Optimising Global Physics-Biogeochemistry Reanalyses for Initialising Seasonal Forecasts

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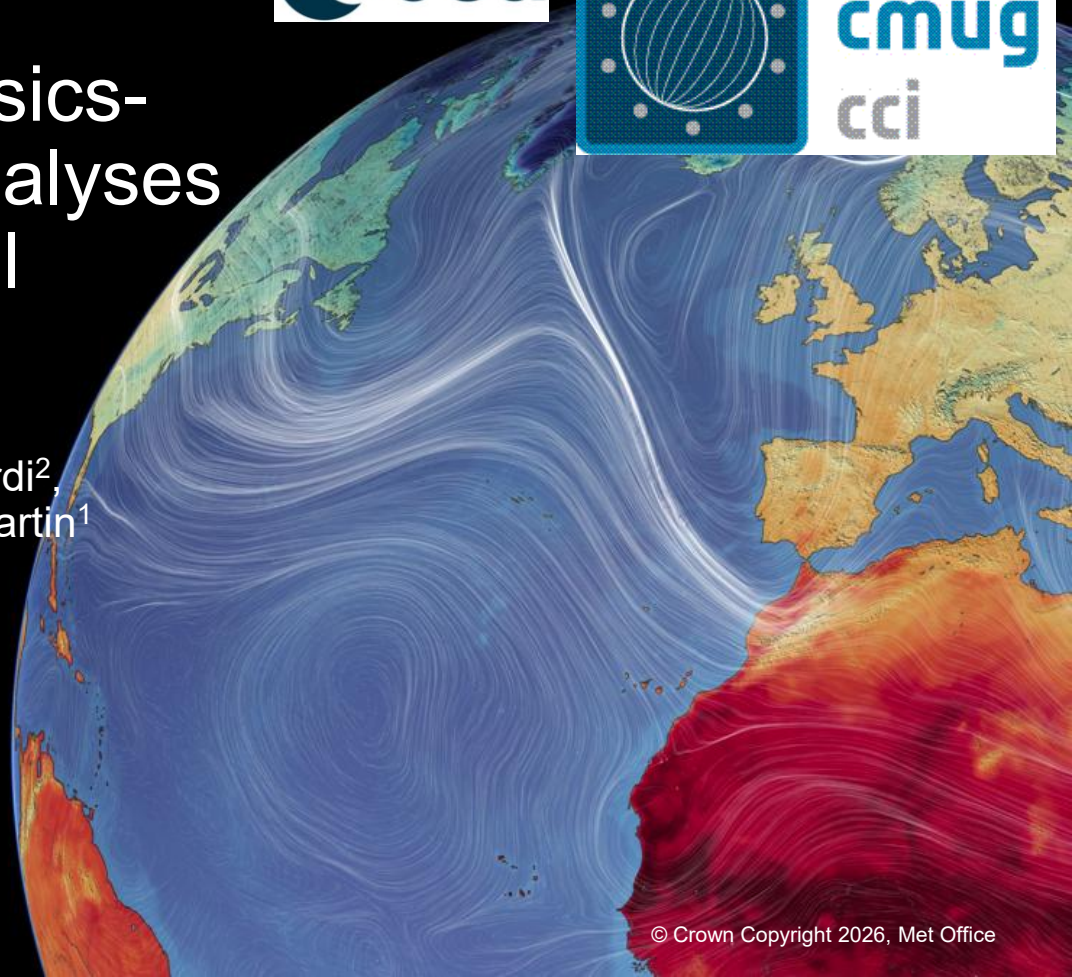
OceanPredict MEAP-TT

20 May 2026



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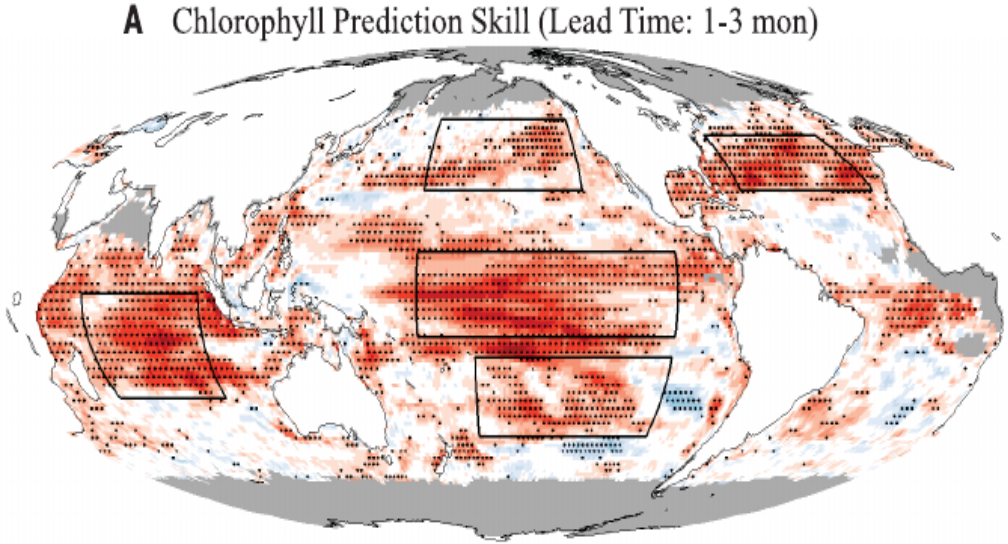
Seasonal forecasts of marine biogeochemistry

Requirements include:

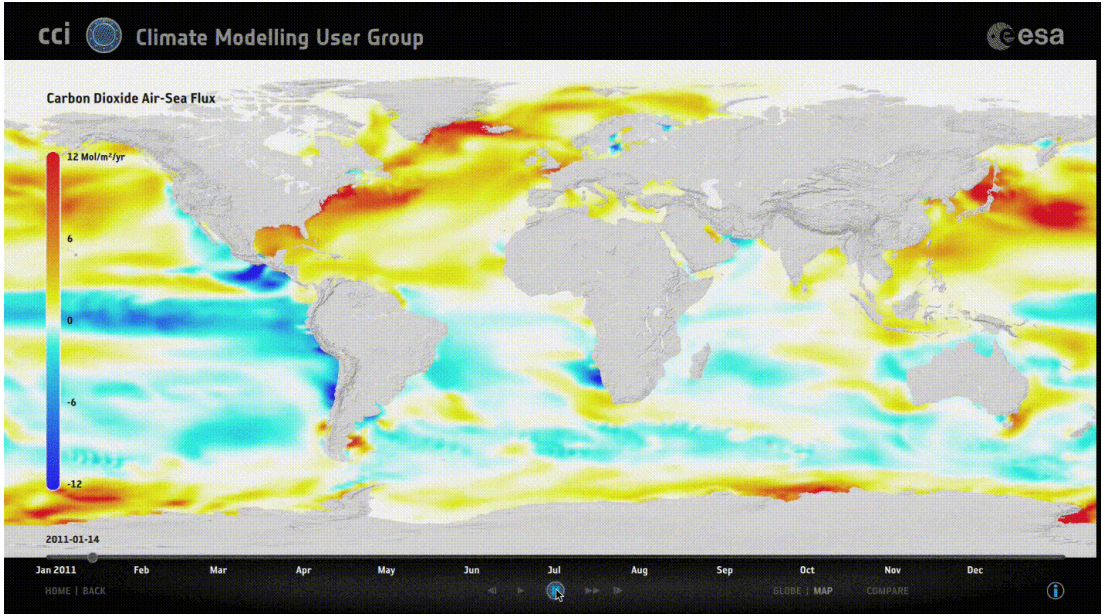
- Primary production for fisheries
- Ocean acidification extremes
- Hypoxia events
- Eutrophication
- Carbon uptake



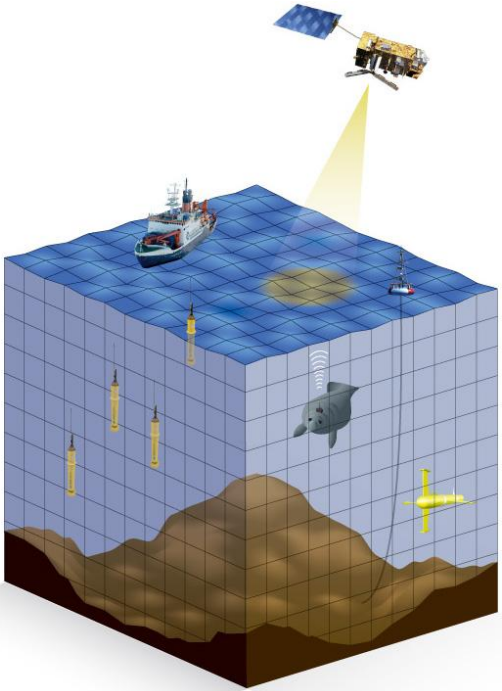
Park, J.-Y. et al., Science 2019, 365, 284–288

Coupled physics-biogeochemistry reanalyses

- Initialise and calibrate seasonal forecasts
- Understand and quantify climate variability
- Evolution of the ocean carbon sink



Data assimilation



https://www.ecmwf.int

https://www.esa.int

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Science questions

1. What is the value of assimilating ESA CCI data in generating initial conditions for seasonal predictions of ocean biogeochemistry?

2. What is the dominant factor at initialisation (the physical or the biogeochemical state) in determining predictive skill at global and regional scales?

3. What is the best strategy for constraining initial conditions to achieve the highest prediction skill in ocean biogeochemistry?

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Modelling systems (run ocean-only)

	BSC	Met Office
System	EC-Earth4	UKESM / GloSea / FOAM
Physics	NEMO	NEMO
Sea ice	SI^3	SI^3
Biogeochemistry	PISCES	MEDUSA
Assimilation	Nudging	NEMOVAR (3D-Var)
Resolution	1°	1/4°
Period	1998-2022	2016-2020

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BSC experiments (1998-2022)

	In situ temperature and salinity	Sea surface temperature	Sea surface salinity	Ocean colour
CONTROL	EN4			
SST_CCI	EN4	ESA CCI	ORAS5	
SST_CCI+PhyC	EN4	ESA CCI	ORAS5	ESA CCI-derived phytoplankton carbon

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Met Office experiments (2016-2020)

	In situ temperature and salinity	Sea surface temperature Sea ice concentration Sea level anomaly	Sea surface salinity	Ocean colour
FREE				
STANDARD	EN4	ESA CCI		
STANDARD+SSS	EN4	ESA CCI	ESA CCI	
STANDARD+SSS+OC	EN4	ESA CCI	ESA CCI	ESA CCI chlorophyll
STANDARD+SSS+OCbal	EN4	ESA CCI	ESA CCI	ESA CCI chlorophyll
SSS			ESA CCI	

