

Joint CP-TT/DA-TT Workshop
26 – 30 October 2026
Reading, UK

Impact of assimilating biogeochemical data from multiplatform observing systems on ecosystem indicators

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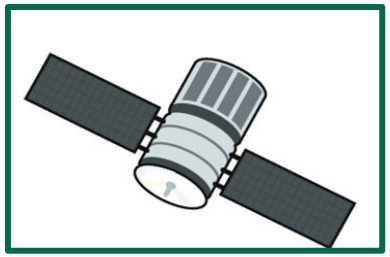
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004032

Outline

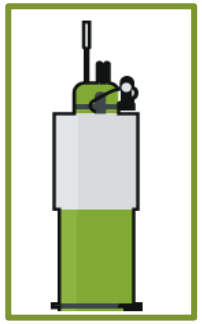
- Multiplatform assimilation in biogeochemistry
- Results in 1D and 3D in three domains
- Summary on impact on indicators

Background

- Data assimilation in marine biogeochemistry



Ocean colour DA
Widely applied for chlorophyll and other variables



In-situ profiles DA
More recently implemented for chlorophyll, nutrients and oxygen not only for BGC-Argo floats

- Ensemble biogeochemical DA

Few examples exist with three-dimensional real domains

→ Uncertainty of key ecosystem indicators

Ensemble data assimilation in 1D and 3D applications in the framework of the SEAMLES EU project
(Cossarini et al., 2026; https://doi.org/10.1016/j.ocemod.2026.102805)

Approach (Cossarini et al., 2026)

- Ensemble multiplatform cholrophyll DA

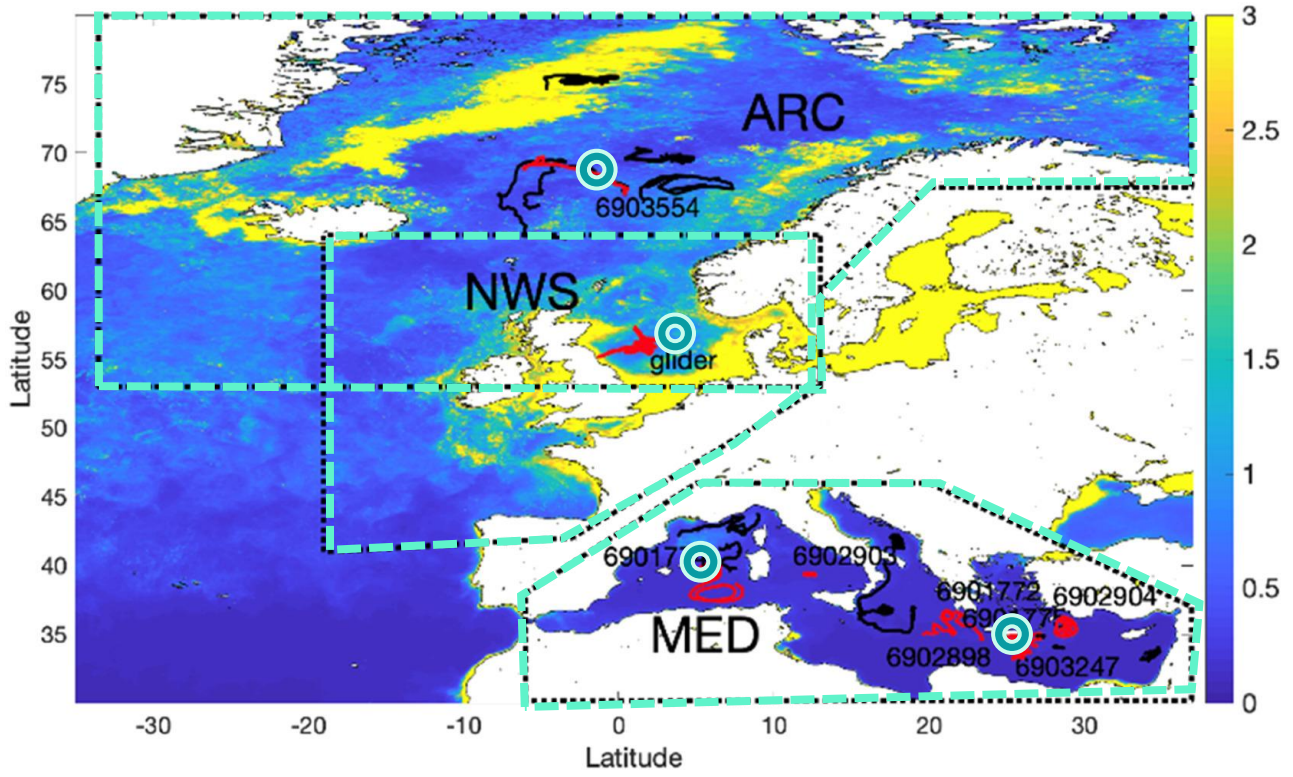
  Three areas → Three models
  Arctic Sea (ARC) → ECOSMO
  Northwest European Shelf (NWS) → ERSEM
  Mediterranean Sea (MED) → BFM

- 1D simulations

  Four locations
  Set of different DA configurations

- 3D simulations

  Three regional domains
  One DA configuration



→ RMSDs with respect to satellite and in-situ observations in 1D

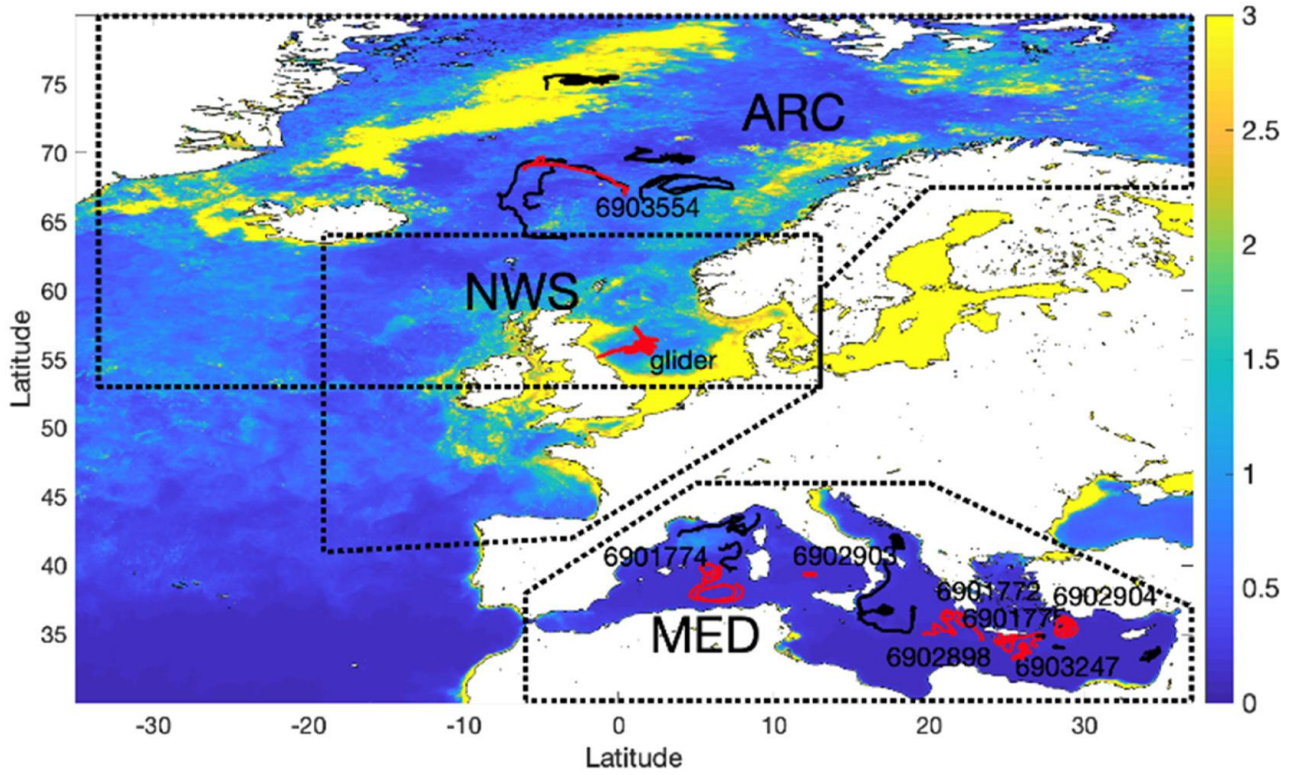
→ Impacts on ecosystem indicators in 1D and 3D

Ecosystem indicators

- Particulate organic carbon
  POC
  non-living carbon fraction of particulate organic matter

