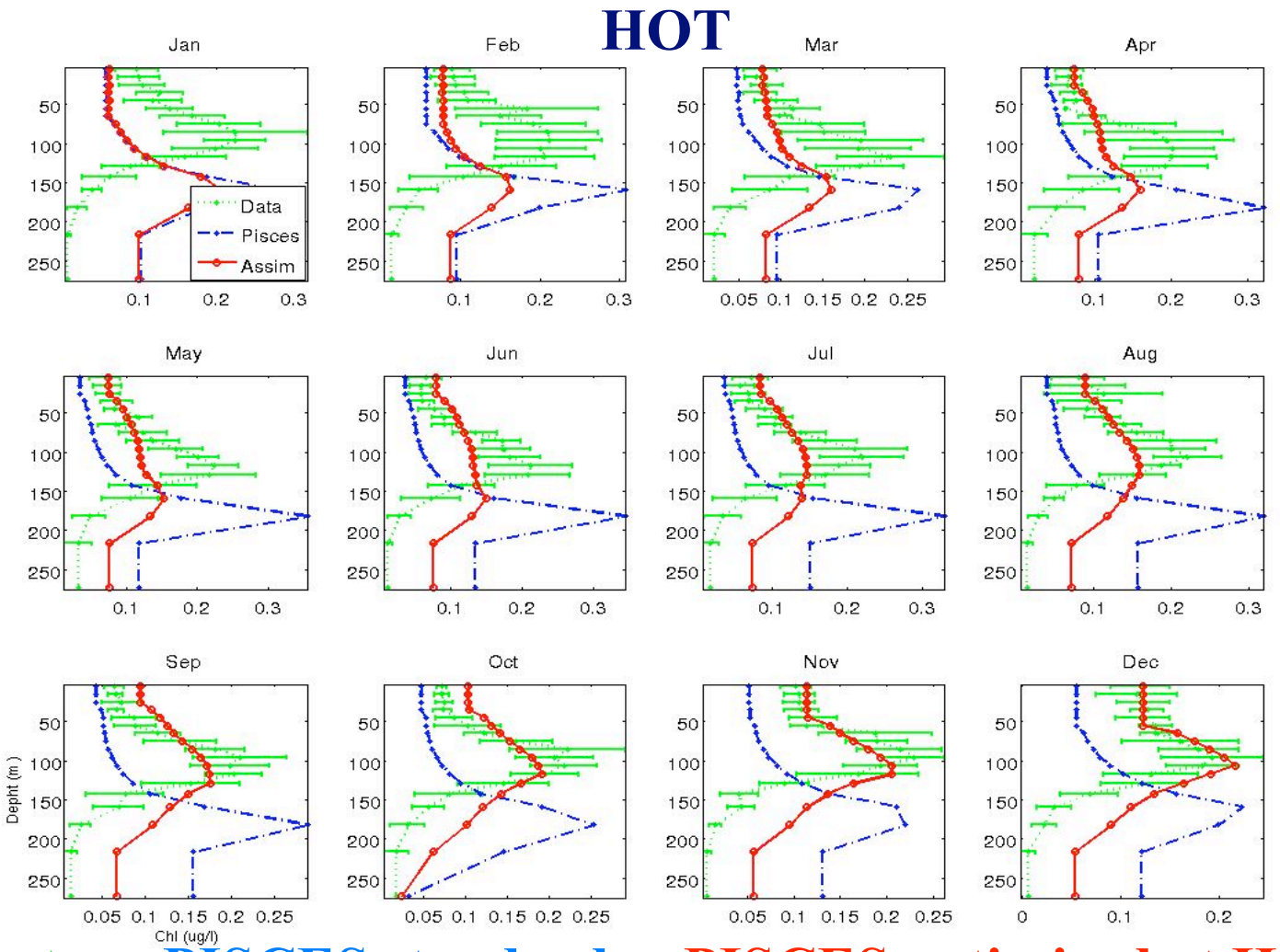
- Implementation of a 1D version of PISCES in YAO (using the formalism of the modular graph structure).

- Method Development: Identification of key parameters through sensitivity tests, definition of error matrices, validation using twin experiments,…

- Preliminary results: Optimization of 6 parameters at one station.

