

Motivation

- Discrepancies between models and observation-based estimates for the ocean carbon sink. Observation-based estimates also differ from direct observations due to sparse sampling.
- Ventilation and mixing biases, characterized by depth gradients, impact modelled CO₂ fluxes.
- The high vertical resolution of BGC-Argo data allows to detect these mixing biases.
- There is a need to reconcile CO₂ flux estimates and ocean models using direct observations and not using observation-based flux estimates.
- We investigate origins of biogeochemical biases in ocean models, as a basis for improving the DIC interior budget and consequently the air-sea CO₂ fluxes.
- Create a dataset of metrics based on direct observations to evaluate the ocean biogeochemical content and ventilation in FESOM-RECoM.
- Separate biases in:
 - Profiles: biases in circulation and biological processes → natural carbon
 - Depth gradients: biases in ventilation processes → anthropogenic carbon

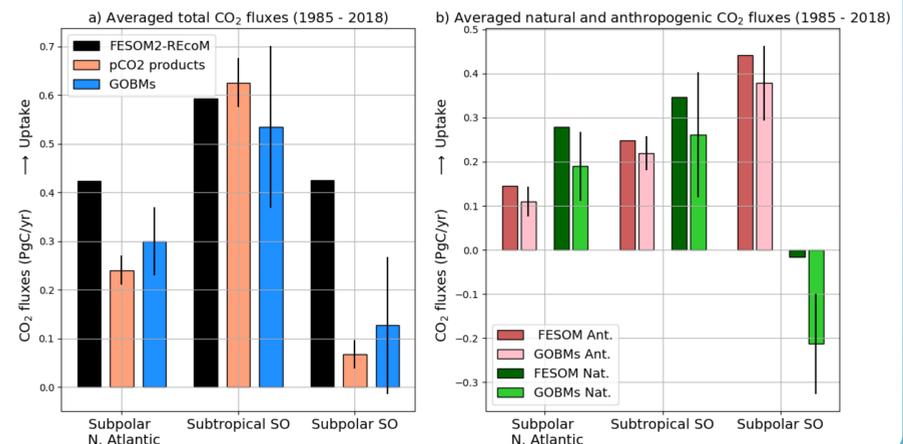
Conclusions and next steps

1. Biases' impact on natural carbon:

- Too low carbon and nitrate contents above 1000 m → nutrient and carbon trapping at depth. Correlation with a low DIC - C* and Apparent Oxygen Utilization → too weak remineralization in the upper ocean.
- Biases are advected across biomes (not shown) → errors in circulation also affect carbon and nutrient contents.
- Natural carbon is strongly impacted by the circulation and remineralization biases.

2. Biases' impact on anthropogenic carbon:

- We need more ventilation at the surface in high latitude biomes → change the mixing schemes to adjust the depth range of maximum stratification. Overall the surface gradient is reasonably well represented.
- Natural carbon (profiles) is more biased than anthropogenic carbon (gradients).



Methods

Ocean Model FESOM-RECoM:
~1° resolution, with biogeochemistry component and historical carbon.



Observations:

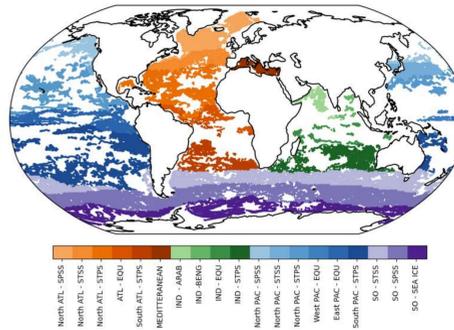
- BGC-Argo
- GLODAP

Variables: Density (ρ), Dissolved Inorganic Nitrate (DIN), App. Oxyg. Utilization (AOU), Dissolved Inorganic Carbon (DIC), Alkalinity (TA),

$$C^* = DIC - r_{C:O2} * AOU - \frac{1}{2} * (TA + DIN)$$

~ preformed DIC,
DIC - C* = biological processes (DIC_{bio})

BGC-Argo available profiles (for temperature)



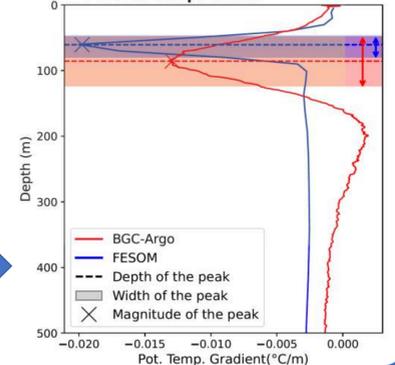
I. Processing:

- Division into RECCAP2 biomes
- Selection of model grid points to match observations in space and time → direct comparison.

