

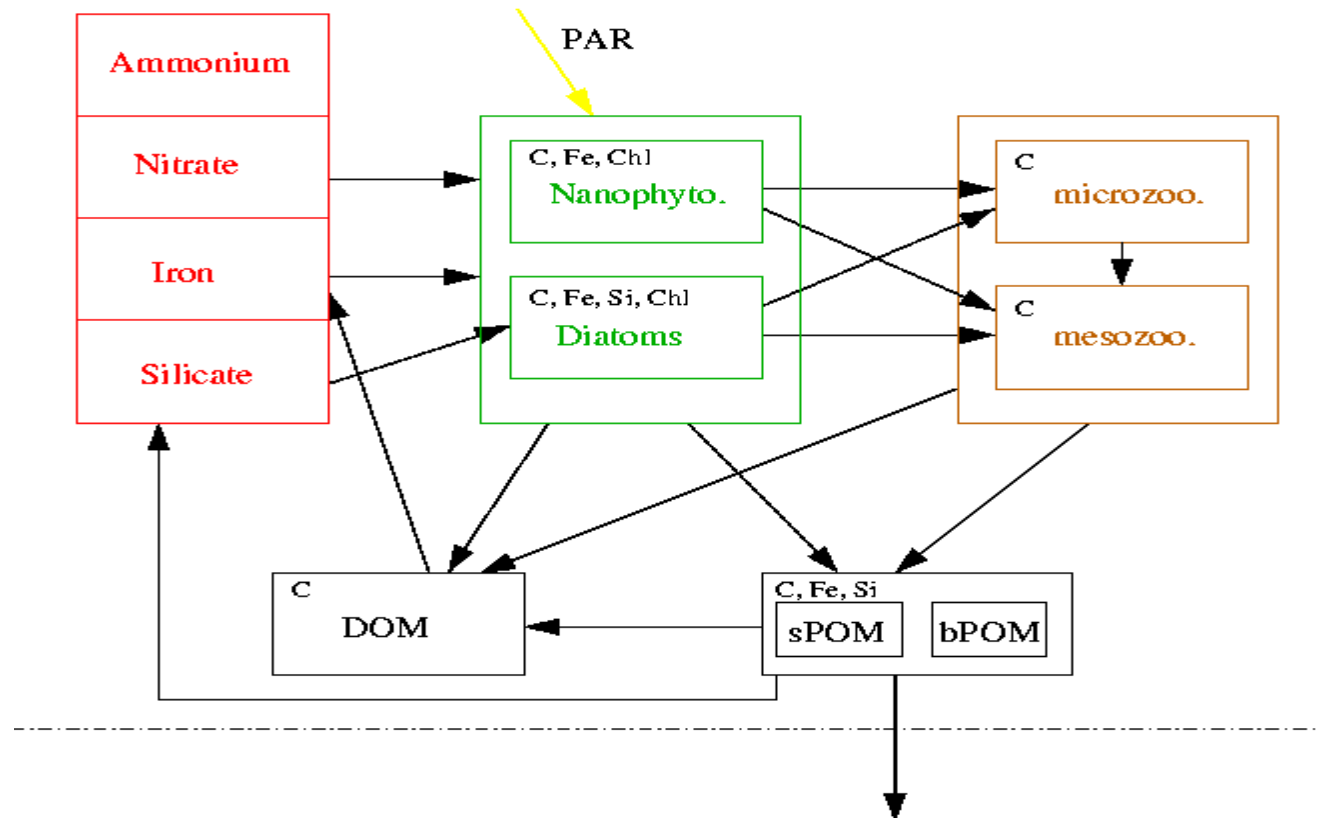


The evolution of PISCES in the NEMO system

The PISCO community



PISCES-v2: standard version of the code in NEMO3.6

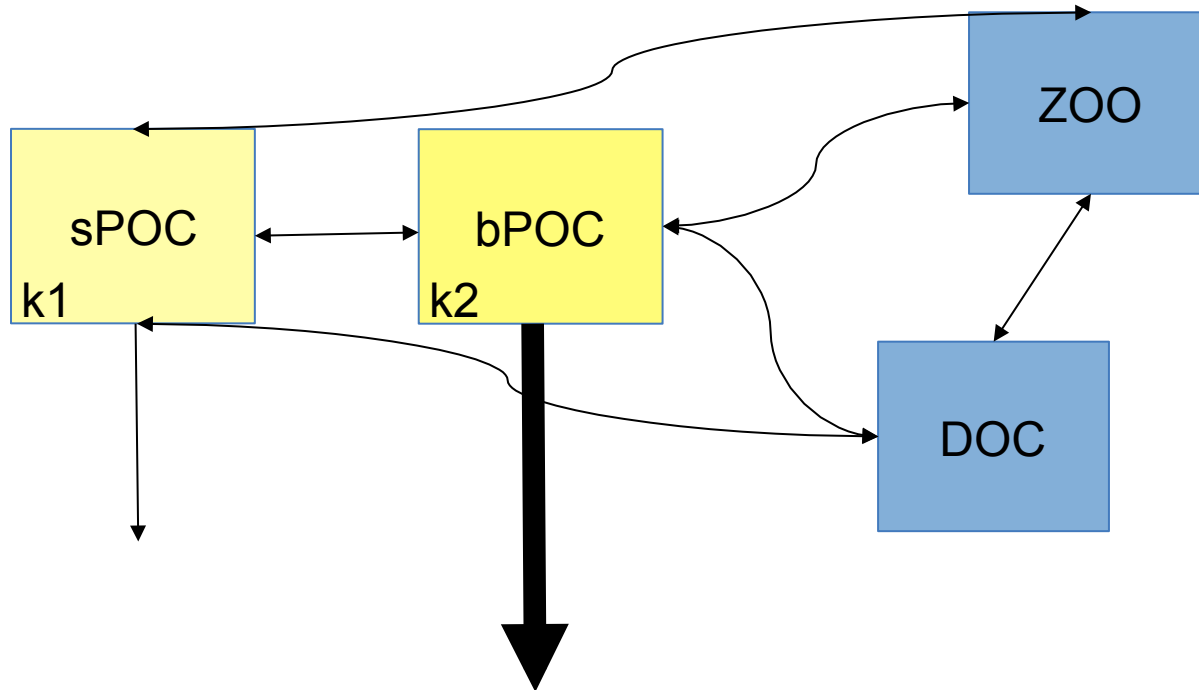


- Includes the carbon cycle and oxygen
- 24 tracers

Major changes planned for NEMO4.0

- Parameterization of a variable lability of POC (Aumont et al., 2017)
- PISCES-QUOTA: a version of PISCES with variable stoichiometry and improved algal physiology (Kwatkowski et al., 2018)
