



# living planet symposium

**BONN**  
23-27 May  
**2022**



Copernicus  
Marine Service

TAKING THE PULSE  
OF OUR PLANET FROM SPACE



## Assimilating Satellite and BGC-Argo data into operational modelling of the Mediterranean Sea biogeochemistry



**OGS**

Istituto Nazionale  
di Oceanografia  
e di Geofisica  
Sperimentale

Anna Teruzzi, Stefano Salon, Laura Feudale, Giorgio Bolzon, Gianpiero Cossarini

25 May 2022

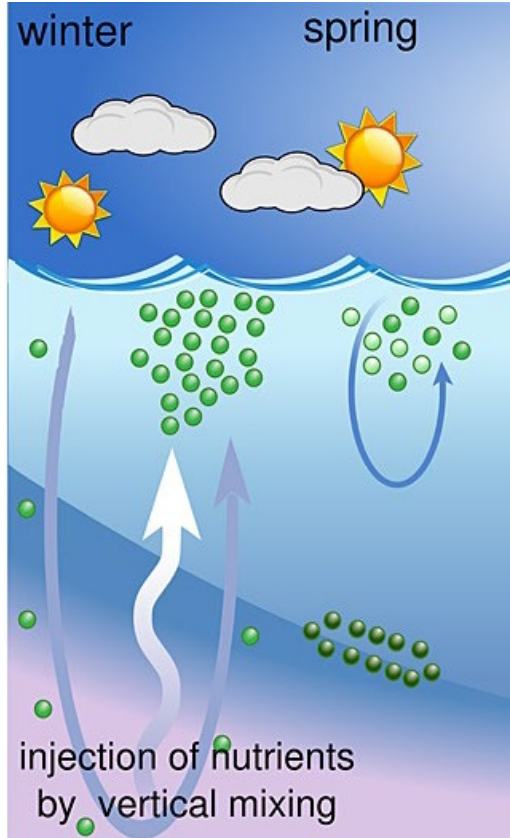
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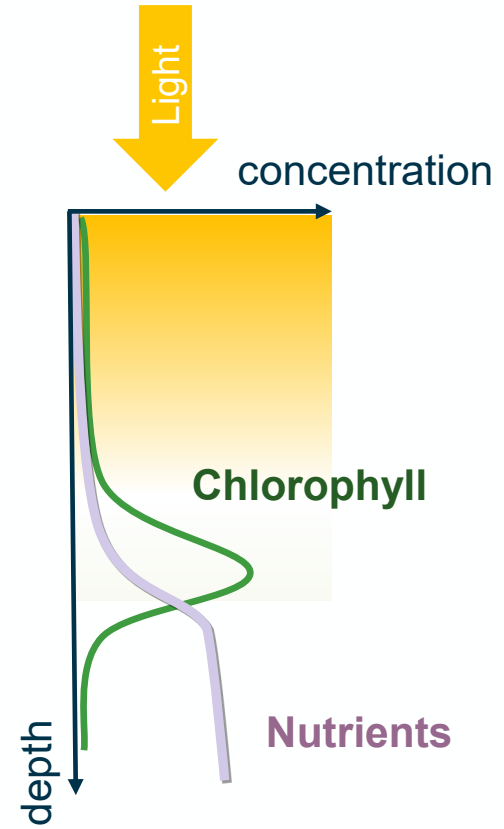
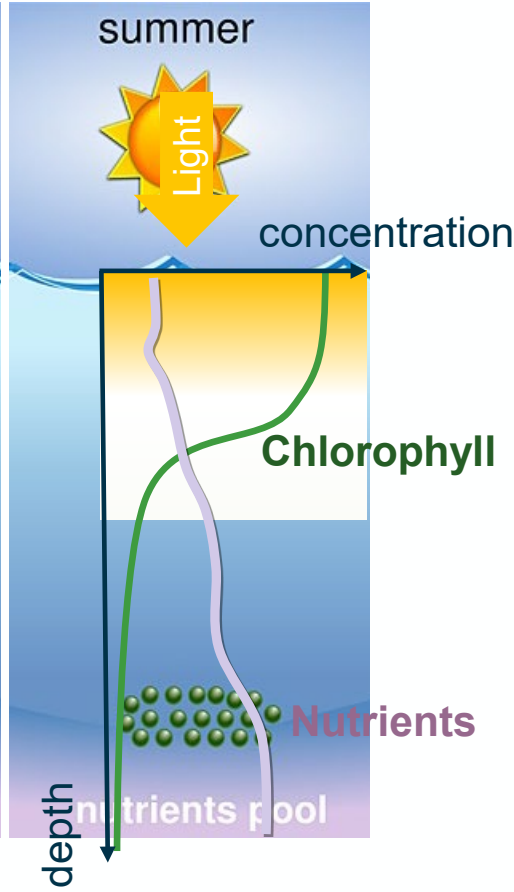
→ THE EUROPEAN SPACE AGENCY