- Current Results: Optimization of 45 parameters at 5 stations and validation through a comparison between a 3D simulation and satellite data.

Optimization of 6 parameters (growing, mortality, grazing) at one station



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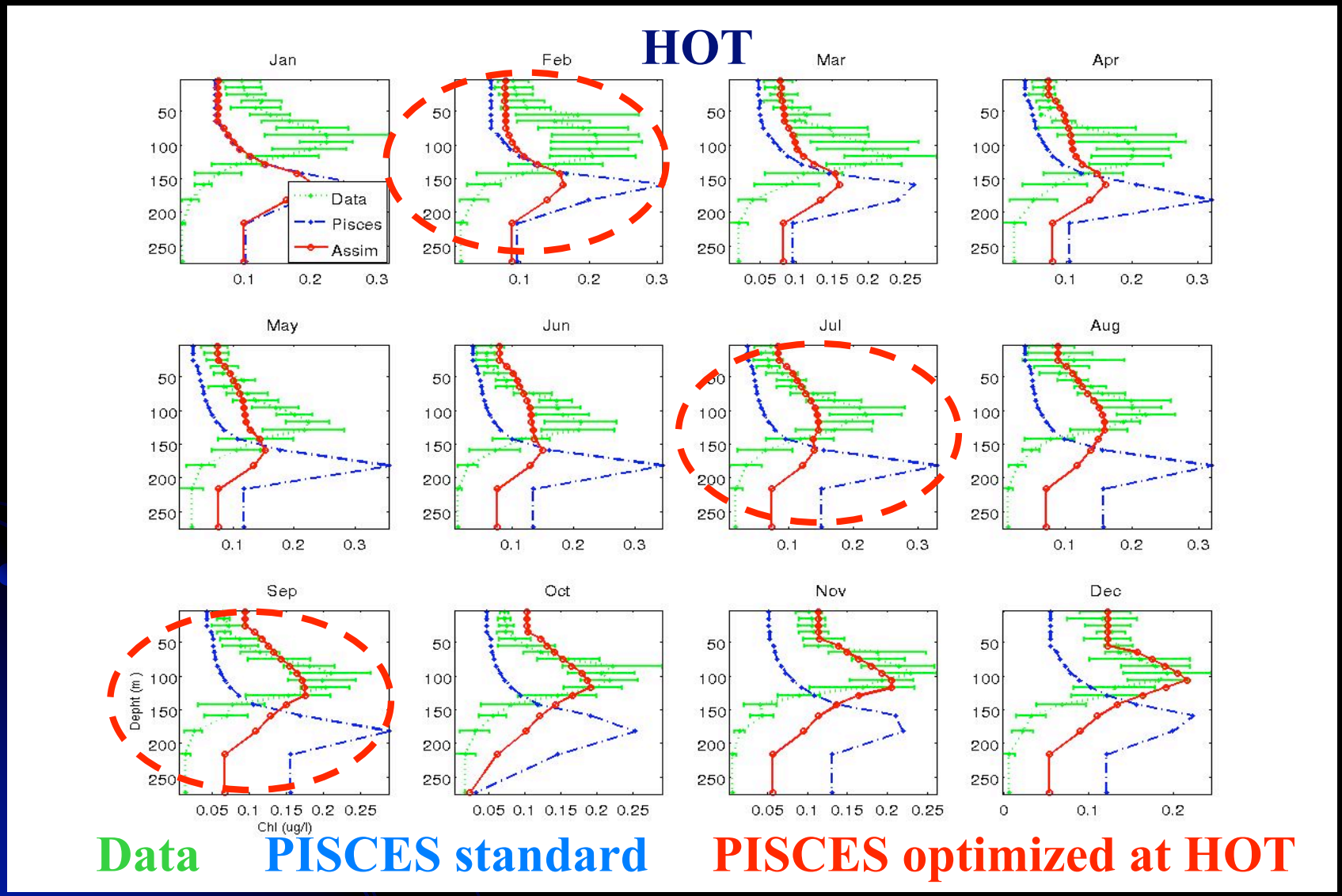

