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The assimilation of phytoplankton functional types for operational forecasting in the North-West European Shelf

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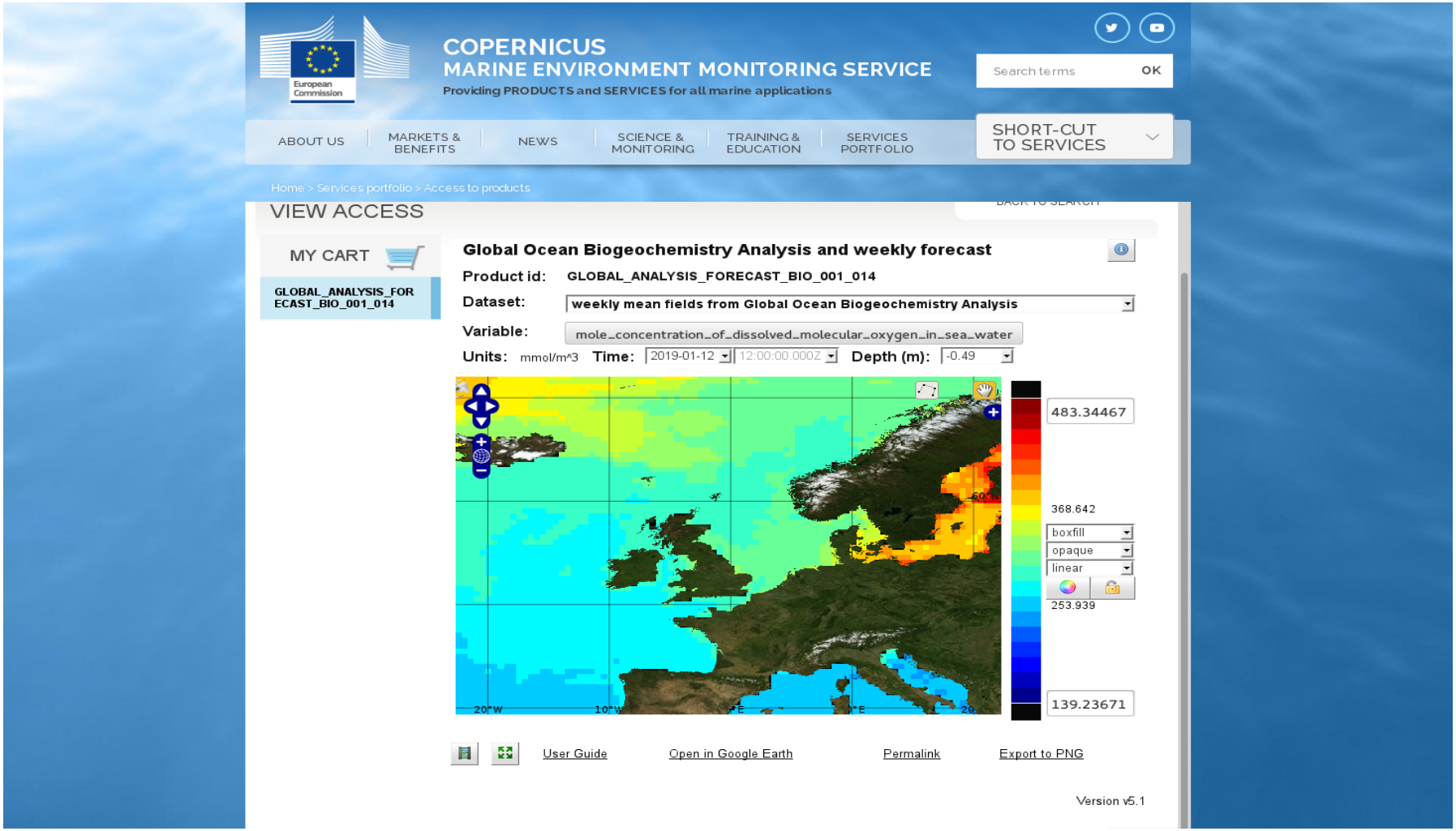
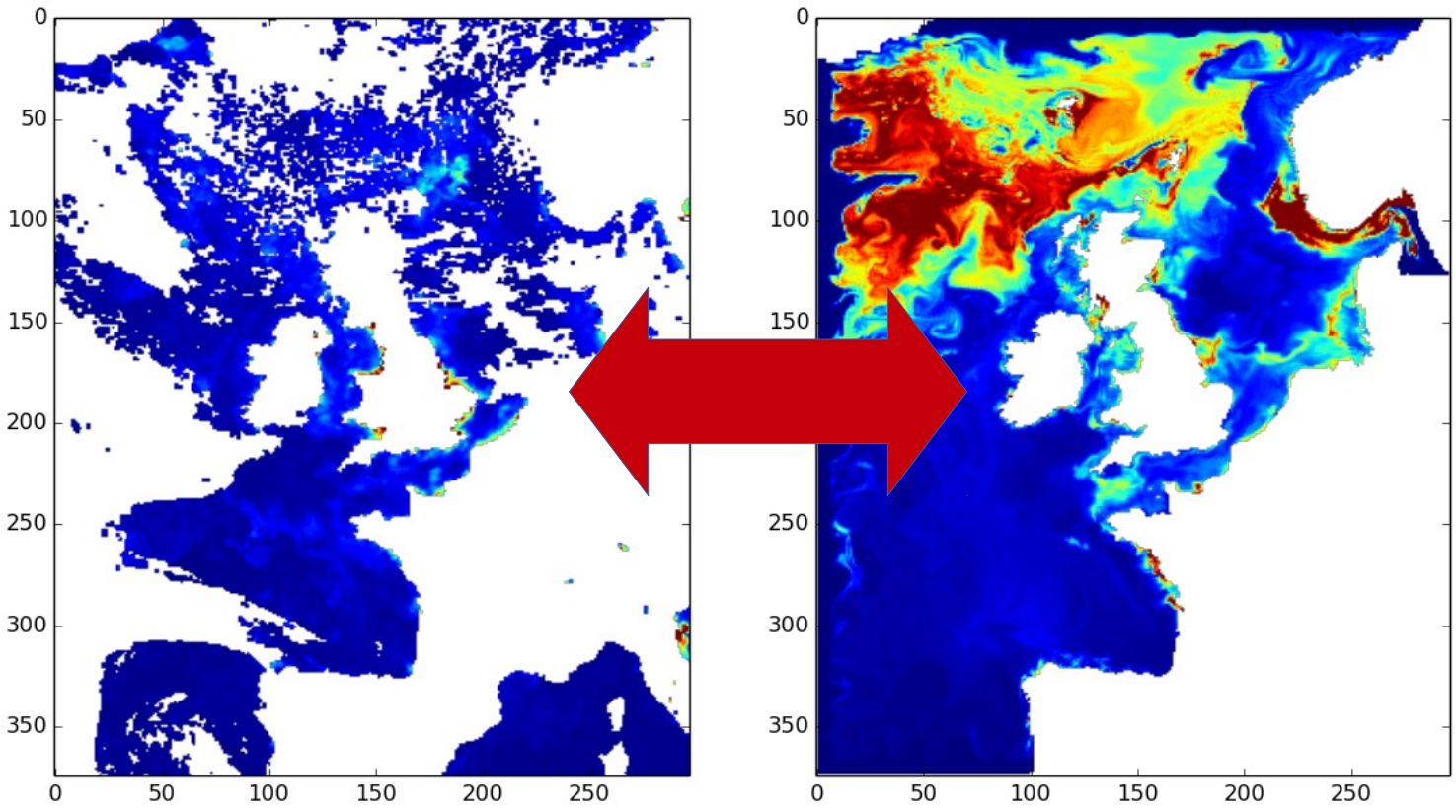
Atlantic from space, Southampton, 01/2019