Adapted from Mignot et al., 2014

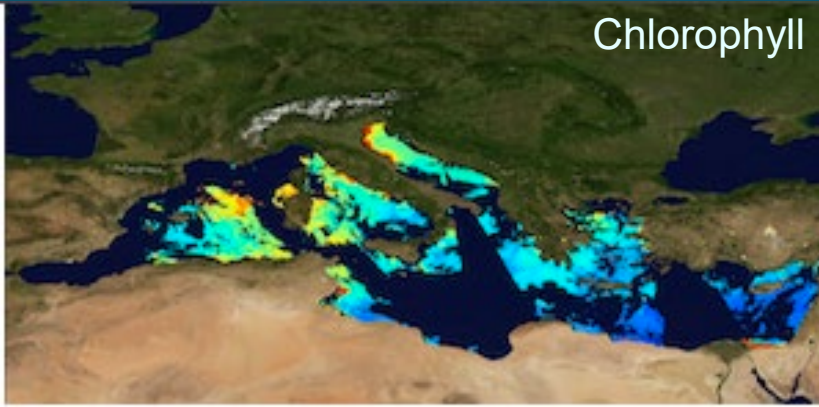
## Winter bloom



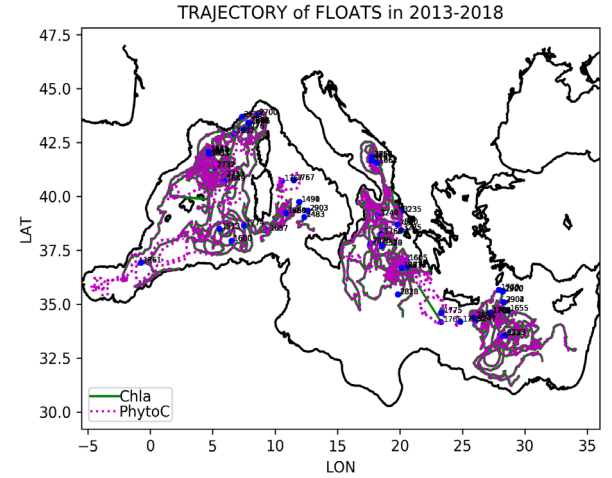
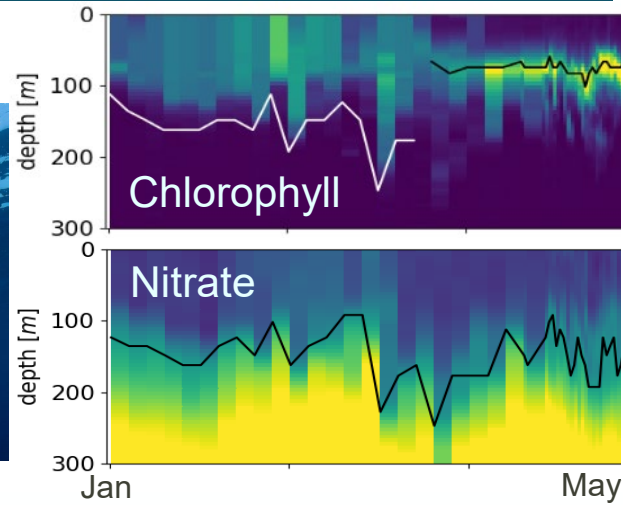
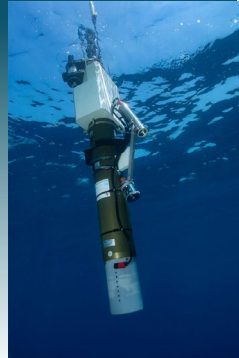
## Deep chlorophyll maximum (DCM)