- Iron cycle: Prognostic ligands following Völker and Tagliabue (2015)
- Functional and improved diagenetic module
- Some additional minor changes (light limitation, zooplankton grazing, ...)

POC degradation : standard version of the code

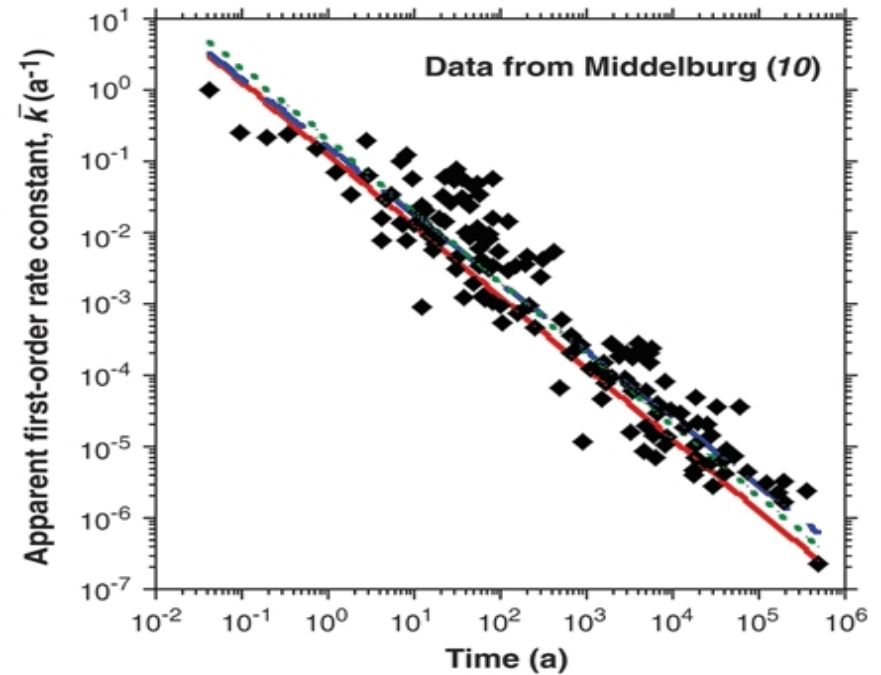
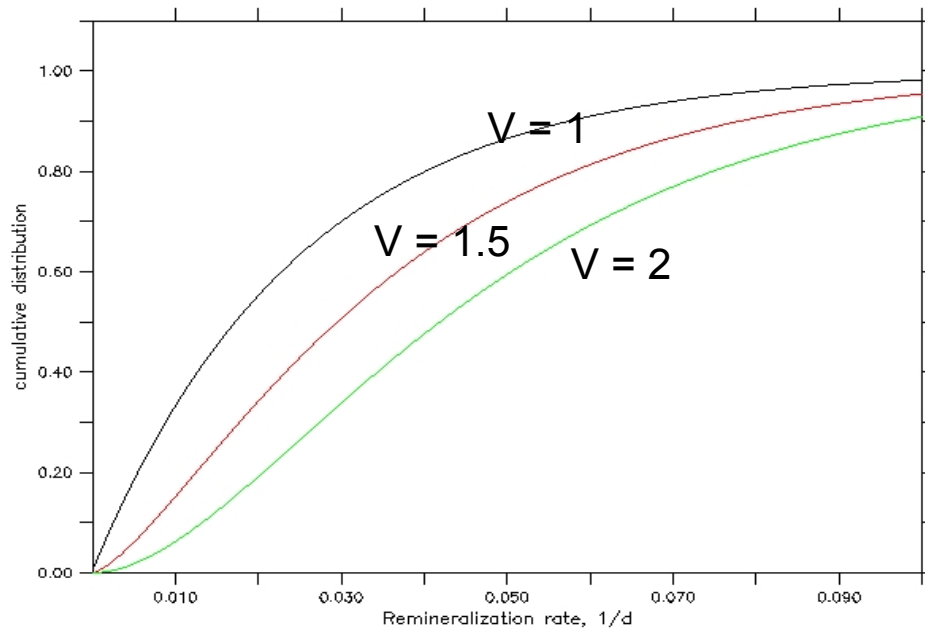


- Degradation rates are constant with time ($k_1, k_2 = \text{Cst}$)
- No change of lability with time

