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3-5 May, online

Entering in the BGC-Argo era: improvements of the Mediterranean Sea biogeochemical operational system

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OGS – National Institute of Oceanography and Applied Geophysics

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MARINE ENVIRONMENT MONITORING SERVICE

OGS National Institute of Oceanography and Applied Geophysics

CMEMS MEDITERRANEAN SEA MFC
Contract CMEMS MFC MED Until 31 March 2021

OUTLINE:

- **CMEMS** Mediterranean Sea monitoring and forecast centre (**Med-MFC**): the BIOGEOCHEMISTRY unit (**MED-BIO**)
- **BGC-Argo Floats in MED-BIO**
  - NRT Quality Control at OGS
  - Operational validation framework:
    - monitor model skill
    - multivariate metrics assessing uncertainty in physical-biogeochemical processes
- **New perspectives in model validation**

Med-MFC overview

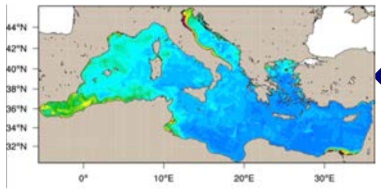
The Mediterranean Monitoring and Forecasting centre (Med-MFC) for the Copernicus Marine Service is a consortium of 3 research institutes

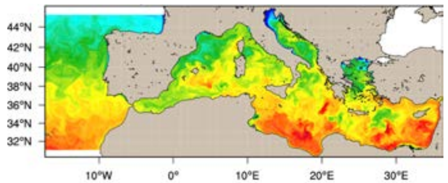
CMCC (Leader of the consortium and responsible for the Physical product) → **Med-PHY**
OGS (Responsible for the Biogeochemical product) → **Med-BIO**
HCMR (Responsible for the Wave product) → **Med-WAV**

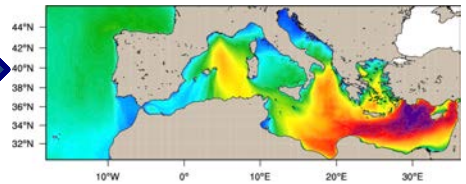
Med-Biogeochemistry PU
OGS

Med-Physics PU
cmcc

Med-Wave PU
hcmr







BGC Argo in the Med Sea biogeochemical operational system

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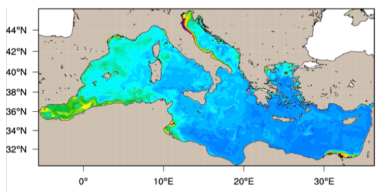
Med-Biogeochemistry (MED-BIO) overview

MED-BIO is responsible for Mediterranean Sea Biogeochemistry products:

- Reanalysis (multi-year product, MYP)
- Analysis & Forecast (near real time product, NRT)

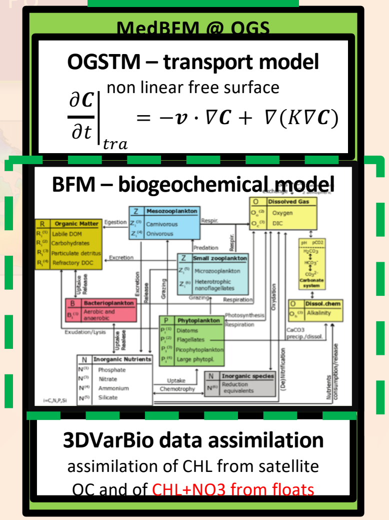
Med-Biogeochemistry PU

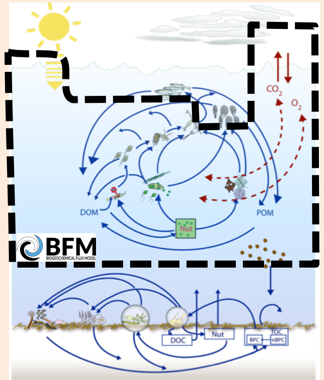
OGS



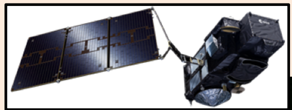
- MED-BIO MYP and NRT are produced by the MedBFM model system:
  - Forced by MED-PHY NEMOv3.6 model
  - Biogeochemical Flux Model (BFM) is at its core
  - Assimilating data from satellite and BGC-Argo floats