- Primary production
  NPP
  Phytoplankton
  Gross production - Respiration

- Community structure
  CommSt
  Large (diatoms) over all phytoplankton



→ Uncertainty reduction considering the ratio of coefficients of variation

$$CVratio = \frac{DArun\ std/DArun\ mean}{ENSrun\ std/ENSrun\ mean}$$

Ciavatta et al., 2025

1D settings

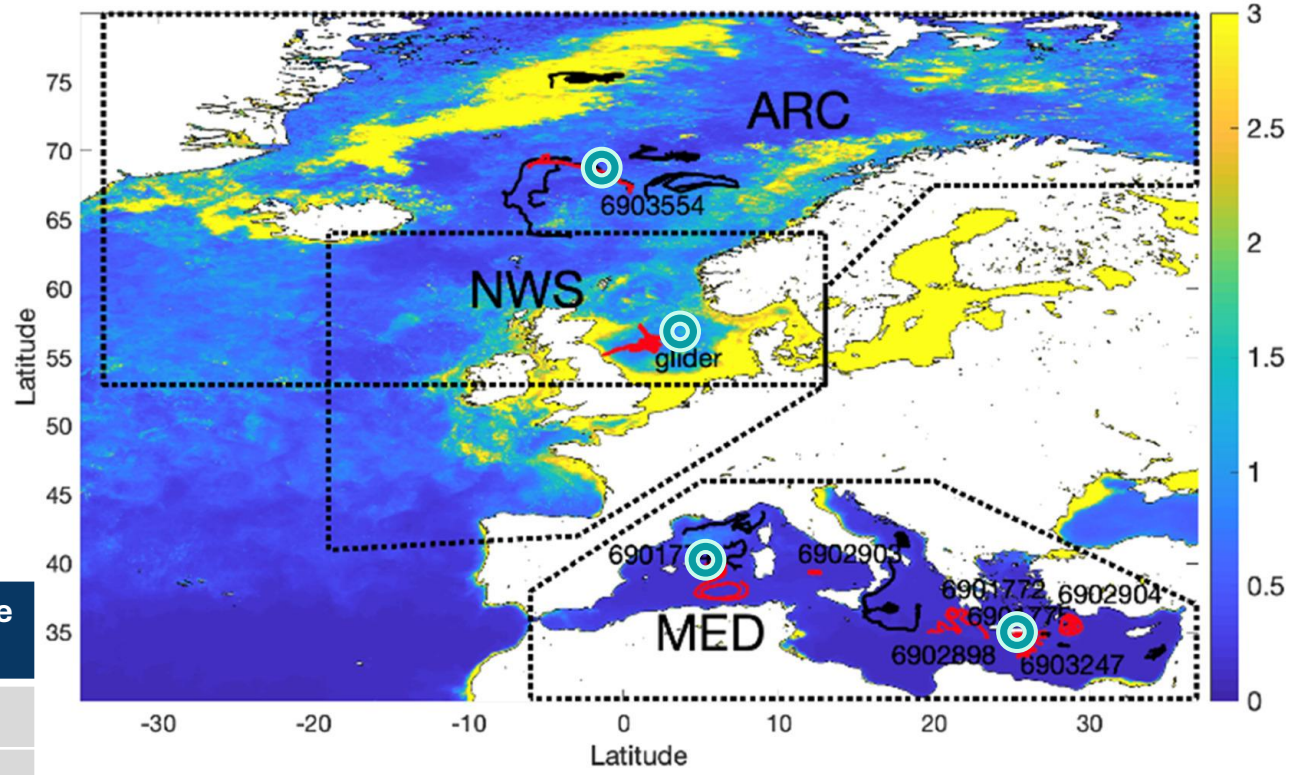
- Four locations

  ARC → BGC-Argo float
  NWS → BGC Glider
  West MED → BGC-Argo floats
  East MED → BGC-Argo floats

- DA configurations

  Ensemble assimilation tool (EAT; Bruggeman et al., 2024; https://doi.org/10.5194/gmd-17-5619-2024)

Name	Satellite DA	In-situ error	In-situ profile resolution
ENS	No DA		
OC_Ht	Daily		
P_Le_Fc		Low	Full
OC_Ht P_Le_Fc	Daily	Low	Full
OC_Lt P_Le_Fc	10-day	Low	Full
OC_Ht P_He_Fc	Daily	High	Full
OC_Ht P_Le_Hc	Daily	Low	Half



1D settings

- Four locations

  ARC → BGC-Argo float
  NWS → BGC Glider
  West MED → BGC-Argo floats
  East MED → BGC-Argo floats

Different Model complexity
Medium complexity ERGOM in ARC and high complexity ERSEM and BFM in NWS and MED

Different trophic regimes
Eutrophic ARC and NWS and oligotrophic West and East MED

- DA configurations

  Ensemble assimilation tool (EAT; Bruggeman et al., 2024)

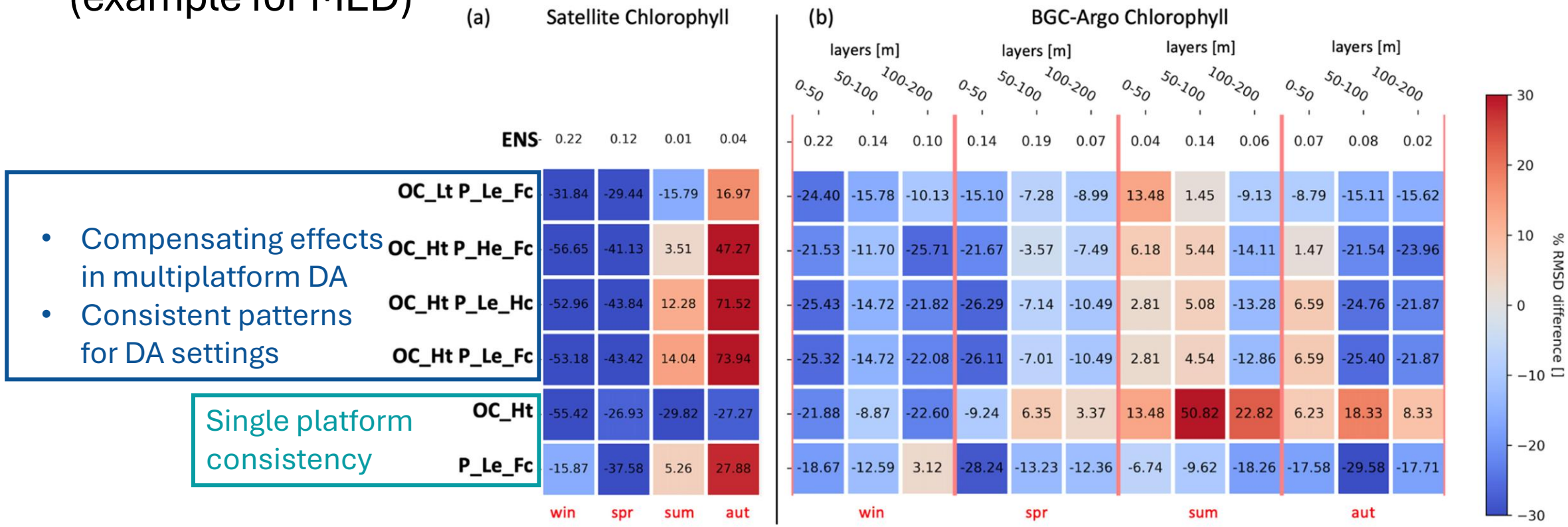
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OC_Lt P_Le_Fc	10-day	Low	Full
OC_Ht P_He_Fc	Daily	High	Full
OC_Ht P_Le_Hc	Daily	Low	Half

Ensemble data assimilation scheme
ESTKF in NWS and MED and EnsKF in ARC

Ensemble perturbation
Initial conditions, biogeochemical parameters and atmospheric forcings

1D Results

- Relative differences of RMSDs with satellite and in-situ chlorophyll (example for MED)



- Compensating effects in multiplatform DA
- Consistent patterns for DA settings

Single platform consistency

Different model systems with different improvements in seasons and layers

Any specific pattern related to model complexity

OC_Ht P_Le_Fc with best results in ARC and NWM

1D Results

- Impacts on indicators (example for East MED)