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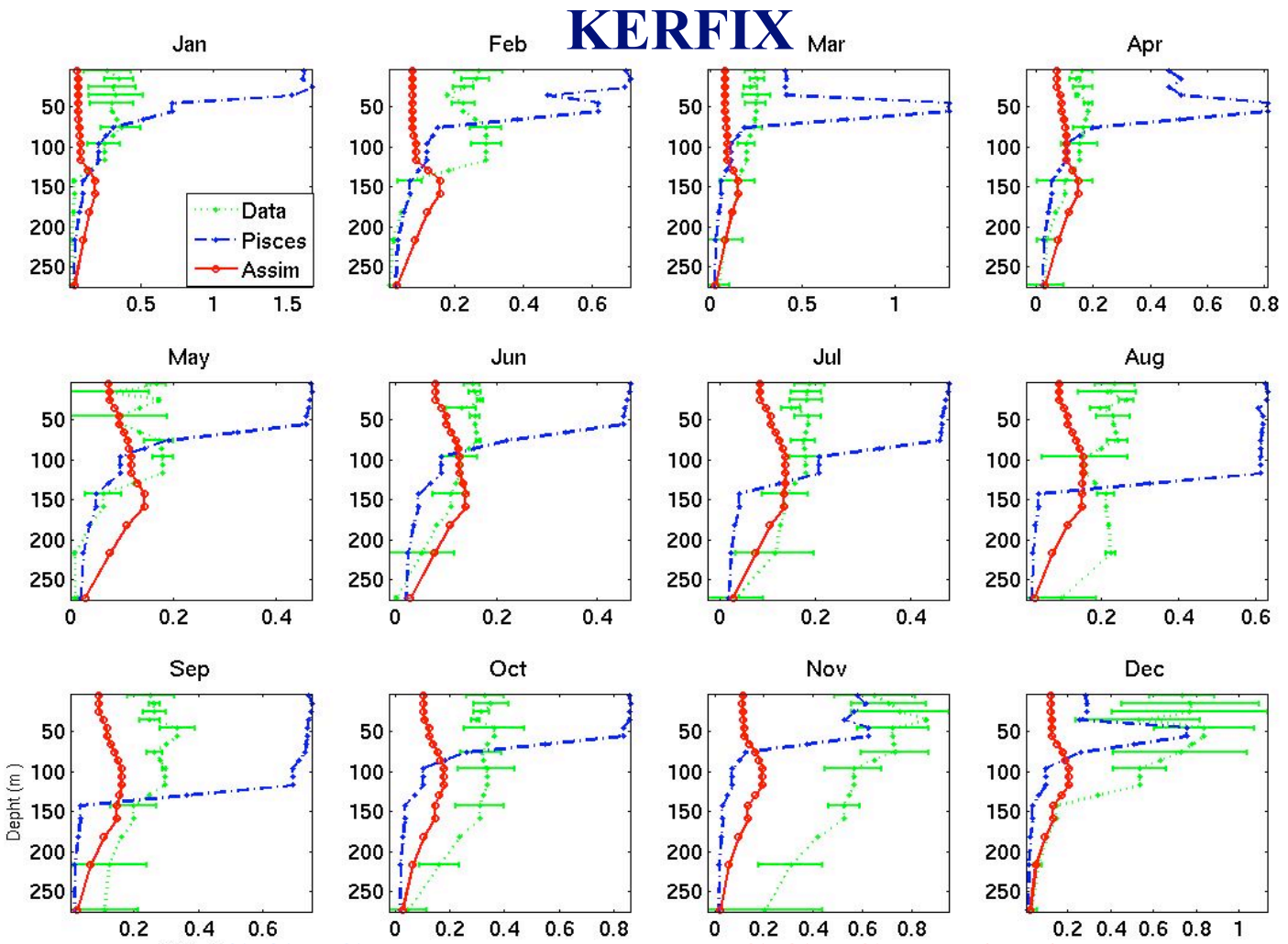