Copernicus Marine Ecosystem Monitoring Service (CMEMS) currently provides reanalysis of the ecosystem state on the NWE Shelf based on total chlorophyll assimilation. The Copernicus service will be updated with PFTs DA (the presented work) for reanalysis (2019) and near-real time operational forecasting (2020).



Data Assimilation

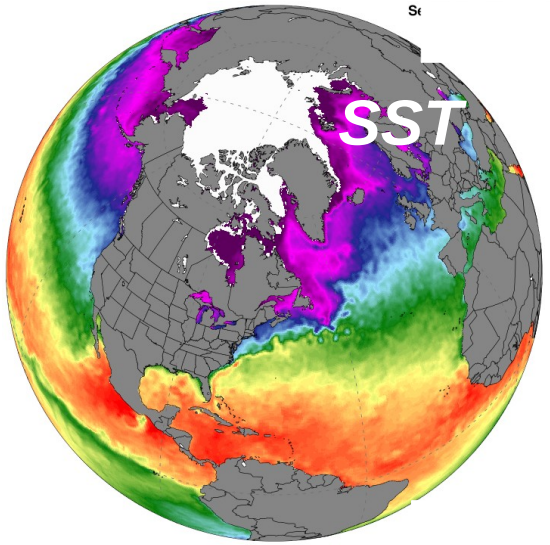


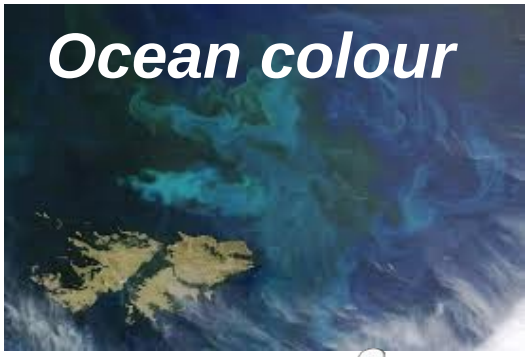
The Earth Observations (EOs)

NASA MODIS

NASA SeaWiFS

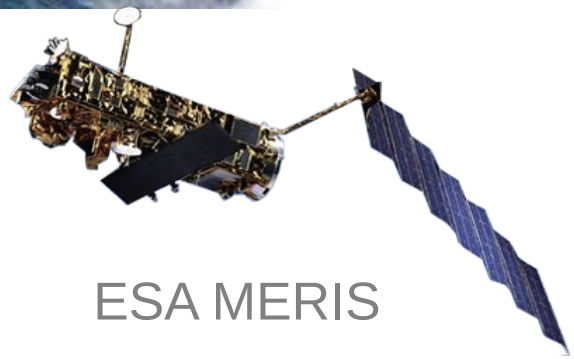
NOAA OISST





NERC NC, MIOS, BGC-Argo

NASA VIIRS



ESA MERIS

ocean colour cci

Regional product for SCC & PFTs

PFT chlorophyll distributions with errors (17-24/6/08), will be operationally available through CMEMS