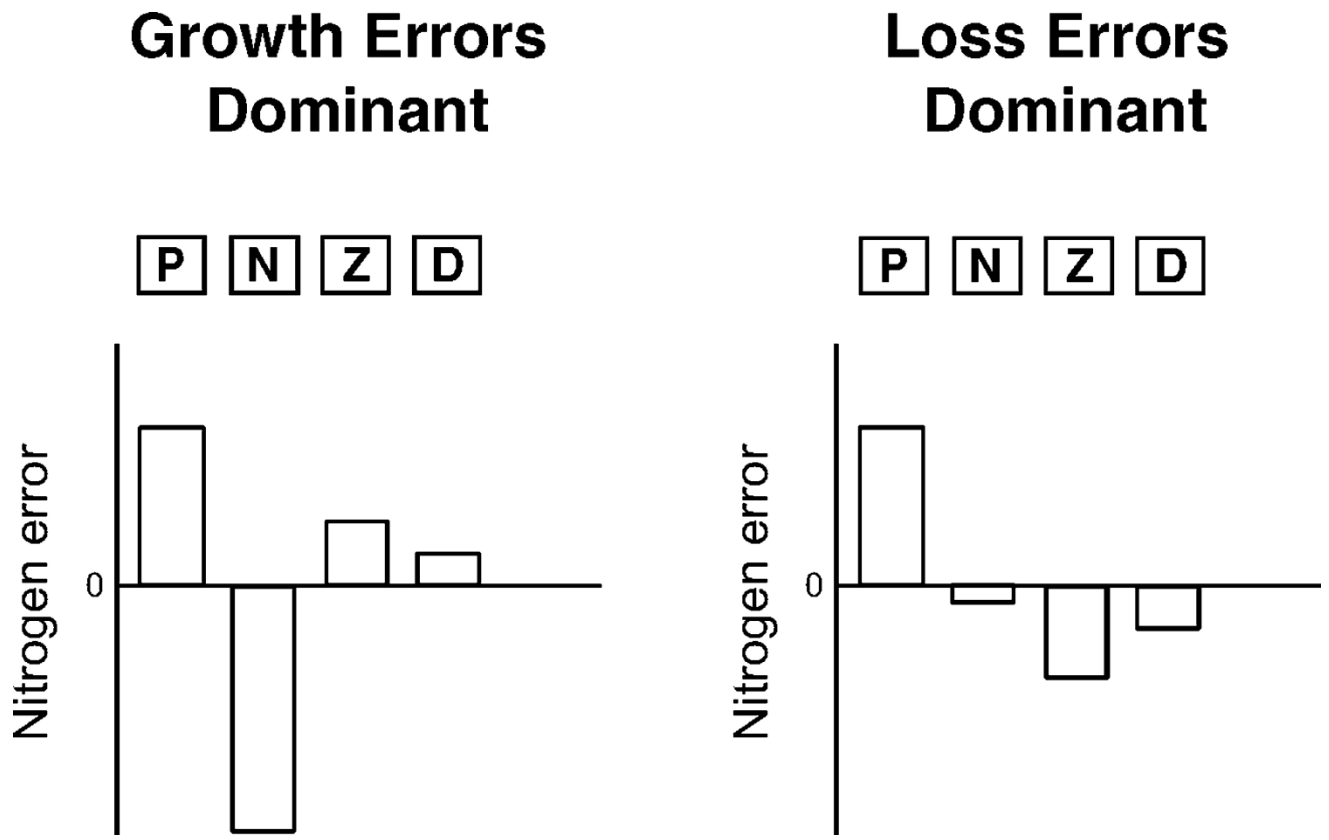
Nitrogen balancing

Home / Journal of Marine Research, Volume 66, Number 1

Ocean color data assimilation with material conservation for improving model estimates of air-sea CO_2 flux

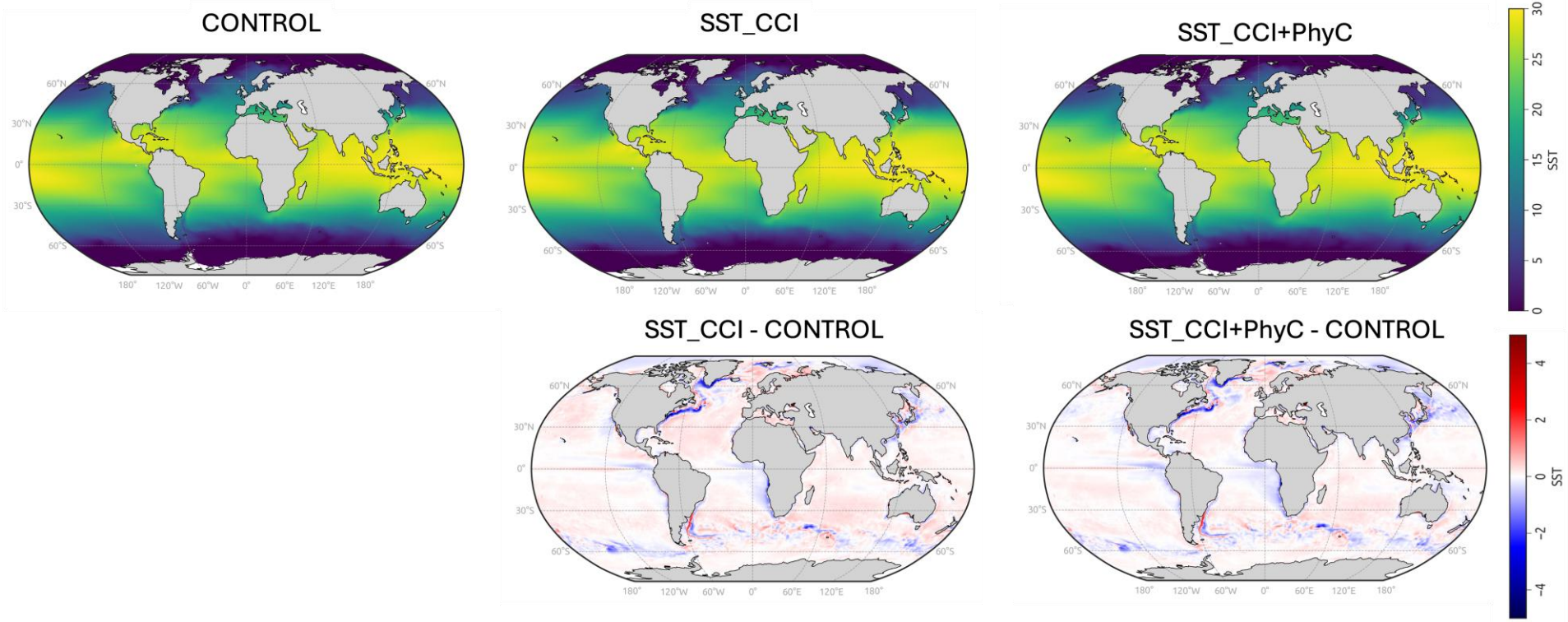
Authors: Hemmings, John C. P.; Barciela, Rosa M.; Bell, Michael J.
Source: Journal of Marine Research, Volume 66, Number 1, January 2008, pp. 87-126(40)
Publisher: Sears Foundation for Marine Research
DOI: https://doi.org/10.1357/002224008784815739

