

Marine Biogeochemistry from Operational Prediction to Climate Scales

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and
the Marine Biogeochemistry team*





Contents

- Marine Biogeochemistry capability
 - Short-range prediction
 - Climate
- Connections to Task Team topics
- Future work



Marine Biogeochemistry Capability

Operational

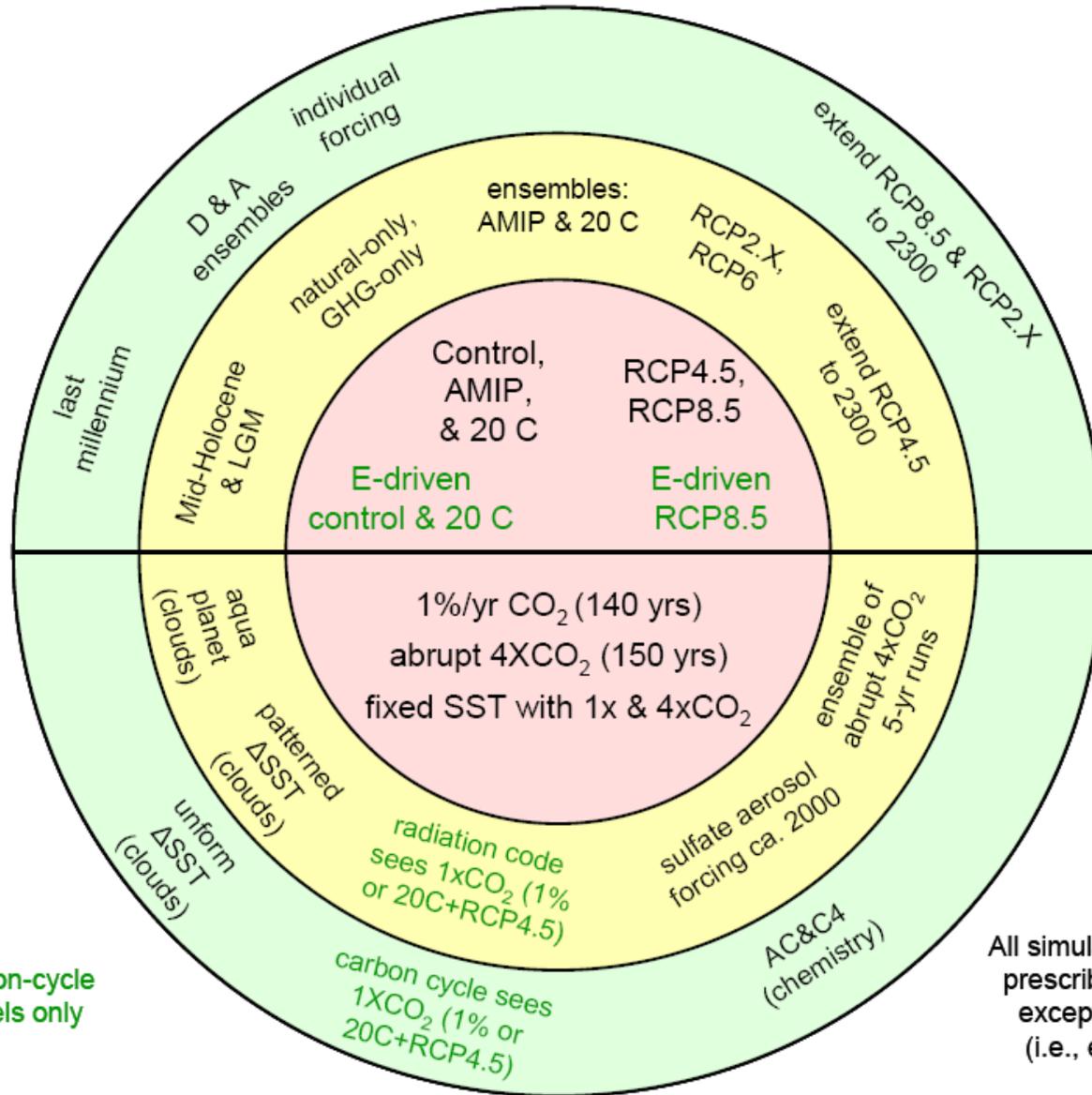
- Short-range daily forecasts and 10 year hindcasts for global, North Atlantic and North West European Shelf regions
 - 3D physical open oceans and shelf seas (NEMO)
 - Nutrients, sediments & biology (HadOCC/ERSEM)
 - Operational monitoring - http://www-nwp/~ocean/foam_monitoring/index_opfc.html (next slide)

Climate Science

- Centennial simulations (HadGEM2-ES) – IPCC AR5
- Future assessments of impact of climate change on marine (UKCP09) likely to include ecological variables



AR5 centennial "pie"



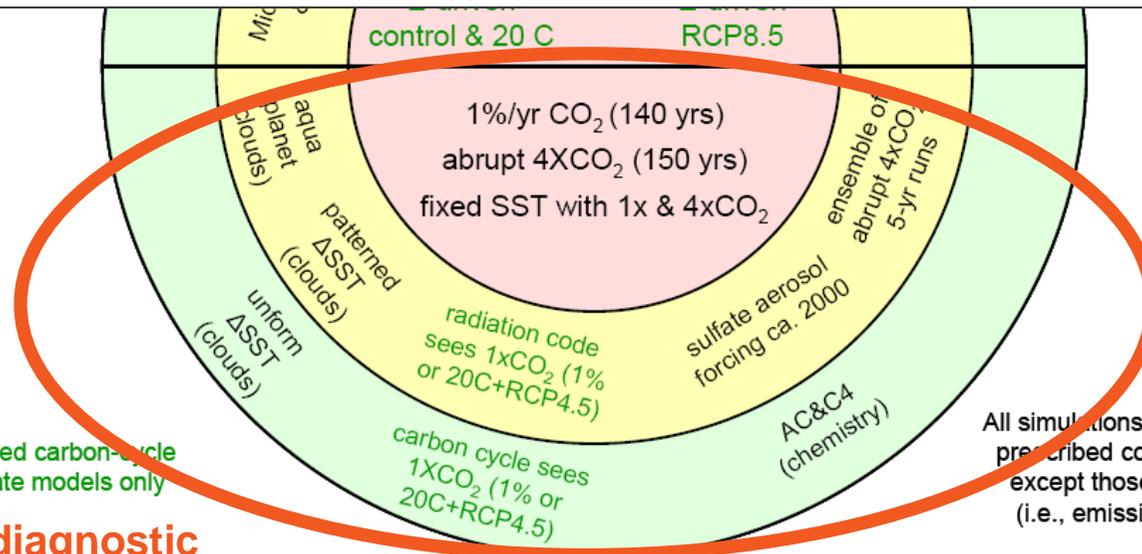
Coupled carbon-cycle climate models only

All simulations are forced by prescribed concentrations except those "E-driven" (i.e., emission-driven).



AR5 centennial simulations

- 1% CO₂ increase, 4xCO₂ step change...
 - Cloud processes/feedbacks
 - Carbon cycle feedbacks / loop-cutting
 - Diagnosing forcing