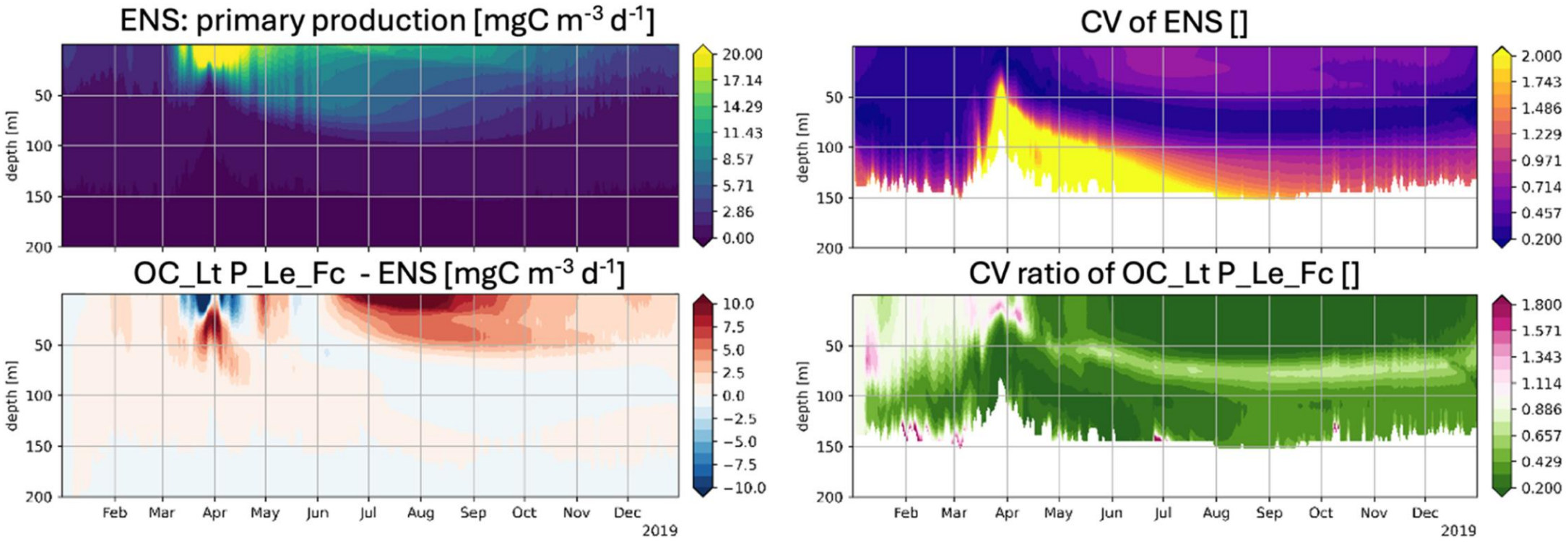
NPP in East MED

Typical seasonal behaviour

Largest CV in transition phase

DA impacts in the most productive layers and times

Reduction of uncertainty above and below deep chlorophyll maximum (DCM)

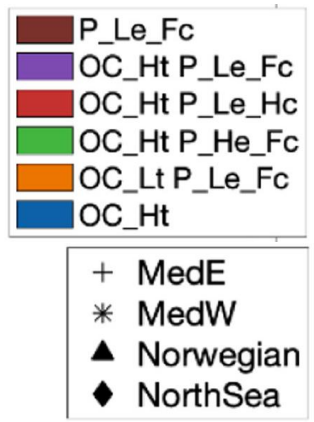


1D Results

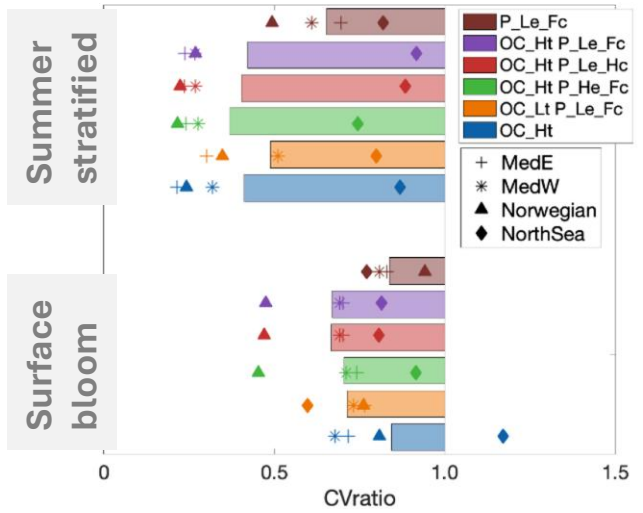
- CV ratios across domains and DA settings

  General CV ratio reduction

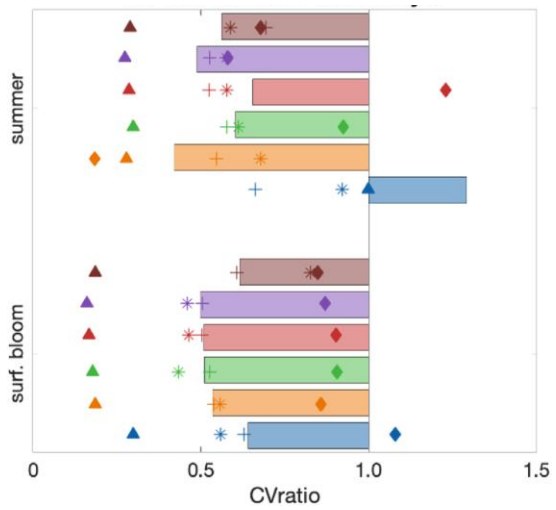
  Exceptions and variability across indicators, domains and DA settings