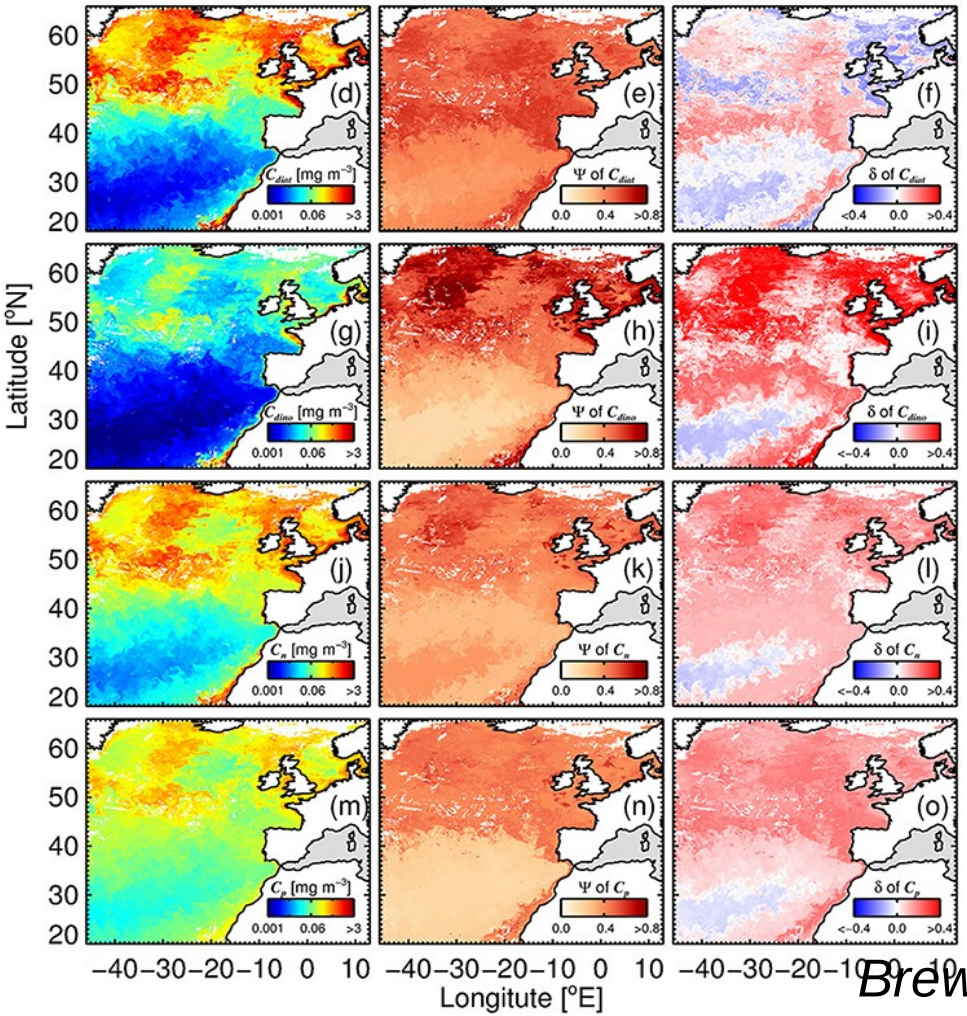
[Chl] RMSD Bias

Diatoms

Dinoflagellates

Nano-phytopl.

Pico-phytopl.



Brewin et al., 2017

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Importance of phytoplankton size/type

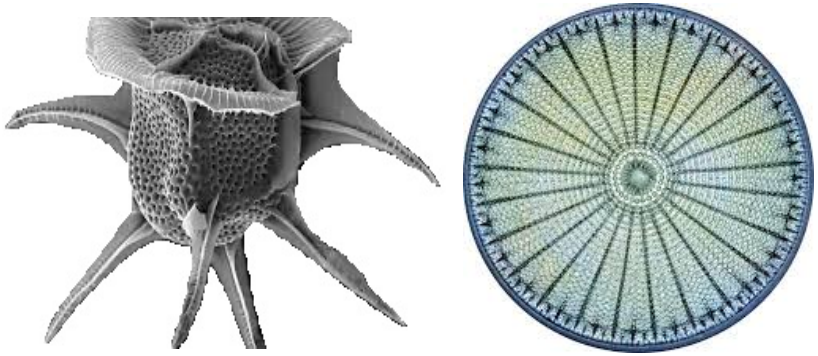
Pico-phytoplankton (<2µm)

- High remineralisation of organic matter
- Low export (outgas CO_2)
- High growth rates
- High light absorption
- High surface-to-volume ratio
- Loss grazing

Nano-phytoplankton (2-20µm)

- Moderate remineralisation
- High sinking rates
- Moderate growth rates
- Moderate absorption
- Calcium carbonate cycle
- DMS cycle (e.g. *Phaeocystis*)

Micro-phytoplankton (>20µm)



- Lower remineralisation
- High export production
- High sinking rates
- Lower (flat spectral) absorption
- Silicate cycle
- DMS cycle (e.g. some dinoflagellates)
- Rich food source (↑ in some essential fatty acids)

