Sedimentary particulate iron : the missing micronutrients ?

Houda Beghoura*, T. Gorgues*, O. Aumont¤, H. Planquette§

* Laboratoire d'Océanographie Physique et Spatiale (LOPS)
¤ Laboratoire d'Océanographie et du Climat : Expérimentation et Approches Numériques (LOCEAN)
§ Laboratoire des sciences de l'Environnement MARin (LEMAR)

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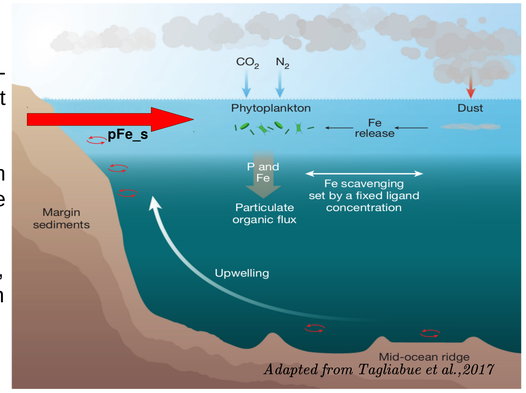
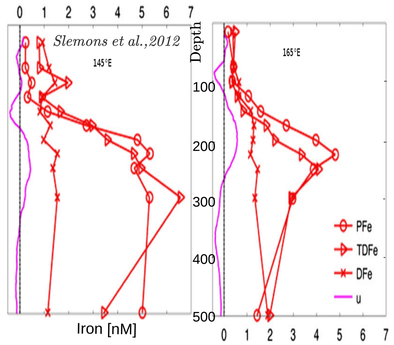
Why iron ?

- Iron limits phytoplancton growth in the High-Nutrients Low Chlorophyll areas (HNLC), that represent ~30 – 50 % of the ocean's surface.
- Iron exerts an influence on marine ecosystem structure, and has an impact of marine primary production.
- Iron sources are multiple : dust, sea ice, hydrothermal vents, and **sediments** that can be transported through the open ocean



Iron's physical speciation



- Iron is present in the ocean under various forms : dissolved, colloidal, particulate (of biogenic, lithogenic, or sedimentary origin).
- The dissolved phase has been studied extensively as it is considered as the most bioavailable form of iron.
- **Sediment particles are increasingly receiving attention since they can represent a substantial source of iron. These sedimentary particles can be transported far away from the margins** *(Lam et al., 2008)*.

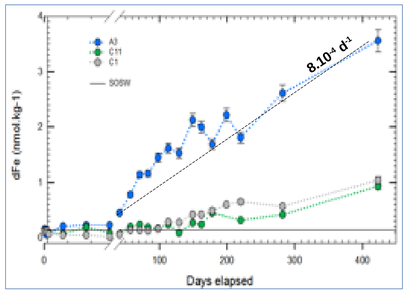
Experimental design

Global 3D simulation at 2° resolution (ORCA2) of a biogeochemical model (PISCES) forced by climatological seasonal ocean circulation (Temperature, Salinity, U, V, W)

Reference numerical simulation (REF) is using the standard configuration of the PISCES biogeochemical model *(Aumont et al., 2015)* **:**

- 5 Colimiting nutrients for phytoplankton growth : nitrate, ammonia, phosphate,silicate and **iron (Fe)**.
- 24 compartments
- Dissolved Fe (dFe) sources from coasts (2µmol.m^{-2}.d^{-1})
- Only biogenic particulate Fe
- Constant and uniform concentration of ligand (0.6 nM)

Including pFe sed in PISCES

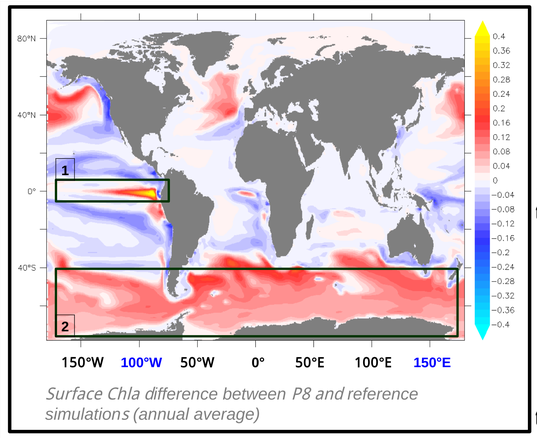


Sensitivity tests have been run using the same setup with an additional source of particulate iron originating from the sediments.