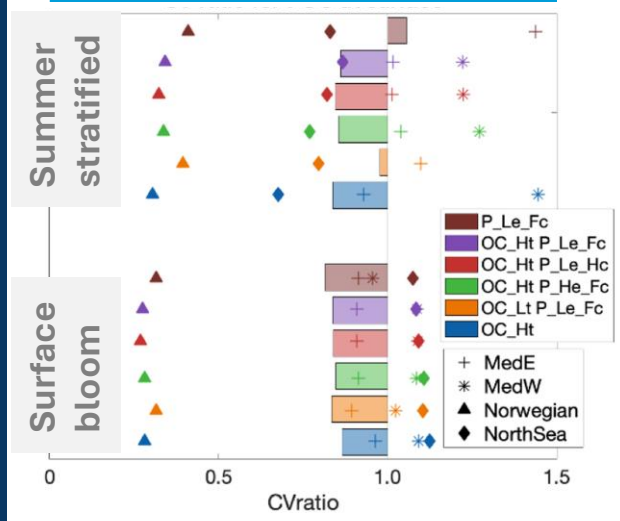
NPP surface



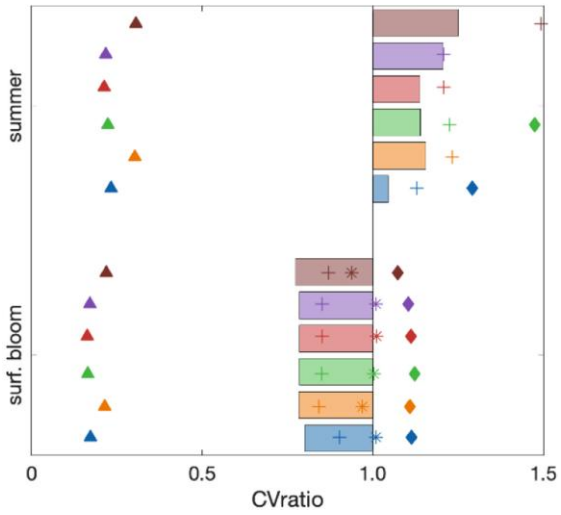
NPP DCM layer



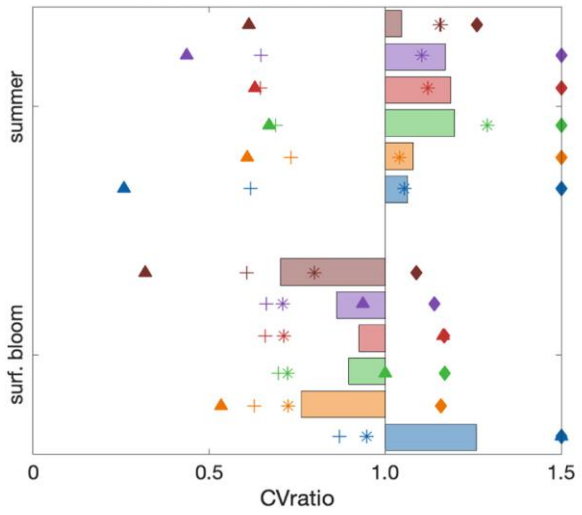
POC surface



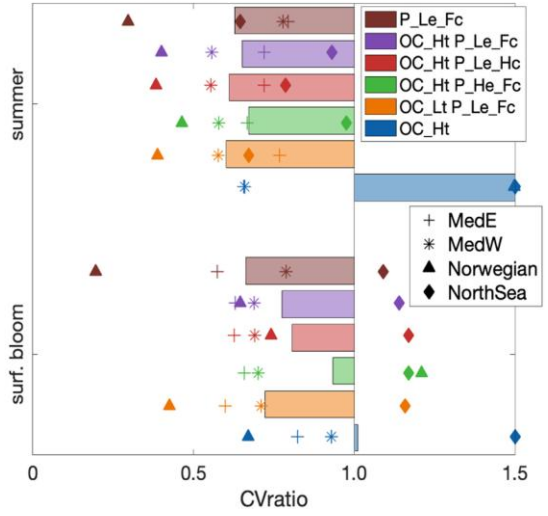
POC DCM layer



CommSt surface



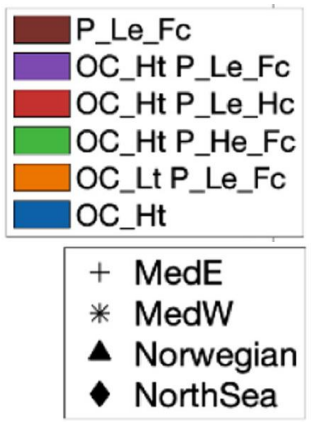
CommSt DCM layer



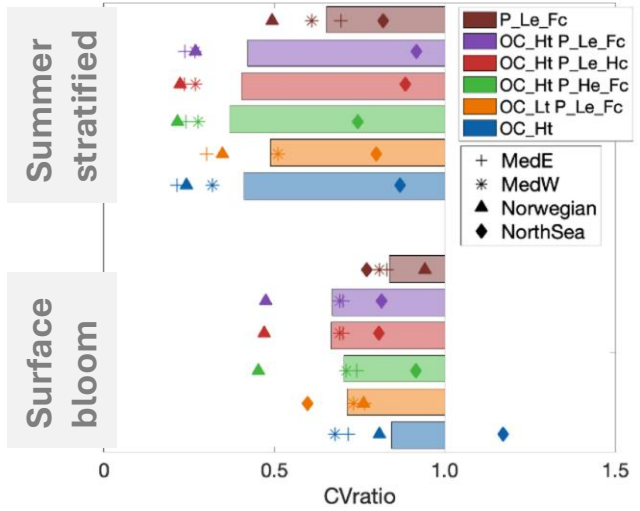
1D Results

- CV ratios across domains and DA settings

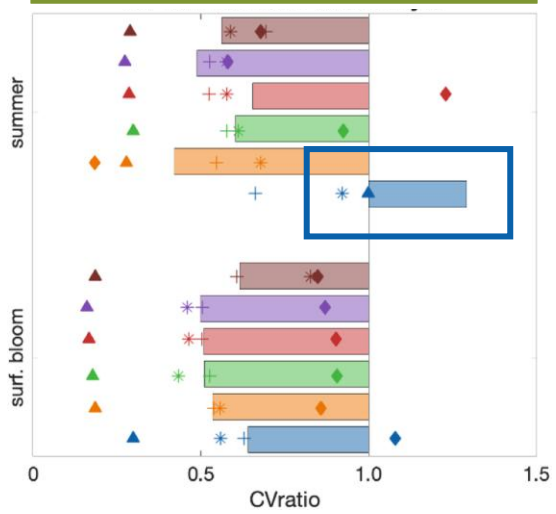
Satellite chlorophyll DA alone can increase CV ratio



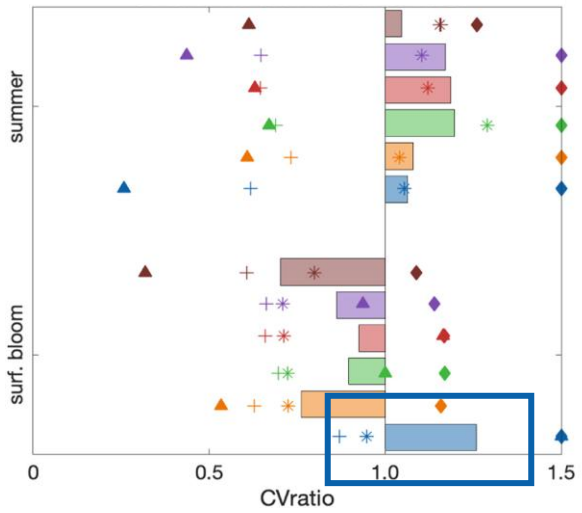
NPP surface



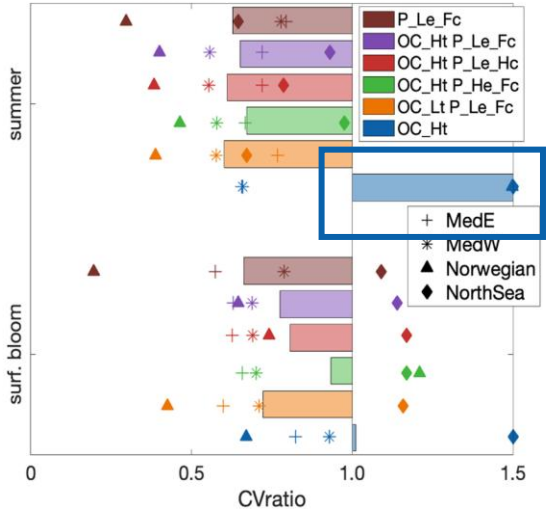
NPP DCM layer



CommSt surface



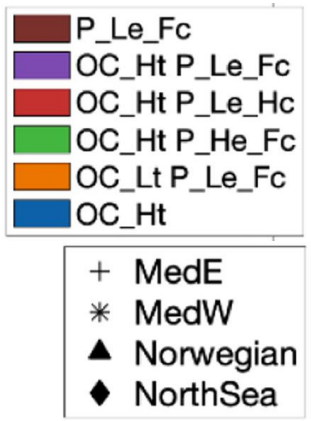
CommSt DCM layer



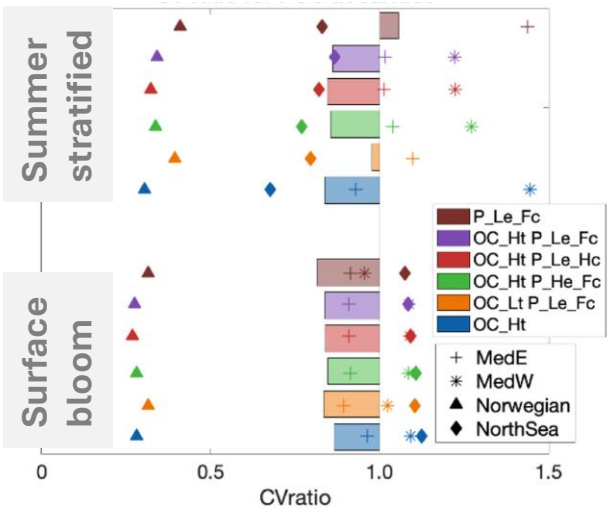
1D Results

- CV ratios across domains and DA settings

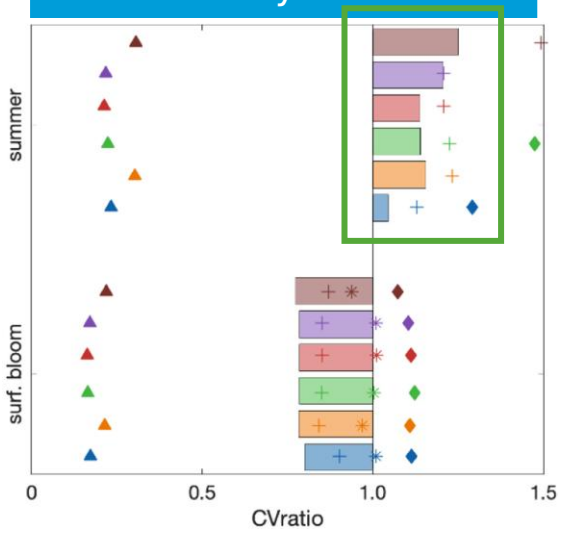
CV ratio increases in all DA settings in summer for POC (DCM) and for CommSt (surface)