Nitrogen balancing

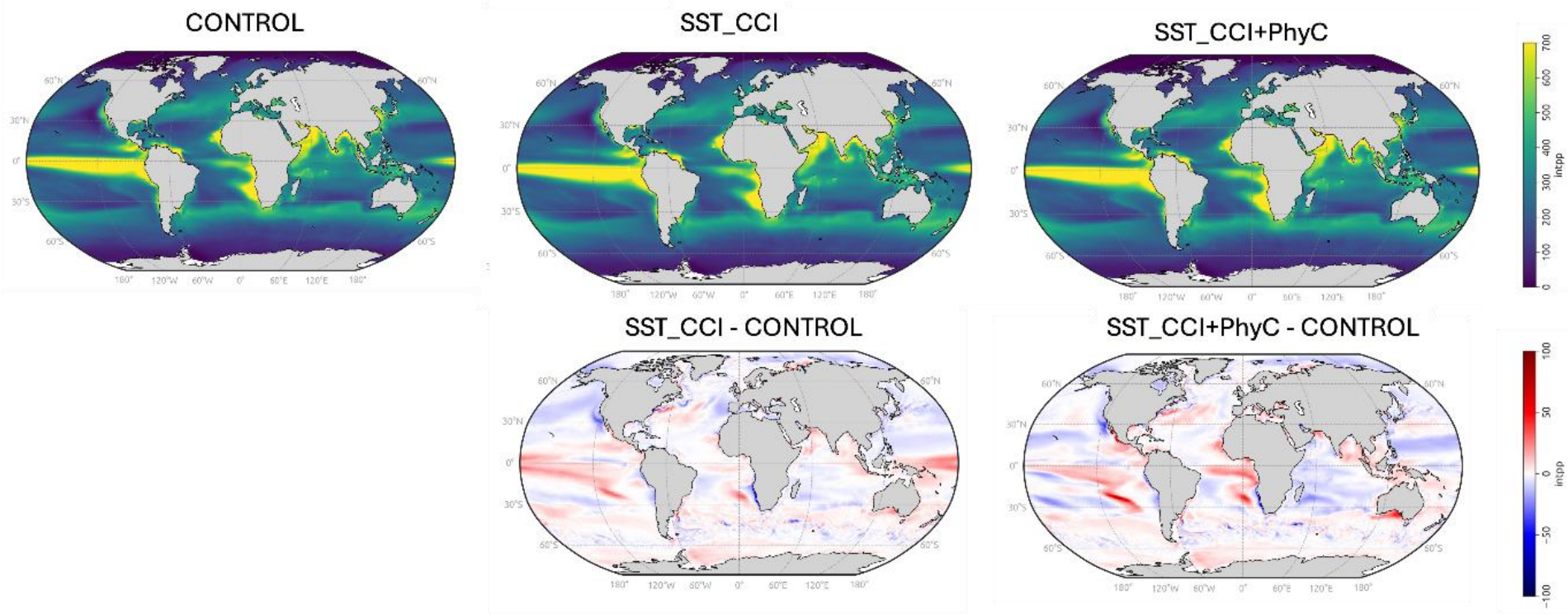


Hemmings et al., 2008, J. Mar. Res.