MED-BIO





BFM



FORECAST & REANALYSIS PRODUCTS

CMEMS catalogue at marine.copernicus.eu

Entering in the BGC Argo Era in the Med Sea

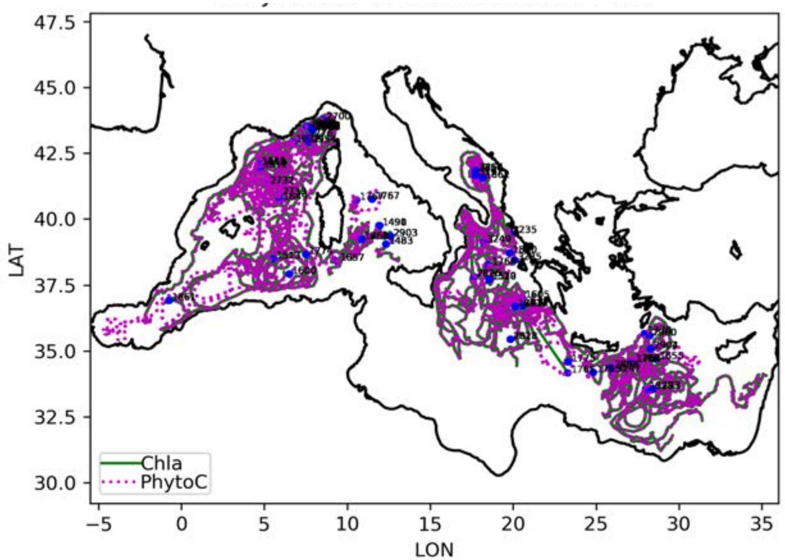
BGC Argo float: a multivariate observation dataset

- Chlorophyll (Chla)
- Oxygen (O2)
- Nitrate (N3n)
- Biomass of Phytoplancton (PhytoC) → retrived from Bbp700 using Bellacicco et al. (2019)

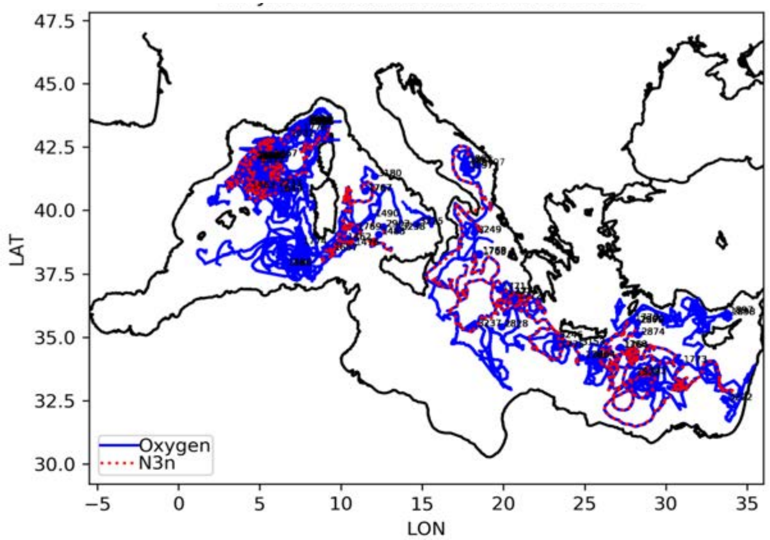
Chla - N floats: 55 N profiles: 7465
O2 - N floats: 86 N profiles: 10559
N3n - N floats: 28 N profiles: 3779
Bbp - N floats: 60 N profiles: 9367

TRAJECTORY of FLOATS 2013-2021

Chlorophyll & PhytoC



Oxygen & Nitrate



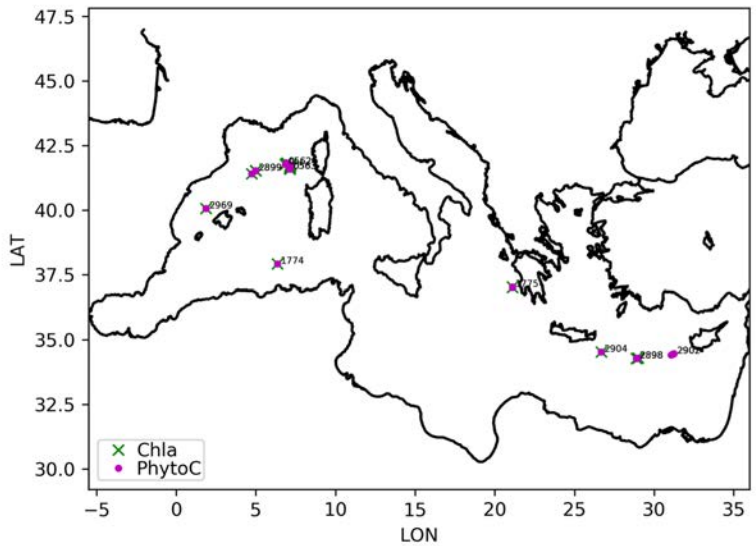
(https://fleetmonitoring.euro-argo.eu)

BGC Argo float at NRT:

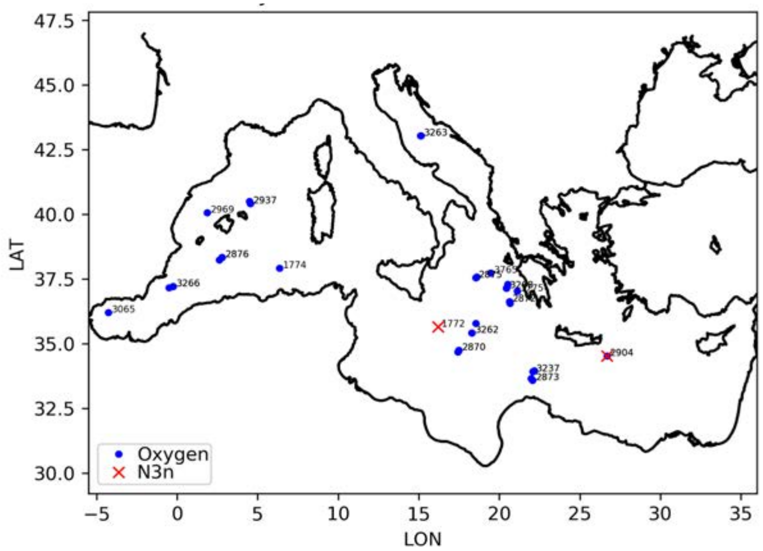
Every week (before the integration in the DA system) we have just few profiles

TRAJECTORY of FLOATS in NRT
(week 2021-04-19)

Chlorophyll (8) & PhytoC (9)



Oxygen (17) & Nitrate (2)

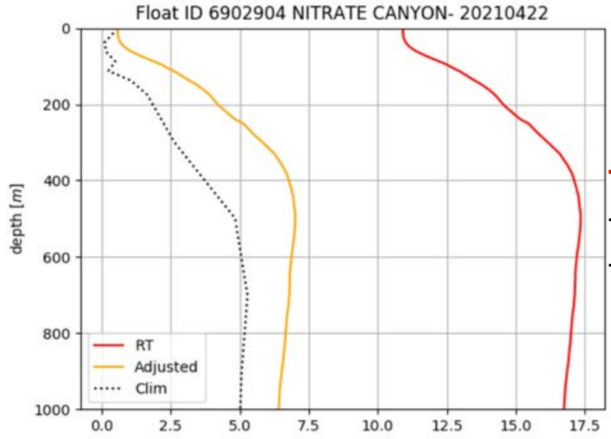


Entering in the BGC Argo Era in the Med Sea

BGC Argo float at NRT:

Every week (before the integration in the DA system) we have just few profiles, in RM or maybe AM.

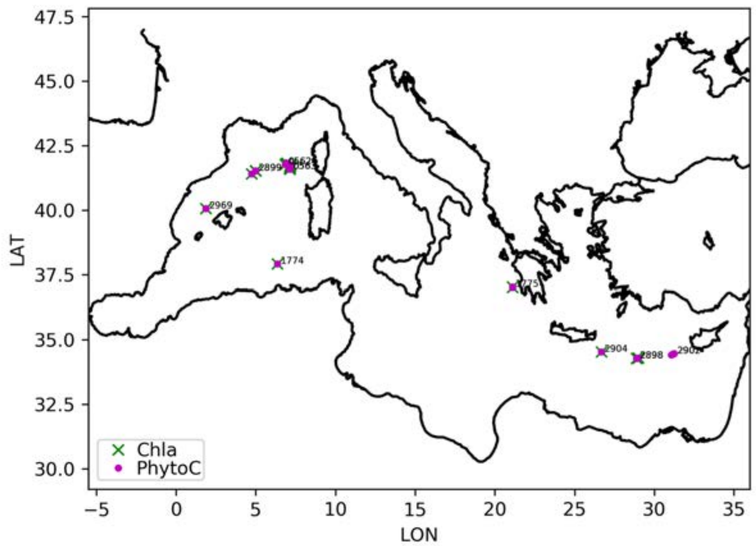
=> How good are for operational purposes?



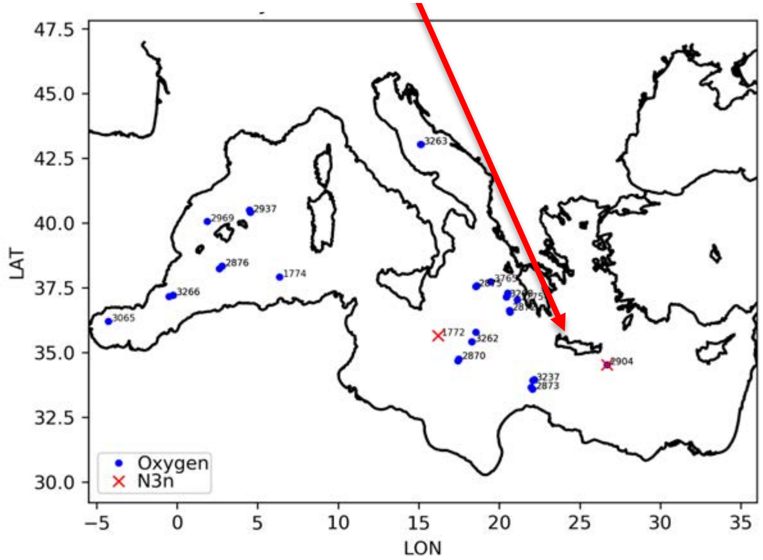
--- RT RAW DATA
--- RT ADJUSTED
--- CLIMATOLOGY