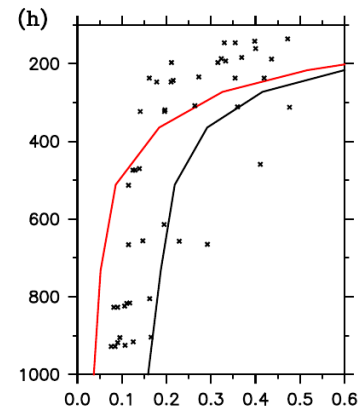
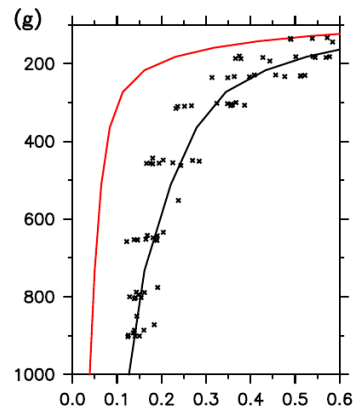
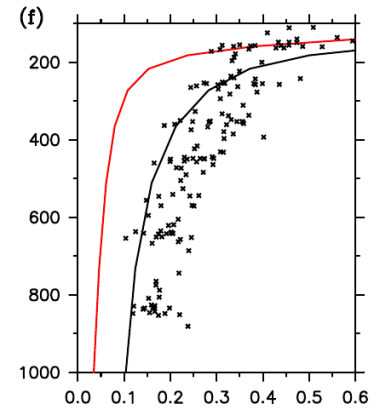
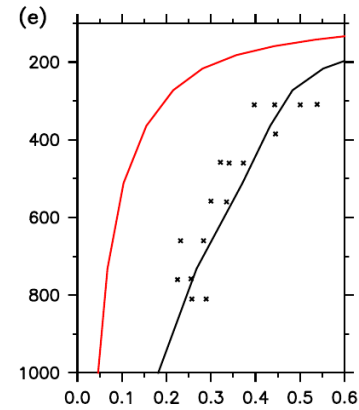
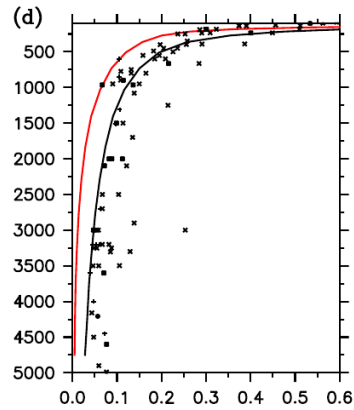
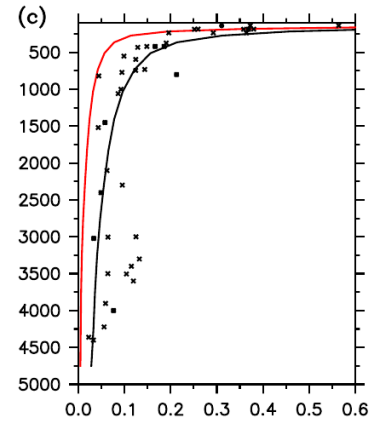
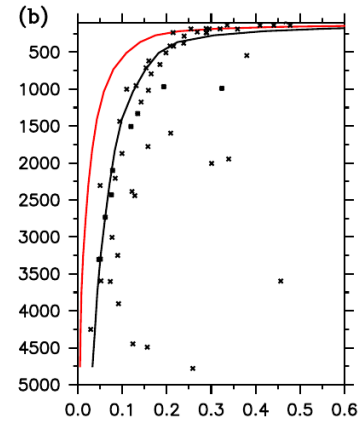
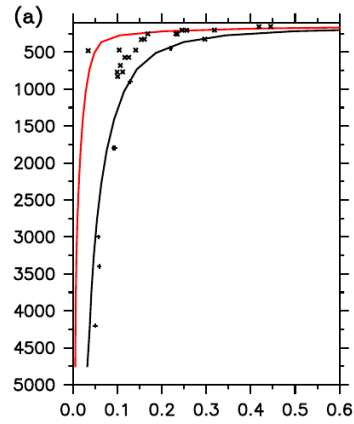
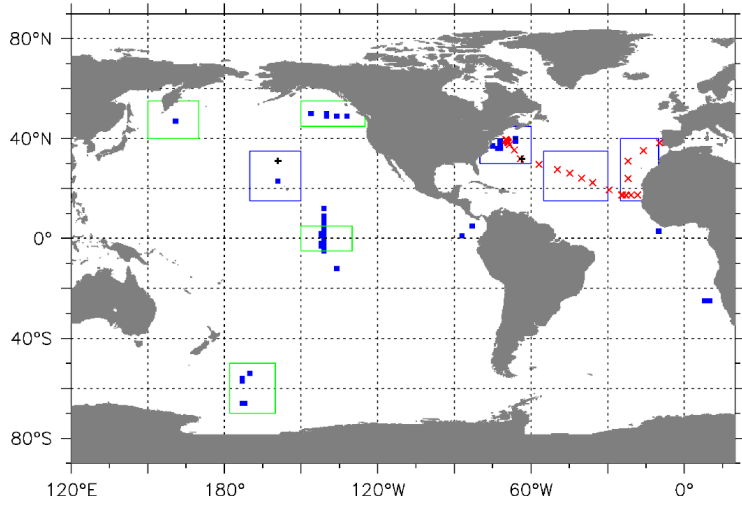
Lability continuum

- Variable lability : continuum of lability (Boudreau et Ruddick)

$$\bar{k} = \frac{\int_0^{\infty} k^v e^{-ak} e^{-kt} dk}{\int_0^{\infty} k^{v-1} e^{-ak} e^{-kt} dk} = \frac{v}{(a+t)}$$