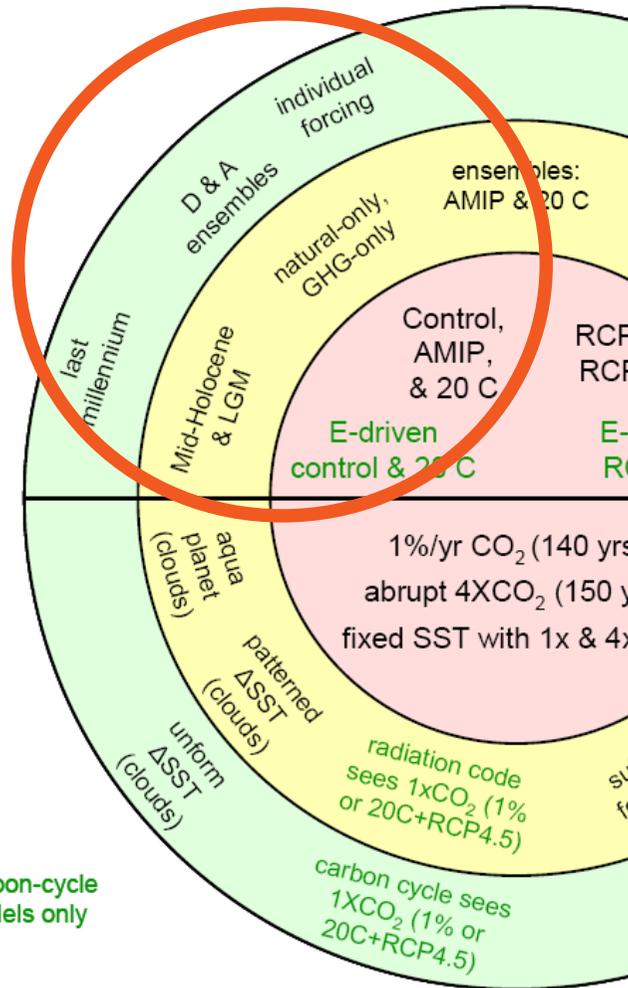




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AR5 centennial simulations

Understanding the past



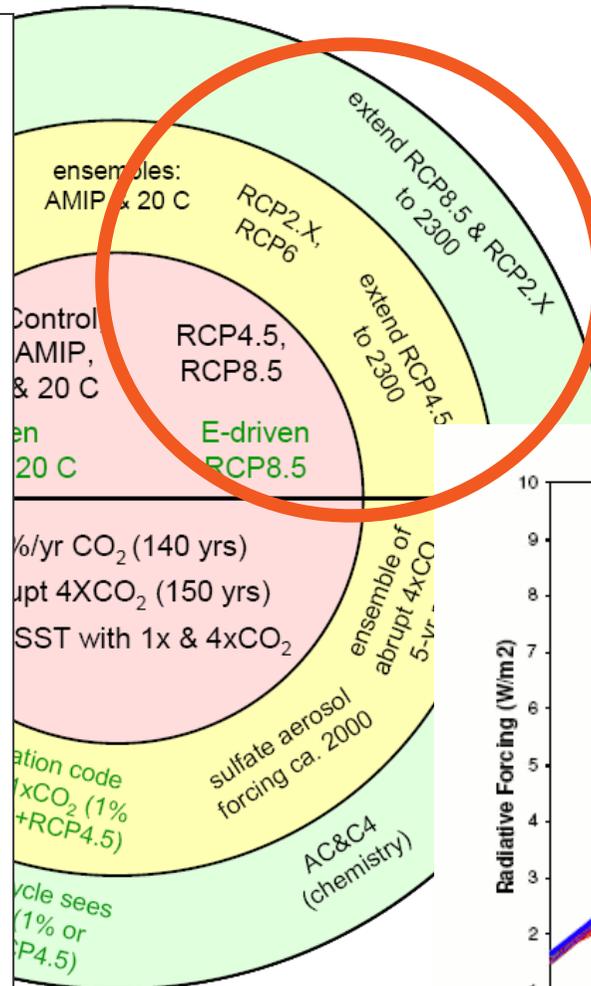
- Historical runs
 - Ensemble
- Detection and attribution
 - Natural
 - GHG
 - Other...
- Palaeo
 - Mid-Holocene (6k)
 - LGM (20k)
 - Last millennium



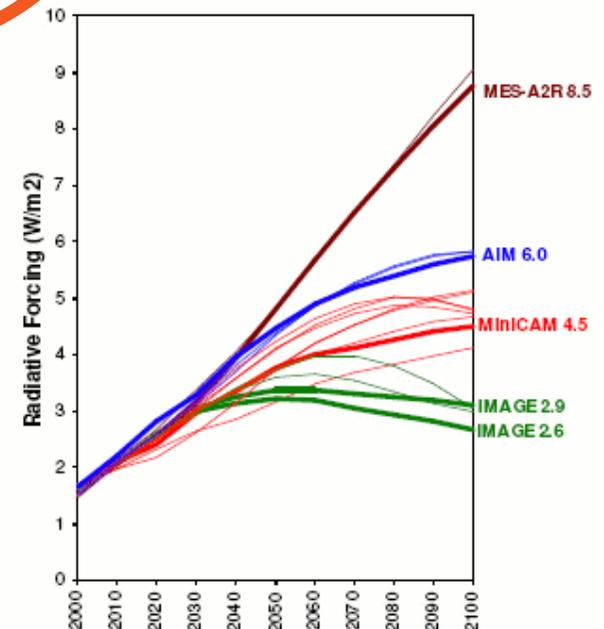
AR5 centennial simulations

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- Scenario runs
 - “RCP”s: Representative Concentration Pathway
- RCP 8.5
 - High-end (“business as usual”)
- RCP 4.5, 6
 - ~ stabilisation
- RCP 2.6 (aka RCP 3 PD)
 - Peak-and-decline
 - Aggressive mitigation
- First time climate-policy included in IPCC scenario runs



Predicting the future





Biogeochemical Models

- Deep water (simple BGC models)
 - Carbon cycle simulation in climate models
 - Hindcasts assimilating satellite ocean colour and pCO₂ data
- North-West European Shelf (more complex BGC models)
 - Daily running of ERSEM and sediment models
 - ERSEM North West Shelf products delivered for MyOcean



**National Oceanography
Centre, Southampton**
UNIVERSITY OF SOUTHAMPTON AND
NATURAL ENVIRONMENT RESEARCH COUNCIL



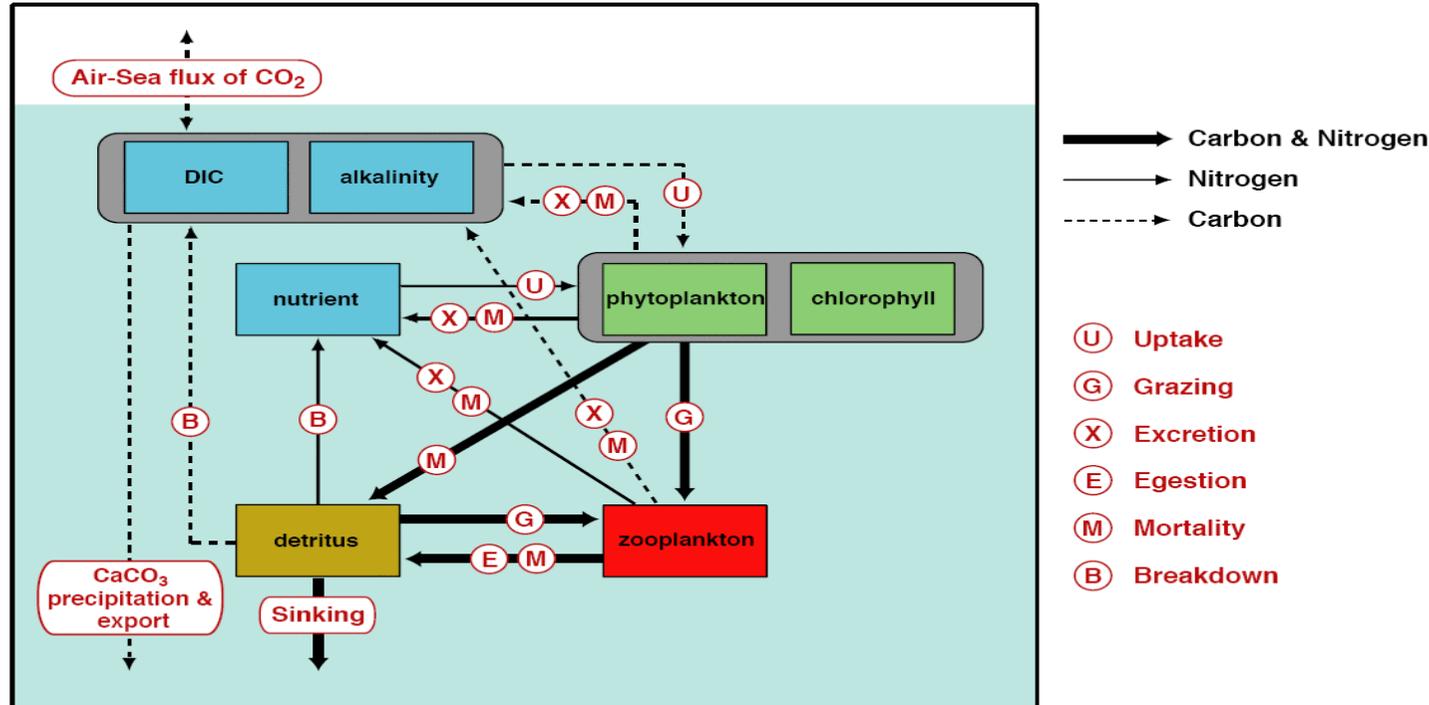
**Proudman
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NATURAL ENVIRONMENT RESEARCH COUNCIL