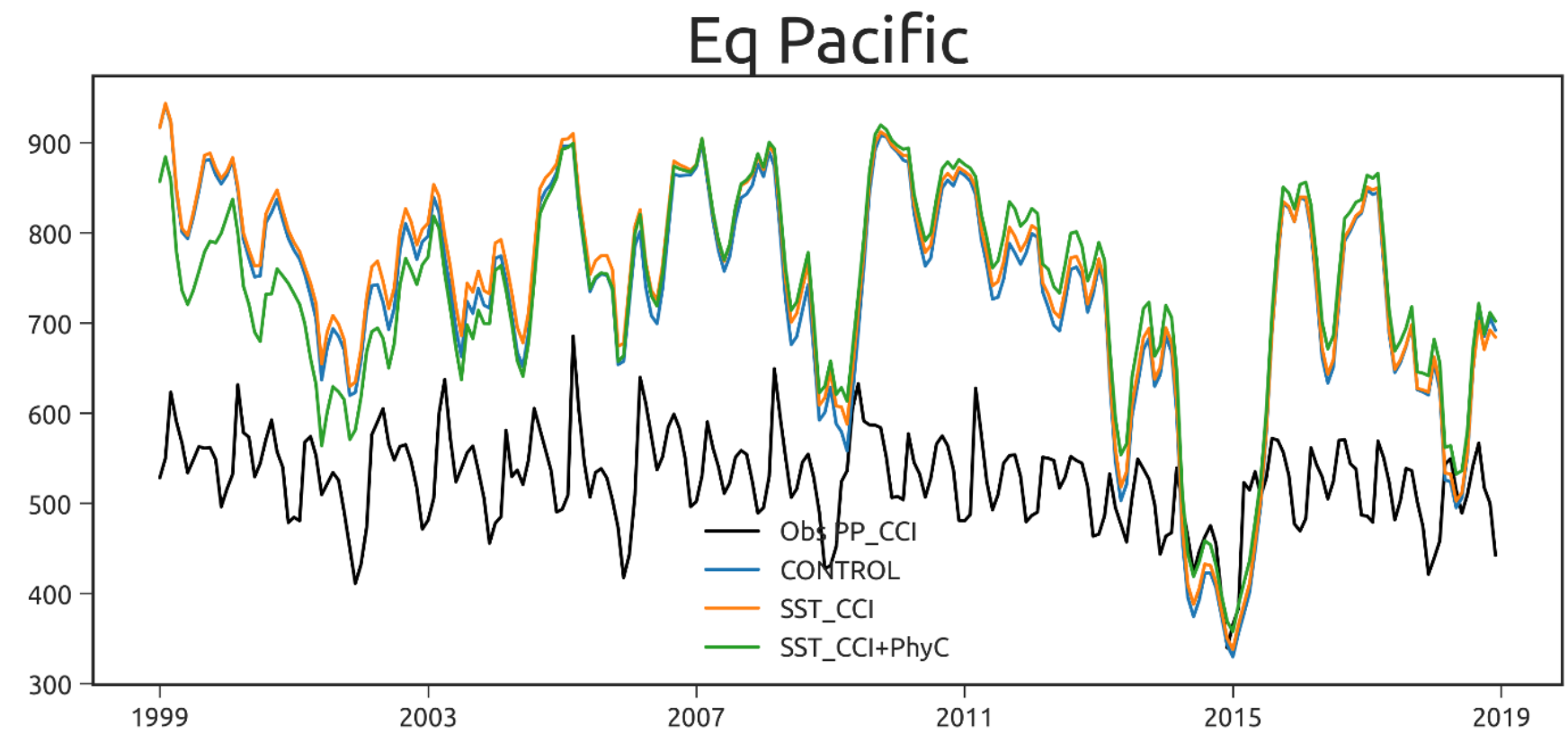
BSC: 2000-2019 mean SST



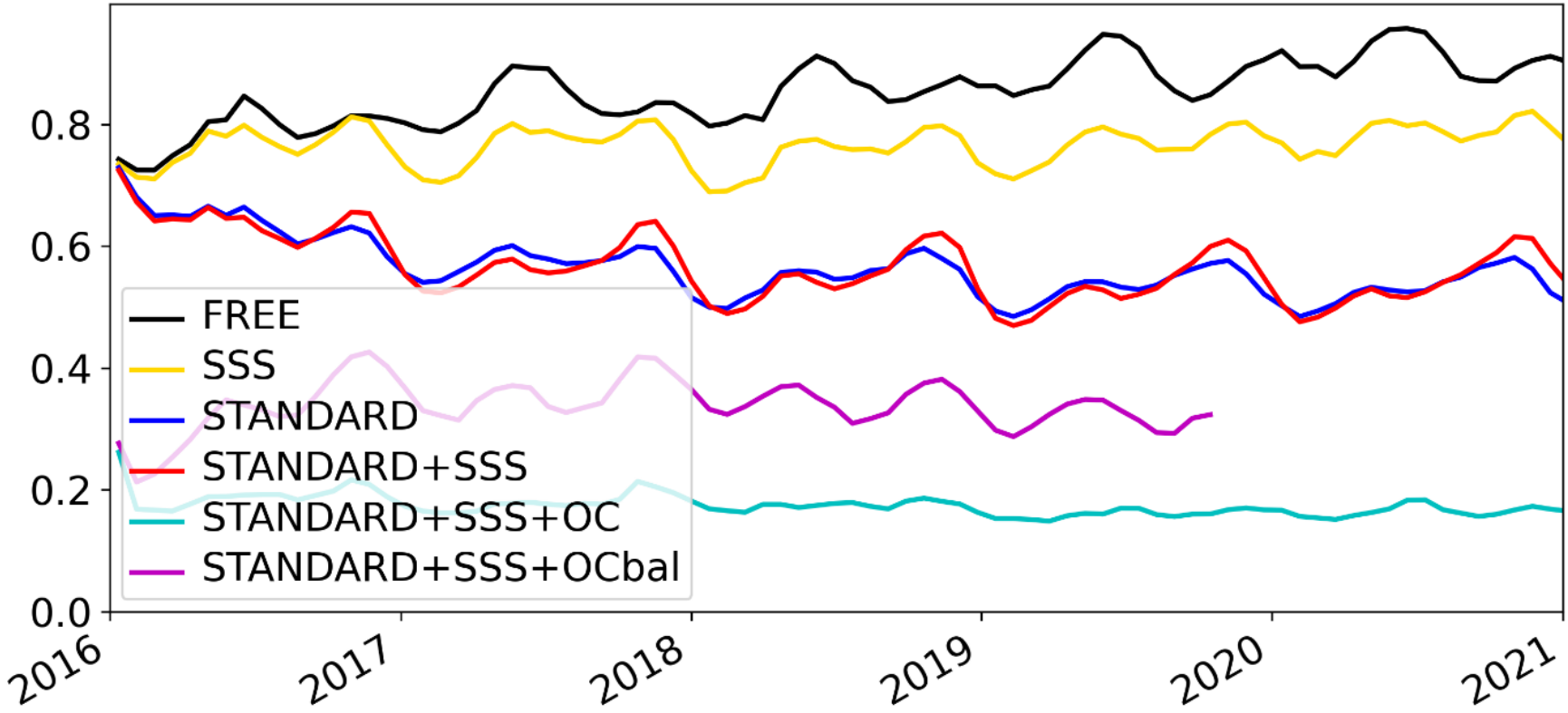
BSC: 2000-2019 mean integrated PP



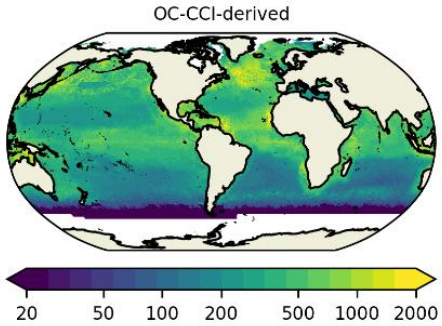
BSC: 2000-2019 integrated PP

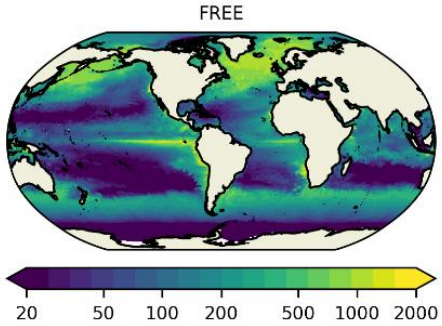


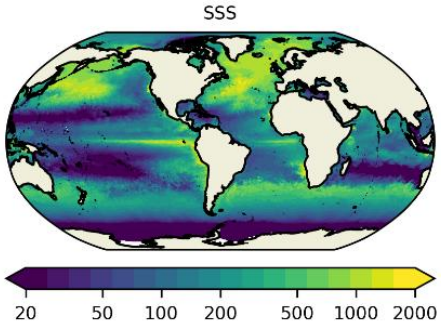
MO: Global surface $\log_{10}$(chlorophyll) (background RMSE vs CCI ocean colour)

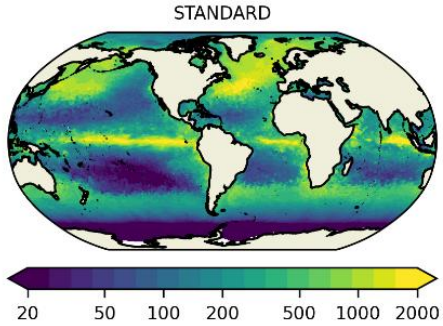


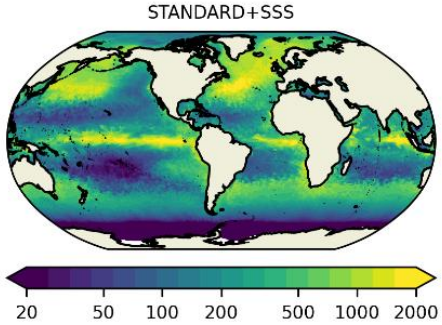
MO: June 2019 integrated PP (comparison to CCI-derived product)