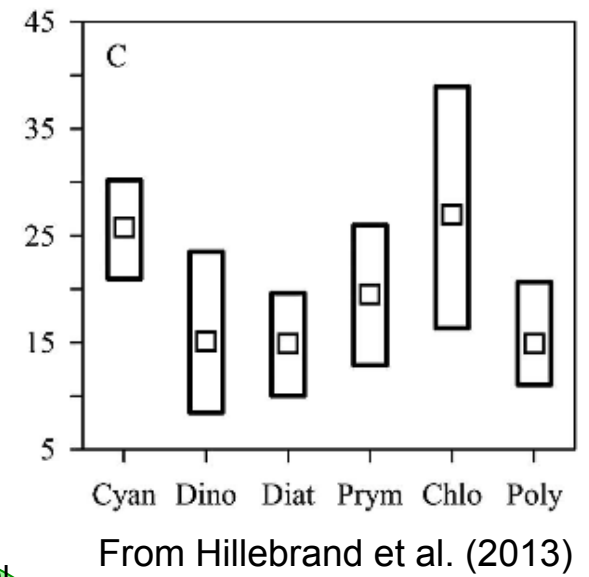
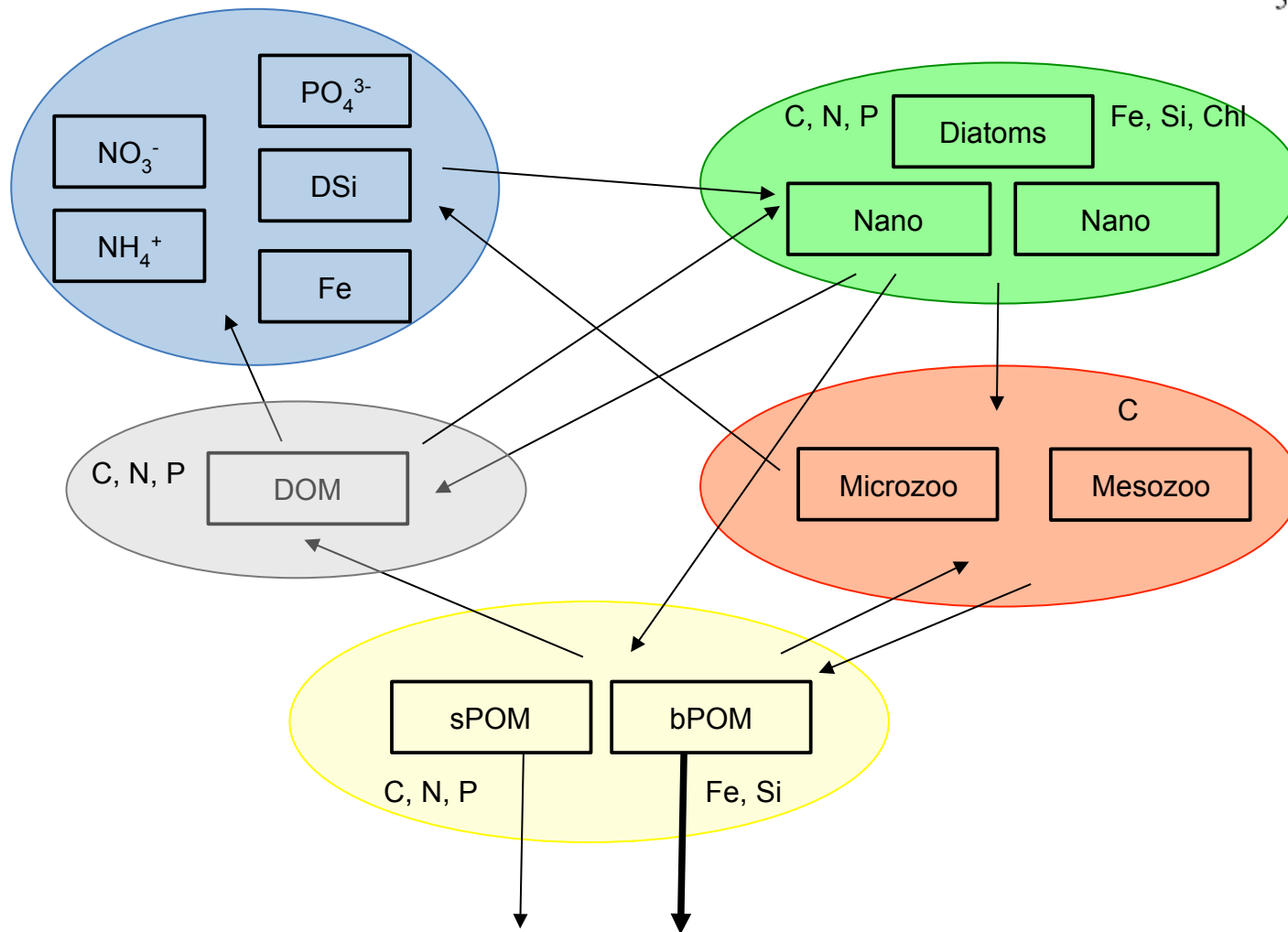
Examples of vertical profiles



Do we need more physiology in models?

- Easy question, difficult answer!
 - No large-scale (global) modeling study addressed that question!
 - Local studies suggest: It depends
- Cons
 - More parameters, more variables, difficult to adjust/evaluate
 - Not necessary for many scientific questions: Cant uptake, Chl distribution, deep-sea biogeochemistry, ...
- Pros
 - Monod and fixed stoichiometry are invalidated by observations/expts
 - Necessary for many scientific questions: C fluxes, surface biogeochemistry, N/P cycles
 - Important for ecosystem interactions (food quality)

PISCES-QUOTA



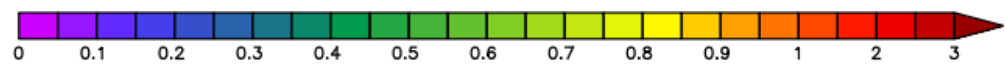
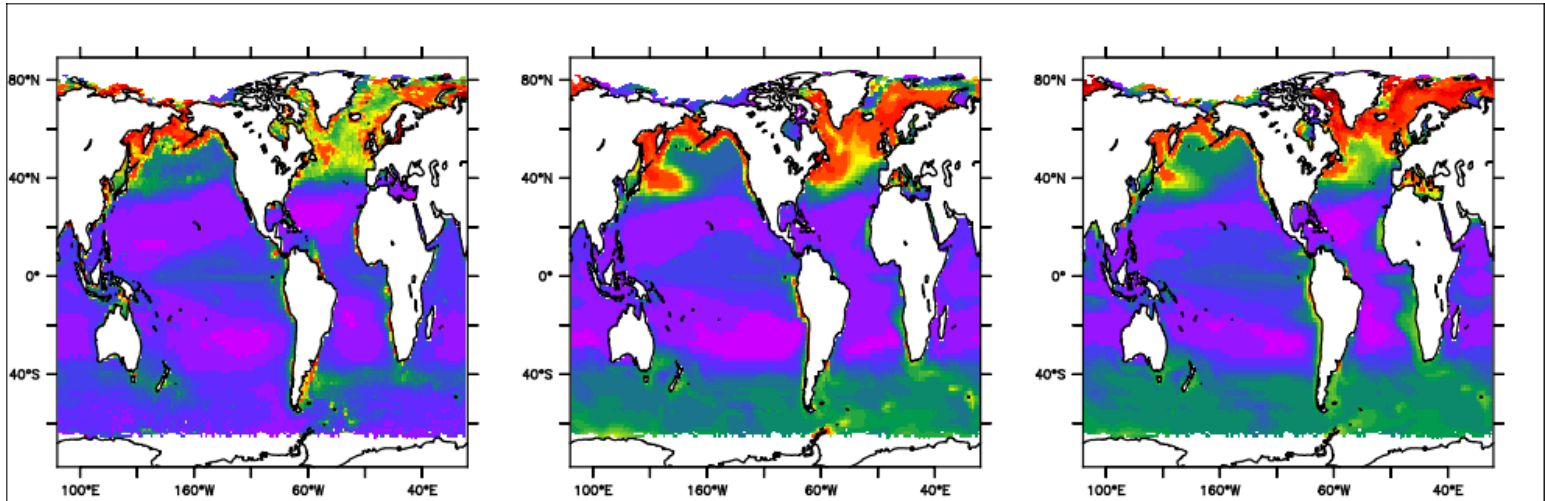
Chlorophyll distribution