NCOF



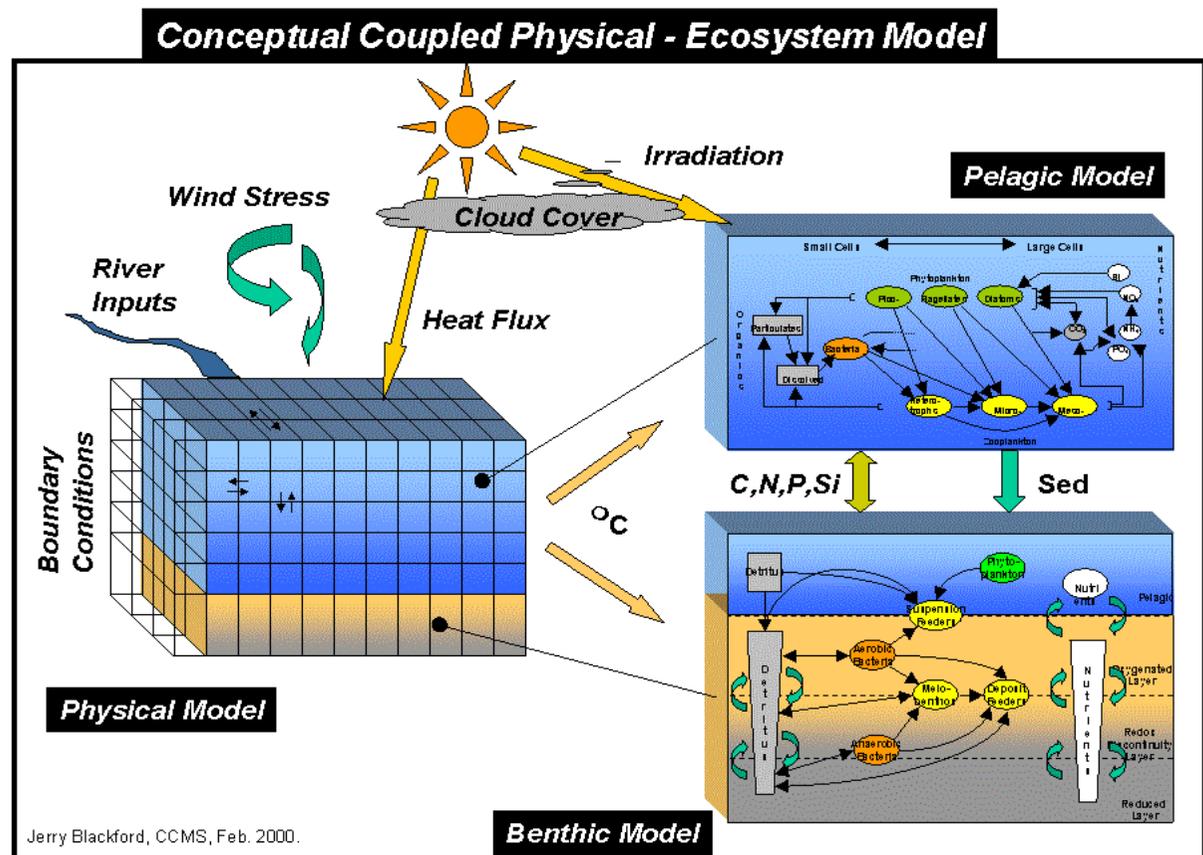
Open Ocean Ecosystem Model

- FOAM-NEMO ORCA1
- Pre-operational daily running since 2009, with biological data assimilation
- ESA GlobColour, ESA CCI OC
- Diat-HadOCC for climate studies



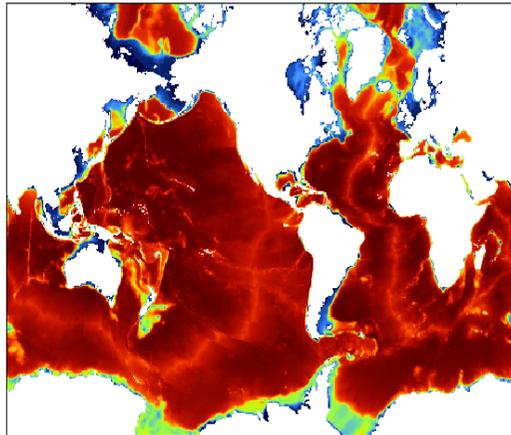
Shelf Seas Ecosystem Model

- FOAM NEMO AMM7, operational analysis and daily 5-day forecast
- Validation against available *in situ* (PML, CEFAS SmartBuoy, MyOcean TACs) and satellite datasets
- Products include:
 - Visibility diagnostics
 - Bloom indicators (EA),
 - Ecosystem indicators (MyOcean)
- Coupled to a simple sediment model



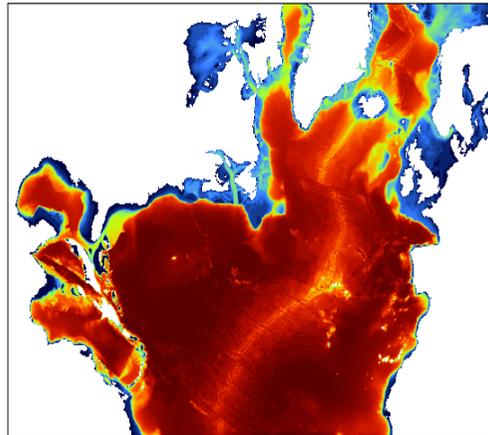


Operational Biogeochemistry Systems



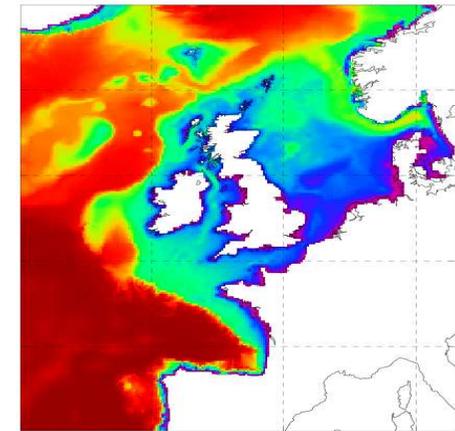
Global 1/4° (NEMO-ORCA025-HadOCC)

Open ocean



1/12° North Atlantic (NEMO-NATL12)

Open ocean



7km Atlantic Margin Model (NEMO-ERSEM-SPM)

Coastal ocean



Topic 1 –

Assess & demonstrate value (“fitness for purpose”) of OO products for ecosystem monitoring & prediction

WG00FE

HOOKING UP DATA USERS WITH DATA

Barbara Berv, Mark Dickey-Collas, and Morten Skogen describe a dialogue between data producers and data users, and explain how WG00FE is making new connections.

ICES Working Group on Operational Oceanographic Products for Fisheries and the Environment.

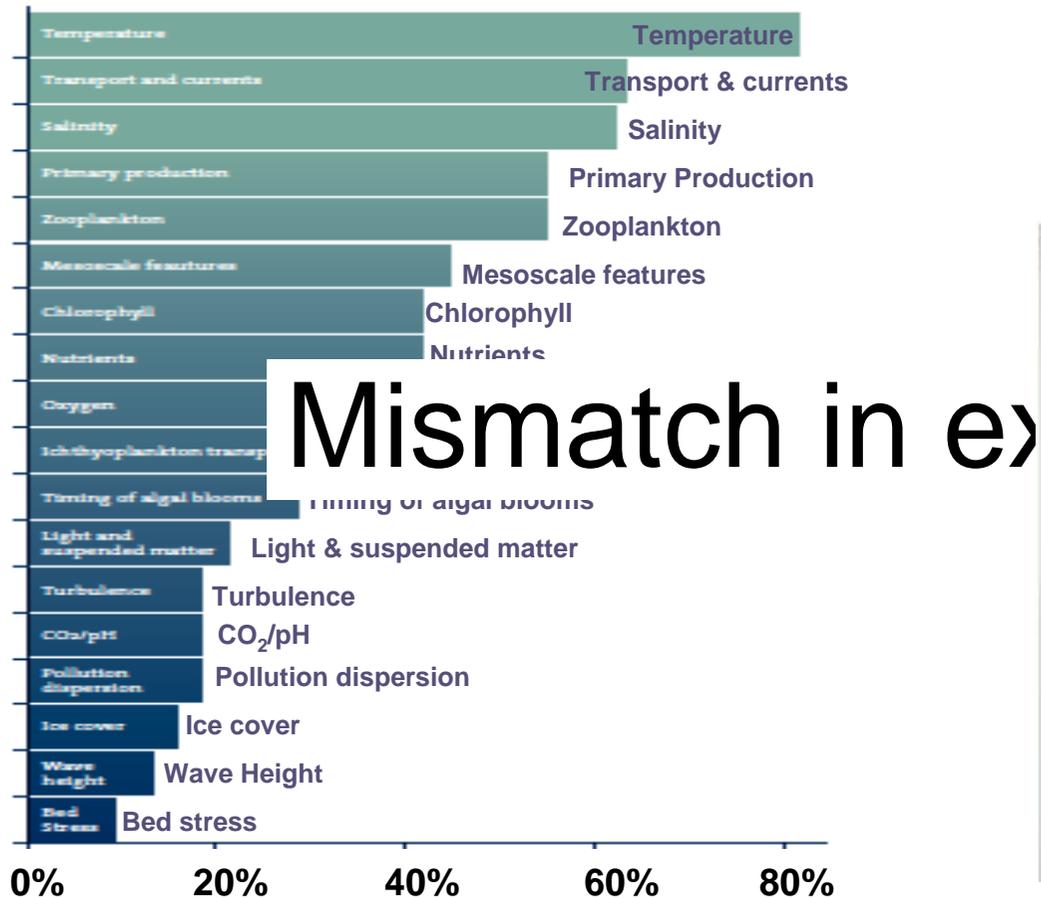




Results from survey by ICES WGOOFE

- Responses from marine scientists dealing with management of exploited species and ecosystem management (Berx *et al.*, 2010)

Oceanographic data products requested by the ICES community of marine researchers, in order of importance.