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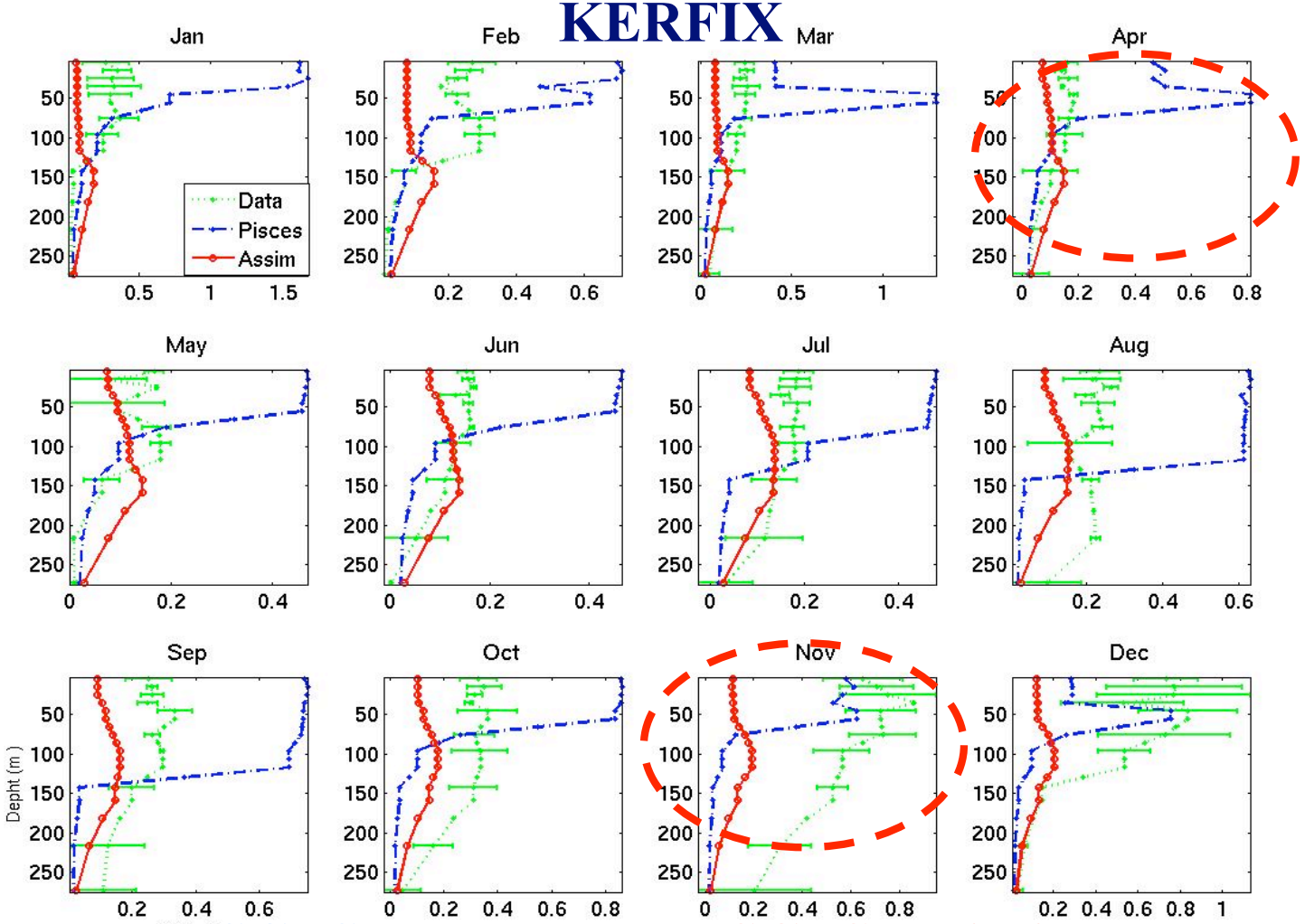


Optimization of 6 parameters (growing, mortality, grazing) at one station

Clear improvement at the considered station, but not for other locations:

- Parameters are specific to the station or at least to the local biogeochemical conditions.