Satellite

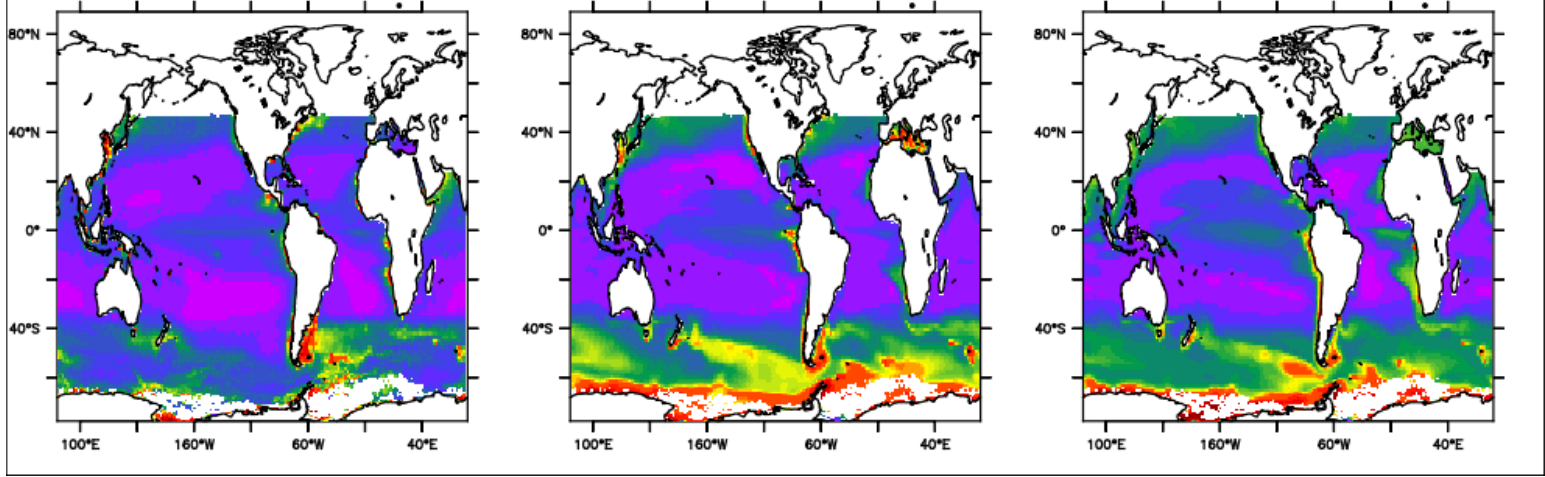
PISCES-v2

PISCES-QUOTA

AMJ

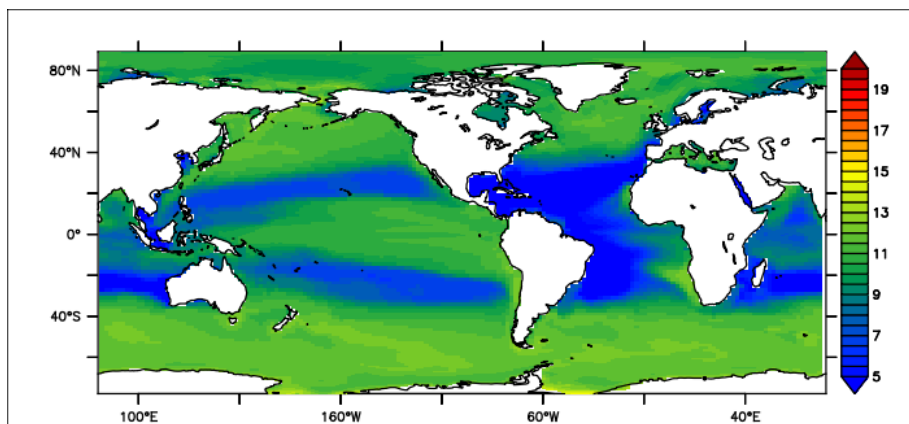


NDJ

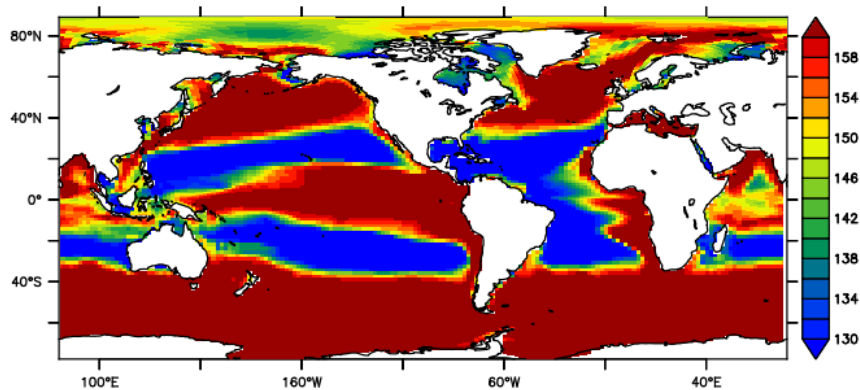


C/N/P ratios

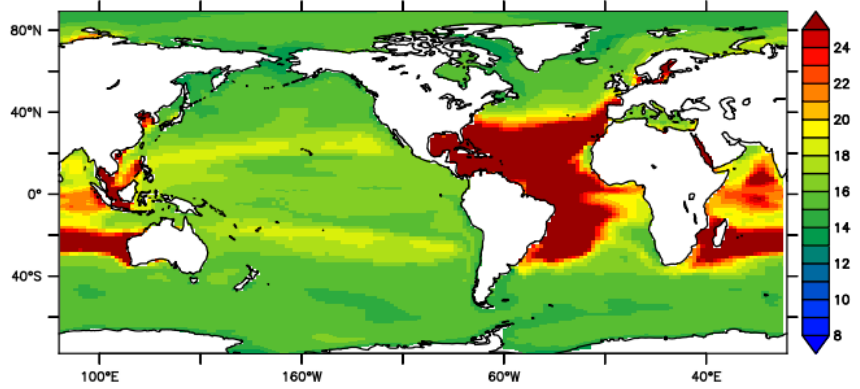