Mismatch in ex



Percentage of users requesting oceanographic products



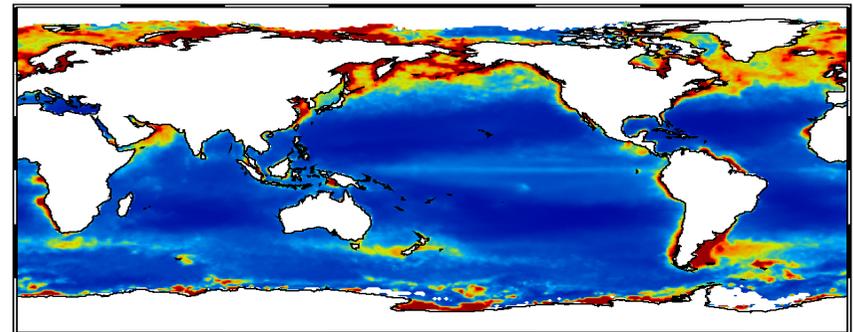
Topic 3 –

Impact of physical assimilation on biogeochemistry

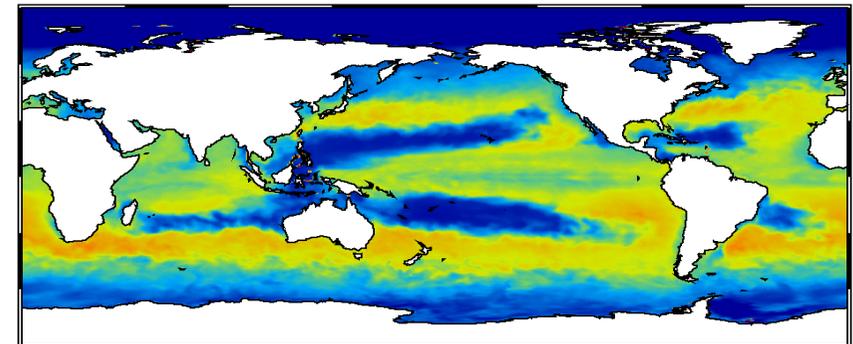


Ocean Colour Data Assimilation

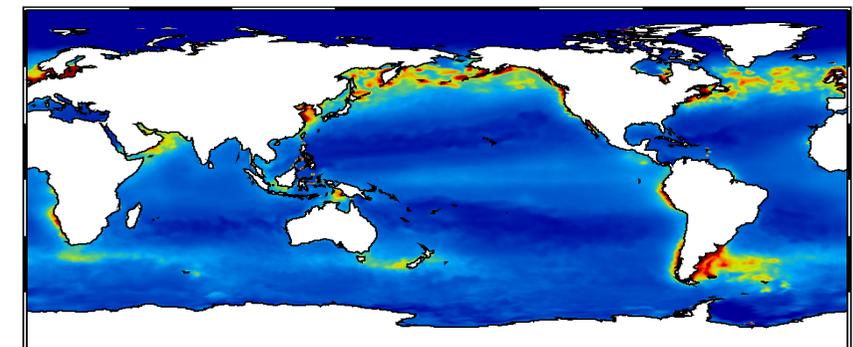
- ESA's Globcolour & Climate Change Initiative
- Biological data assimilation scheme implemented & tested with individual sensor and merged ocean colour products
- Observation-operator developed to allow comparison of obs vs. chl model field.
- Results show a significant improvement in chlorophyll as well as on other variables (next slide)
- FOAM-HadOCC assimilating ocean colour was transitioned to daily n.r.t. run in June09
- The assimilation of GlobColour and CCI OC derived chl will test the impact of these observations on our carbon cycle model



Observations (2008 mean)



