WP5.4: Seasonal predictability of ocean biogeochemistry and potential benefits of ESA CCI data assimilation

Partners: Met Office (David Ford) and BSC (Pablo Ortega + TBC)

ECVs: SST, SSS, Sea Ice, Sea Level, Ocean Colour

Models: EC-Earth3-CC and GloSea6/MEDUSA

Tentative start date: April 2024

- WP1: Assimilation of ESA CCI variables to produce reconstructions
  - Subtask 1.1: assimilate only physical CCI variables
  - Subtask 1.2: assimilate physical and biogeochemical CCI variables
- WP2: Impact of assimilation choices of these reconstructions on physical and biogeochemical properties
  - Subtask 2.1: evaluate physical properties of reconstructions
  - Subtask 2.2: identify best strategy to reconstruct ocean biogeochemistry
- [Option, unfunded] WP3: Impact of assimilation choices of these reconstructions on seasonal predictions
  - Subtask 3.1: production of seasonal predictions
  - Subtask 3.2: evaluation of seasonal predictions

Seasonal predictability of ocean biogeochemistry and potential benefits of ESA CCI data assimilation

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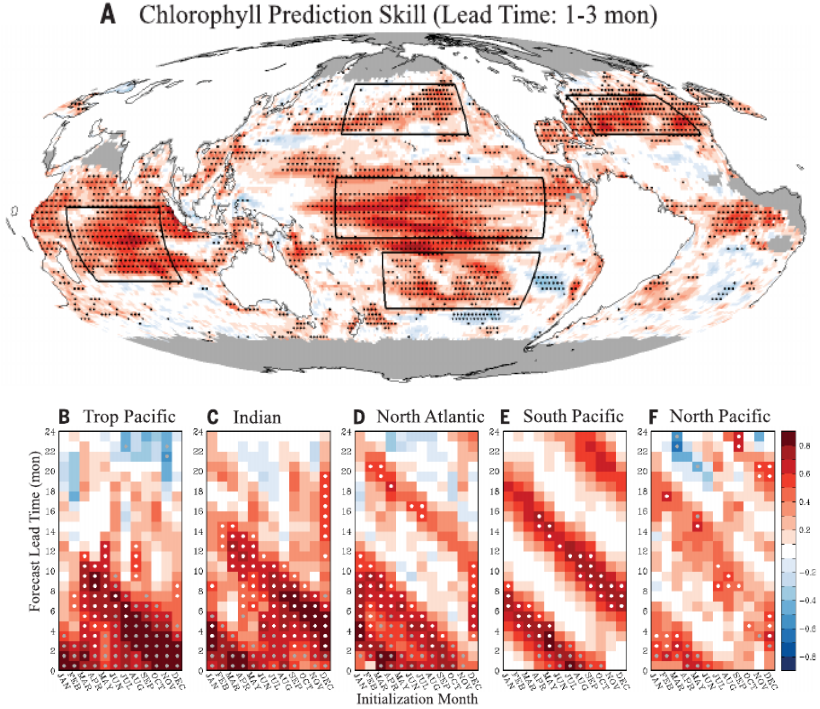
[1]Met Office, [2]Barcelona Supercomputing Centre

(thanks to Eleftheria Exarchou, formerly of BSC, for leading on the proposal)

CMUG CCI+ Phase 2 Kick off meeting, 18 September 2023

ESA CCI data assimilation impact on seasonal predictability of ocean biogeochemistry - background

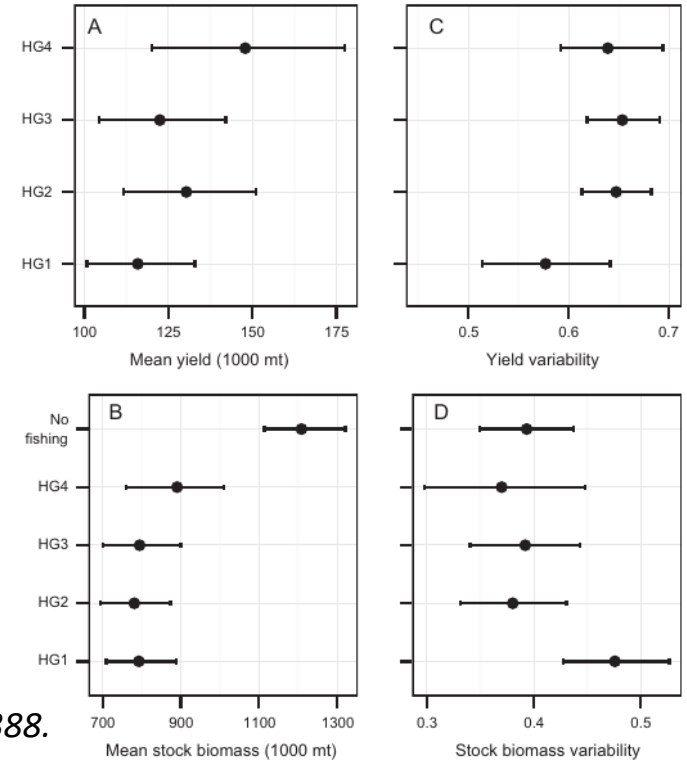
Recent progress in Earth System Models (ESM), in particular the incorporation of biogeochemistry in the ocean models, has enabled the use of ESMs for predicting changes in key biogeochemical variables that act as ecosystem drivers (e.g., pH, oxygen, net primary production, chlorophyll) at seasonal to decadal time scales.