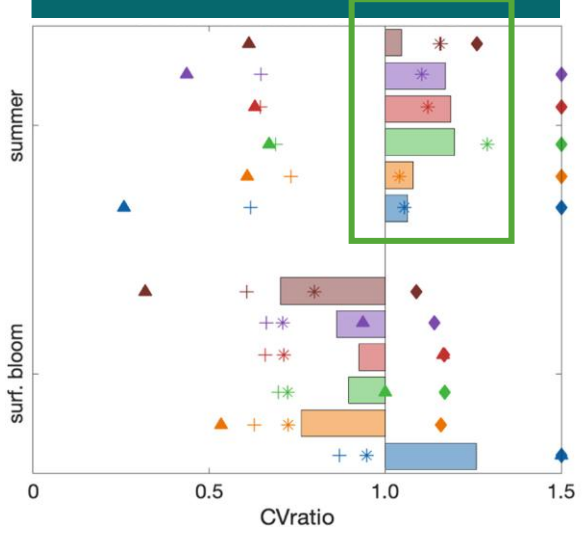
POC surface



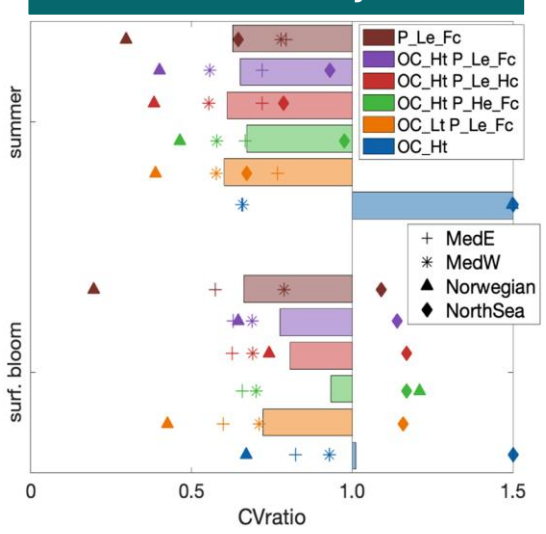
POC DCM layer



CommSt surface



CommSt DCM layer

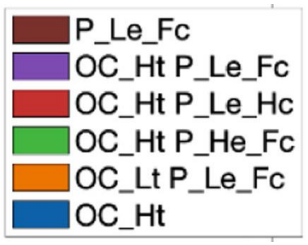


1D Results

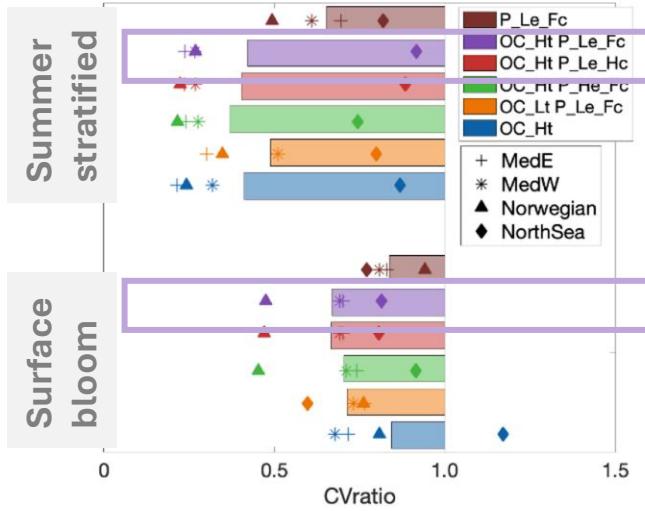
- CV ratios across domains and DA settings

Name	Satellite DA	In-situ error	In-situ profile resolution
OC_Ht P_Le_Fc	Daily	Low	Full

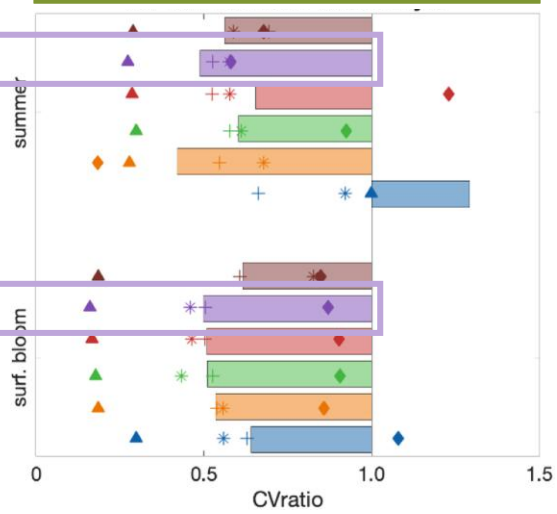
Similar settings in 3D DA



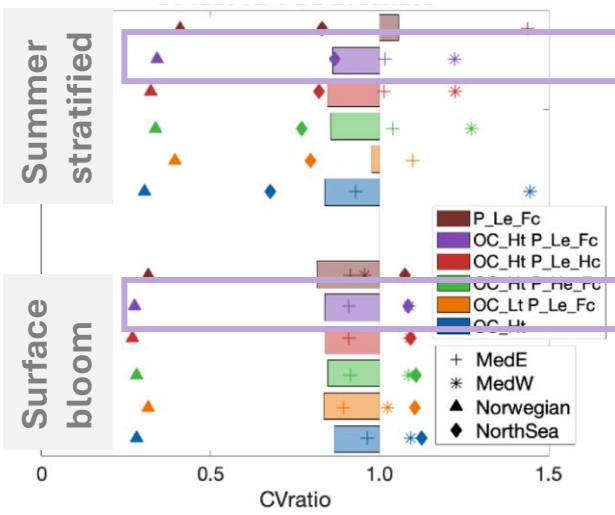
NPP surface



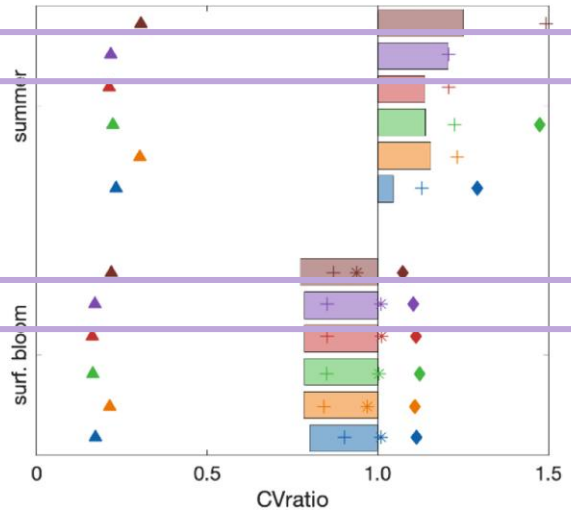
NPP DCM layer



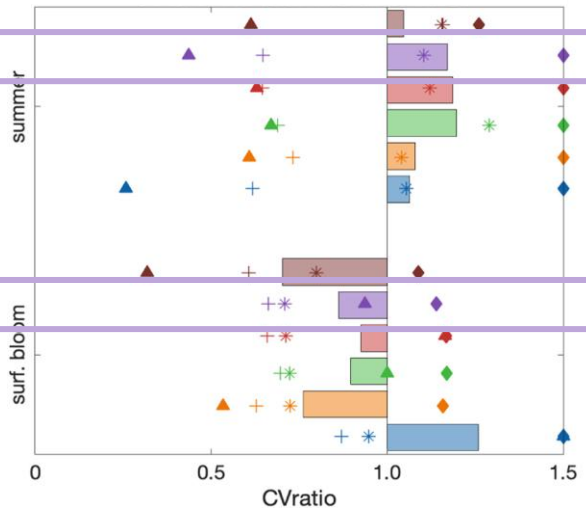
POC surface



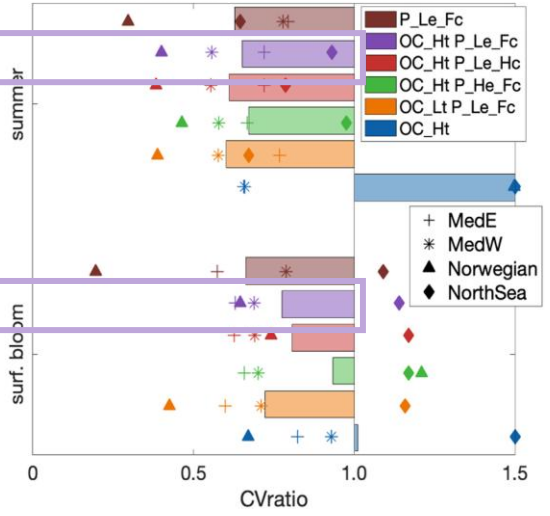
POC DCM layer



CommSt surface



CommSt DCM layer



3D Settings

- Ensemble multi-platform chlorophyll DA (posterior)