## Satellite

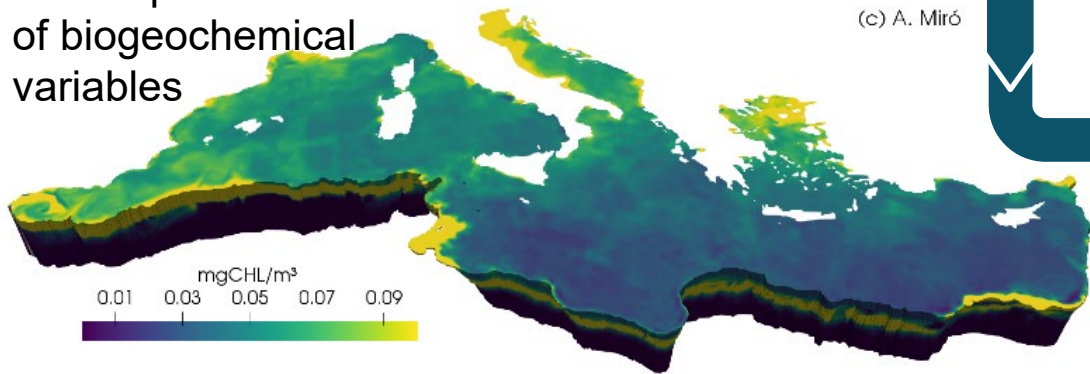


## BGC-Argo floats



## Models

3D temporal evolution of biogeochemical variables

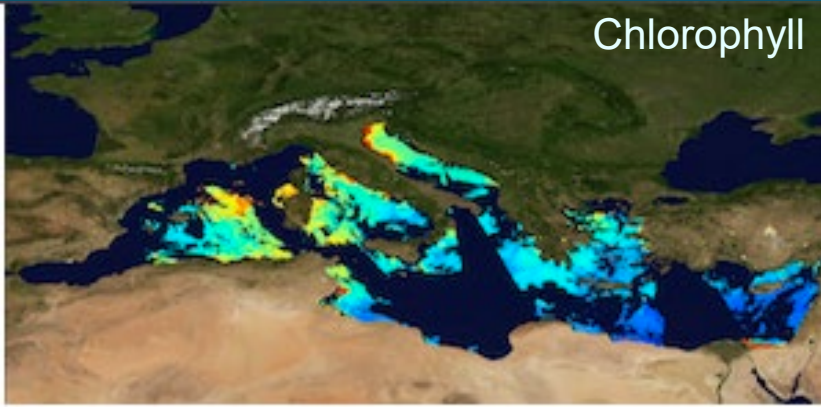


(c) A. Miró

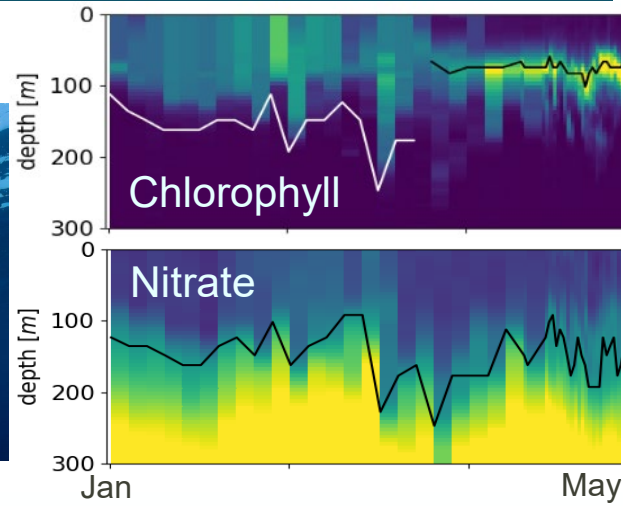
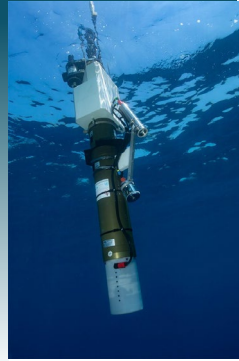
## Data assimilation

Combines observations and model with their uncertainties to provide a better representation of reality

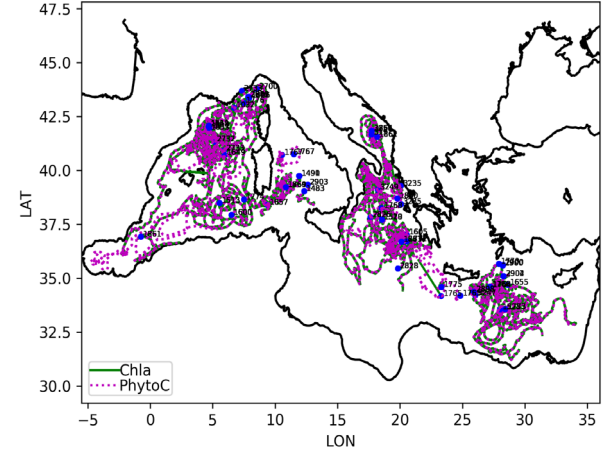
## Satellite



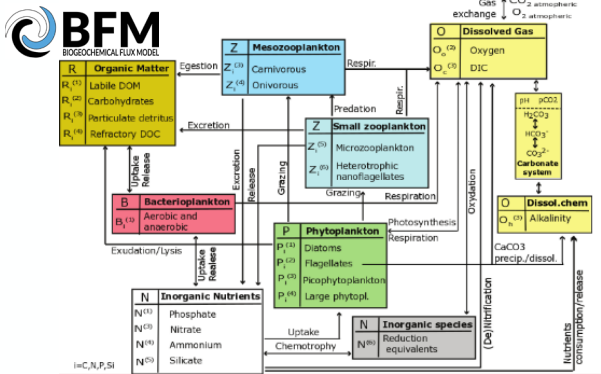
## BGC-Argo floats



TRAJECTORY of FLOATS in 2013-2018



## Models



1/16° horizontal resolution

70 levels

One year simulation  
2015

## Data assimilation

Daily assimilation of BGC-Argo chlorophyll and nitrate

Weekly assimilation of BGC-Argo chlorophyll and nitrate

Updates of phytoplankton and nutrient variables

# Results – Assimilation impact on nitrate

Simulation WITH data assimilation (DAsim)

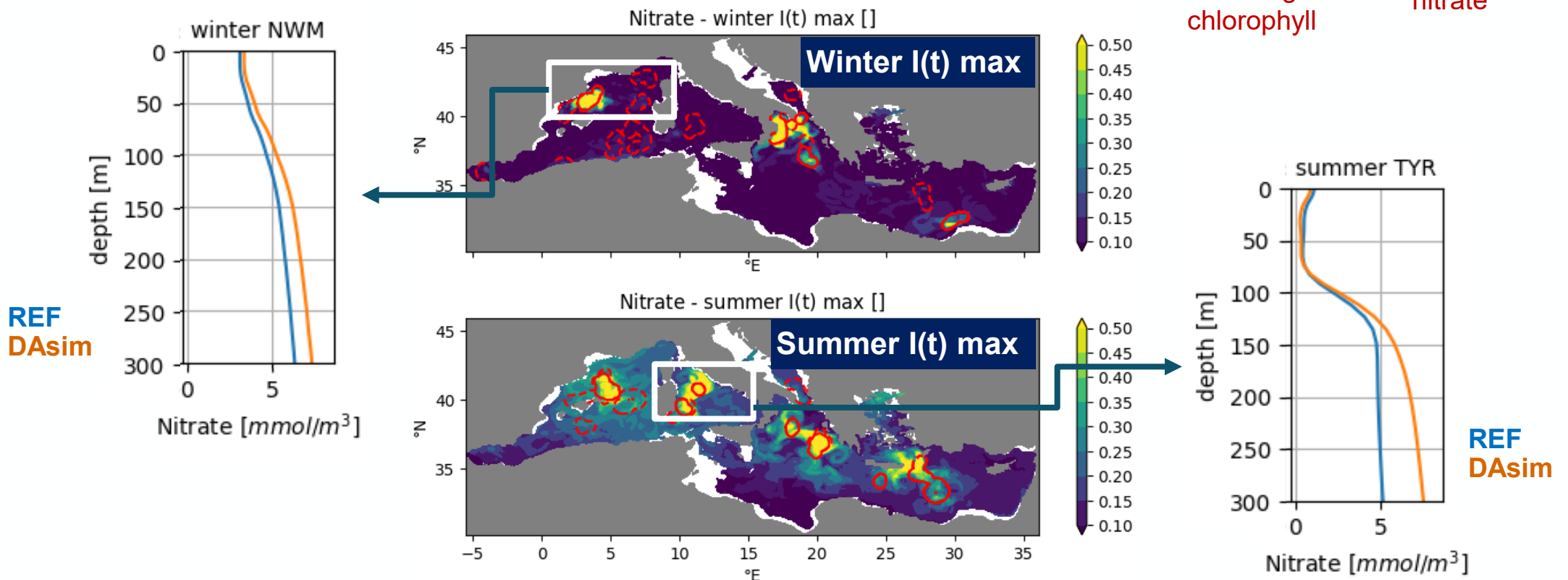
REF simulation WITHOUT data assimilation

$$\text{Impact indicator } 0 - 200 \text{ m } I_{xy}(t) = \frac{|ScFcn(t) - REF(t)|_{200}}{REF(t)_{200}}$$