To solve this problem:

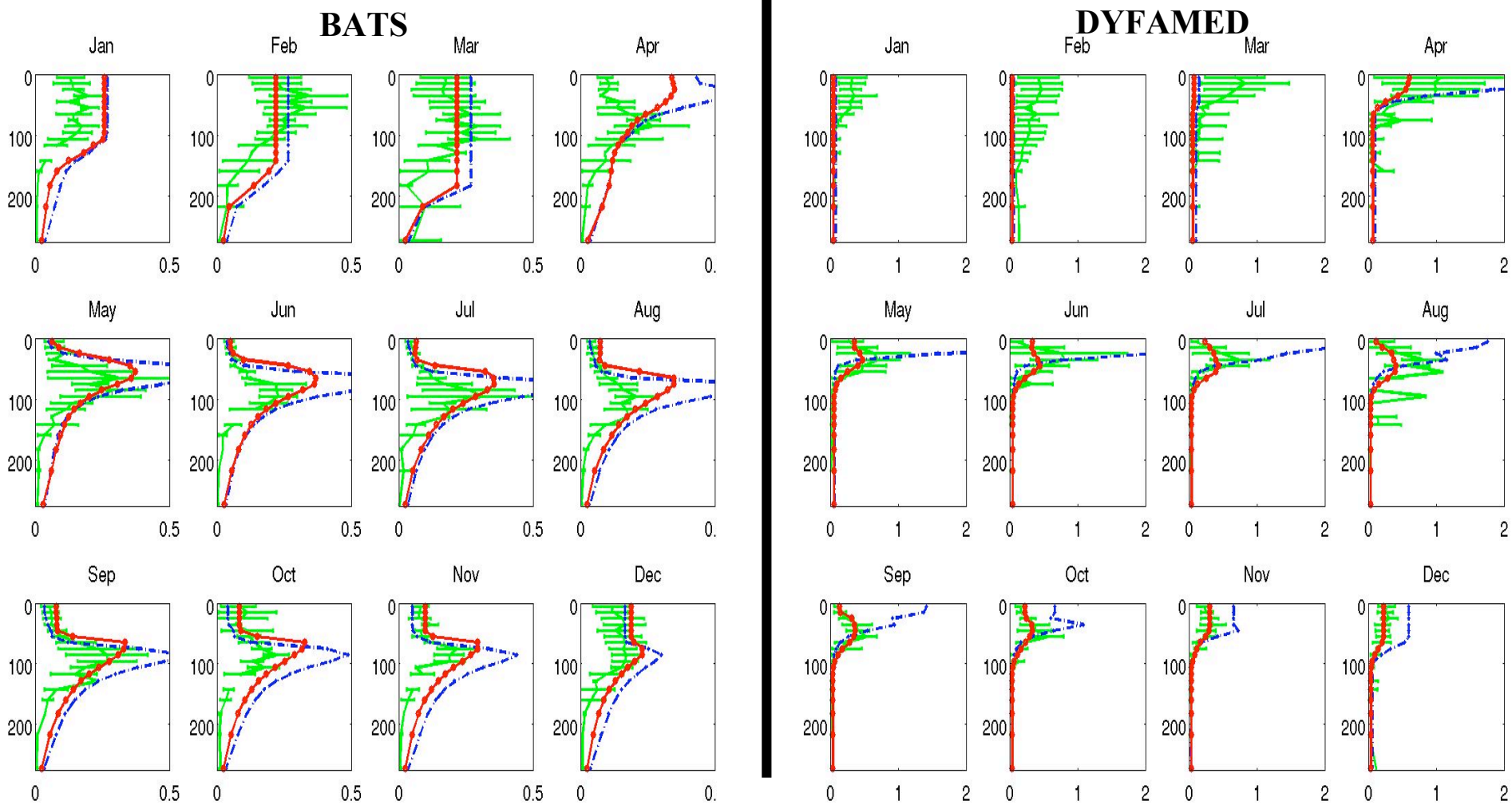
- Consider 45 parameters in the optimization to increase the number of degree of freedom
- Limit the range of variation for each parameter
- Optimize for the 5 stations at once to account for different biogeochemical conditions.

To validate this approach:

- Run a global 3D simulation (ORCA 2°, 500 years) for comparison with the standard simulation.

