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 1/12° 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 – 1/12° global
- Physical forcing (offline): NEMO3.6 – PYS4 global 1/12° coarsened to 1/4° assimilation of SLA, MDT, SST, T, S
- Activation in PISCES of a climatological relaxation for NO3, PO4, O2, DIC, A1k, SLA, 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
  - 3D FfGAT 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 turbine (modulation with depth)
  - Chla distribution is log-normal analysis fully performed in log-transformed space
  - Forecast error covariance of the bio analysis is built from a pseudo-ensemble of BGC variables anomalies from a 2007-2016 free model simulation

Validation

- Against BGC-Argo floats
- 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.

Observations

- CMEMS daily L4 global 1/4° surface Chla concentration (1 map per week) + Operational QC to remove statistically unrepresentative values (e.g. spurious spikes)

Impact of Assimilation of OC

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

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

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 CN 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