BGC-Argo chlorophyll

BGC-Argo chlorophyll and nitrate



# Results – Assimilation impact on chlorophyll

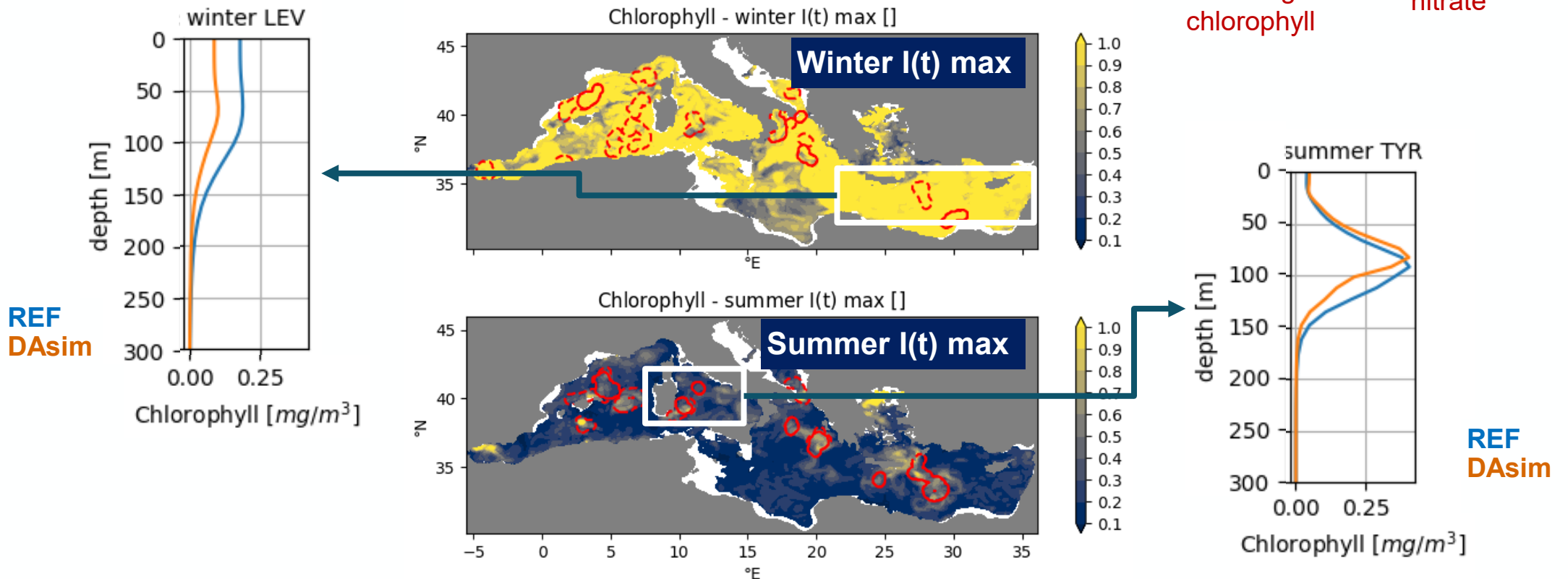
Simulation WITH data assimilation (DAsim)

REF simulation WITHOUT data assimilation

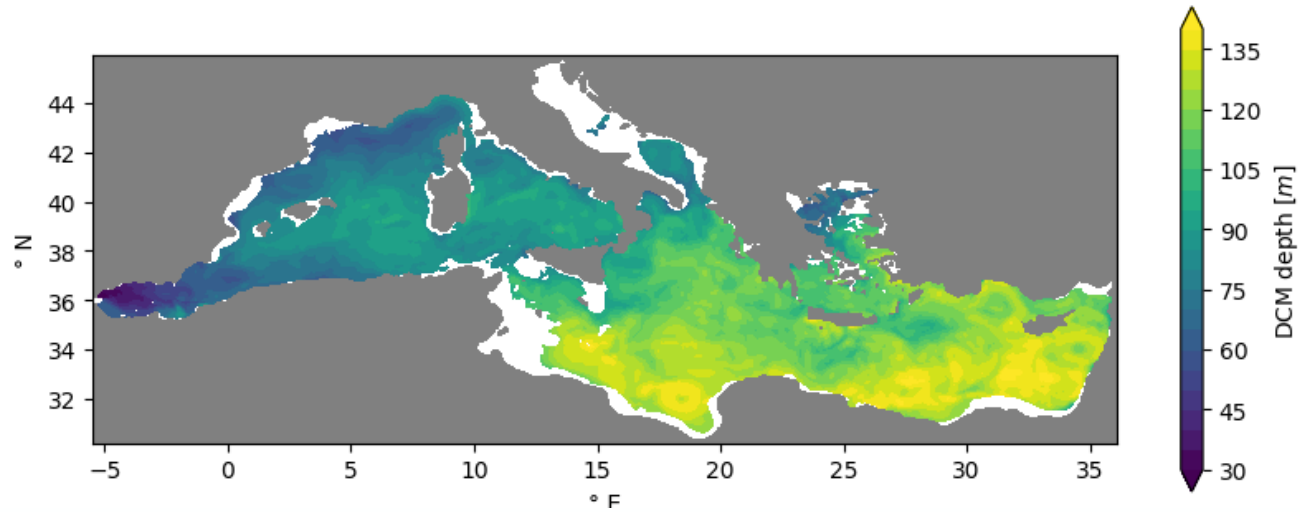
$$\text{Impact indicator } 0 - 200 \text{ m } I_{xy}(t) = \frac{|ScFcn(t) - REF(t)|_{200}}{REF(t)_{200}}$$