Optimization of 45 parameters at 5 stations

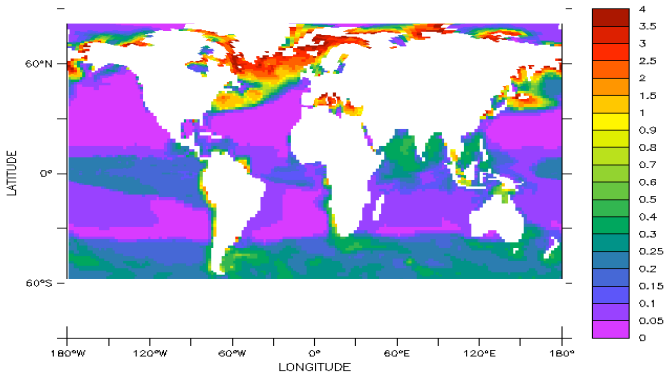
(Chl vertical profile)



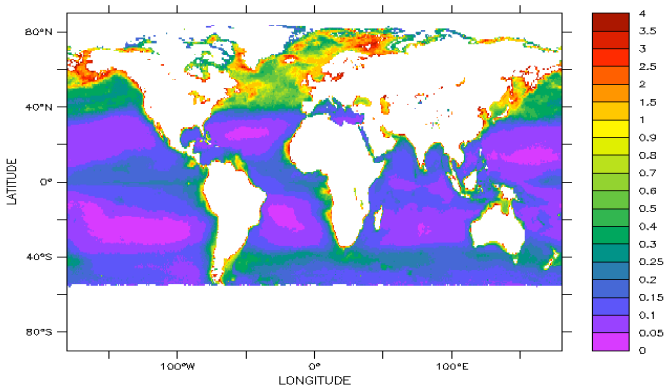
Chl (ug/ l) vs **PISCES Standard** vs **PISCES optimized**

Optimization of 45 parameters at 5 stations (surface Chl)

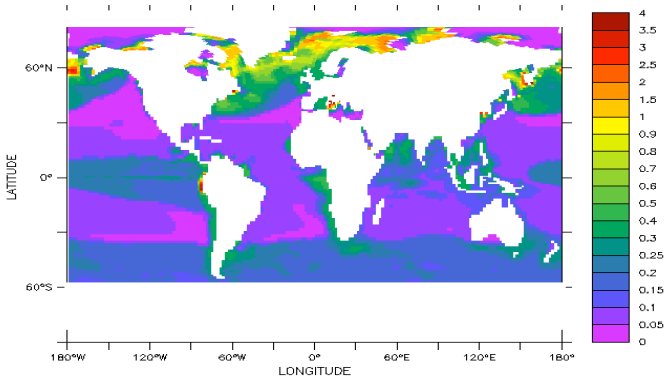
MAY



PISCES STANDARD

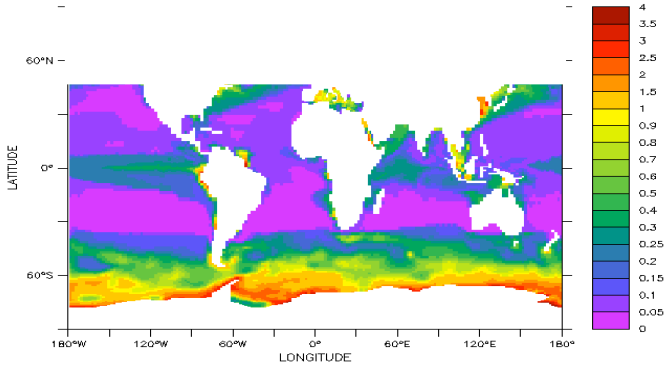


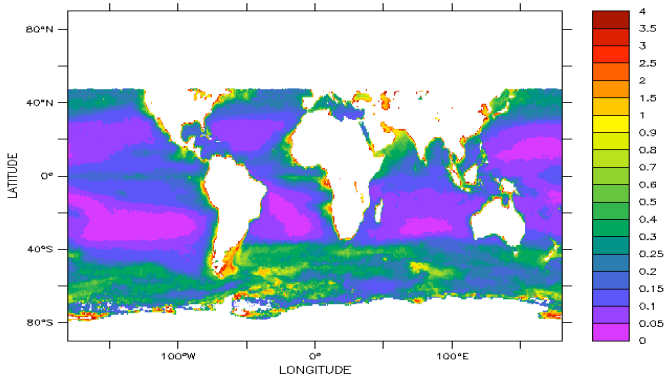
SEAWIFS (1997-2006)