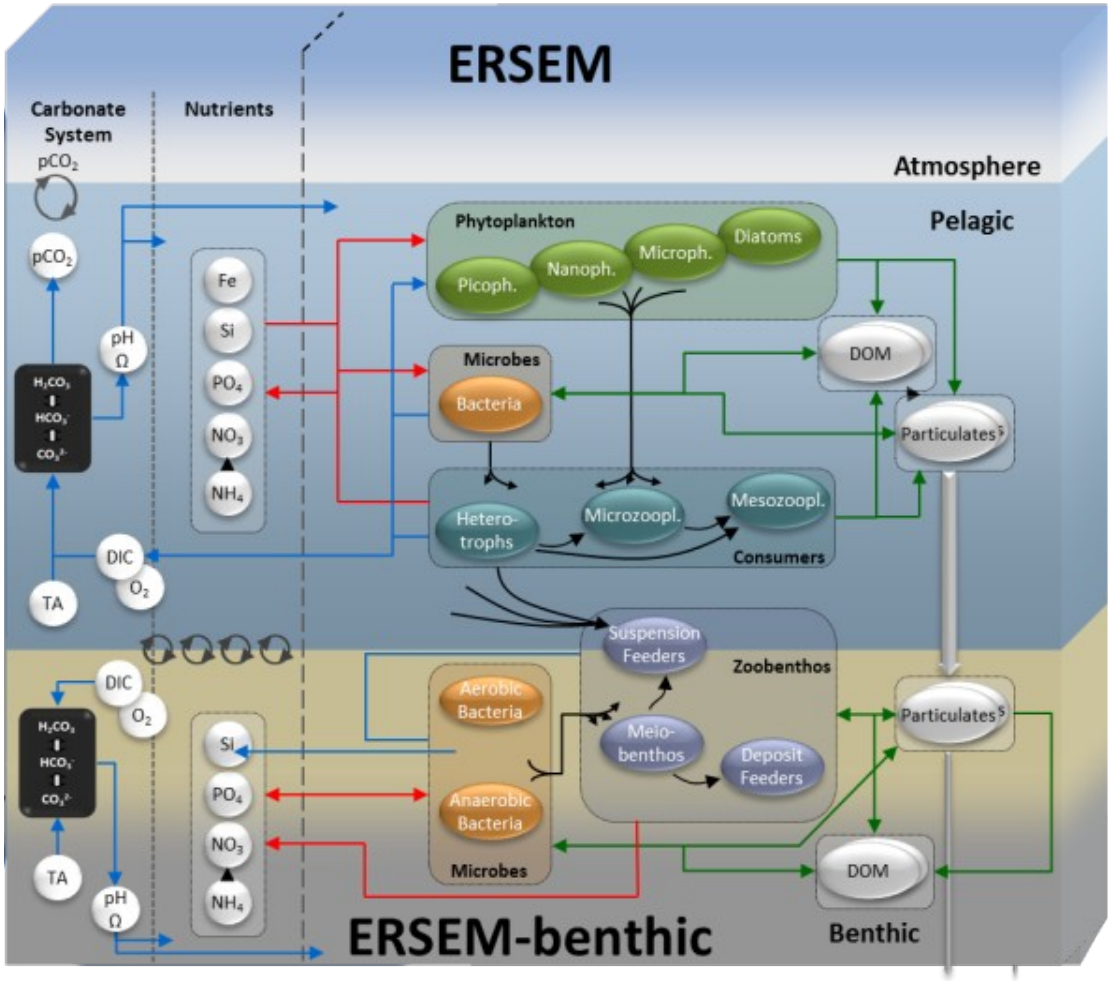
Operational forecasting

The ecosystem model: NEMO-FABM-ERSEM

NEMO V3.6

NEMOVar

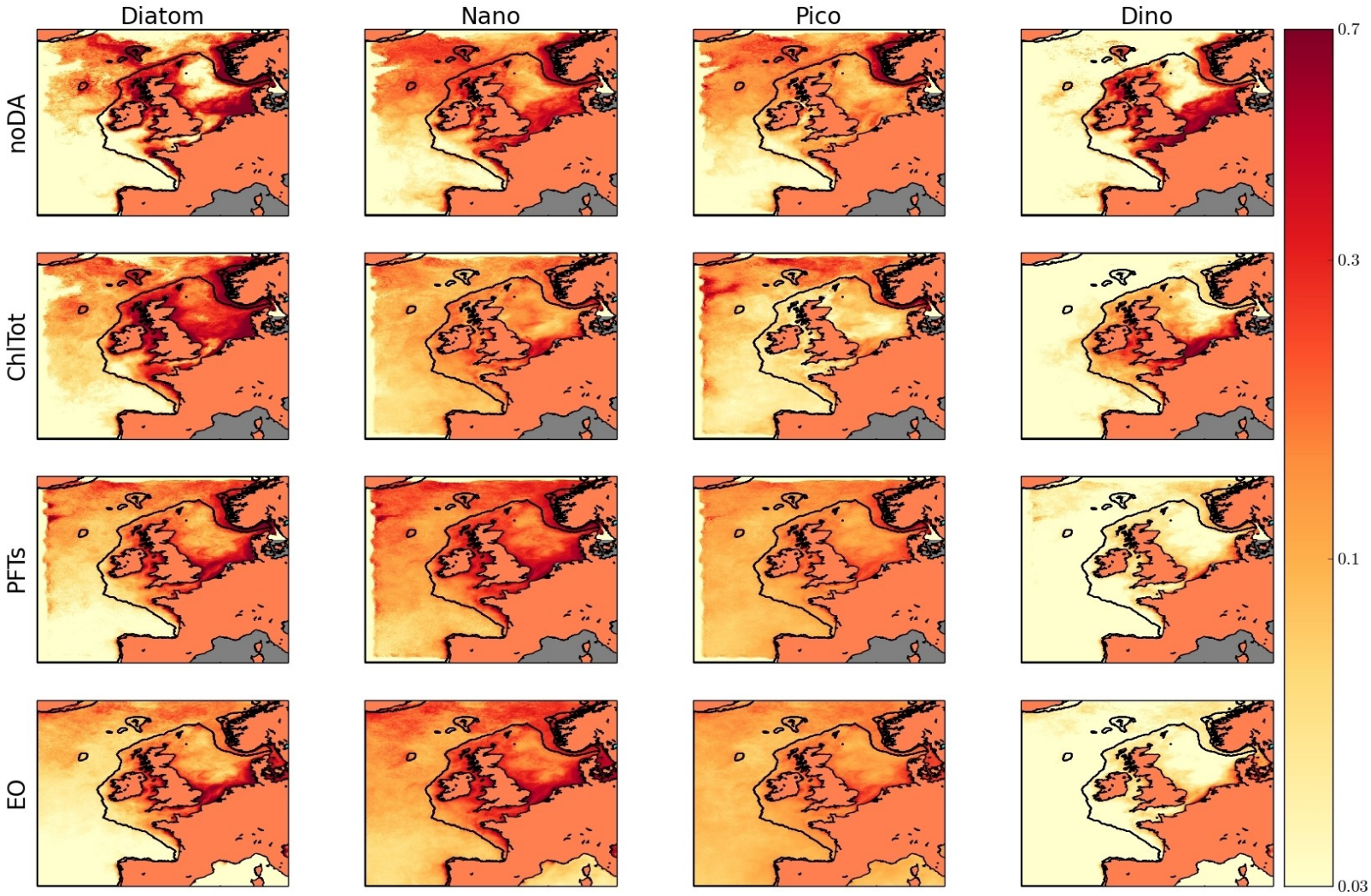
3D-VAR
First-Guess-at-Appropriate-Time
Log-transformation
Incremental Analysis Update
Daily DA (12 UTC). 1 year (2010) simulations. Correlation length scales on the level of Rossby radius (1/4 deg). 3:1 model-to-observational error ratio. The DA updates PFT chlorophyll and subsequently the other PFT variables (carbon, nitrogen, phosphorus, silicon) to preserve the background stochiometry. Each DA step followed by a 5 day forecast.