P/C



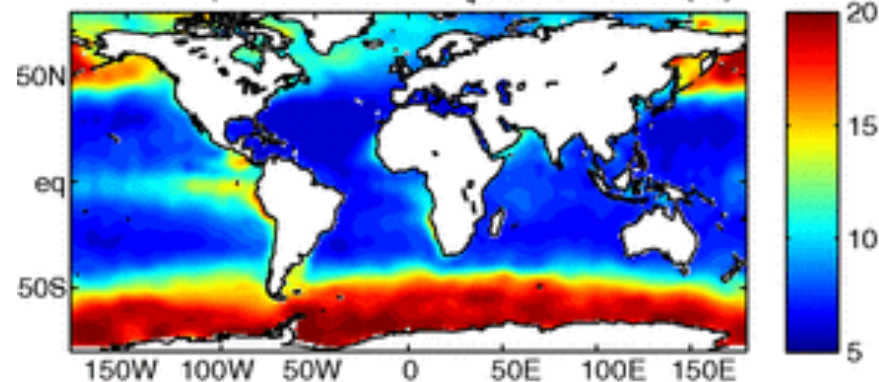
N/C



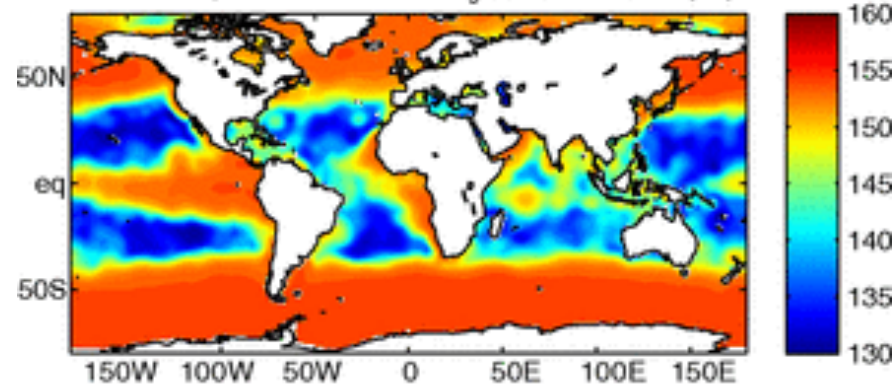
N/P



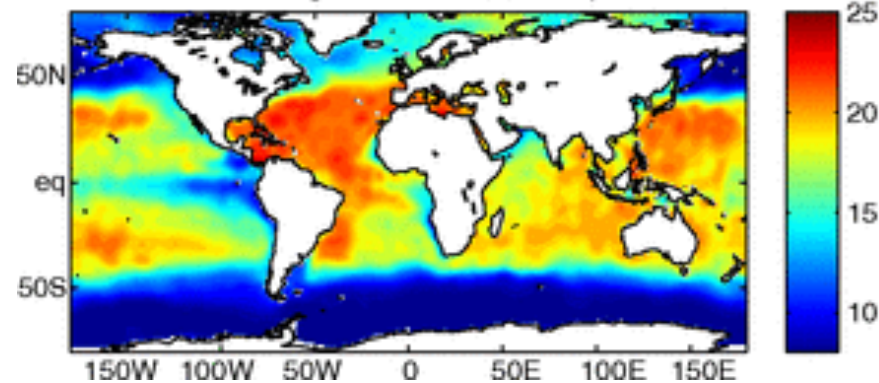
P:C predicted from PO₂ concentration (‰)



N:C predicted from NO₃ concentration (‰)