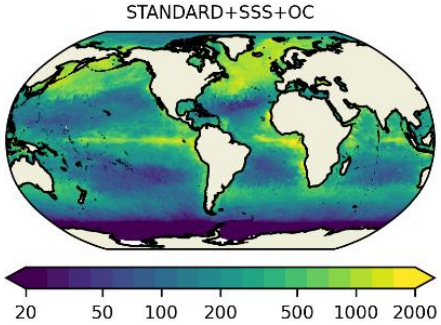


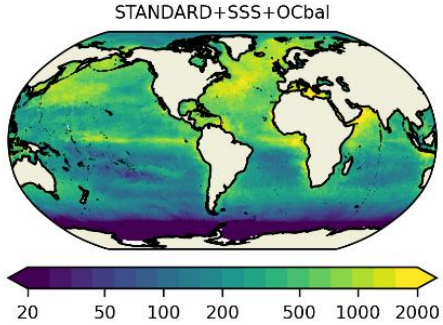




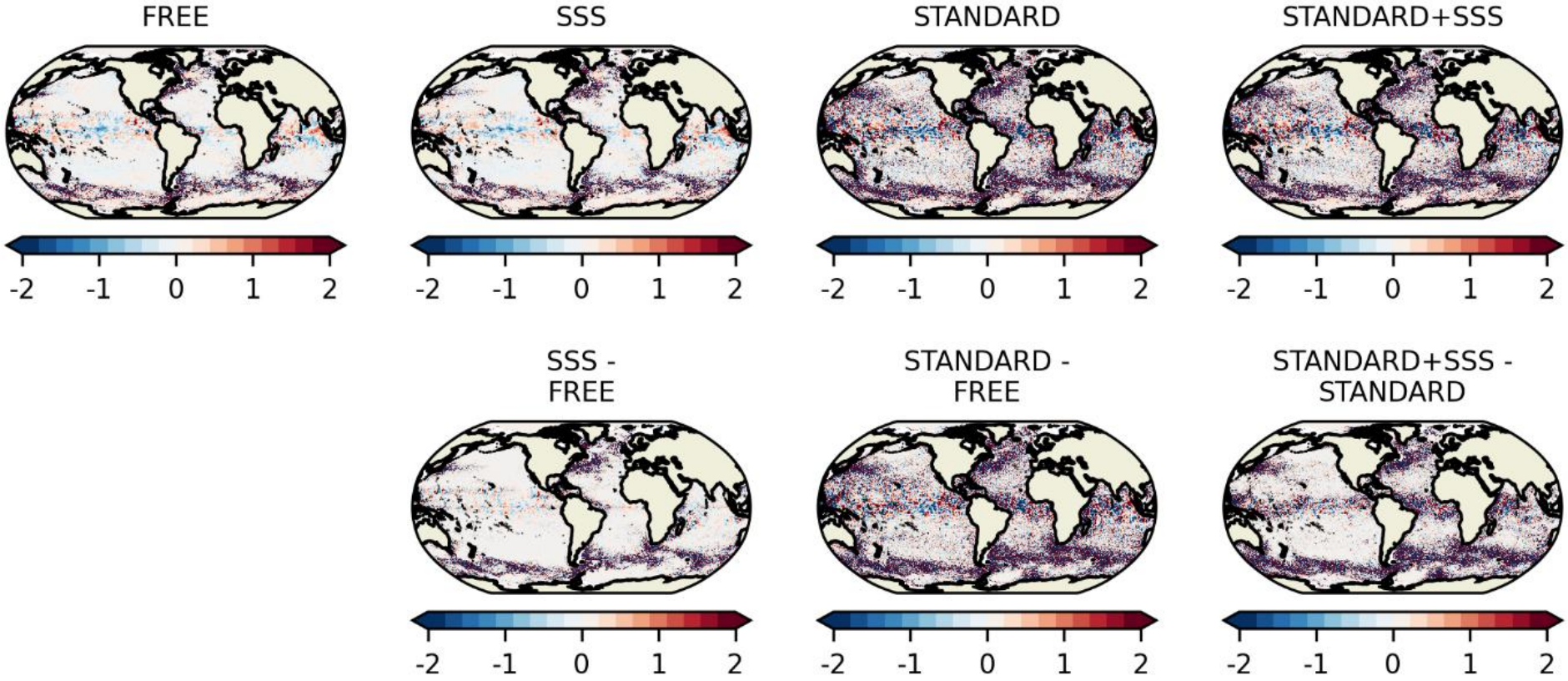




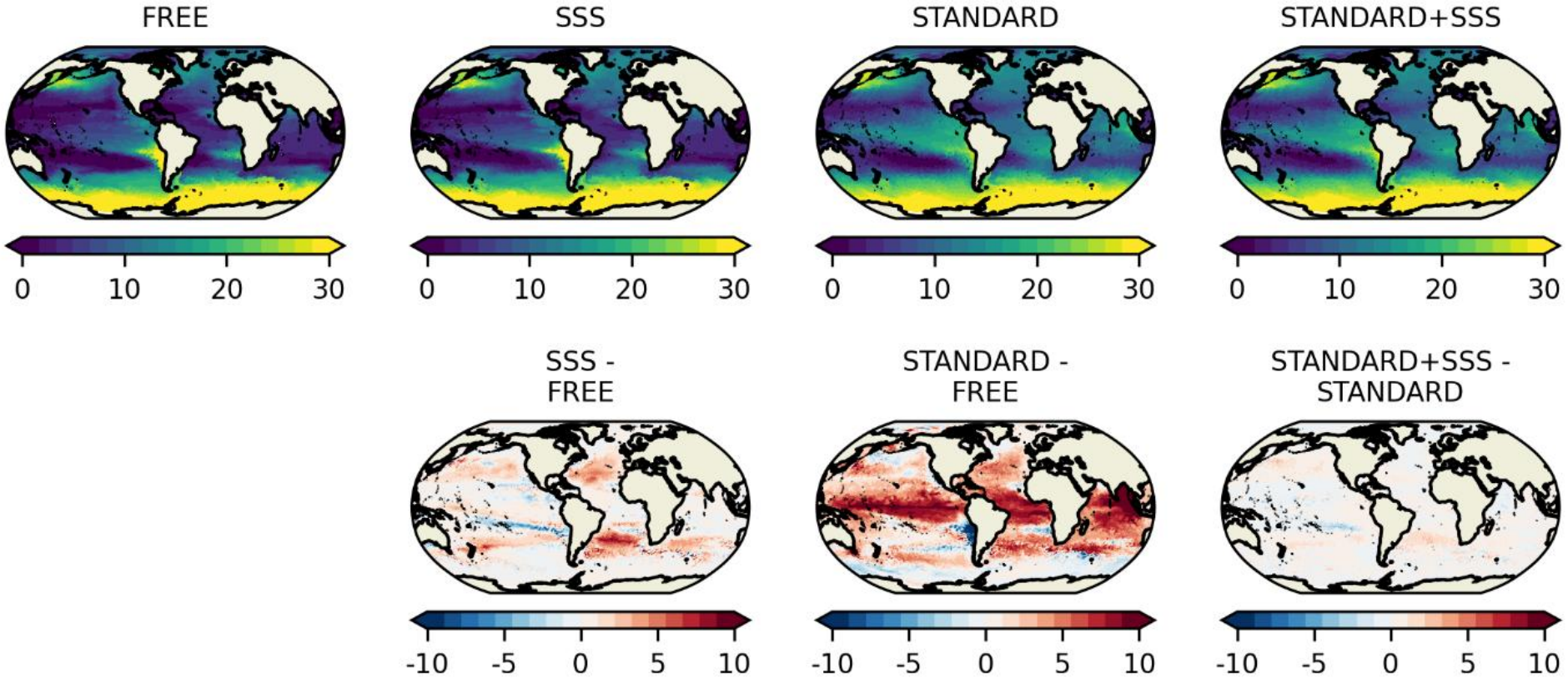




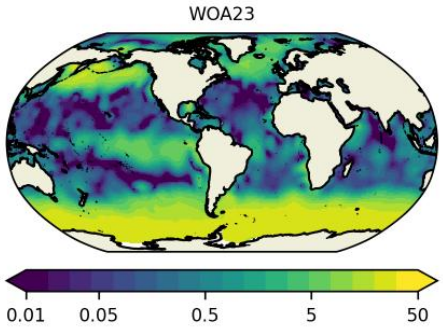
MO: June 2019 500m vertical velocity

