Assessment of the CMEMS Global biogeochemical forecasting operational system, with assimilation of Ocean Colour data

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Framework and objectives

The operational production of data-assimilated biogeochemical state of the ocean is one of the challenging core projects of the Copernicus Marine Environment Monitoring Service. In that framework, Mercator Ocean is in charge of improving the realism of its global ¼° BIOMER coupled physical-biogeochemical (NEMO/PISCES) simulations, analyses and re-analyses, and to develop an effective capacity to routinely estimate the biogeochemical state of the ocean, through the implementation of biogeochemical data assimilation. Primary objectives are to enhance the time representation of the seasonal cycle in the real time and reanalysis systems, and to provide a better control of the production in the equatorial regions.

Methodology

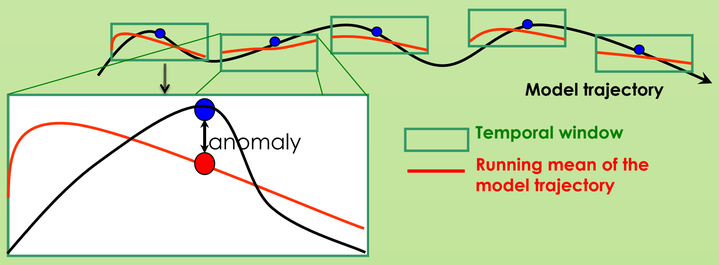
Model configuration

- **NEMO-PISCES 3.6 – ¼° global**
- Physical forcing (offline): **NEMO3.6 - PSY4 global 1/12° coarsened to ¼°** - assimilation of SLA, MDT, SST, T, S
- Activation in PISCES of a **climatological relaxation** (for NO3, PO4,O2,DIC,Alk,Si,DOC,Fe) to mitigate the negative impact of the physical data assimilated forcing (nutrients rise)

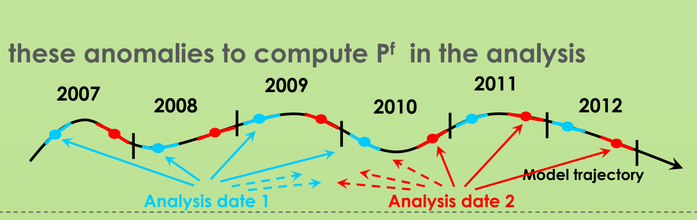
Mercator Ocean BGC data assimilation system

- ***Main features***
  - Based on a 2D local multivariate SEEK filter using 3D multivariate error sub-space
  - 3DFGAT method to calculate innovation vector
  - Forecast error covariance is built from an **ensemble of model anomalies**
  - Incremental Analysis Update (IAU)
- ***Application to the biogeochemical configuration***
  - **State vector**: **[total Chla, Nanophyto Chla, Diatoms Chla, NO3]** (other nutrients not included so far) Analysis cycle = **7 days**
  - Calculation of a **surface-only increment + vertical projection** in the turbocline (modulation with depth)
  - [Chla] distribution is ~log-normal ➔ **analysis fully performed in log-transformed space**:
  - **Forecast error covariance P^f** of the bio analysis is built from a **pseudo-ensemble of BGC variables anomalies** from a **2007-2016 free model simulation**