TRAJECTORY of FLOATS in NRT
(week 2021-04-21)

Chlorophyll (8) & PhytoC (9)



Oxygen (17) & Nitrate (2)



BGC Argo data Near Real Time QC at OGS

- **Chla** NRT adjustment are already checked and implemented: Chla is the variable with the best QC

BGC Argo data Near Real Time QC at OGS

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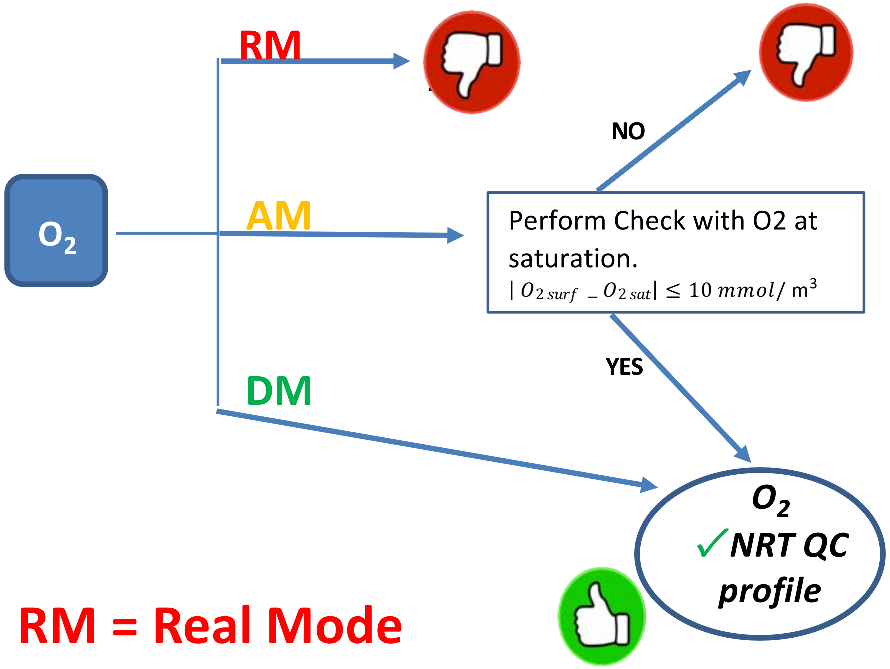
- **O_2 check**