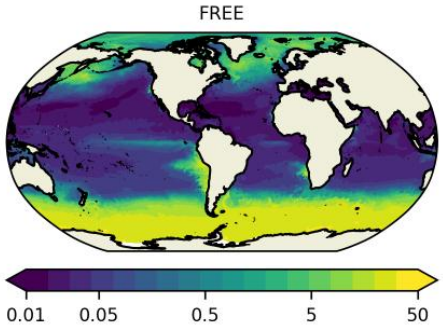


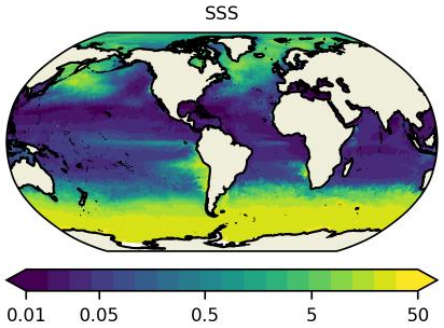
MO: June 2019 surface passive tracer

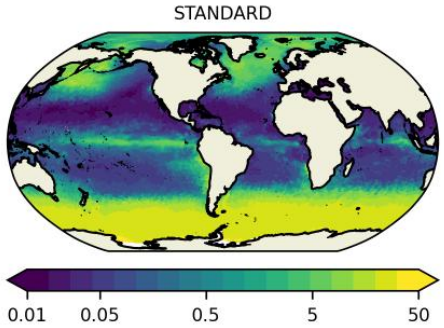


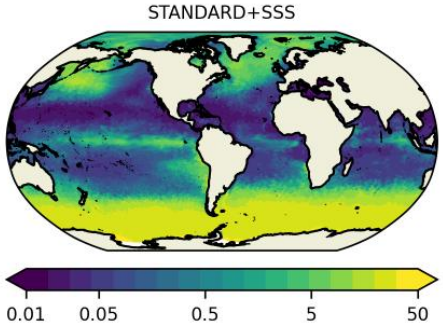
MO: June 2019 nitrate (comparison to World Ocean Atlas)