Skakala et al, JGR-Oceans, 2018

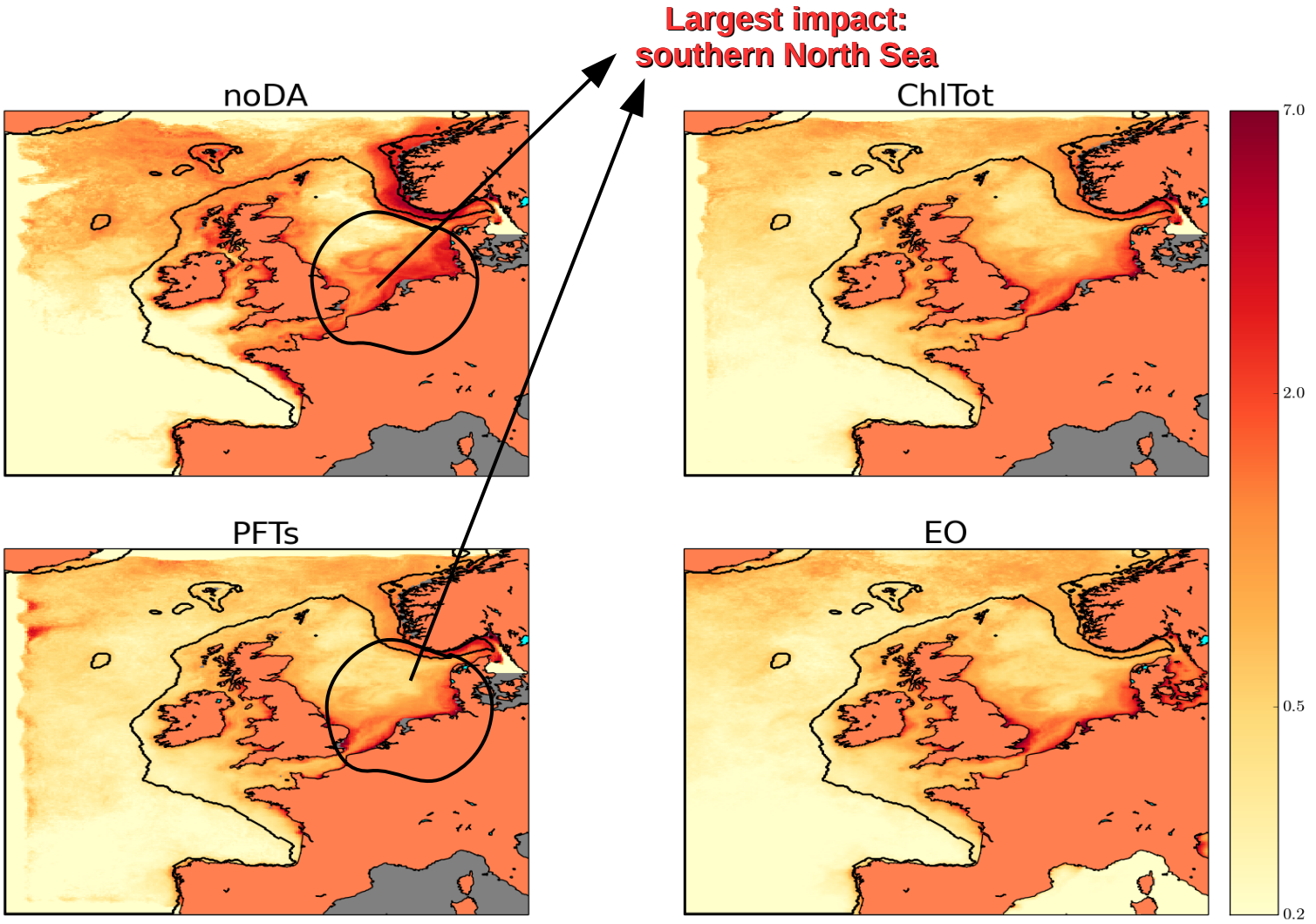
Results

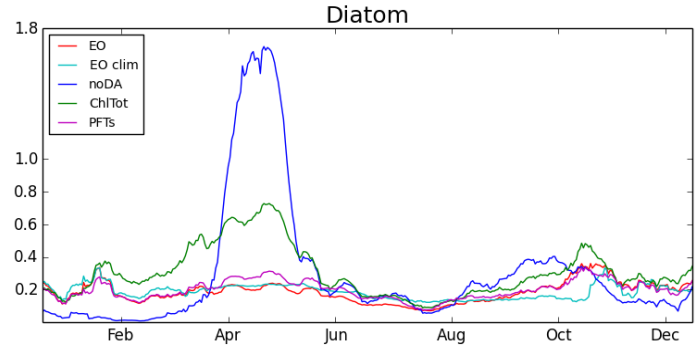
Annual spatial medians of the four PFT chlorophyll