FOAM-HadOCC – no chl assim

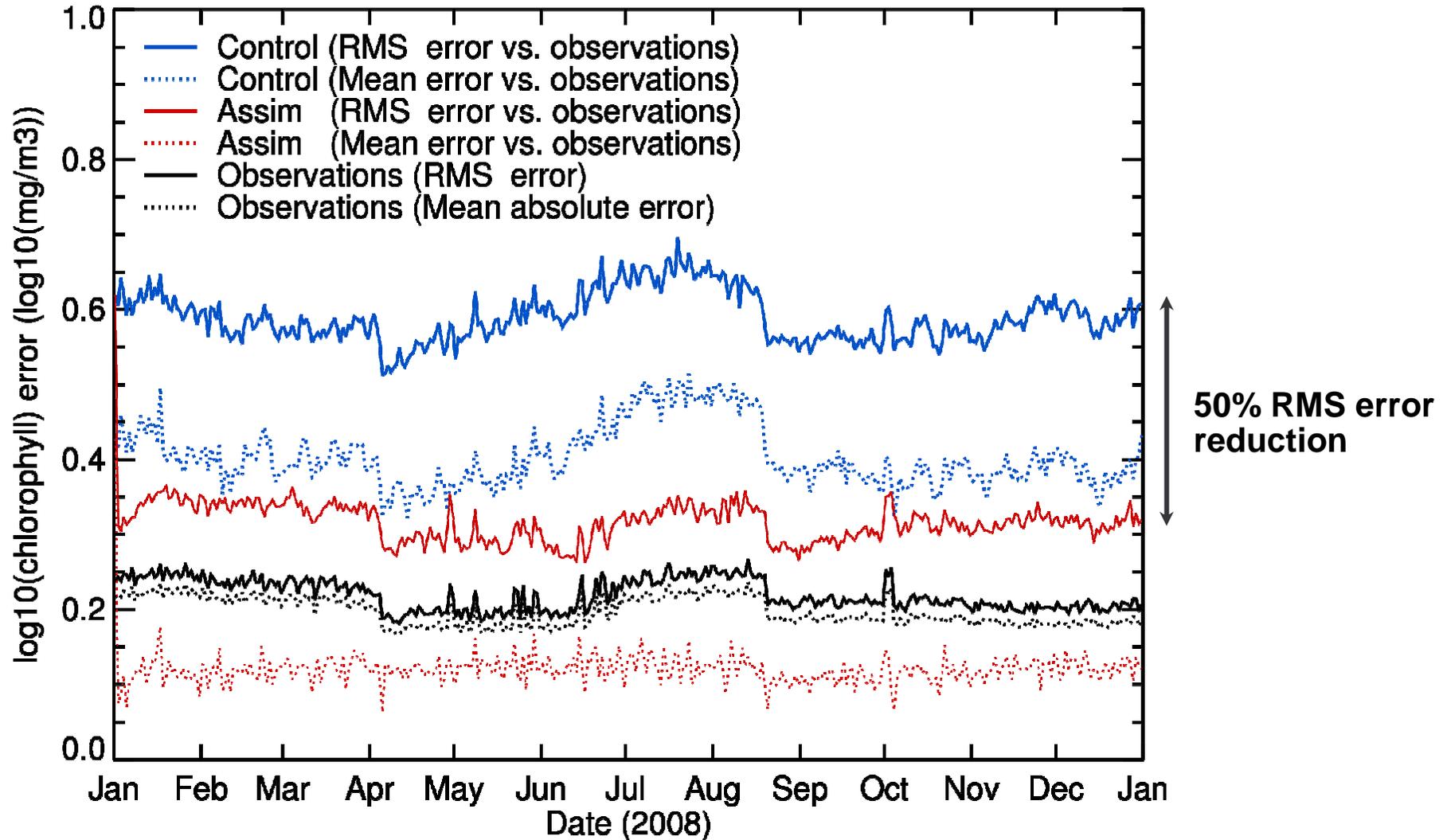


FOAM-HadOCC – chl assim



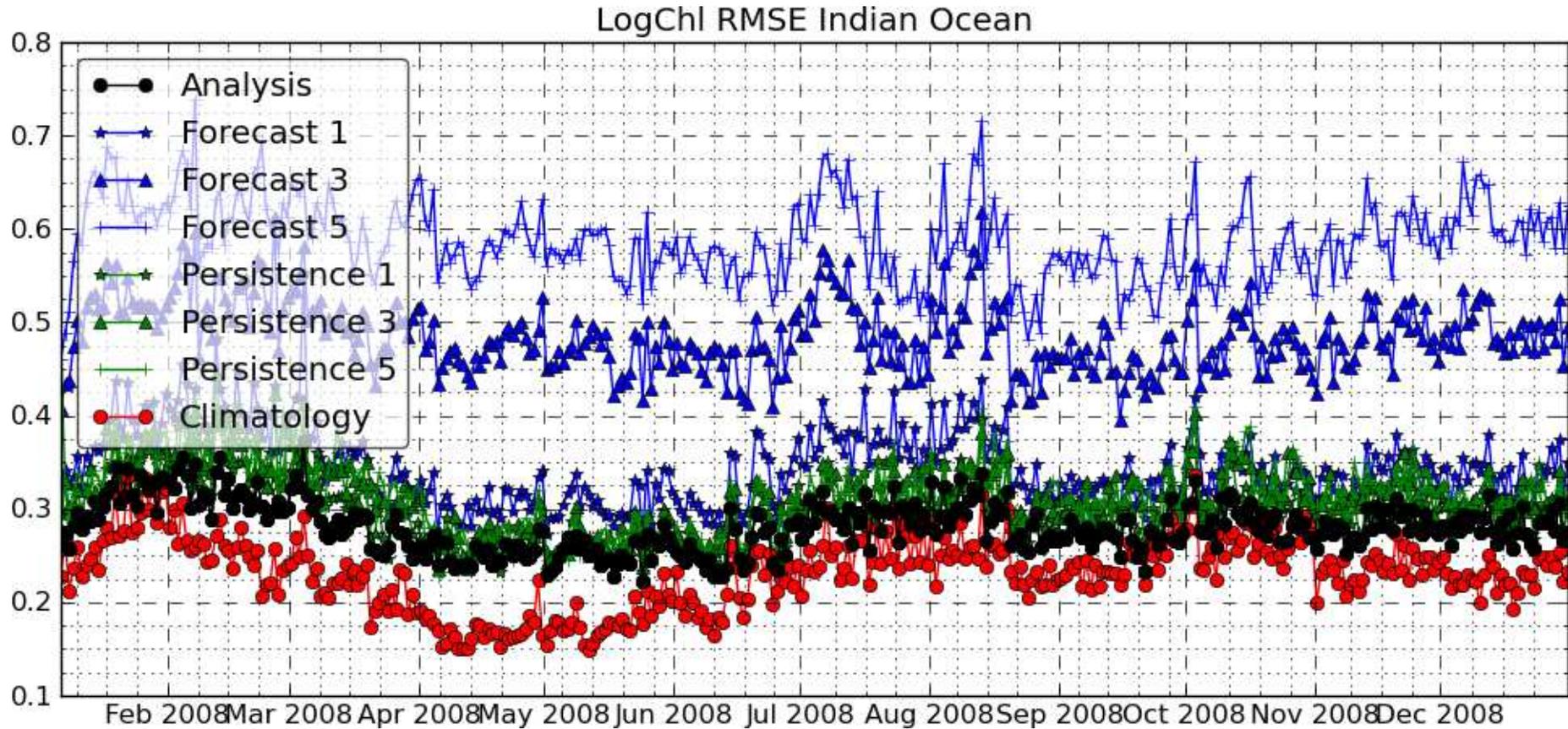


Impact of chlorophyll assimilation





Time series of RMS error Indian Ocean (2008)



$\log_{10}(\text{chlorophyll})$

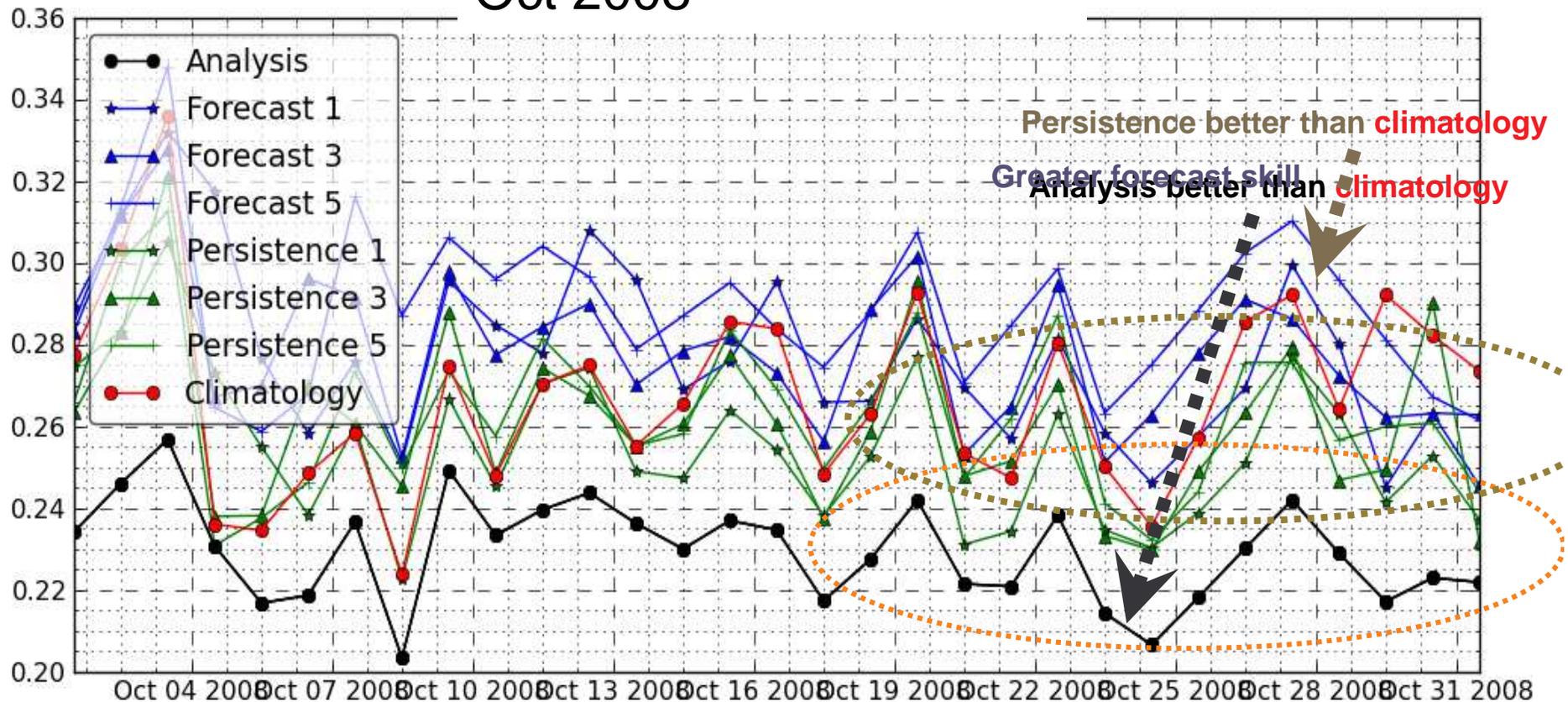
Physical and biological data assimilation

Impact of assimilation on model analysis and forecasts

Time series of RMS error Indian Ocean

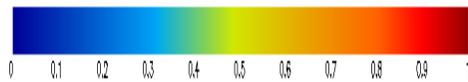
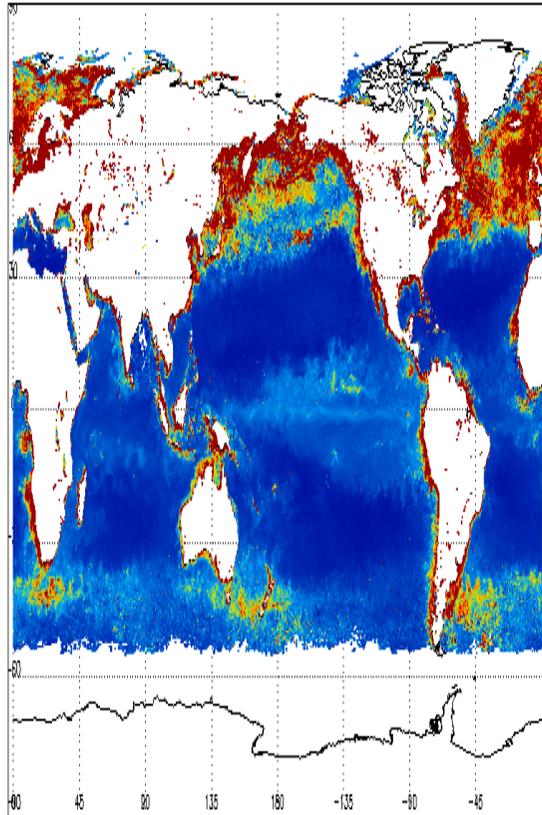
Biological data assimilation only

Oct 2008

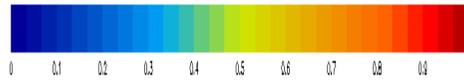
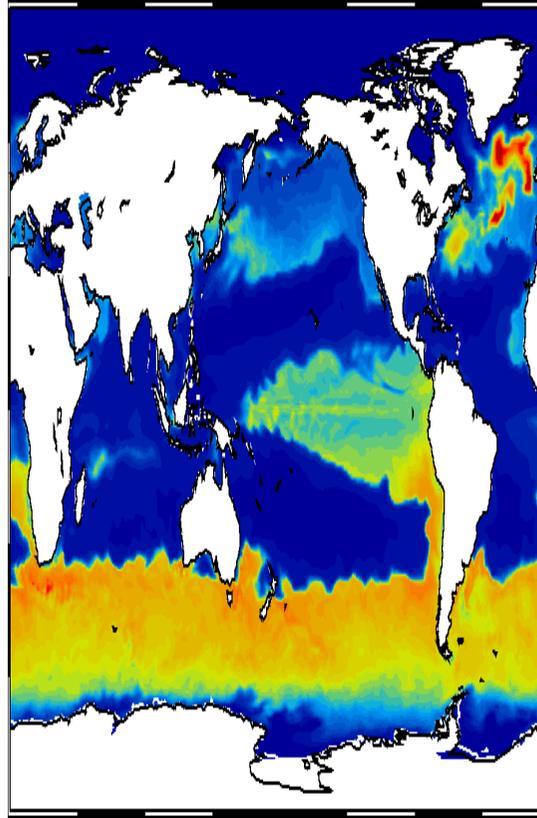