BGC-Argo chlorophyll

BGC-Argo chlorophyll and nitrate



# DCM in the assimilated simulation

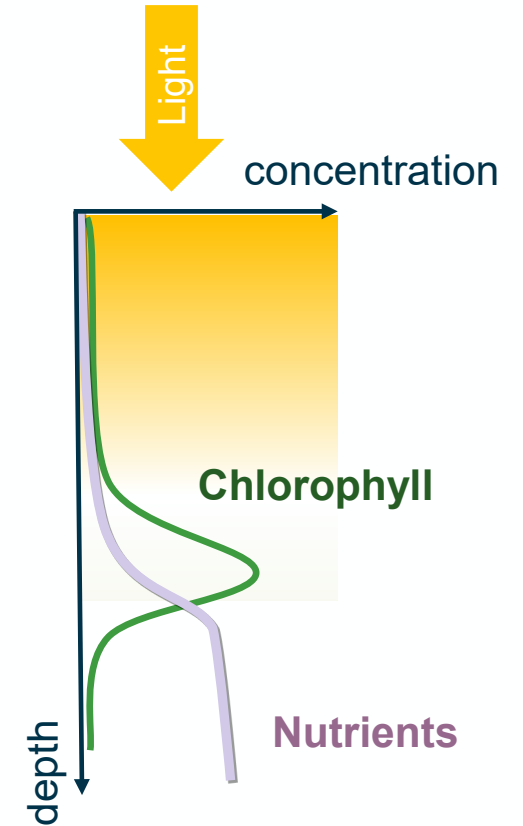
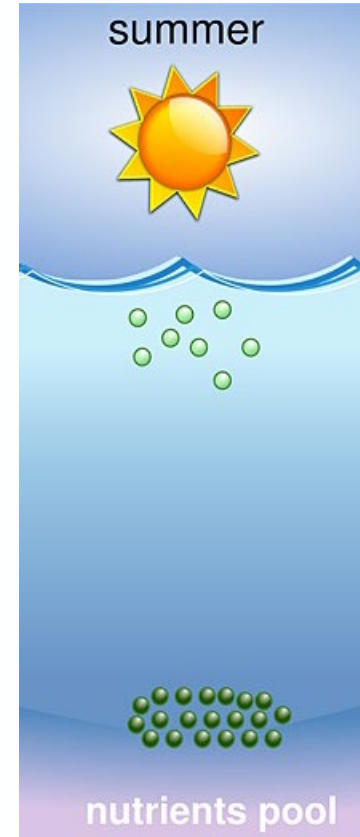


DCM depth west-east gradient  
(Barbieux et al., 2019; Mignot et al., 2014)