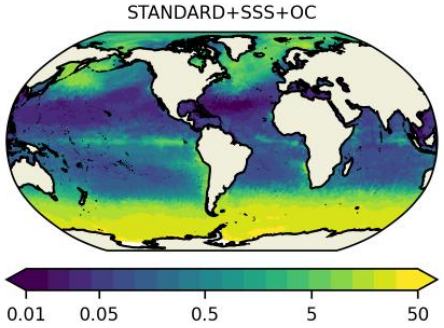


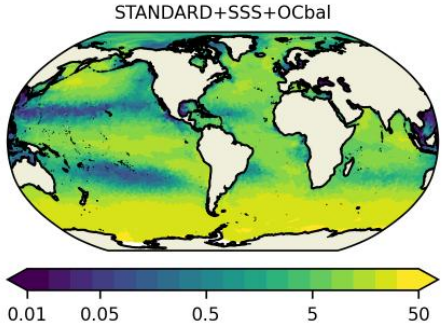




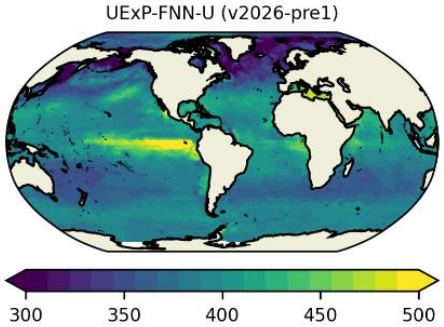


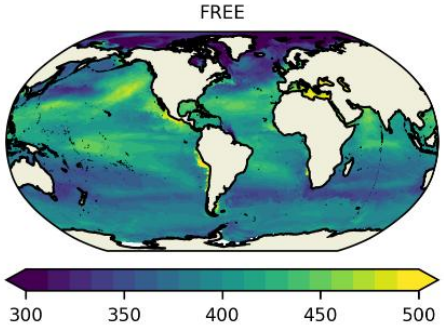


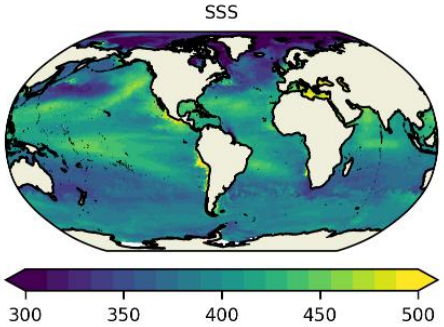


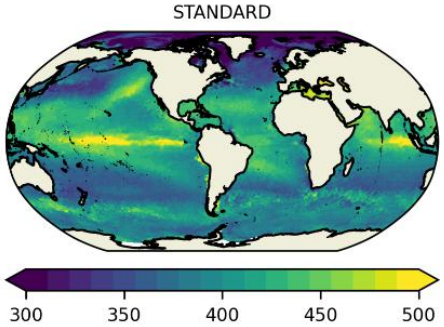


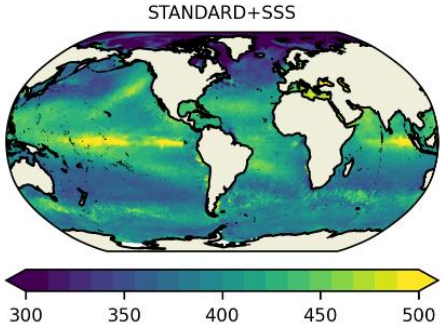
MO: June 2019 fCO_2 (comparison to OC4C machine-learnt product)

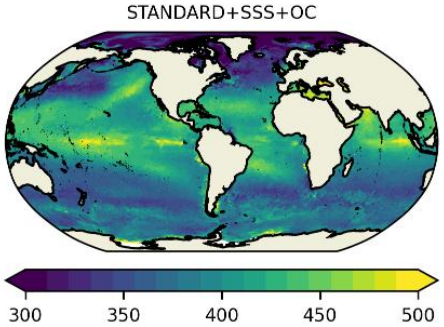


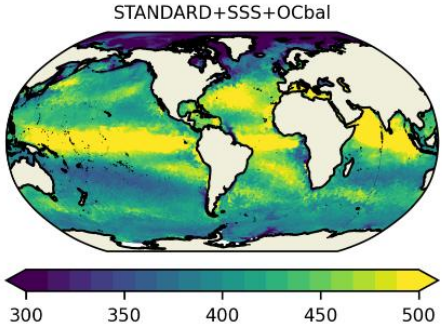




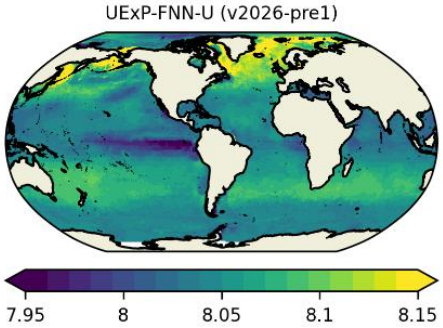


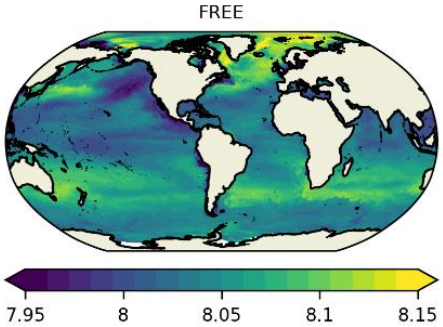


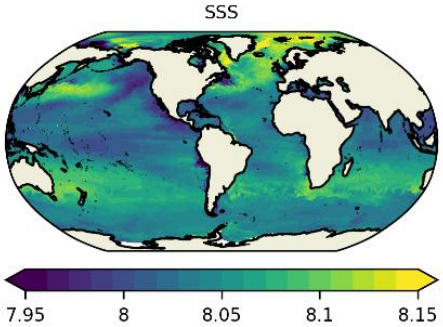


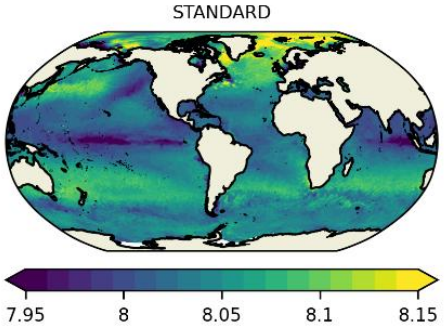


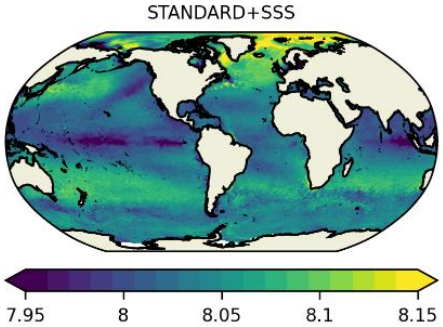
MO: June 2019 pH (comparison to OC4C machine-learnt product)

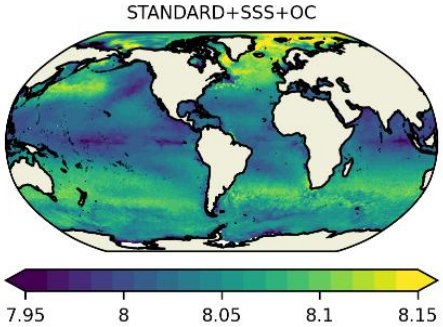


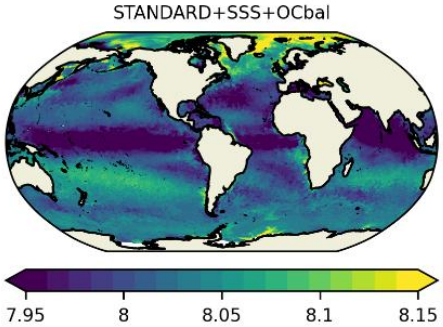












- **Summary**
  - Assimilated different satellite data with two reanalysis systems

- **Conclusions**
  - Physics and biogeochemistry assimilation have distinct impacts
  - Just updating surface fields insufficient to constrain system
    - But 3D multivariate updates can degrade as well as improve
  - Need for high temporal resolution data (along-track or daily)
    - Phytoplankton carbon products currently monthly

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- **Next steps: reanalysis experiments**
  - Turn final ESA CMUG report into a journal paper
  - Further investigate impact of physics assimilation
  - Further investigate multivariate balancing (also with regional ERSEM)

- **Next steps: seasonal forecasting**
  - Couple MEDUSA to full ocean-atmosphere GloSea seasonal forecasting system (in progress!)
  - Run seasonal reforecasts using reanalyses as initial conditions
  - Assess potential ocean biogeochemistry seasonal forecasting skill

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Questions?