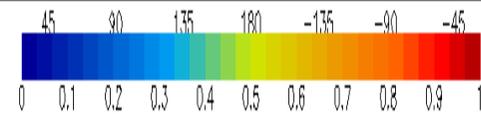
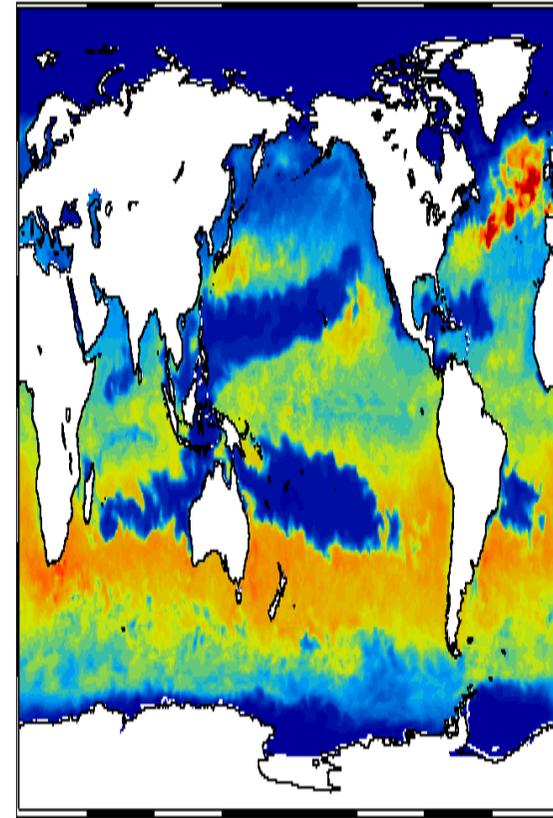
Surface chlorophyll (May 2008)



Observations



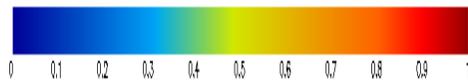
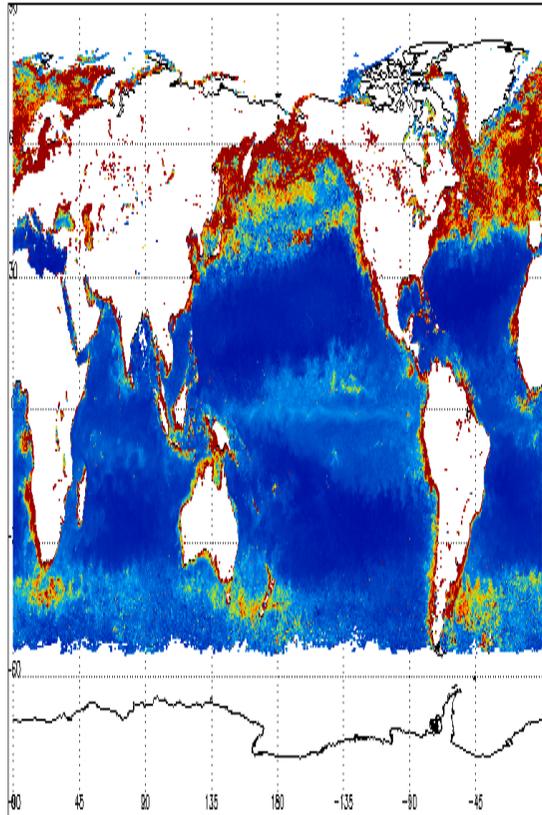
NoAsm



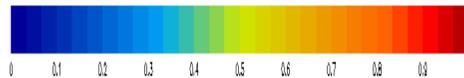
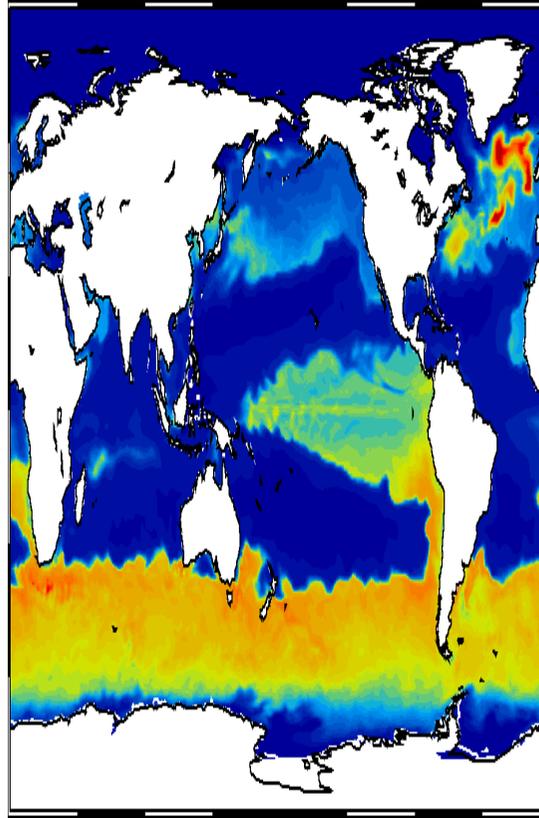
PhysAsm



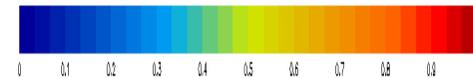
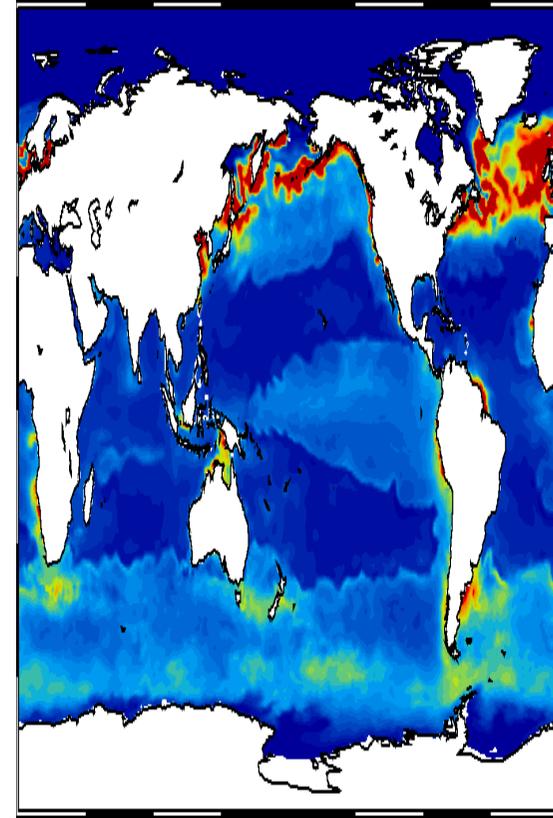
Surface chlorophyll (May 2008)



Observations



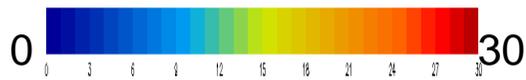
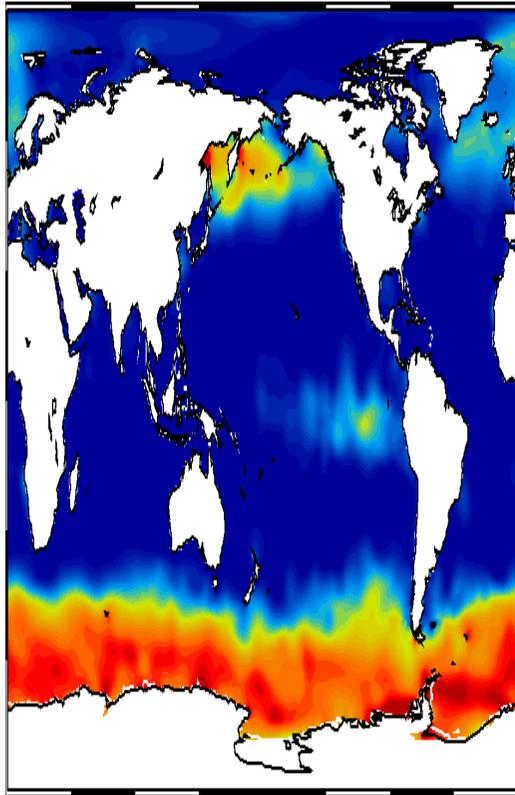
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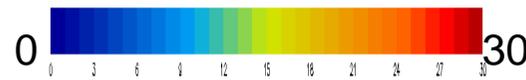
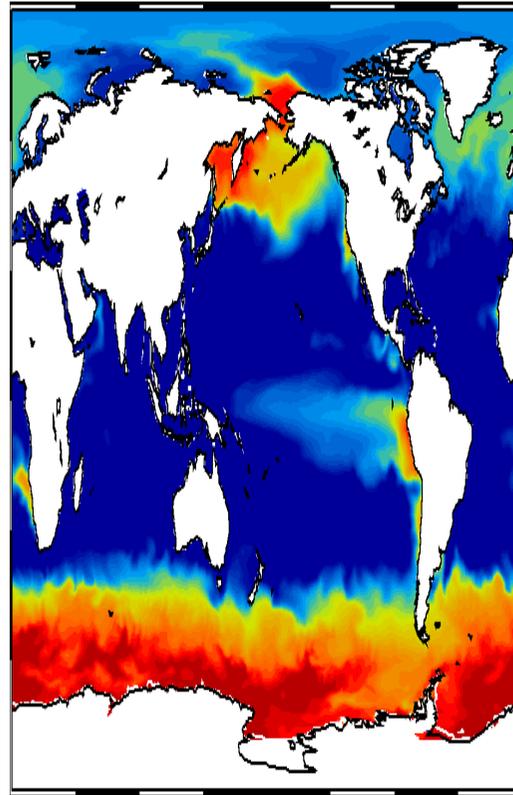
BioAsm