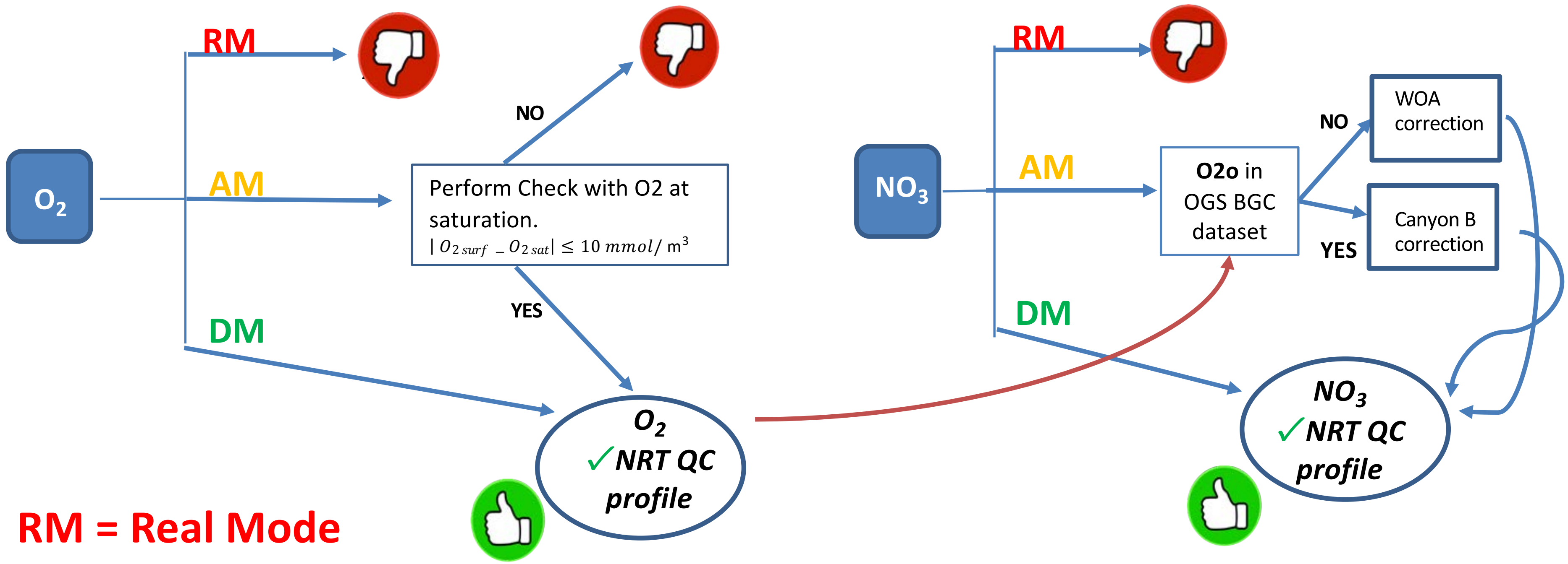


RM = Real Mode
AM = Adjusted Mode
DM = Delayed Mode

BGC Argo data Near Real Time QC at OGS

- **Chla** NRT adjustment are already checked and implemented: Chla is the variable with the best QC

- **O_2 check + NO_3 correction procedure**



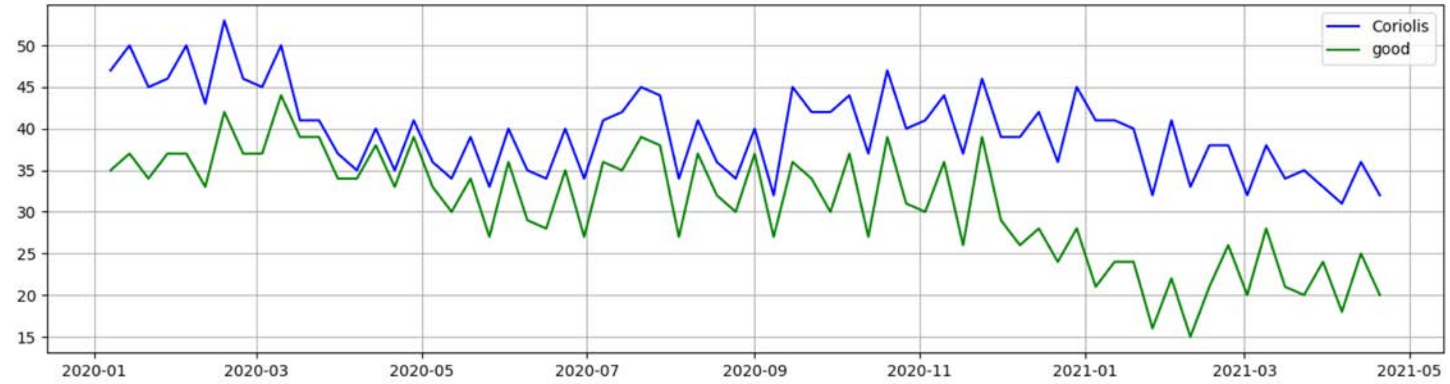
RM = Real Mode

AM = Adjusted Mode

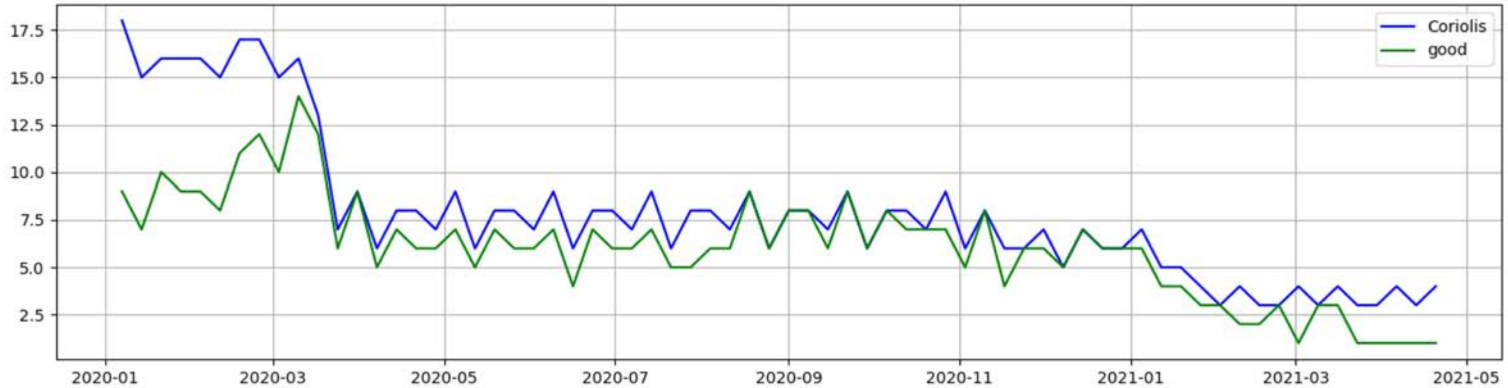
DM = Delayed Mode

As a result of our internal OGS QC…

DOXY: n. of original and ready-to-use profiles after OGS QC:

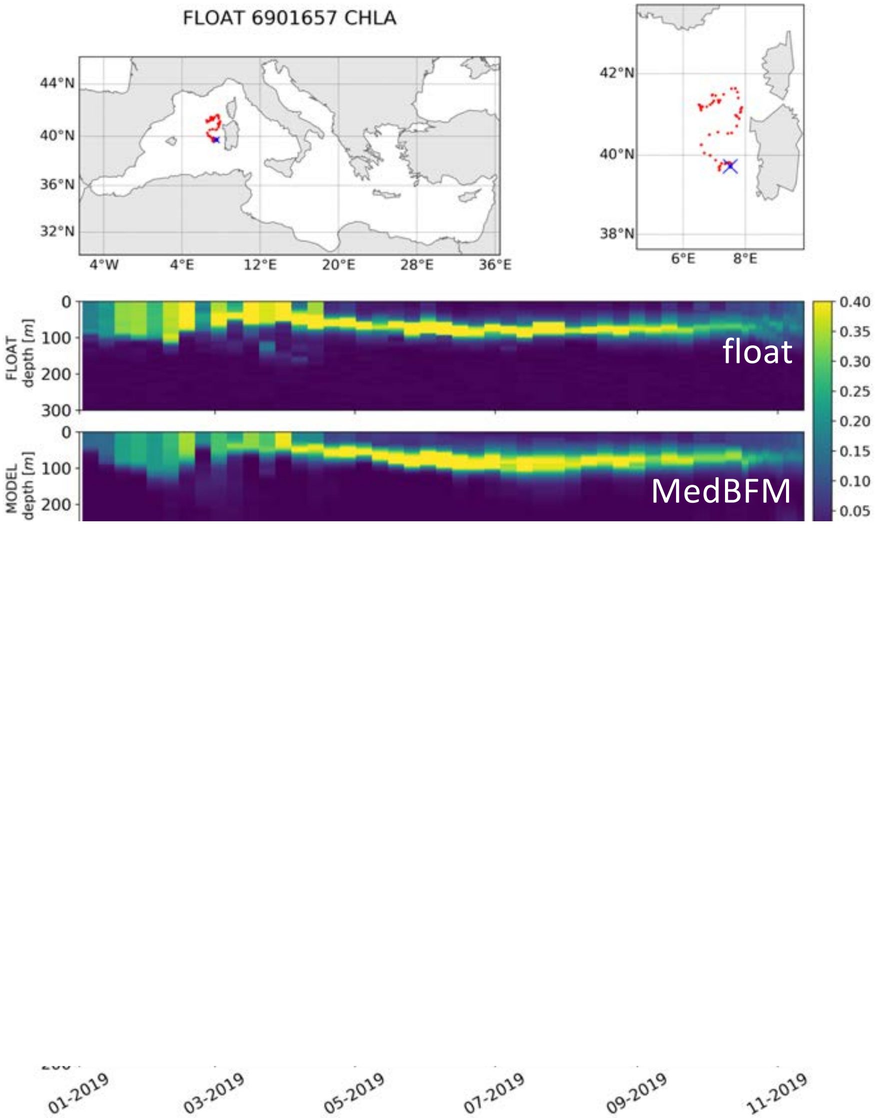


NITRATE



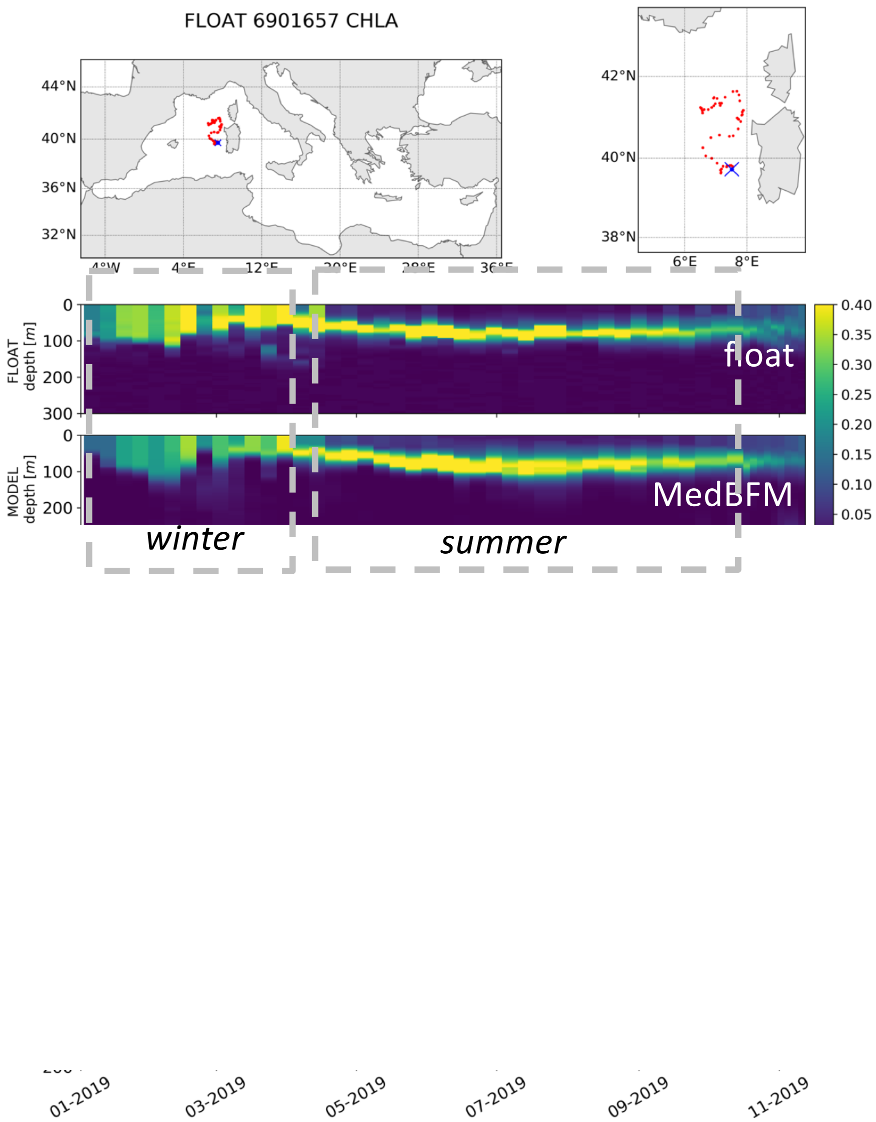
=> added value to standard Coriolis QC !!!