N:P resulting from P:C and N:C predictions

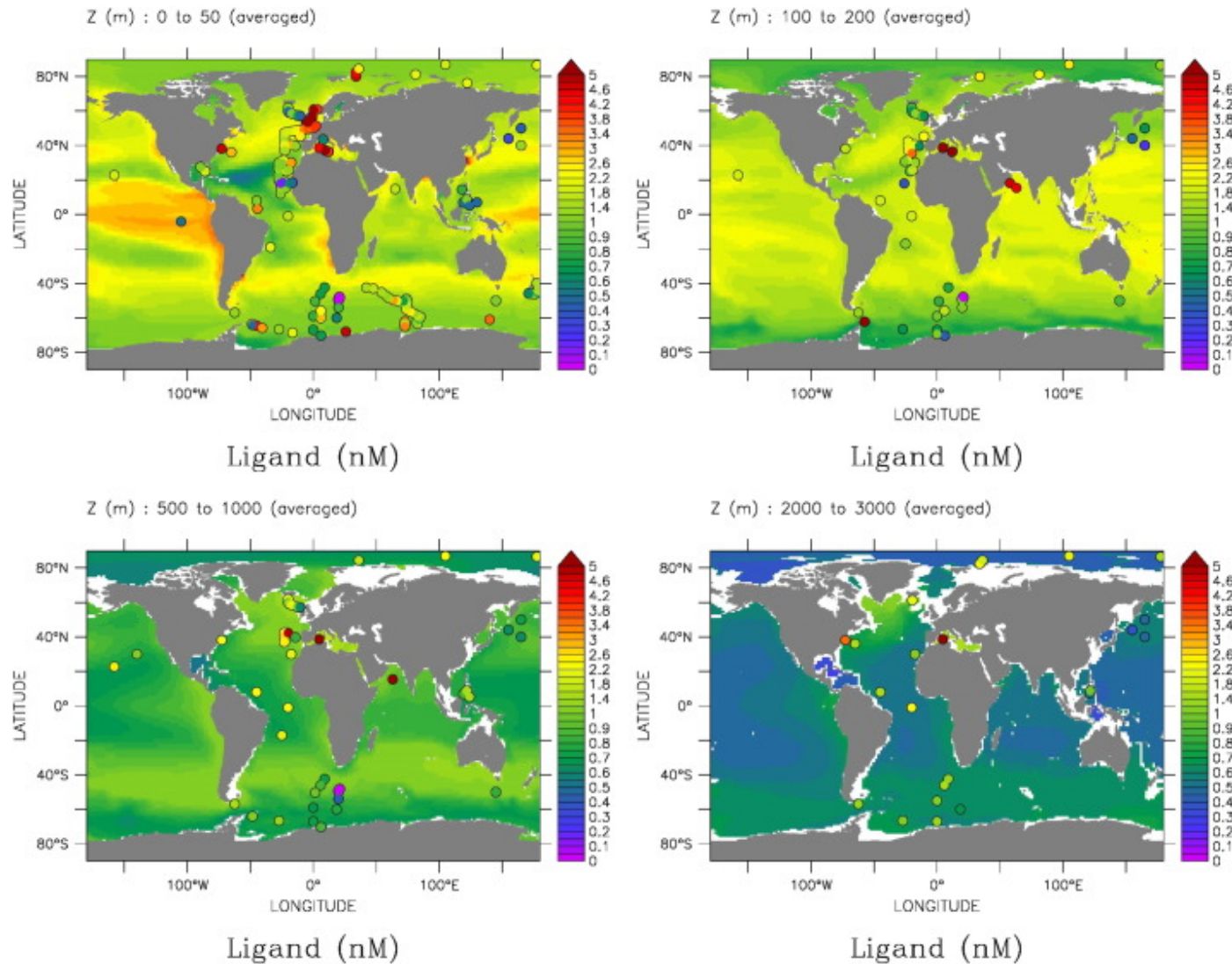


General budget of the upper ocean

	NPP (Gt/yr)	Ratios	Export 150m (Gt/yr)	Ratios
Carbon	57.6		6	
Nitrogen	10	6.7	1	7.2
Phosphorus	1.1	131	0.11	136
PISCES-v2	44.5	7.6/122	6.5	7.6/122

Iron dynamics : prognostic ligands

- In the standard version of PISCES, ligands are prescribed (constant or as a function of DOC)
- Prognostic ligands : Based on Tagliabue and Völker