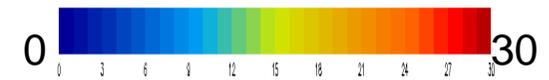
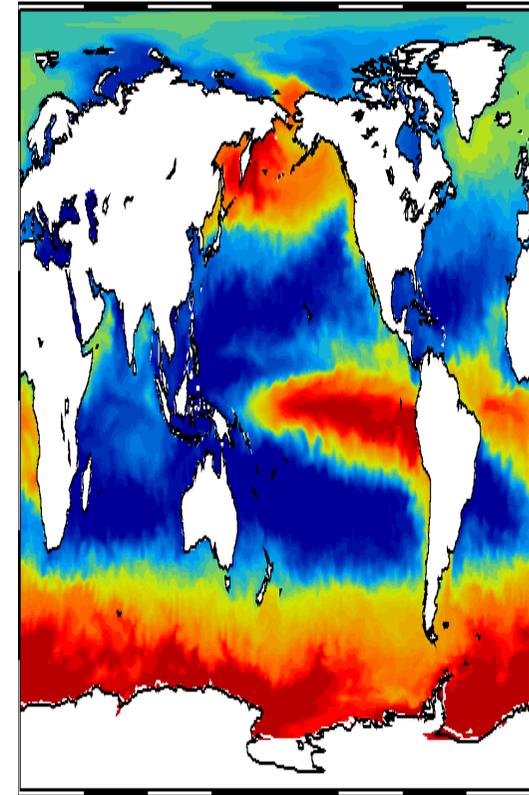
Surface nitrate (December 2008 mean)



Climatology



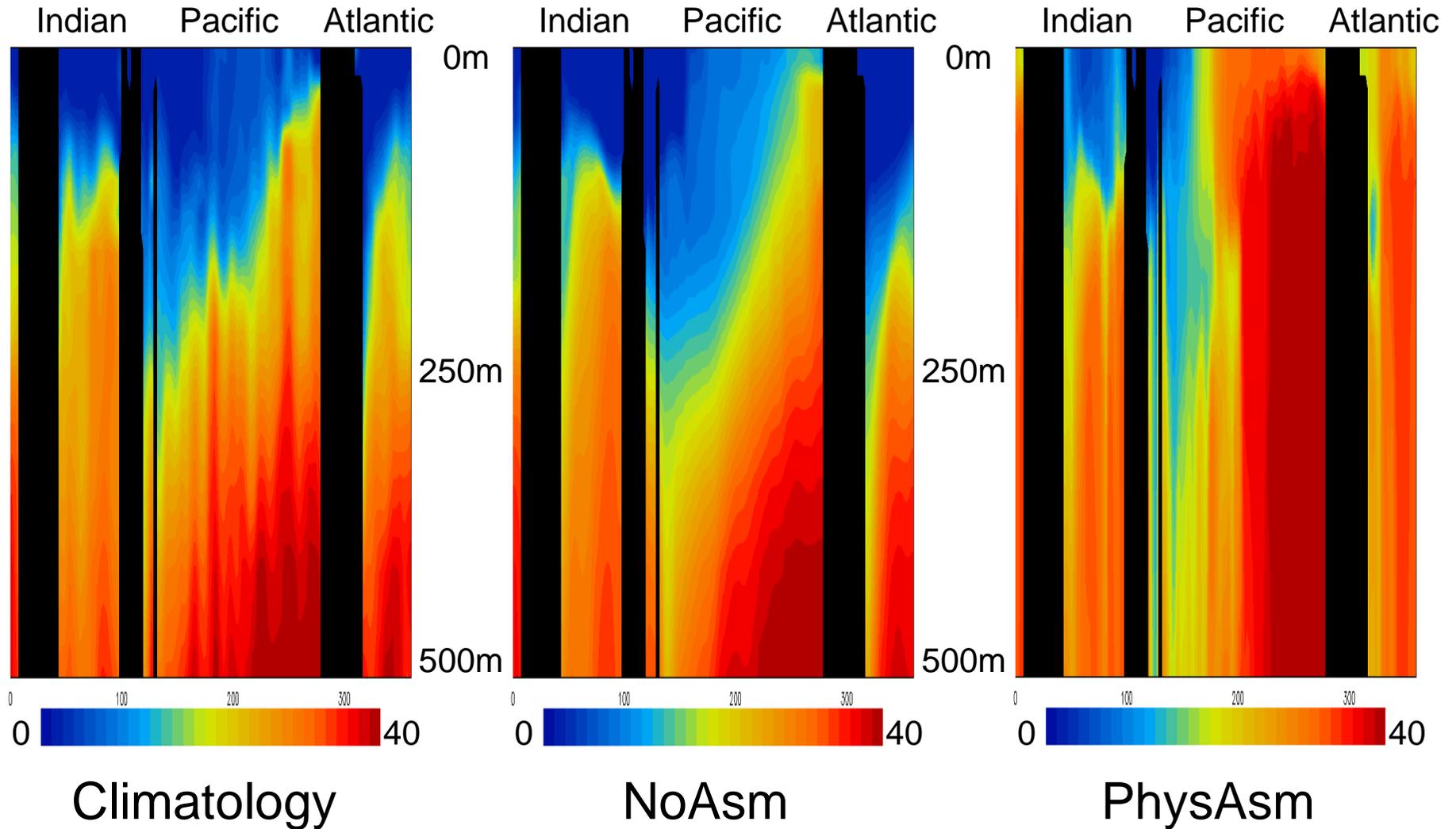
NoAsm



PhysAsm

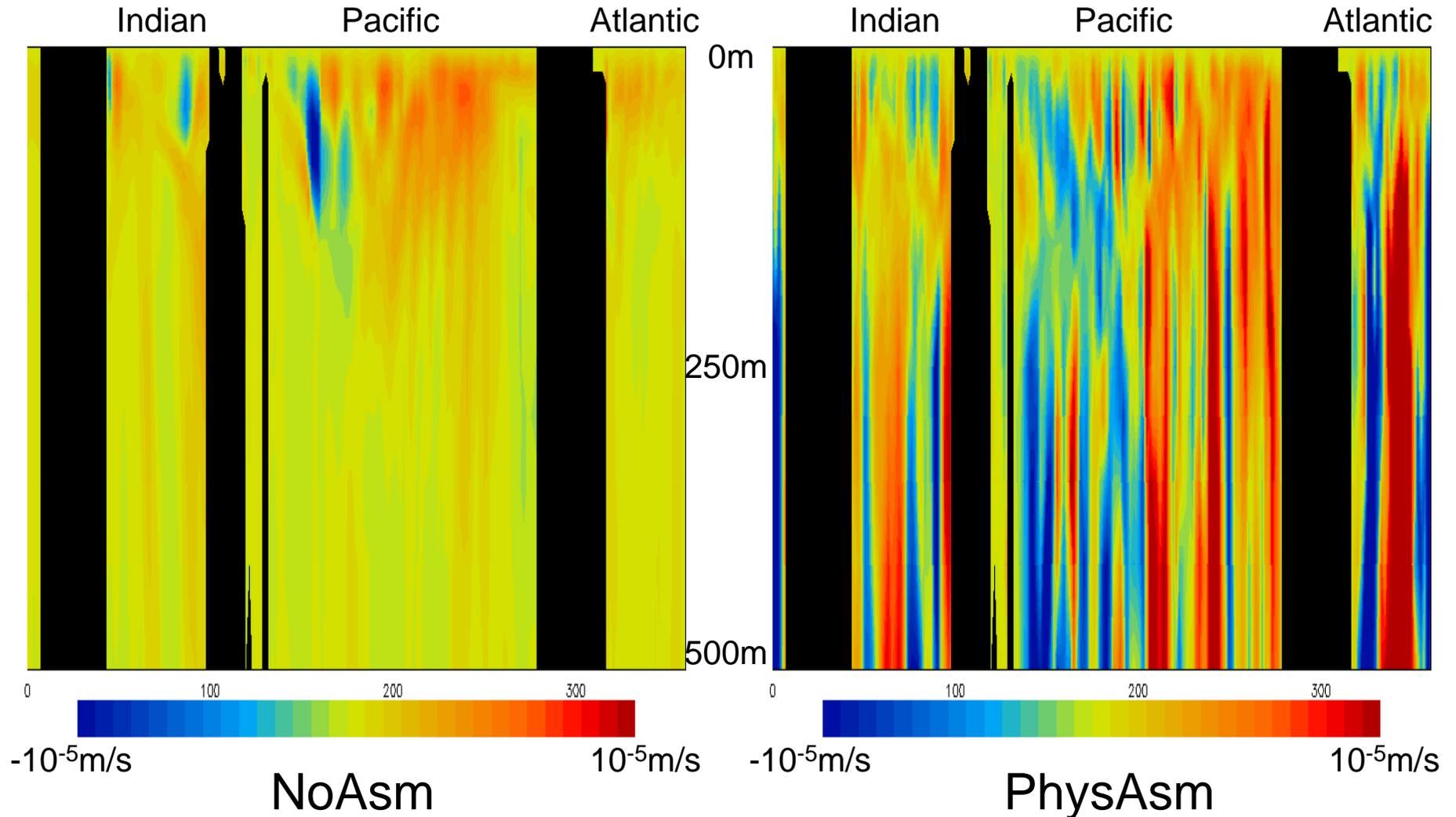


Nitrate at equator (December 2008 mean)