DA scheme and N ensemble members

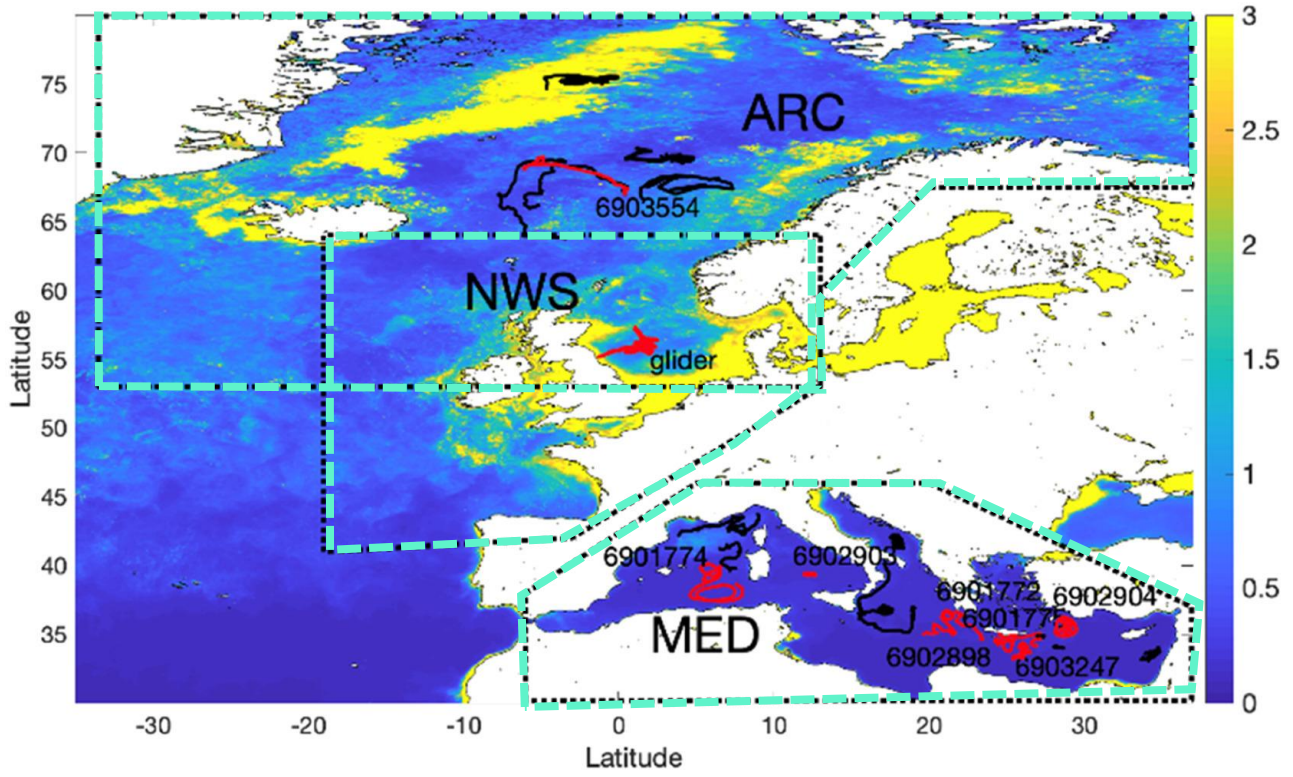
ARC → Lag-1 DEnKS (N = 80)
NWS → En3DVar (N = 30)
MED → ESTKF (N = 24)

DA settings

Daily DA of satellite and in-situ chlorophyll full in-situ profile coverage and low error (OC_Ht P_Le_Fc in 1D)

Computational time and horizontal resolution

ARC → 10 days (1/2°)
NWS → 20 days (1/17°)
MED → 10 days (1/24°)

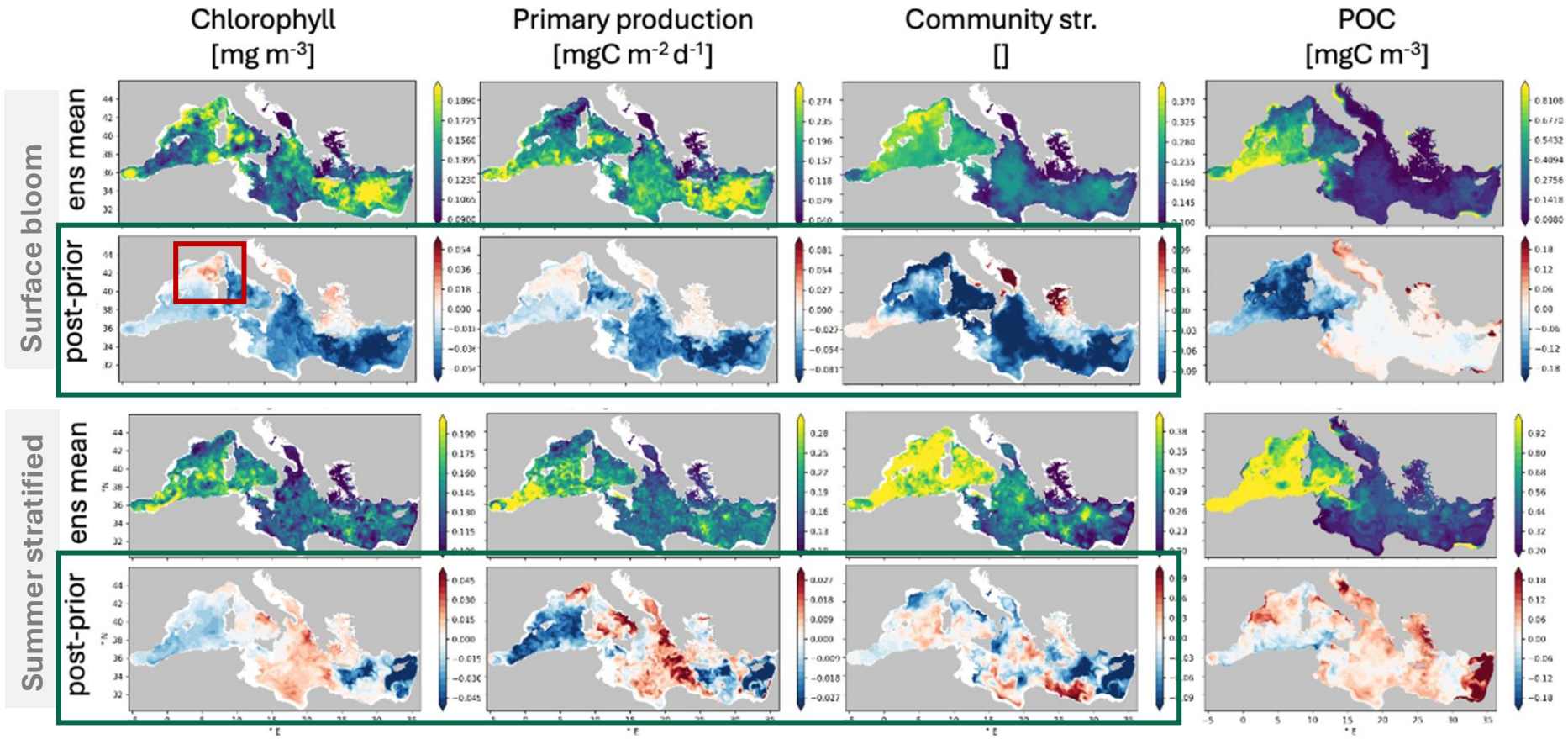


→ Impact on the indicators with CV ratios with respect to ensemble no-DA simulation (prior)

3D Results - MED

- Corrections on chlorophyll reflects on NPP (and CommSt) impacts
- Not clear related impacts on POC

Correction on the intensity of the northwestern Mediterranean bloom reflects on NPP but not on CommSt