➔ **Generation of a pseudo-ensemble from a forced BGC simulation**



➔ **Use these anomalies to compute P^f in the analysis**



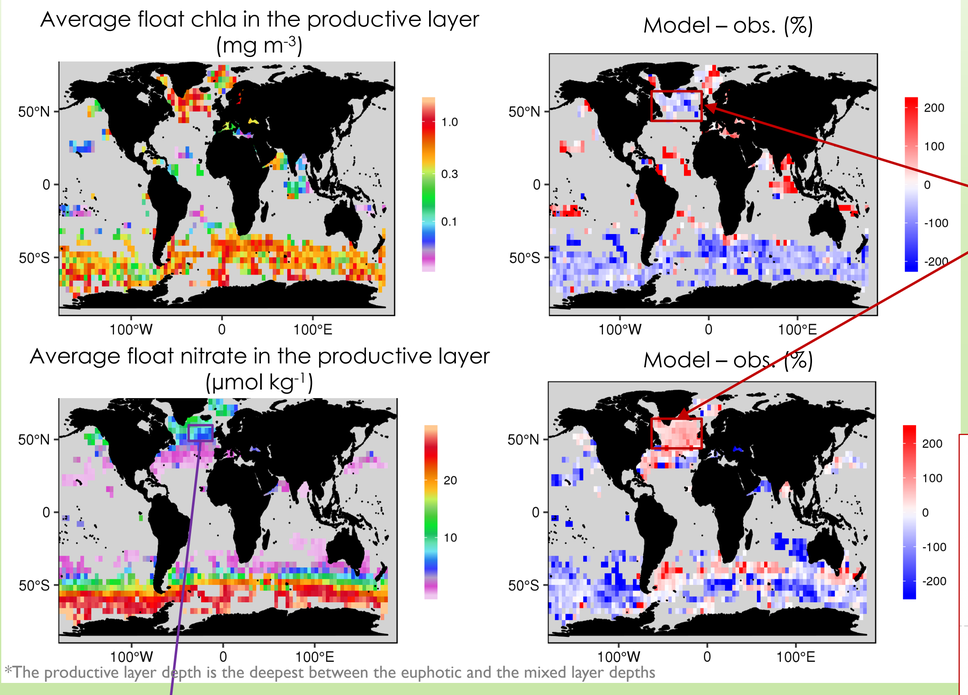
Observations

- **CMEMS daily L4 global ¼° surface Chla concentration (1 map per week) + Operational QC** to remove statistically unrepresentative values (*e.g.* spurious spikes)

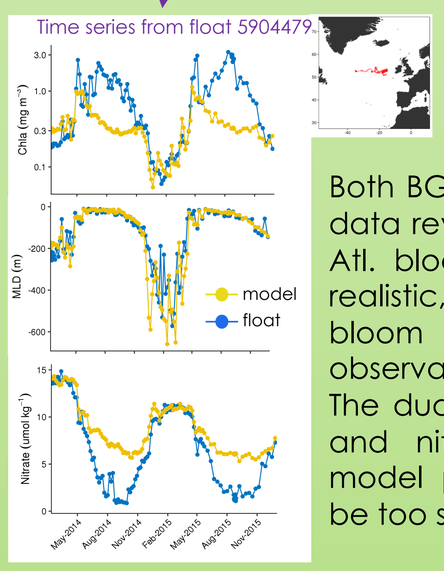
Validation…

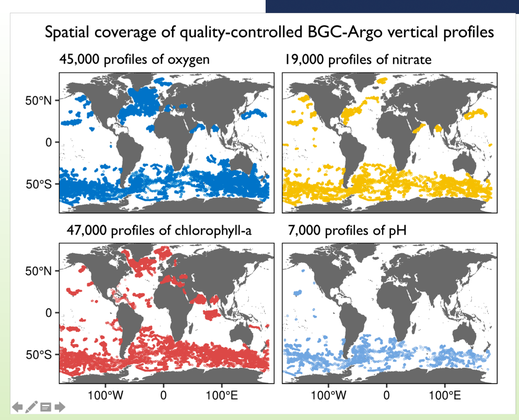
…against BGC-Argo floats

*The float nitrate observations were merged with predictions from the neural network CANYON-B (Bittig et al. 2018)

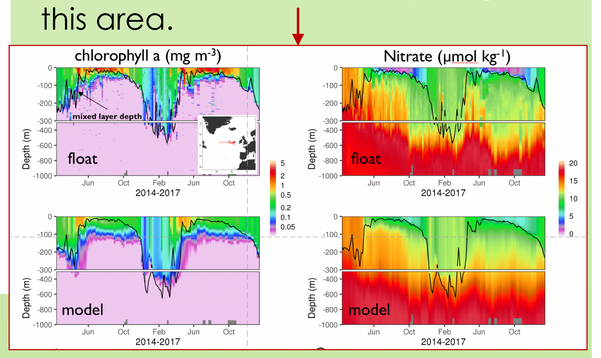


*The productive layer depth is the deepest between the euphotic and the mixed layer depths

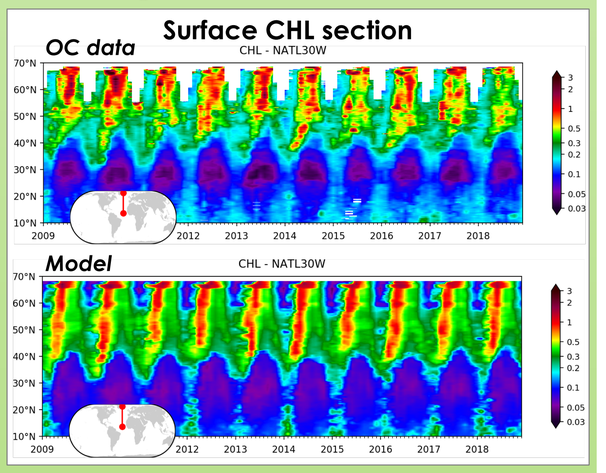




The model provides a satisfying representation of the North Atlantic Bloom variability and the vertical structure of chla and nitrates, but chla, resp. nitrate, concentrations are still a bit too low, resp. high, in this area.