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

ESA CCI data assimilation impact on seasonal predictability of ocean biogeochemistry - background

Such ESM-based predictions have the potential to be used for predicting variations in fish populations and yields, and provide useful information to aquaculture, fishers and policy makers.

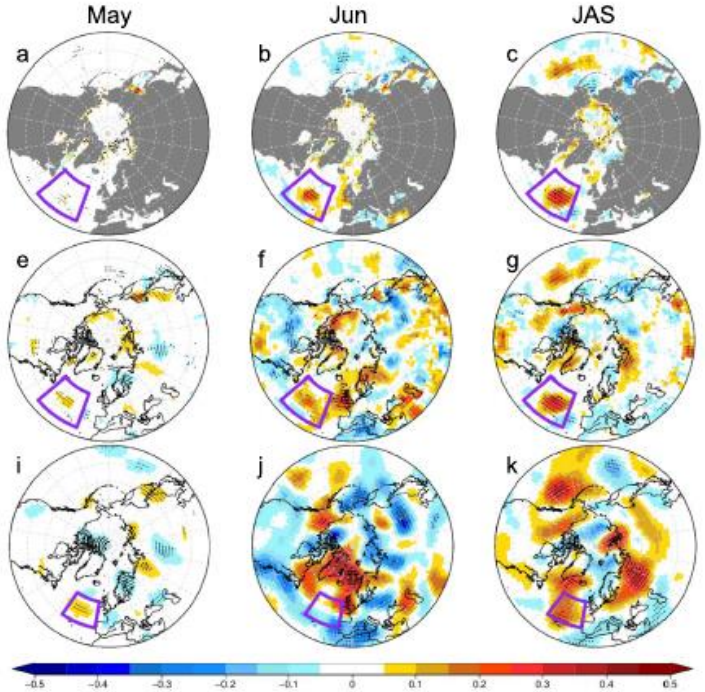


Tommasi, D.et al., Ecological Applications, 2017, 27(2), 378–388.

ESA CCI data assimilation impact on seasonal predictability of ocean biogeochemistry - background

Seasonal predictions are commonly initialized from reanalyses that assimilate observations into the dynamical forecasting systems.

Assimilation of CCI Sea Ice Concentration (WP3.8 in the previous phase of CMUG) demonstrated added value on summer prediction in the Northern Hemisphere

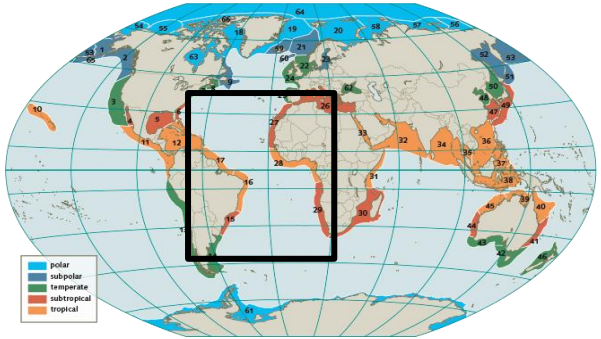


J C Acosta Navarro et al 2022 Environ. Res. Lett. 17 064008

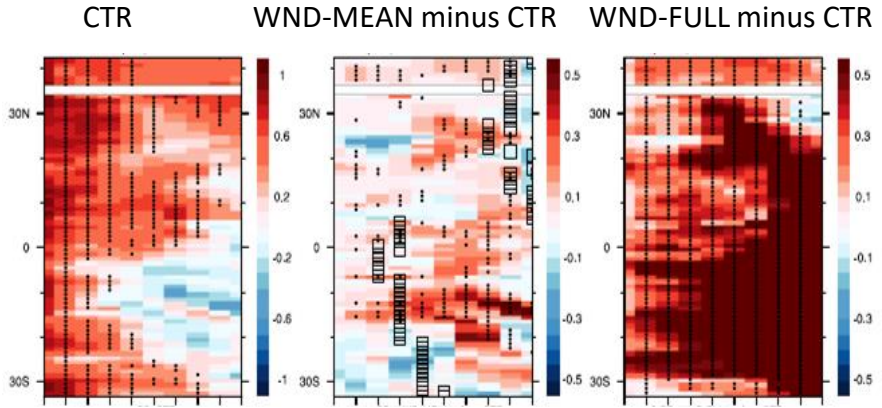
ESA CCI data assimilation impact on seasonal predictability of ocean biogeochemistry - state-of-the-art in EC-Earth3-CC