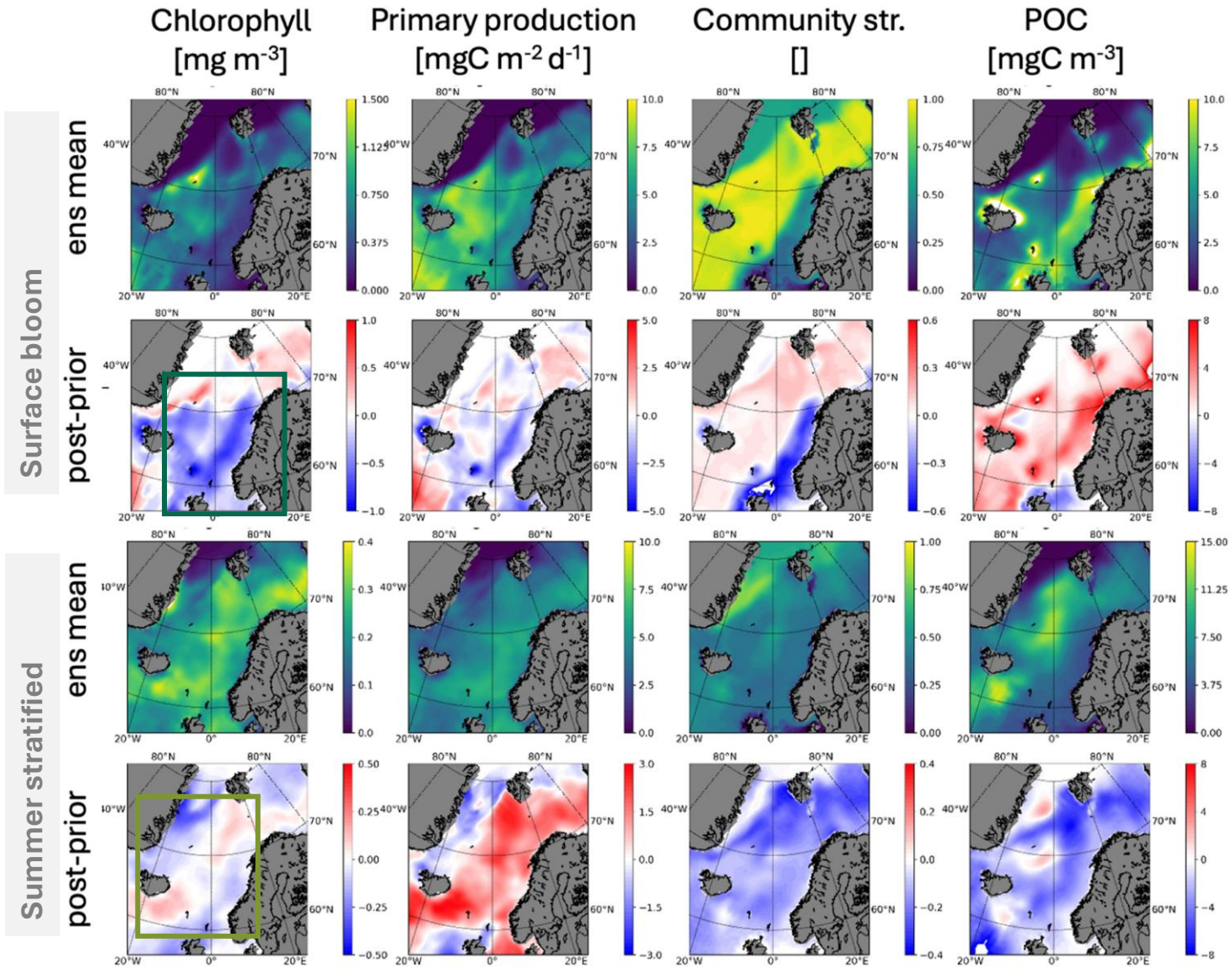
3D Results - ARC

- Correction of a positive bias during the bloom

  The correction reflects on NPP
  Local reduction of CommSt
  POC increase may reflect large phytoplankton increase

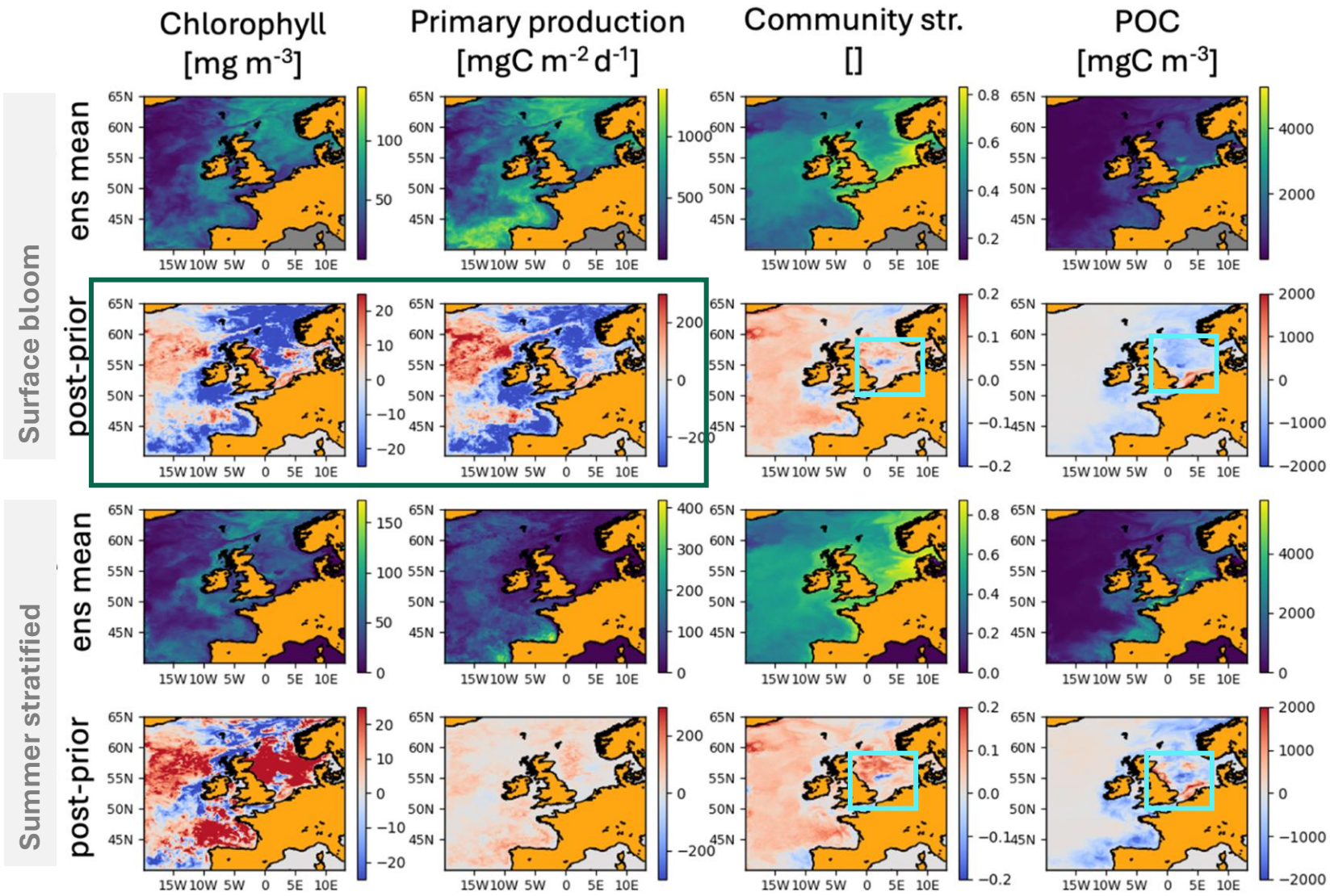
- Positive corrections in central area during post-bloom

  Not clear impact on NPP
  General reduction on CommSt (reduction of large phytoplankton) with impacts on POC



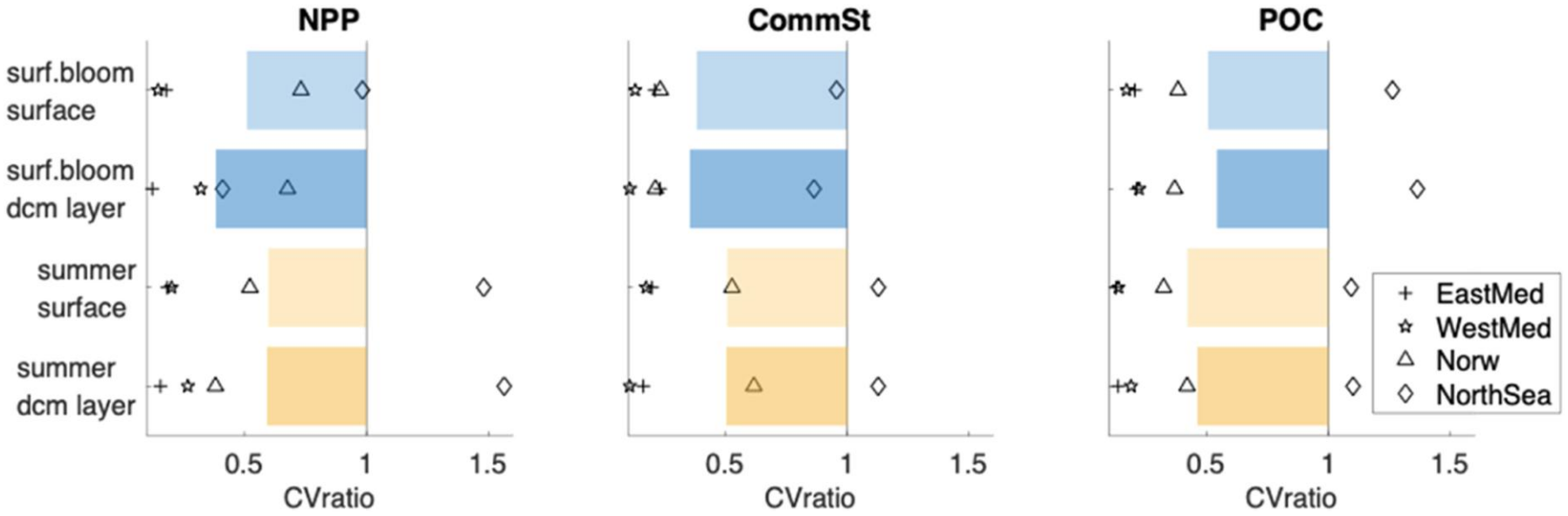
3D Results - NWS

- Corrections on chlorophyll reflects on NPP impacts
- Impacts of glider assimilation



Impact on CV ratios in 3D

- General decrease of the CV ratios
- CV ratio reduction larger in summer for POC in bloom conditions for NPP and CommSt
- No significant differences between surface and DCM layer