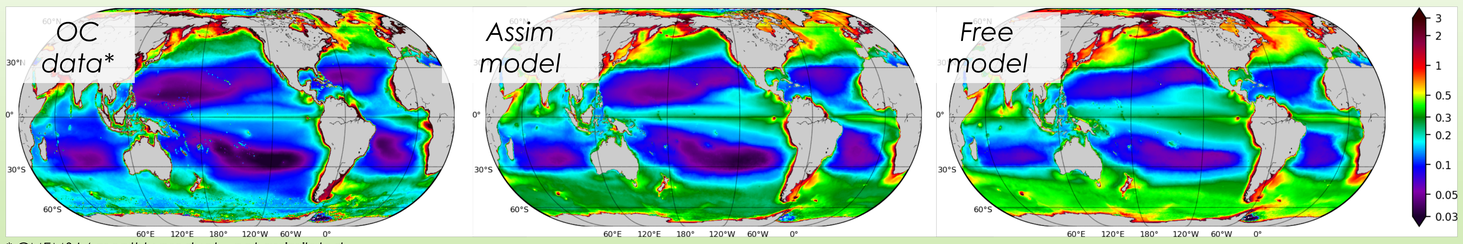
…against Ocean Colour



Both BGC-Argo floats and Ocean Color data reveal that the timing of the North Atl. bloom predicted by the model is realistic, but the magnitude of the bloom is too low compared to the observations.
The dual comparison with chlorophyll-a and nitrate data suggests that the model primary production rates might be too small in summer.

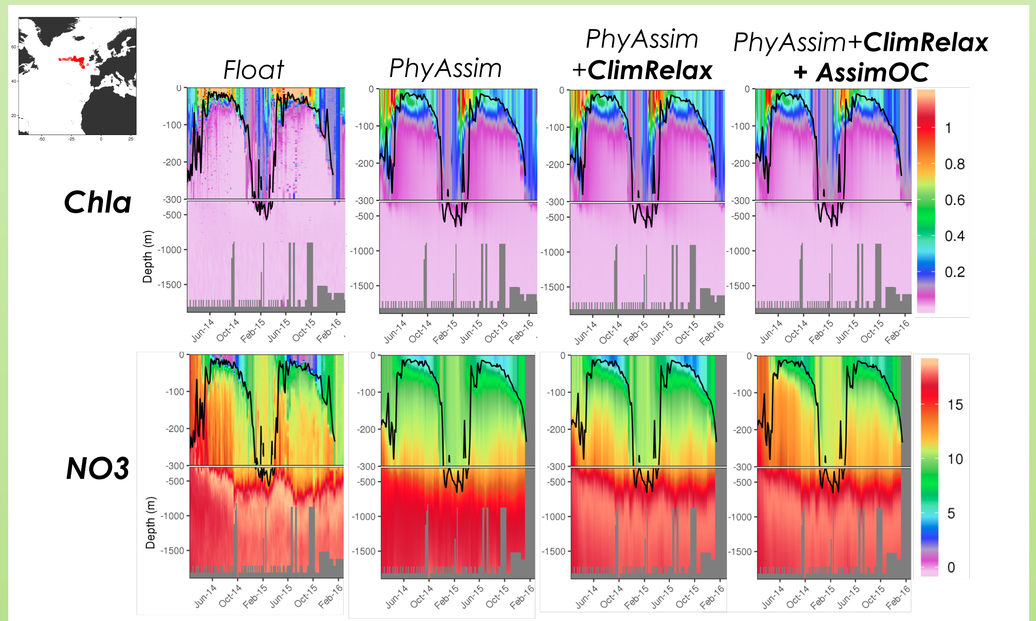
Impact of Assimilation of OC

Global surface CHL 2009-2018 mean



** CMEMS L4 monthly product – not assimilated*

➔Significant impact at large scale. Better extension/amplitude of oligotrophic gyres. Still too productive in Southern Ocean



Focus in North Atl region:

➔OC data assimilation: positive, but tenuous, constraint in productive layer

➔Clim. relaxation: effective and helpful constraint on nutrients fields at depth

Conclusion

- Operational BGC forecast system, with Data Assimilation of Chla (Ocean Colour) NRT products
- Focus on large scale Chla structures
- **Dual correction of both Chl and NO3** + climatological relaxation for other nutrients
- **Stable/durable control** of the model Chl **large scale structures,** especially in oligotrophic regions
- OC data assimilation: **positive, but tenuous, constraint in Productive Layer**
- Helpful action of the **climatological relaxation** to **mitigate** the physical-data-assimilation-driven **nutrient rise**

Work in progress

- **Towards stochastic (*i.e.* ensemble) modelling** for (1) PISCES parameters estimation and (2) data assimilation with an enhanced representation of the model error covariances
- Towards the **assimilation of BGC-Argo profile data**

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