DCM features in the western and eastern Mediterranean

## Deep chlorophyll maximum (DCM)

Adapted from  
Mignot et al., 2014

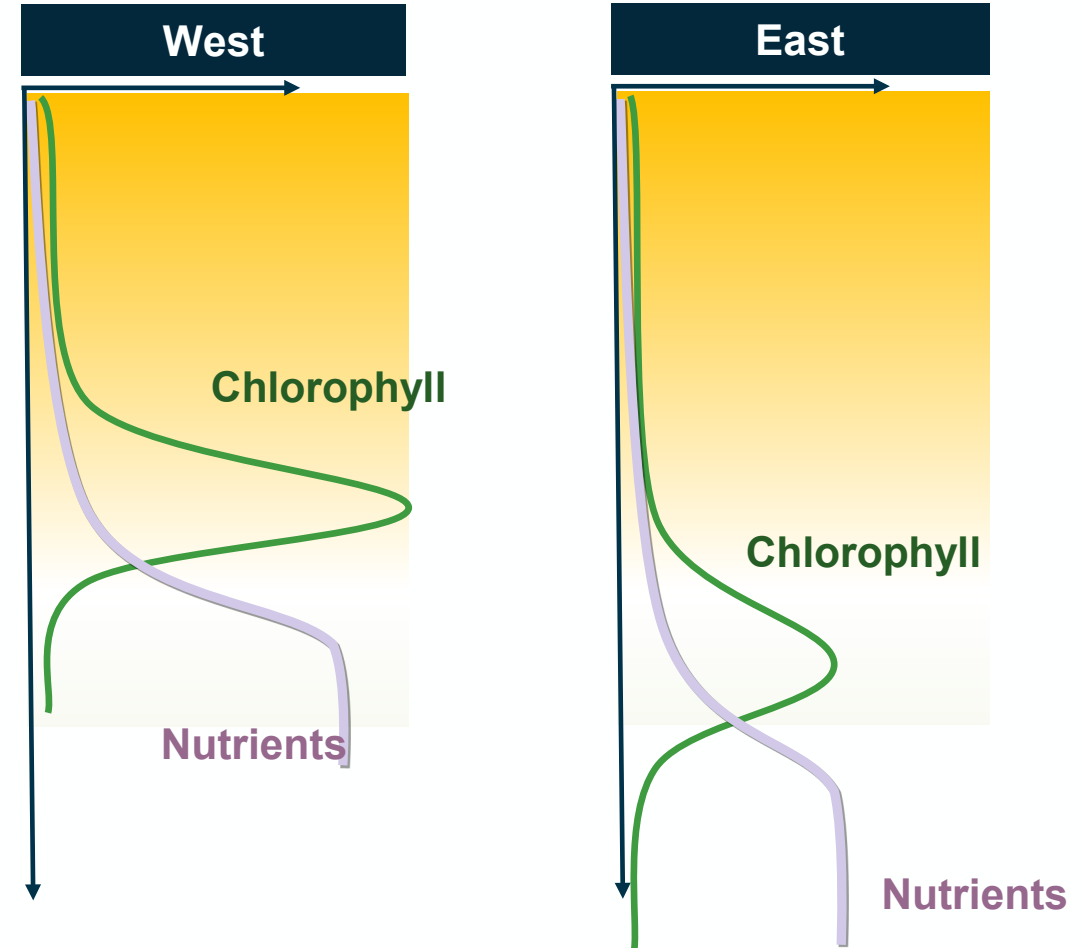


# DCM west-east differences

DCM	West	East
DCM depth [m]	75-90	100-125
Chlorophyll at DCM [ $\text{mg}/\text{m}^3$ ]	0.4-0.48	0.3-0.4
DCM thickness [m] (chlorophyll > 0.5 chlorophyll at DCM)	40-50	50-70

Nitracline (depth of maximum nitrate variation)	West	East
Nitracline depth [m]	80-100	125-150
Nitracline slope [ $\text{mmol}/\text{m}^4$ ]	0.08-0.10	0.03-0.05
Nitrate concentration below DCM layer [ $\text{mmol}/\text{m}^3$ ]	6-7.5	4.5-5

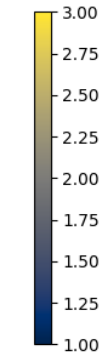
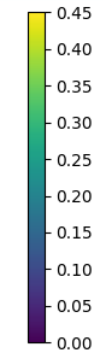
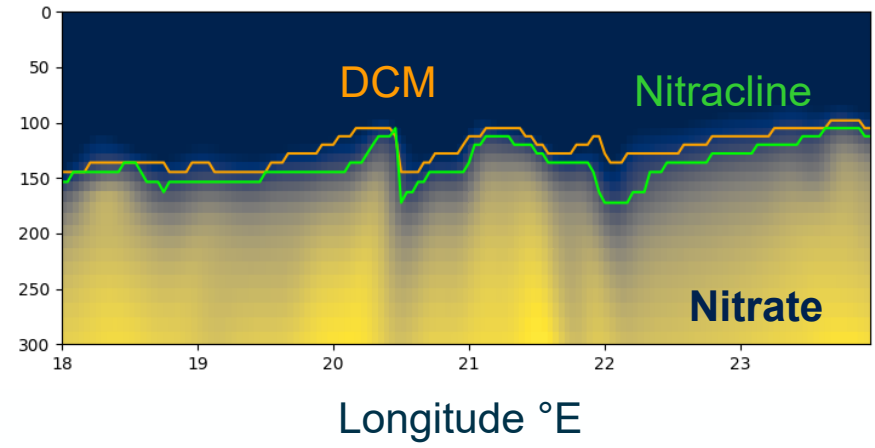
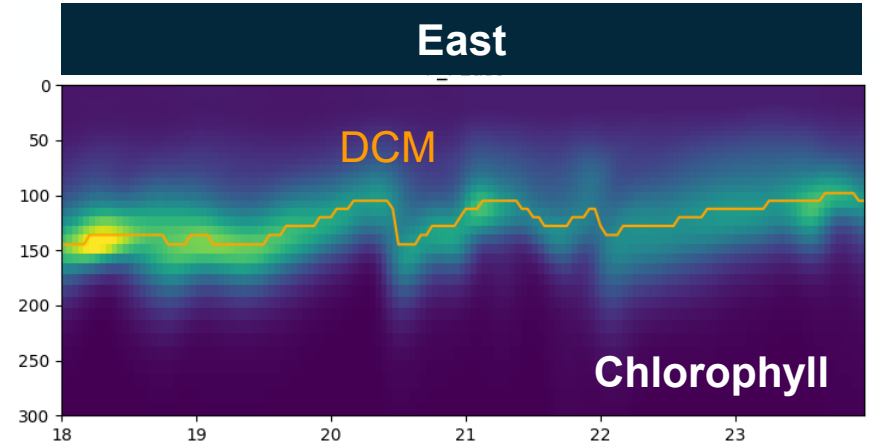
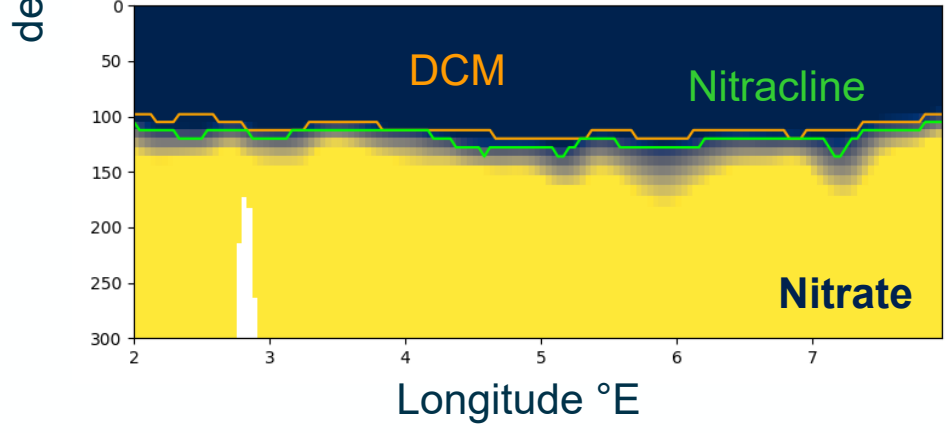
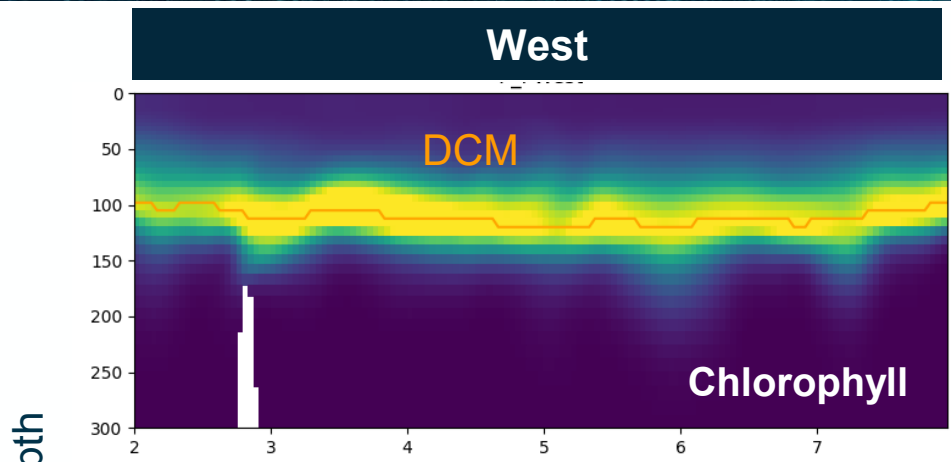
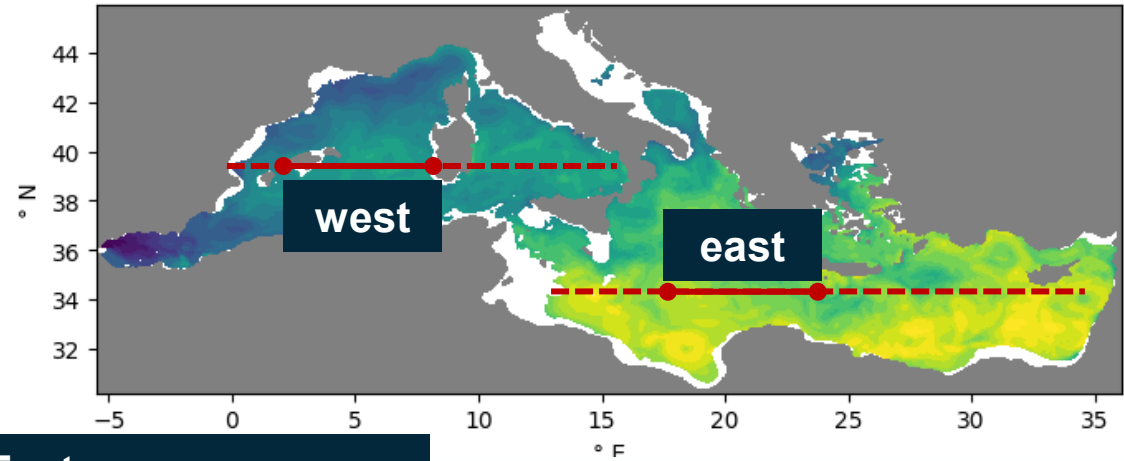
PAR	West	East
PAR at DCM [ $\text{mol quanta}/\text{m}^2/\text{d}^1$ ]	1.5-2	0.6-1