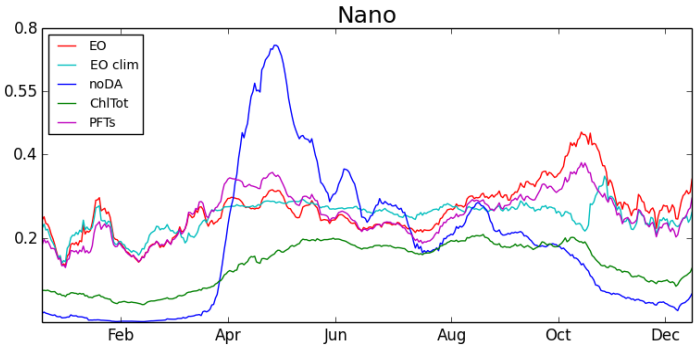


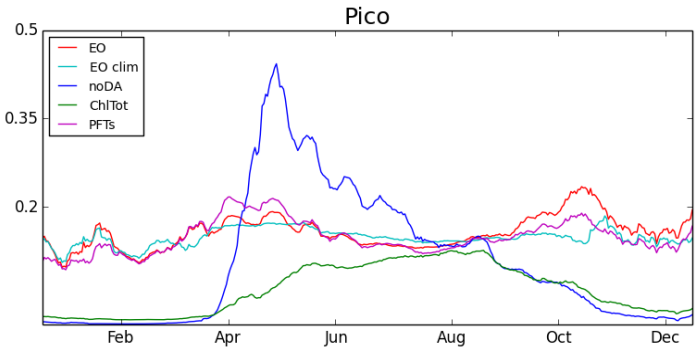
PFTs DA is by far the closest to the Satellite

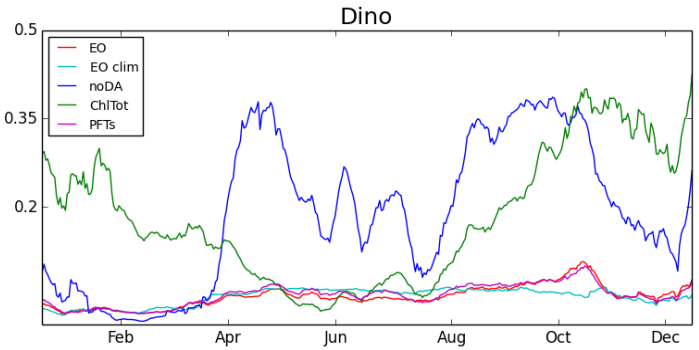
Annual median total chlorophyll-a concentrations