Vertical velocities at equator (December 2008 mean)





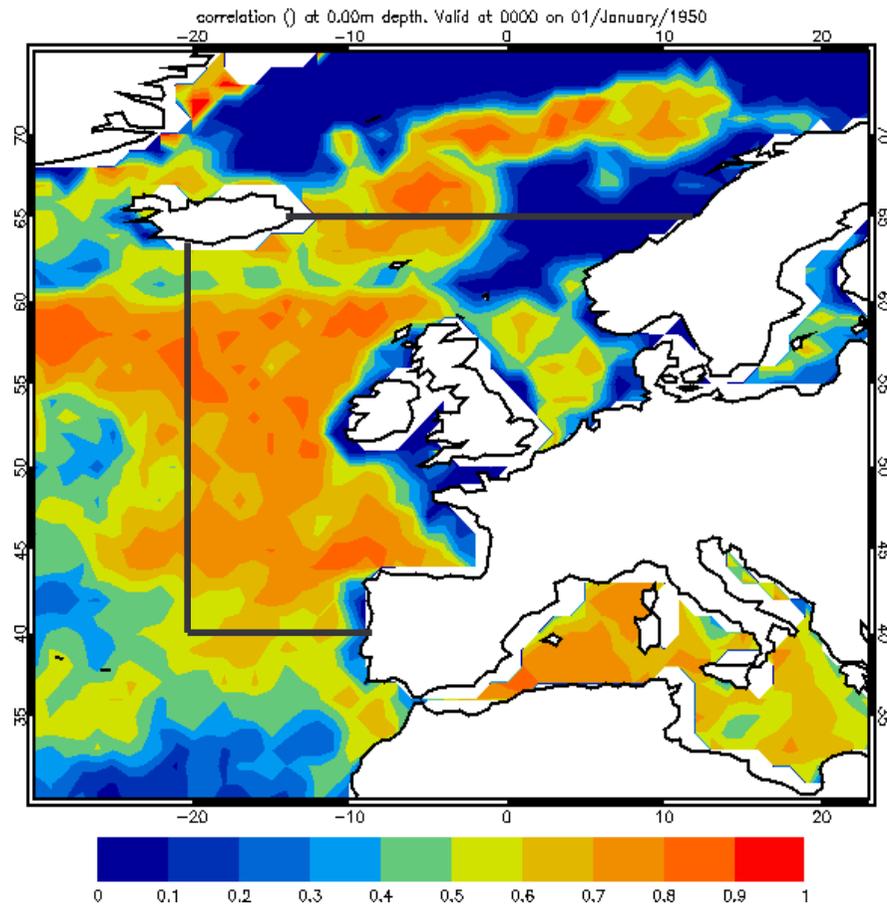
Topic 2 –

BGC developmental phase

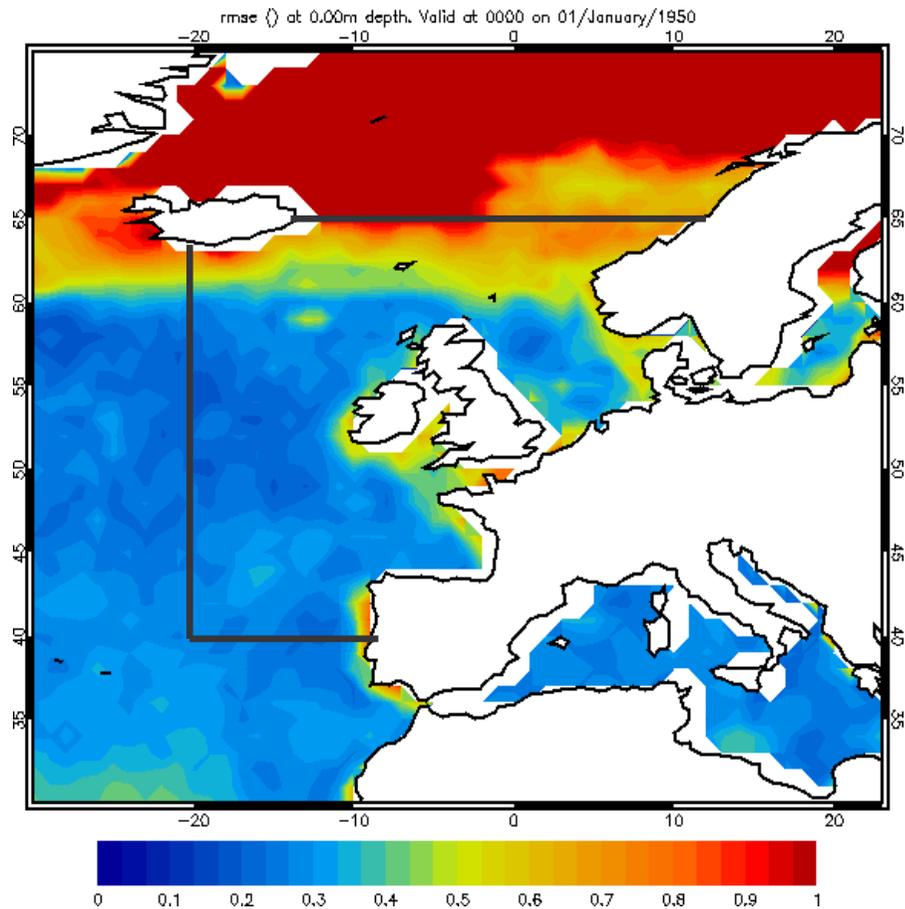


Deep ocean-coastal boundary conditions

Correlation



RMS error





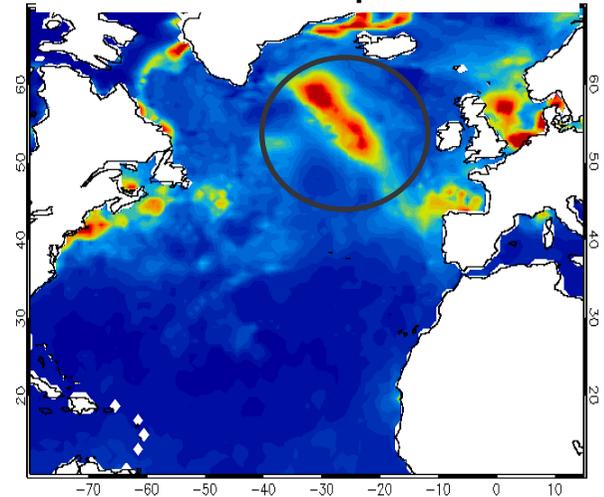
Topic 4 –

Multi-purpose observing system

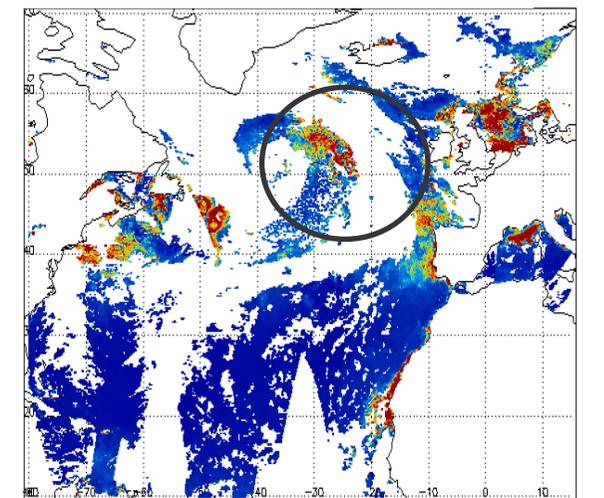
Is there a role for marine ecosystem models to play?

- Integration of models and observations is the key to a successful monitoring programme
 - Observation operators & **data assimilation** techniques are essential to improve models' performance and confidence in results
 - Model **re-analyses** offer the potential to provide high quality datasets that are also methodologically consistent. Re-analyses are key to:
 - understand and differentiate natural variability and climate trends
 - improve models and data gathering (biases)
 - Assist & inform the **design** of optimal **observational systems** via Observation System Simulation Experiments (OSSEs)

Model chl after assimilation of GlobColour L3 products



GlobColour L3 ocean colour





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Future work



The Future

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- Long (15 to 30-year) hindcasts in open ocean & shelf seas configurations
 - Seasonal/inter-annual variability & ICES annual fisheries assessments (**topic 1**)
 - Seamless coastal-deep ocean capability, e.g. LBCs (**topic 2**)
- Further development of bio data assimilation (topic 3)
 - Impact of physical data assimilation on biogeochemistry
 - Extension to shelf-seas configuration
- How does one assess and improve the reliability of the model predictions?
 - Comparisons between models
 - Comparisons with observations
 - Assessment of errors in “realistic” hindcasts



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Thank you!

Any questions ?