DCM more productive in the western Mediterranean



# DCM west-east differences



- **Implementation of satellite chlorophyll and BGC-Argo data assimilation**

Operational in Copernicus Marine Service using OC TAC and BGC-Argo

+ Oxygen data assimilation in November 2022

Further development of multi-platform data assimilation in SEAMLESS H2020 project

- **West-east differences in Mediterranean Sea DCM**

More productive western DCM

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Research article 30 Nov 2021

Deep chlorophyll maximum and nutricline in the Mediterranean Sea: emerging properties from a multi-platform assimilated biogeochemical model experiment

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Received: 16 Apr 2021 – Discussion started: 26 Apr 2021 – Revised: 23 Sep 2021 – Accepted: 18 Oct 2021 – Published: 30 Nov 2021

Sections

- ▶ Abstract
- ▶ Introduction
- ▶ Methods
- ▶ Results
- ▶ Discussion
- ▶ Conclusions
- ▶ Code and data availability
- ▶ Author contributions
- ▶ Competing interests
- ▶ Disclaimer
- ▶ Special issue statement
- ▶ Acknowledgements
- ▶ Financial support
- ▶ Review statement
- ▶ References

Special issue

Biogeochemistry in the BGC-Argo era: from process studies...

Teruzzi, A., Bolzon, G., Feudale, L., and Cossarini, G, Biogeosciences 2021 <https://doi.org/10.5194/bg-18-6147-2021>