$$(\overline{\tau}+\tau)'_{mod} \longrightarrow (\overline{\tau}+\tau)'_{obs}$$

$$(\overline{\tau}+\tau)'_{mod} \longrightarrow \overline{\tau}_{obs} + \tau'_{mod}$$



Mean state wind stress correction leads to a modest but significant improvement in predictive skill in ecosystem drivers (SST, Chlorophyll, PP). Correcting the full field leads to large predictive skill, demonstrating the dominant role of the wind in ocean BGC.



ESA CCI data assimilation impact on seasonal predictability of ocean biogeochemistry - science questions

- What is the value of assimilating physical (e.g., SST, SSS) and biogeochemical (OC or OC-derived) CCI ocean ECVs in seasonal predictions of ocean biogeochemistry?

- What is the dominant factor at initialization (the physical or the biogeochemical state) in determining the ocean biogeochemistry predictive skill at global and regional scales?

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

ESA CCI data assimilation impact on seasonal predictability of ocean biogeochemistry - Methodology

- WP1: Assimilation of ESA CCI variables (SST, Sea Ice, SSS, Sea Level, Ocean Color) to produce reconstructions
  - Subtask 1.1: assimilate only physical CCI variables
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- [Option, unfunded] WP3: Impact of assimilation choices of these reconstructions on seasonal predictions
  - Subtask 3.1: production of seasonal predictions
  - Subtask 3.2: evaluation of seasonal predictions (e.g., ACC, RMS Skill Score)

ESA CCI data assimilation impact on seasonal predictability of ocean biogeochemistry - Methodology

- Assimilation of ESA CCI variables (SST, Sea Ice Concentration and Ocean Color) to produce forced ocean/sea-ice reconstructions with **EC-Earth3-CC & GloSea6/MEDUSA** predictions systems. E.g.,

Reconstruction 1	Assimilation of physical variables: **CCI SST, CCI SIC** & 3D ocean temperatures from EN4 below the ocean mixed layer
Reconstruction 2	Additional assimilation of **CCI OC** to determine the role of non-physical variables to BGC predictability.
Reconstruction 3	Additional assimilation of **CCI SSH, SSS** & 3D ocean salinity from EN4 (GloSea6/MEDUSA)

ESA CCI data assimilation impact on seasonal predictability of ocean biogeochemistry - Overview of ECV

ECV	Product	Time Span	Resolution	Use of the Dataset
SST	ESA L4 v2.1 (new version v3)	01/1982-Present	0.05° (daily)	• Assimilation • Skill assessment
SSS	ESA v03.21	01/2010-09/2020 (end of 2021, available at beginning of 2023)	25km (monthly) (effective resolution is 50 km)	• Assimilation • Validation of reconstruction
Sea Level	C3S CMEMS L4	01/1993-08/2021 01/1993-12/2020	0.25° (daily) 0.25° (daily)	• Validation of reconstruction • Skill assessment
Sea Ice	SIC-OSISAF SIT C3S	01/1979-Present 10/2002-Present (only for winter Northern Hemisphere October through April)	25 km (daily) 25 km (monthly)	• Assimilation • Validation of reconstruction • Skill assessment • Validation of reconstruction • Skill assessment
Ocean Colour (primary production, phytoplankton carbon, others?)	OC-CCI v5.0	09/1997-07/2021	4km (daily)	• Assimilation • Validation of reconstruction • Skill assessment

ESA CCI data assimilation impact on seasonal predictability of ocean biogeochemistry - Methodology

- Seasonal climate predictions, initialized from each reconstruction, will be performed using **EC-Earth3-CC & GloSea6/MEDUSA predictions systems.**

- Prediction skill of OBGC will be assessed with **CCI OC & ESA-derived PP & phytoplankton carbon data,** GLODAP carbon and nutrient data, and SOCAT carbon data.

- Other variables related to the carbon cycle, e.g. pH, will be assessed against in-situ data, or **ESA-OceanSODA** project (depending on availability)**.** Skill in physical variables will be assessed with **CCI SSH, SIC & SIT data.**