Validation Framework (PART 1): CHLA

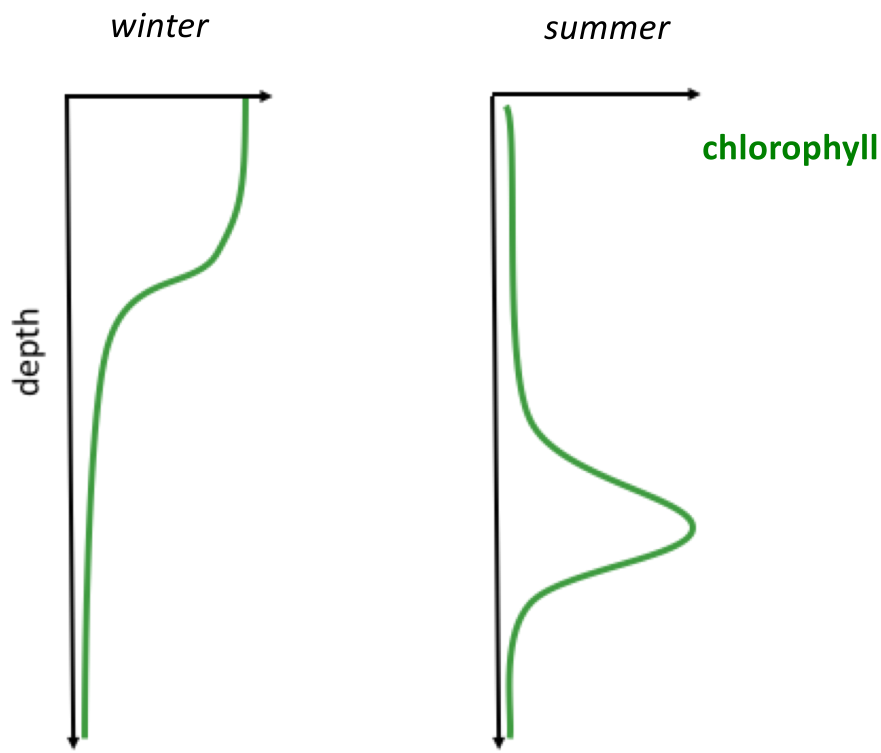


Hovmoller diagram of **chlorophyll**: match-up of model results on the float trajectory