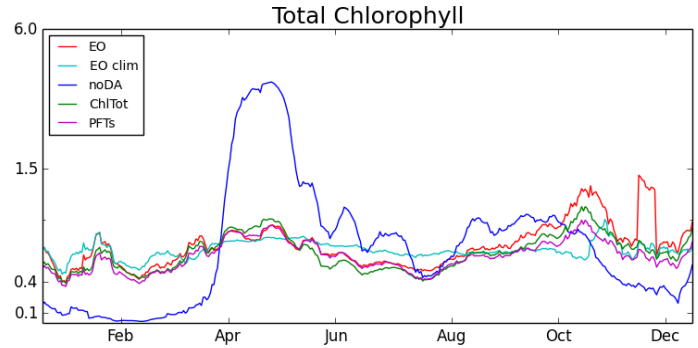


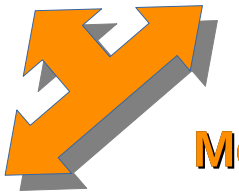








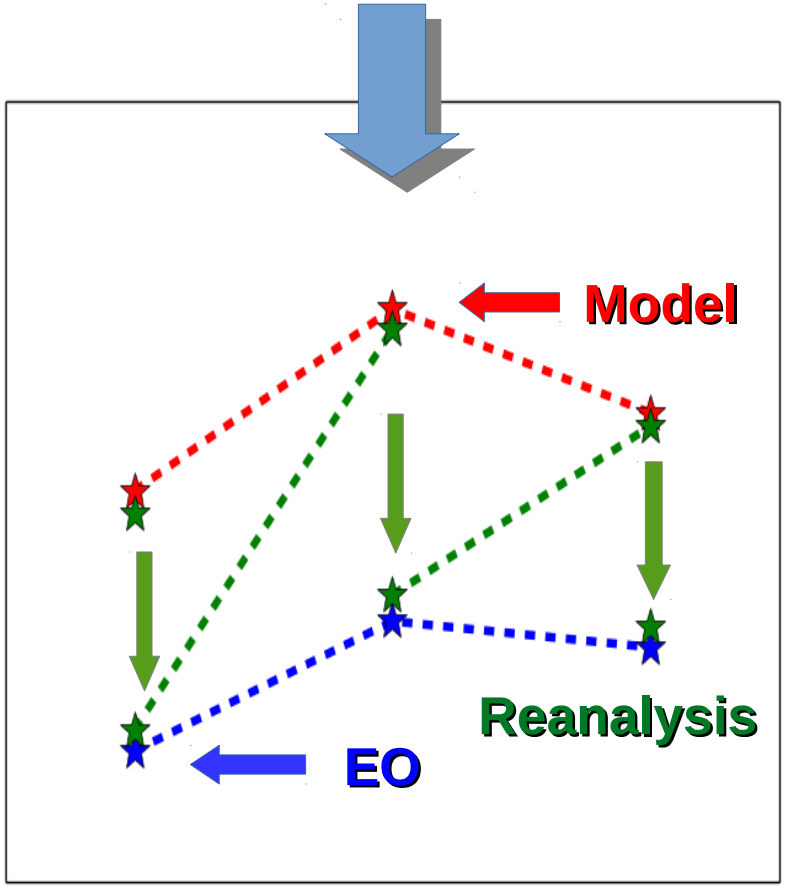




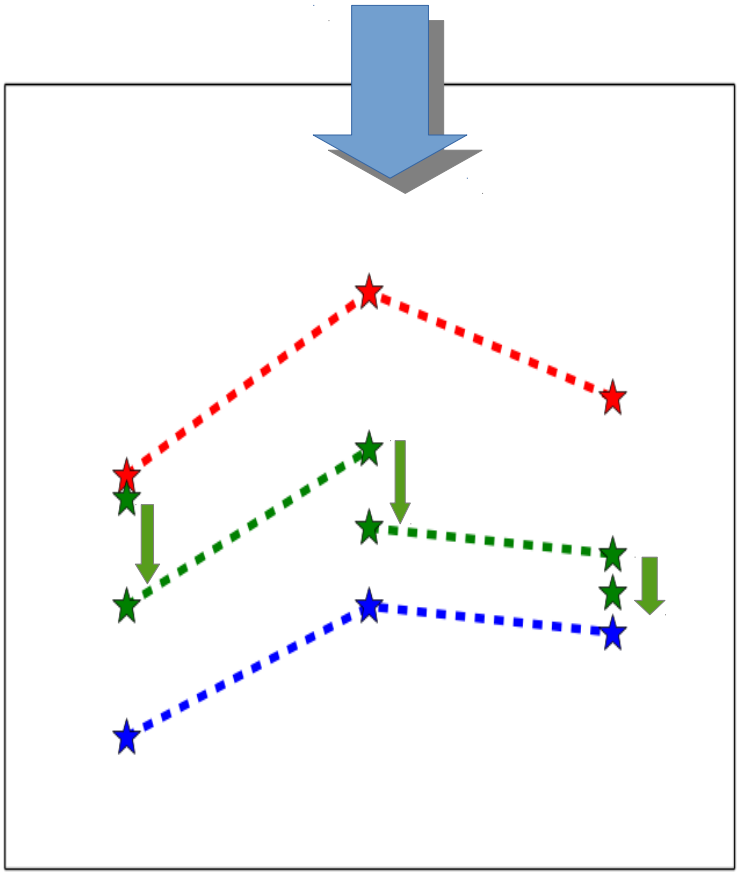
Median Shelf annual time series

Possible interpretations of EO – reanalysis match-ups

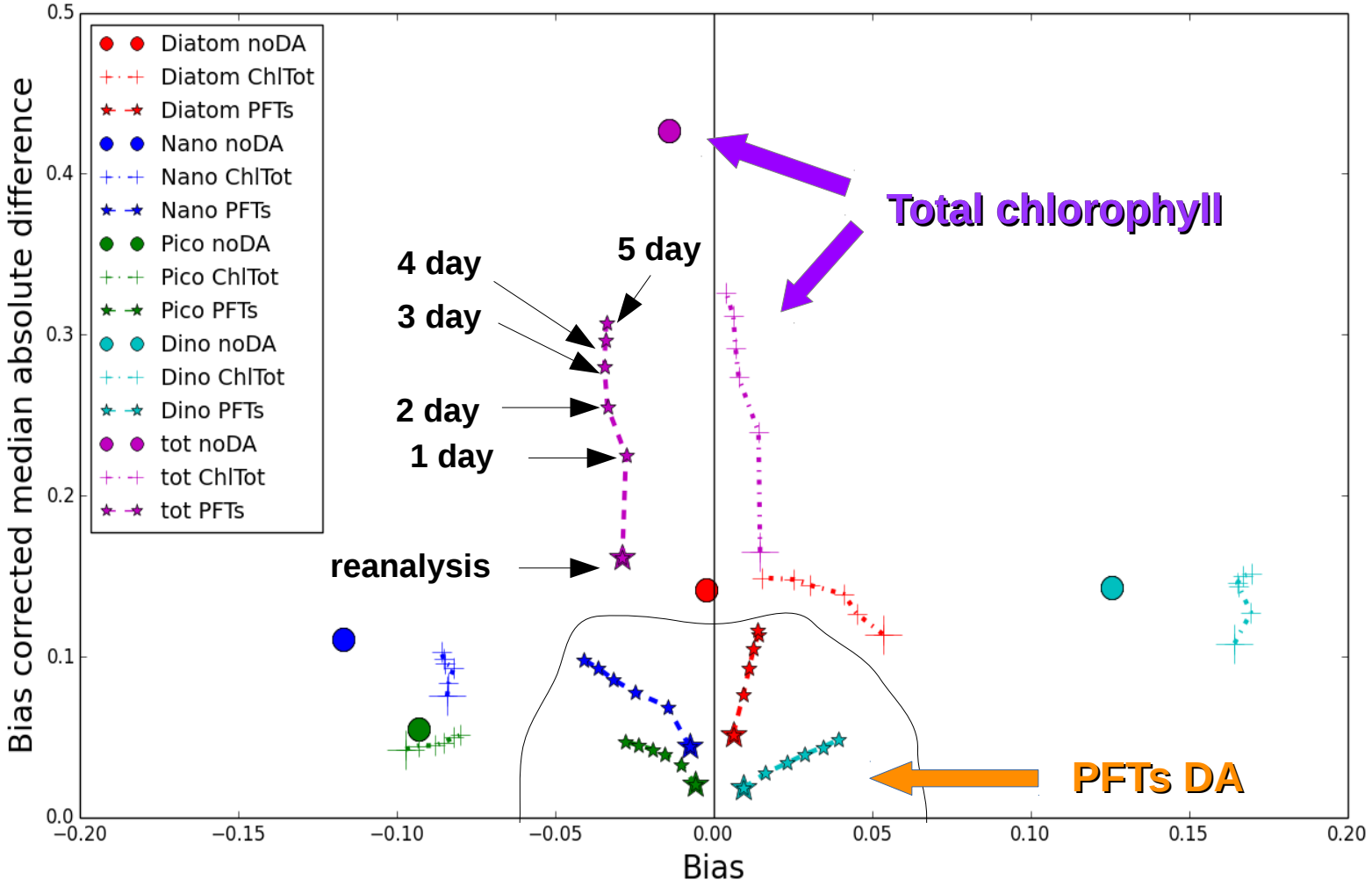
A) Large Model to EO error ratio



B) Consistency between model dynamics and reanalysis increments



Forecast skill



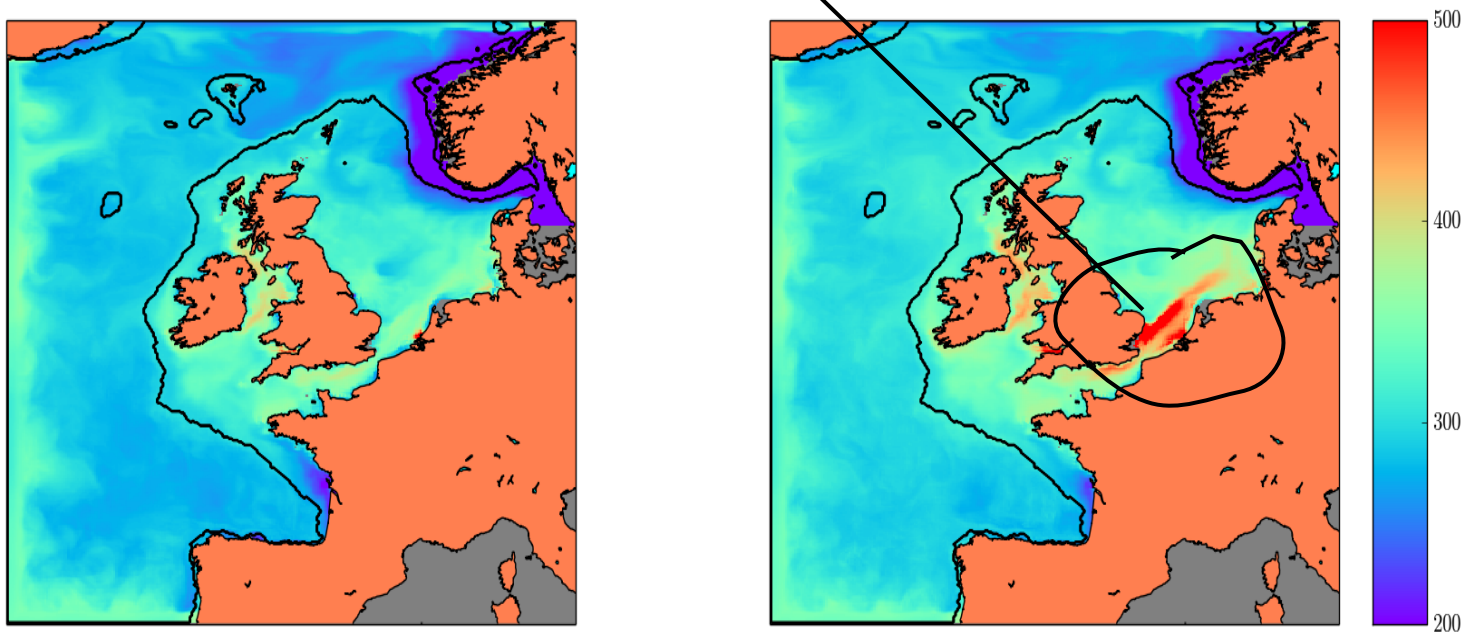
***In situ validation* showed that DA substantially improves representation of pCO2 (bias lowered by 50%), but it has statistically insignificant, or inconsistent impact on nutrients (nitrate, phosphate, silicate).**

Improved representation of surface pCO2 (*u*bar) on the NWE Shelf (annual mean). Maps such as these will be part of Met Office reanalysis products (2019) and available for the near-real time application (2020).

Largest impact: southern North Sea

Free run

DA



Conclusions

- **PFT DA is a useful approach improving the representation of ecosystems on the North-West European Shelf.**
- **PFT DA outperforms TotChl DA in simulating the ocean-colour phytoplankton community structure. PFT DA produces distributions very close to EO, we argue this is a sign of dynamical consistency between EO and model.**
- **PFT DA outperforms TotChl DA in PFT forecasting skill and has comparable results in how it represents / forecasts total chlorophyll.**
- **DA improves representation of pCO2 impacting on the estimate of air-sea carbon flux.**
- **The assimilation system developed here will be part of Copernicus monitoring service for reanalysis (2019) and for forecasting / near-real time applications (2020).**