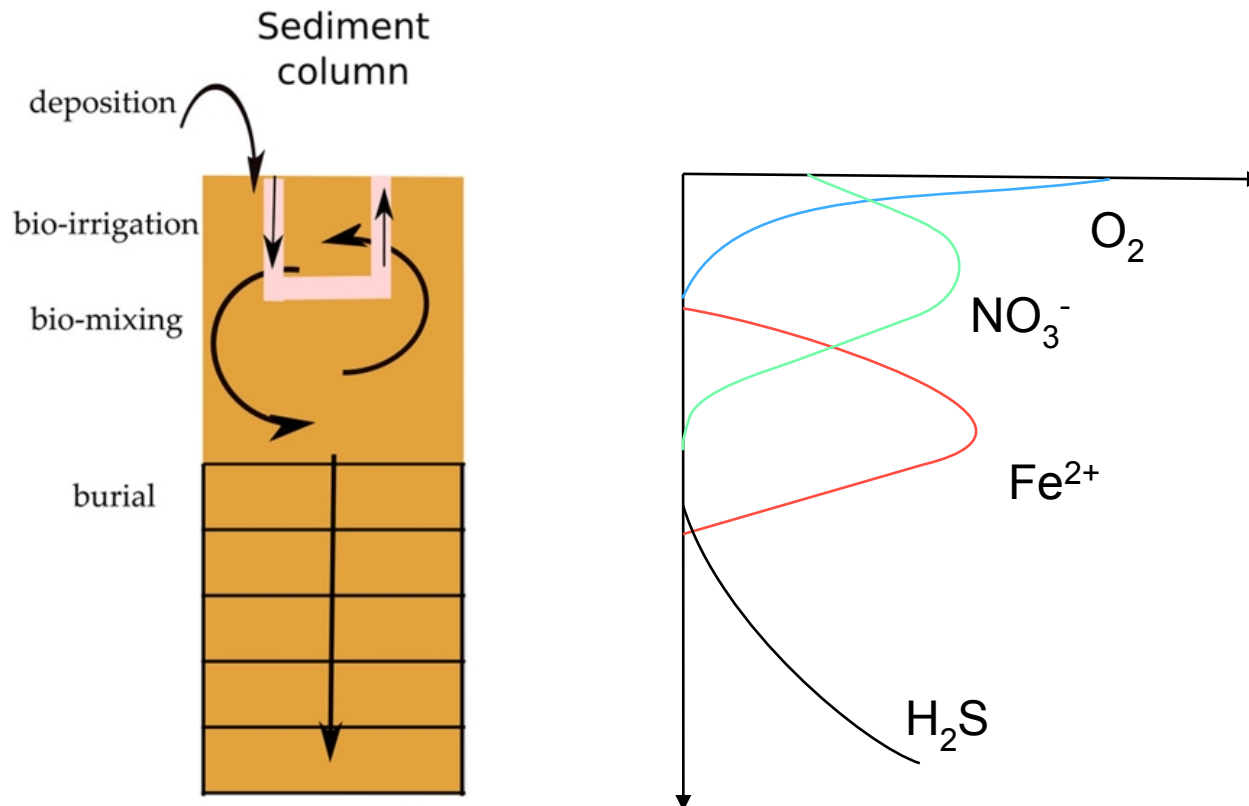


Diagenetic module in PISCES

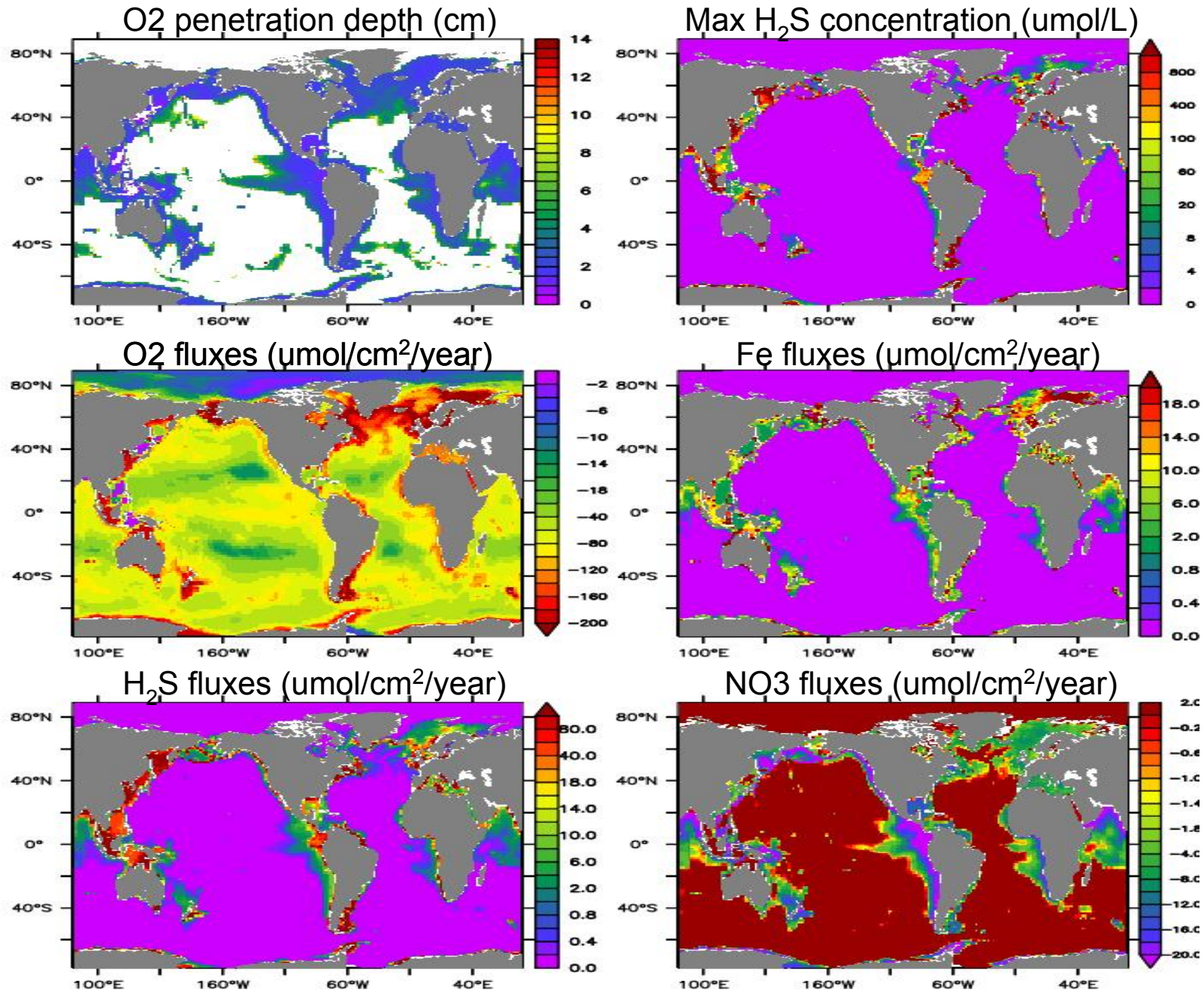
- In PISCES-v2, a simple diagenetic module was embedded based on HAMOCC (Heinze et al., 1999)
- The code was created in 2005 and was not updated since 2007. The code was not functional
- The model was extremely simple and valid only in the open ocean at depth > 1000m
- Degradation of organic matter was restricted to oxic oxidation and dinitrification
- Highly problematic in coastal areas but also in high resolution configuration or in some highly productive areas.

Diagenetic module in PISCES

- A new diagenetic module has been coded in PISCES that replaces the previous module
- Includes oxidation by O_2 , NO_3^- , SO_4 and Fe. Mn pathway is not represented yet.
- Offline mode (without PISCES) as well as 1-way and 2-ways modes.



Fluxes from the sediment to the ocean



Conclusions

- The new version of PISCES and all the functionalities presented here will be available in NEMO 4.0
- All new developments have been fully tested and published except for the new diagenetic module (not published yet)
- Some capabilities of PISCES are available on demand but will not be included in the standard version of PISCES in the near future (isotopes, DMS, N₂O, Mn and Co)
- The future evolution of the code is now planned by the PISCO group (PISCES Community)
- Probable future additions to PISCES: Bacteria, mixotrophic organisms, Trichodesmium, DOC lability, ...