Parameterization of the pFe cycle is derived from observations and experiments:

- **pFe sources set at 8 µmol.m^{-2}.d^{-1}** *(Slemons et al., 2012)*
- **pFe sinking speed of 0.2 m.d^{-1} (assuming a particle size of 1µm** *(Lam et al., 2012)*
- **Remineralization rate set at 8.10^{-4} d^{-1} (from dissolution experiments,** *Cheize et al., in prep.***)**

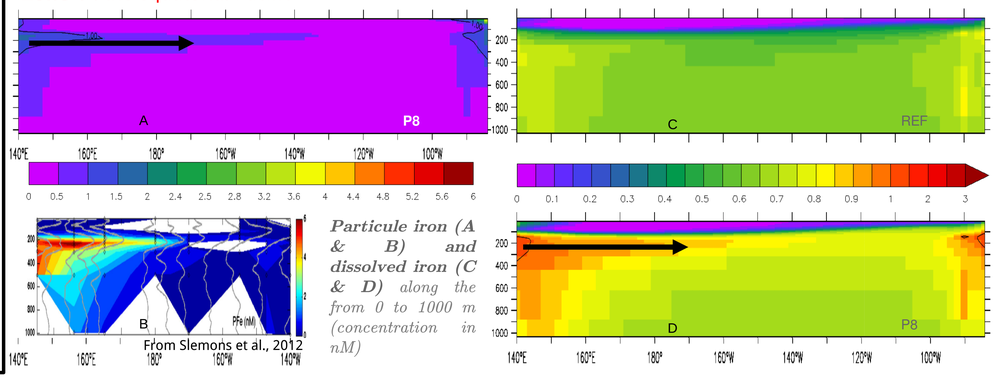
Preliminary results



Surface Chla difference between P8 and reference simulations (annual average)

As expected model response to the additional pFe is most marked in the HNLC zones:

•**Zone 1** : the equatorial Pacific

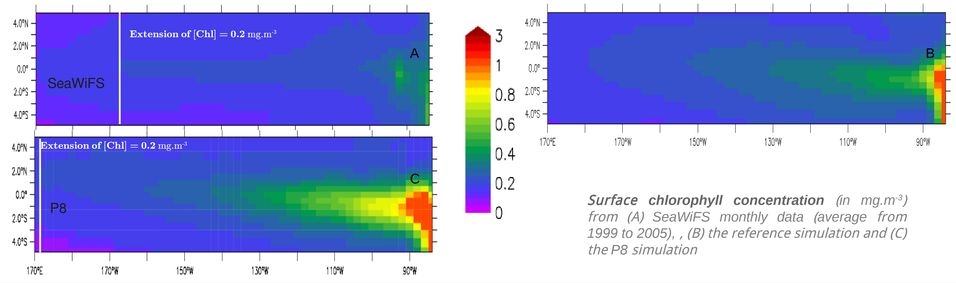


Particule iron (A & B) and dissolved iron (C & D) along the from 0 to 1000 m (concentration in nM)

pFe from sediment of the west equatorial Pacific feed the Equatorial Undercurrent (EUC) → Dissolution of pFe during its transport by EUC → Increased dFe in the EUC

This increased in Fe in the EUC is an observed feature in the particulate phase.

Increased transport of Iron by the EUC
↓
increase phytoplankton concentration in the equatorial upwelling region.

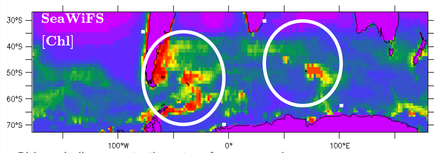


Surface chlorophyll concentration (in mg.m^{-3}) from (A) SeaWiFS monthly data (average from 1999 to 2005). , (B) the reference simulation and (C) the P8 simulation

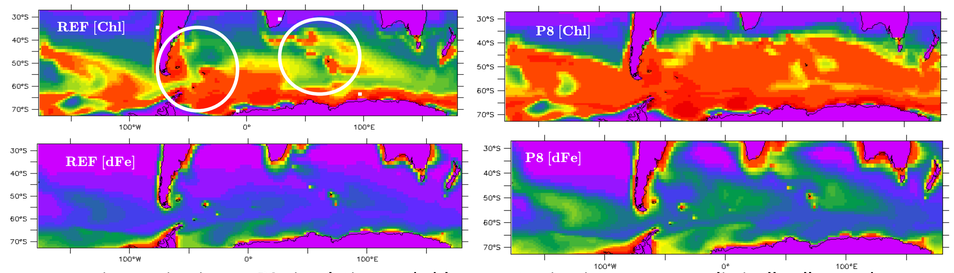
•Chl concentration is over-estimated in the P8 simulation
•meridional gradient of chlorophyll is better represented in the central equatorial Pacific.

Zone 2 : the austral Ocean

Expected impact of the particulate iron sources : better representation of the **islands chlorophyll plumes**



Chlorophyll concentration at surface ocean in mg.m-3 and dissolved iron concentration in nM during austral summer (december).



Plumes are not increasing in our P8 simulation and chl concentration increase unrealistically all over the austral ocean:
•Dissolved iron concentrations increased too much in our P8 simulation all over the austral ocean
•Releaved iron limitation for phytoplankton growth
•Lesser impact of local addition of particulate iron near islands

Take away & Perspectives

- Particulate iron sources (pFe) is needed to reproduce some observed patterns of particulate and dissolved iron concentration (e.g. local maximum within the EUC).
- With the current parameterization of the biogeochemical model, it leads to an overestimation of chl concentration in HNLC regions.

Open questions :

- Need to regionally modulate the source of pFe ?
- What is the sensitivity of the impact of the pFe sources towards the dissolution rate, the magnitude of the sources and the sinking velocities.

References:

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