Summary

- Application of ensemble DA to biogeochemistry in 1D and 3D
- Combined assimilation of satellite and in-situ chlorophyll tested in different settings (1D)
- Reduction in uncertainties across key ecosystem indicators across layers and seasons
- No direct transferability of results from 1D to 3D

→ Findings support the integration of satellite and in-situ observations within current operational systems



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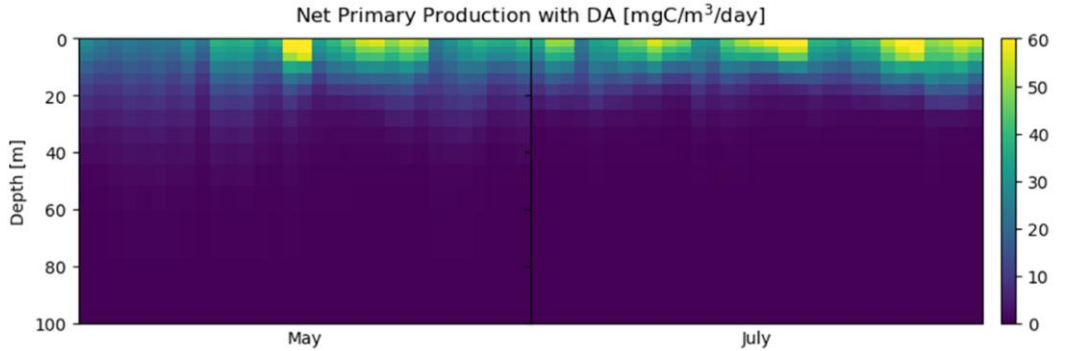
Thank you

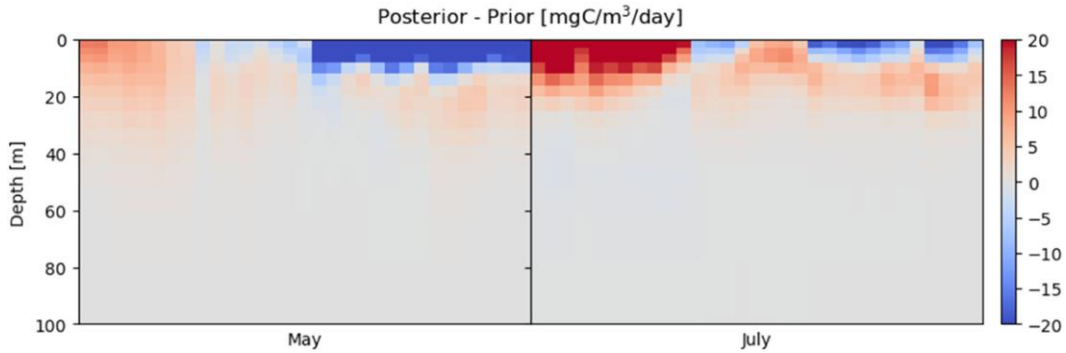
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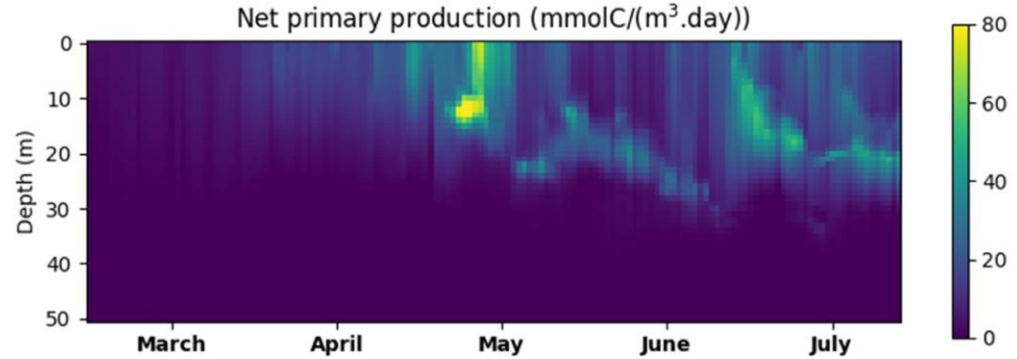
This work → Cossarini et al., 2026; https://doi.org/10.1016/j.ocemod.2026.102805

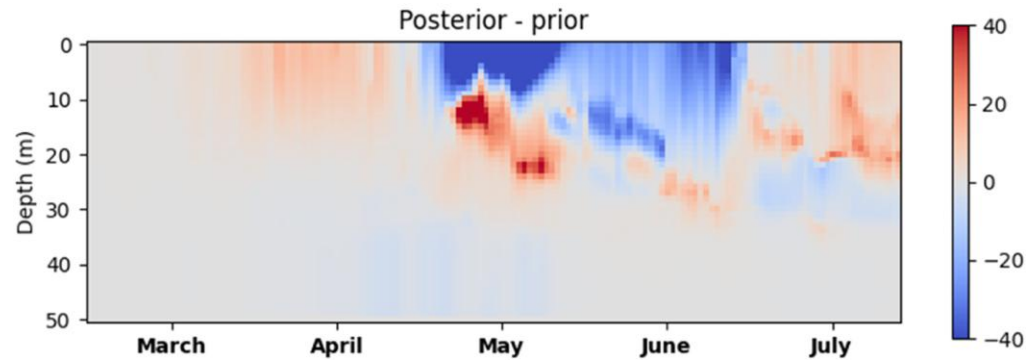
EAT → Bruggeman et al., 2024; https://doi.org/10.5194/gmd-17-5619-2024

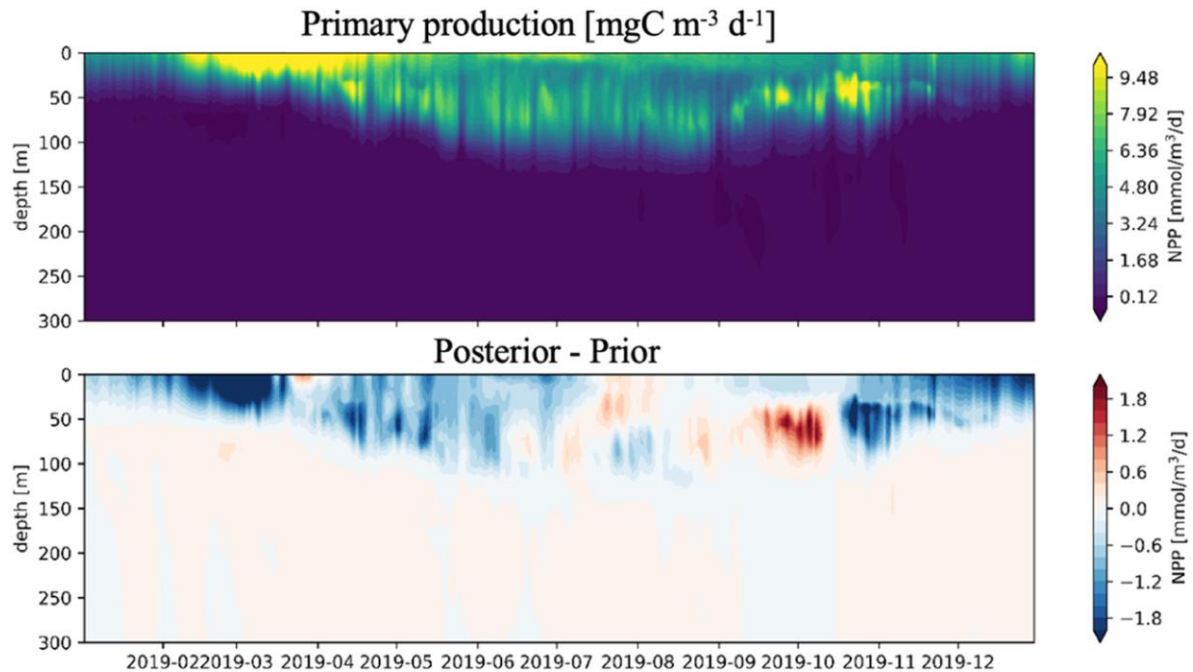
Indicators and CV ratio → Ciavatta et al., 2024; https://doi.org/10.1016/j.pocean.2024.103384


Net Primary Production with DA [mgC/m^3/day]
Depth [m]
May
July


Posterior - Prior [mgC/m^3/day]
Depth [m]
May
July


Net primary production (mmolC/(m^3.day))
Depth (m)
March
April
May
June
July


Posterior - prior
Depth (m)
March
April
May
June
July


Primary production [mgC m^{-3} d^{-1}]
depth [m]
NPP [mmol/m^3/d]
Posterior - Prior
depth [m]
NPP [mmol/m^3/d]
2019-02 2019-03 2019-04 2019-05 2019-06 2019-07 2019-08 2019-09 2019-10 2019-11 2019-12