II. Metrics:

- Detect the maximum of variable depth gradient → gradient peak.
- Measure its magnitude, depth and width

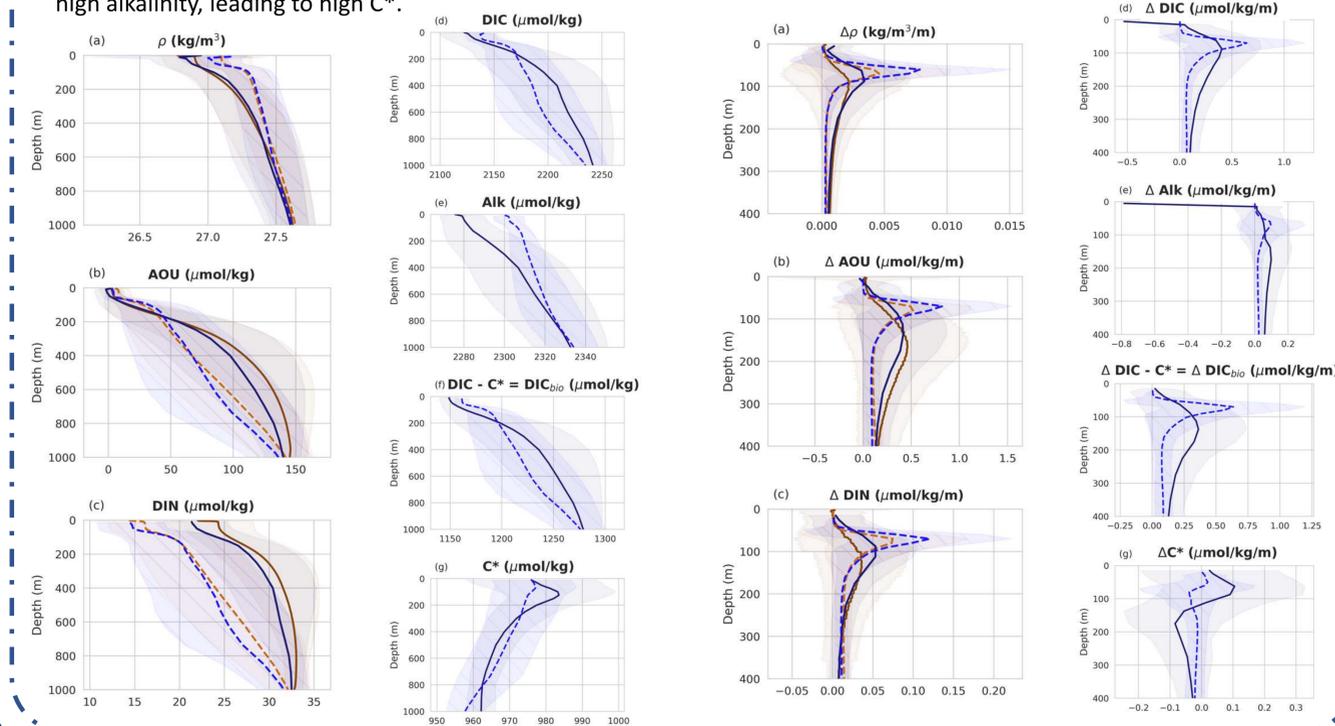
Metrics computation



Results

① Case Study: Subpolar Southern Ocean Profiles

- Too high density (top 600m).
- Mid-depth biases in biogeochemical variables: locally low remineralization.
- Very low nitrate close to the surface (nutrient trapping at depth) but reasonable surface DIC, with compensating high alkalinity, leading to high C*.



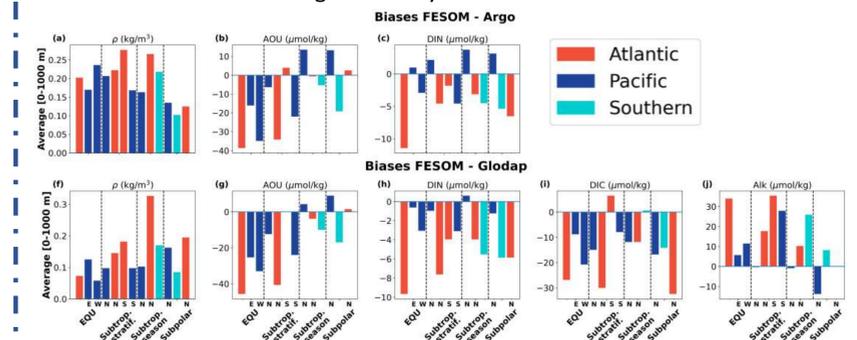
Depth Gradients

- Larger, narrower and shallower gradient peaks above 400 m → more stratified close to the surface (ca 50-80m), less stratified below the stratification peak.
- Larger gradient below 400 m for the biogeochemical variables → different depth ranges of remineralization between model and observations.

② Global biases: FESOM-RECoM minus observations

Profiles biases

- Large positive density bias → less stratified water column in the top 1000 m.
- Negative biases in biogeochemical variables in most biomes → low remineralization. Too high alkalinity in the model.



Gradient peak biases

- Too low magnitude of peak in lower latitudes VS too high in the high latitudes in the model → too little surface mixing in highly mixed regions (maximum of stratification).
- Too shallow depth in the density peak but not in the biogeochemical variables, affected by the biology.
- Narrower depth of strong stratification in the model (except in equatorial biomes).