## BGC-Argo valuable sources of information

View of the ocean interior

Several observed variables

Used in a near time framework → assimilation and validation

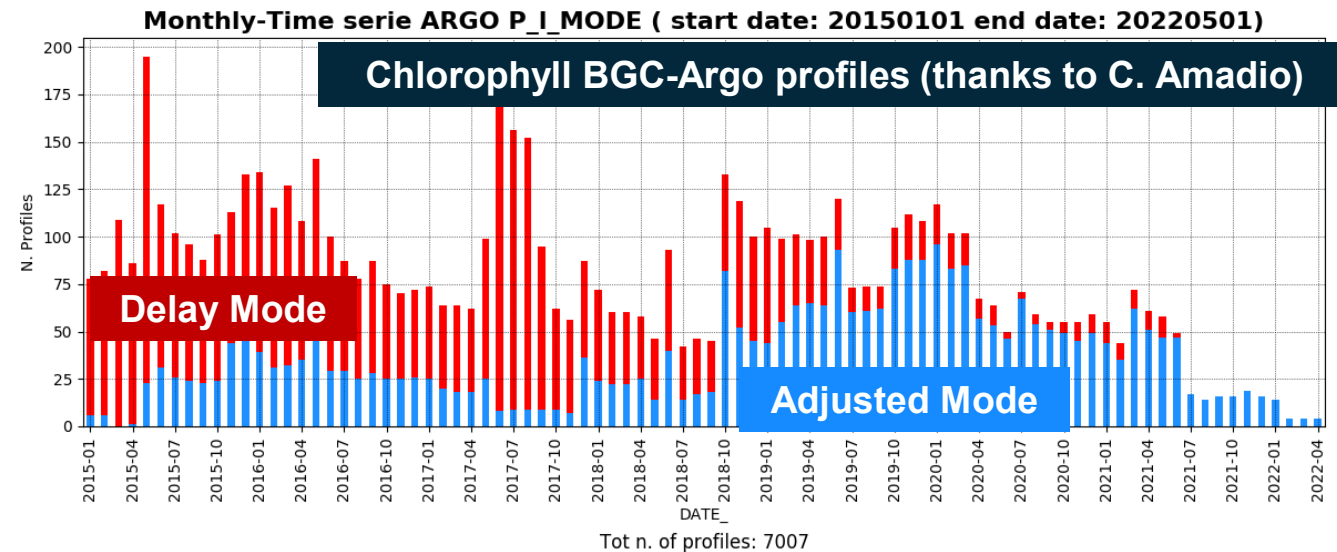
Use of more variable in the future (optics)

Consistency with other data sets → satellite

Quality control in near real time

Good coverage should include at least 2 fully equipped BGC-Argo in the eastern and western Mediterranean

Quality or coverage degradation → impact on Copernicus Marine Service Analysis and Forecast products





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THANK YOU



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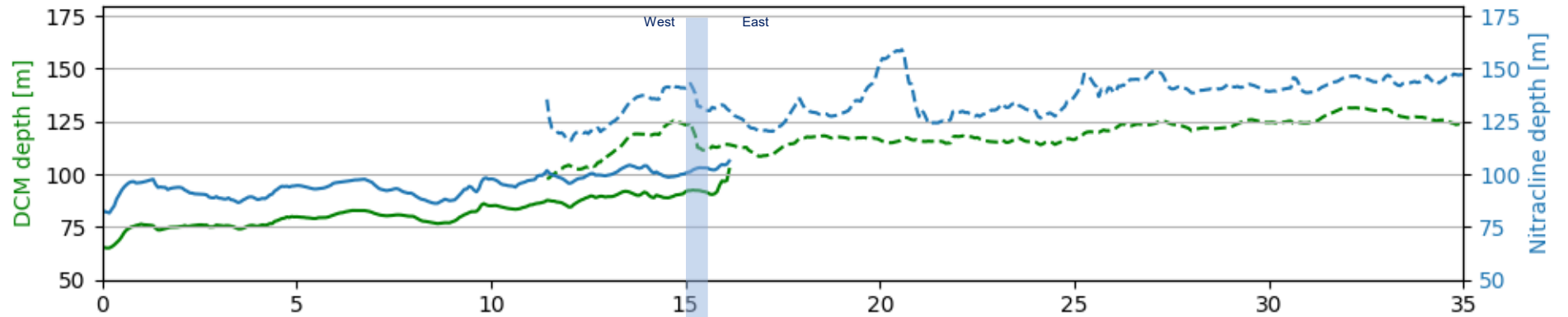
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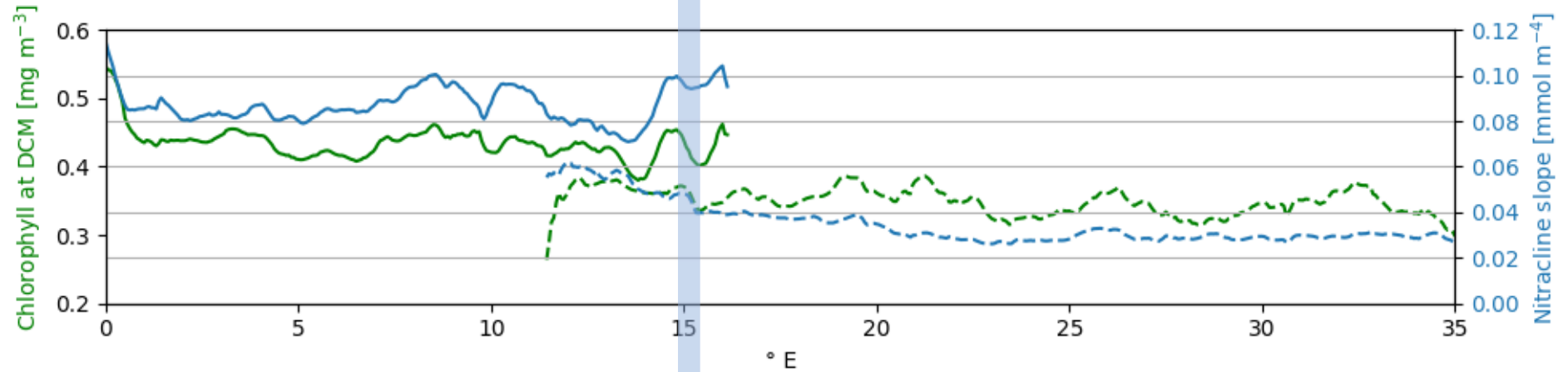
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DCM and  
nutricline depth



Chlorophyll at  
DCM and  
nutricline slope



Light at DCM and  
bottom nutrient  
concentration