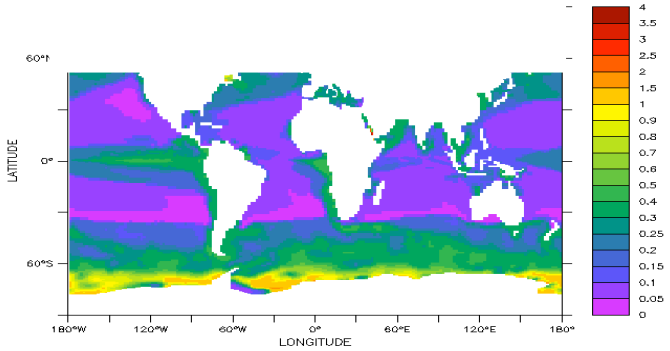


PISCES OPTIMIZED

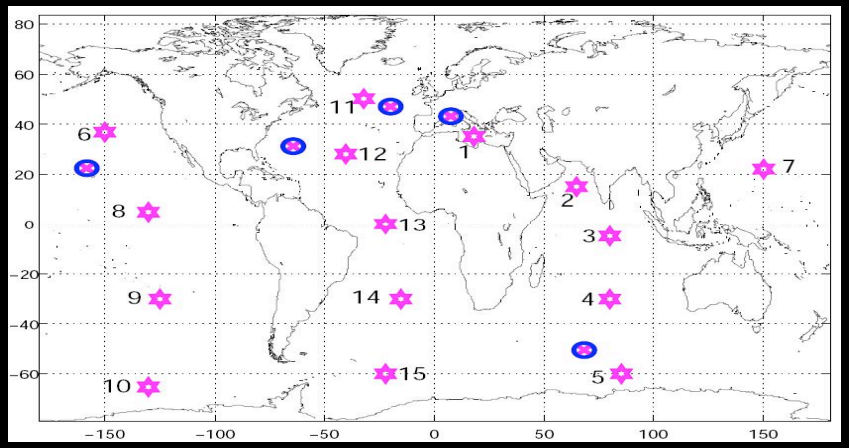
DECEMBER

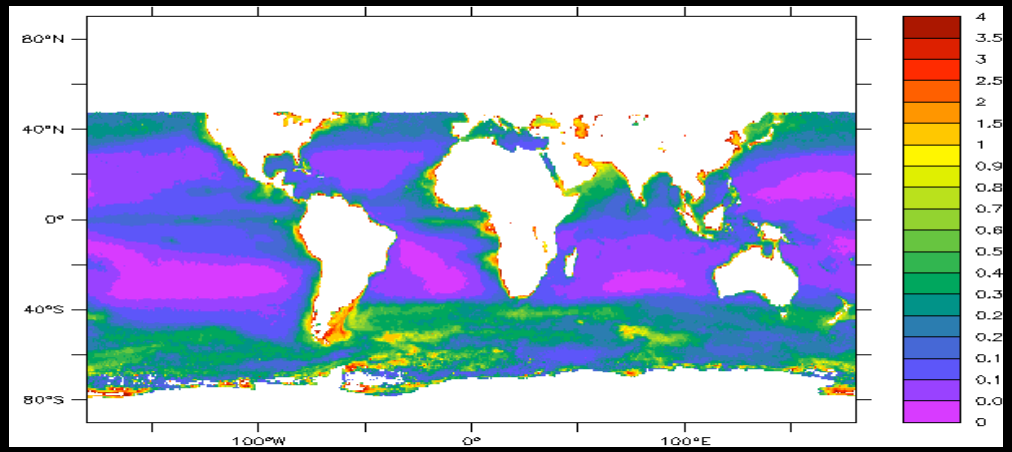


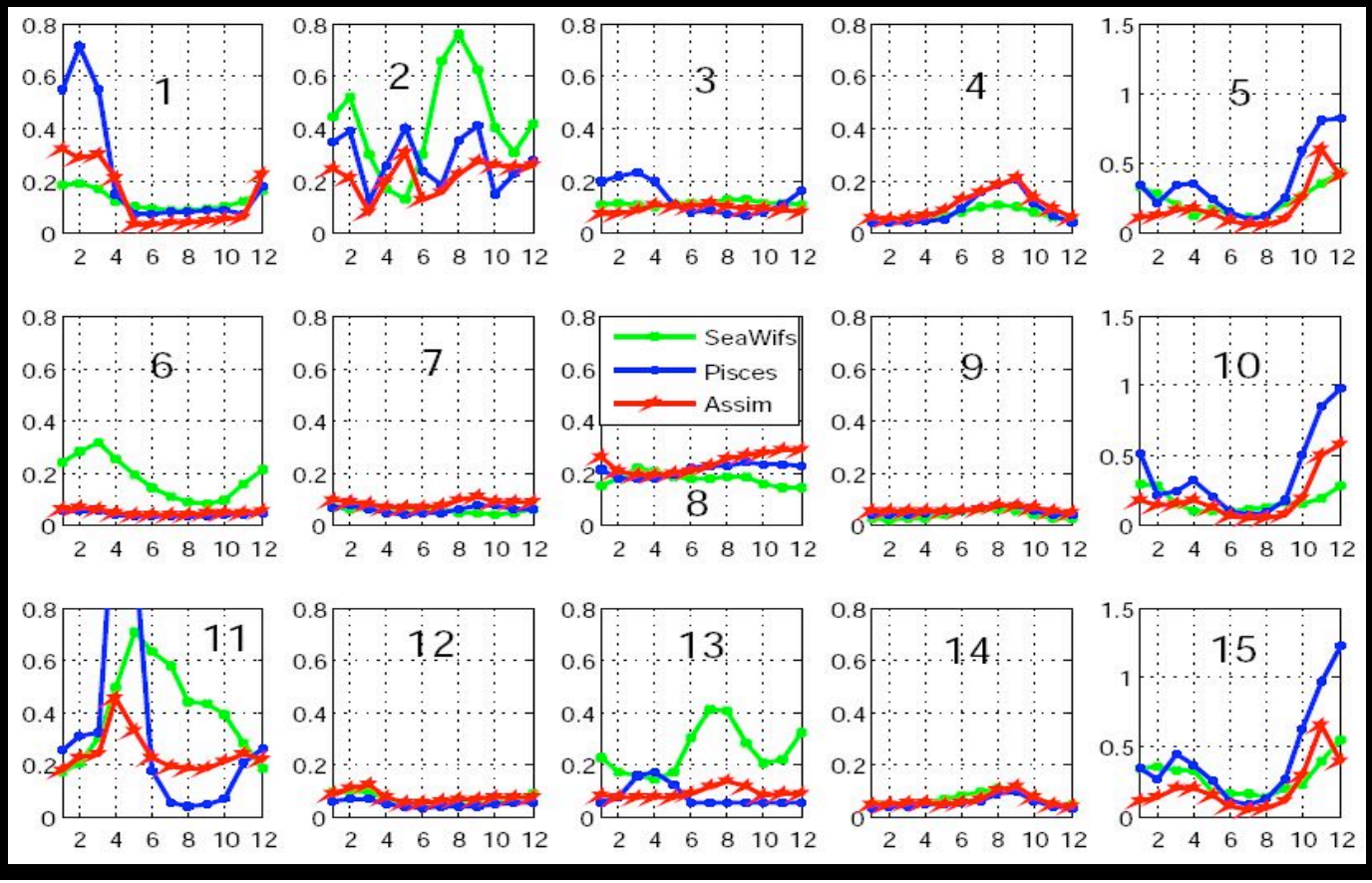




Optimization of 45 parameters at 5 stations (surface Chl)







Conclusions

- The assimilation technique allows optimizing a set of new values for 45 PISCES parameters suitable for global simulations.

- The improvement from the standard version is significant for surface Chl, without modifying the ocean dynamic.

- Five stations are likely not enough to account for all biogeochemical conditions.

Perspectives

- Modify the method to assimilate surface Chl from satellite (almost done).

- Quantify the impact of this set of parameters on oceanic Carbon budget (to be done).