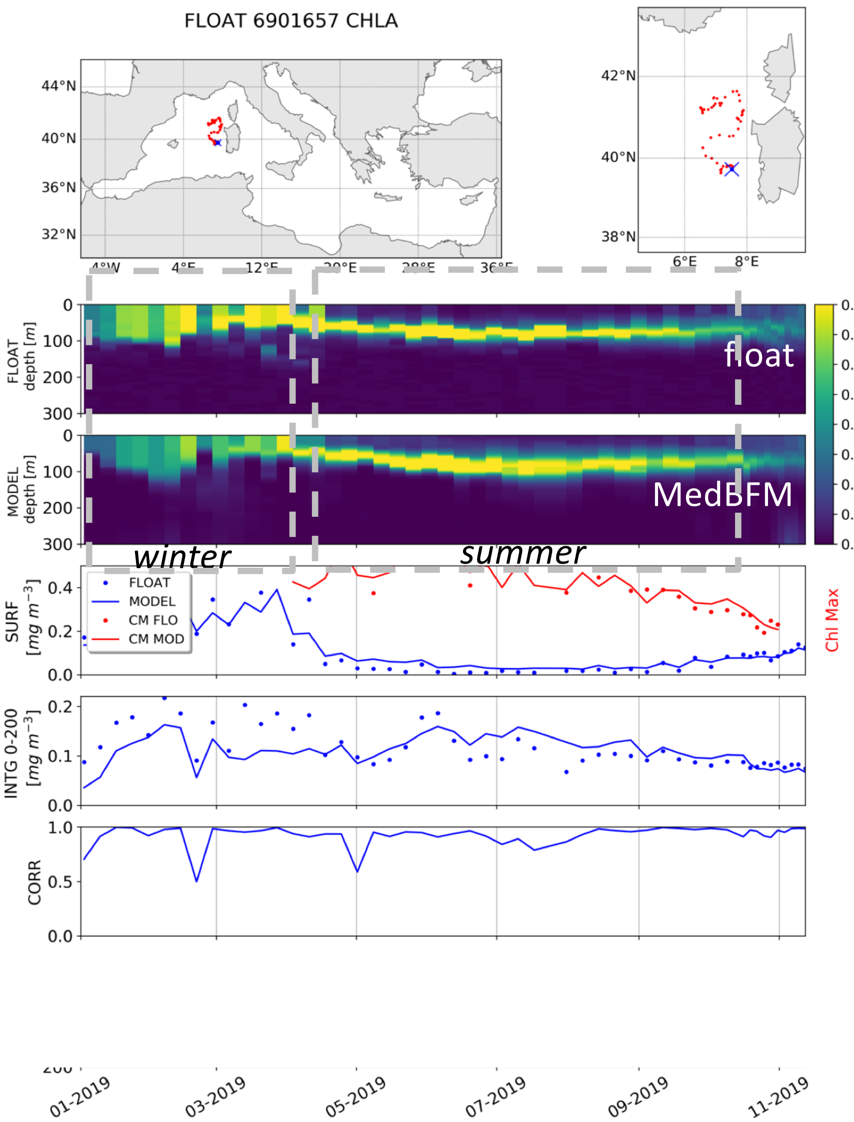
Validation Framework (PART 1): CHLA



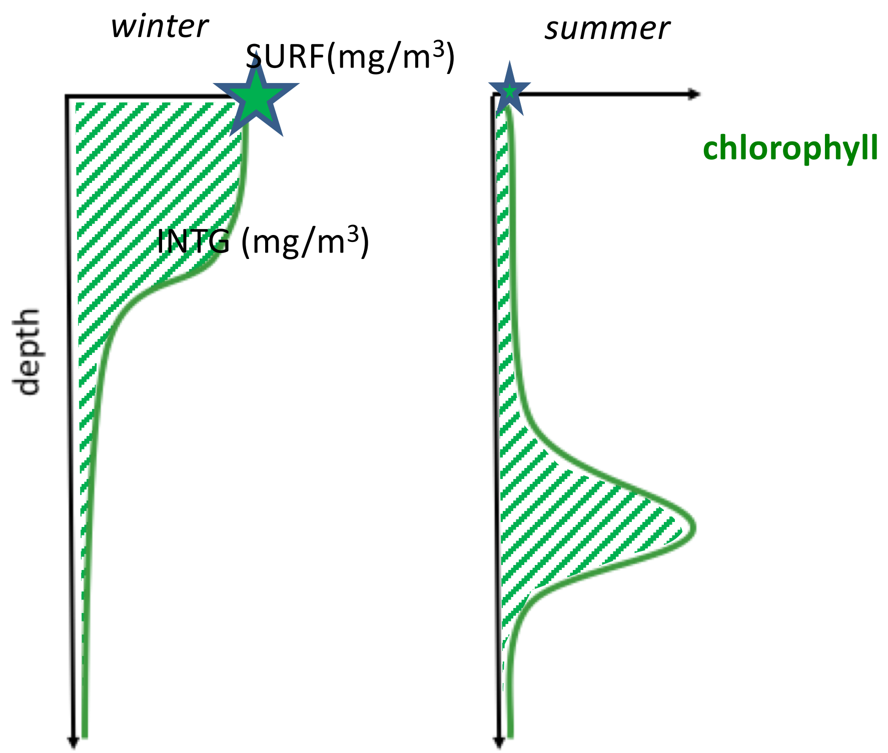
Metrics on vertical shape of **chlorophyll** profiles



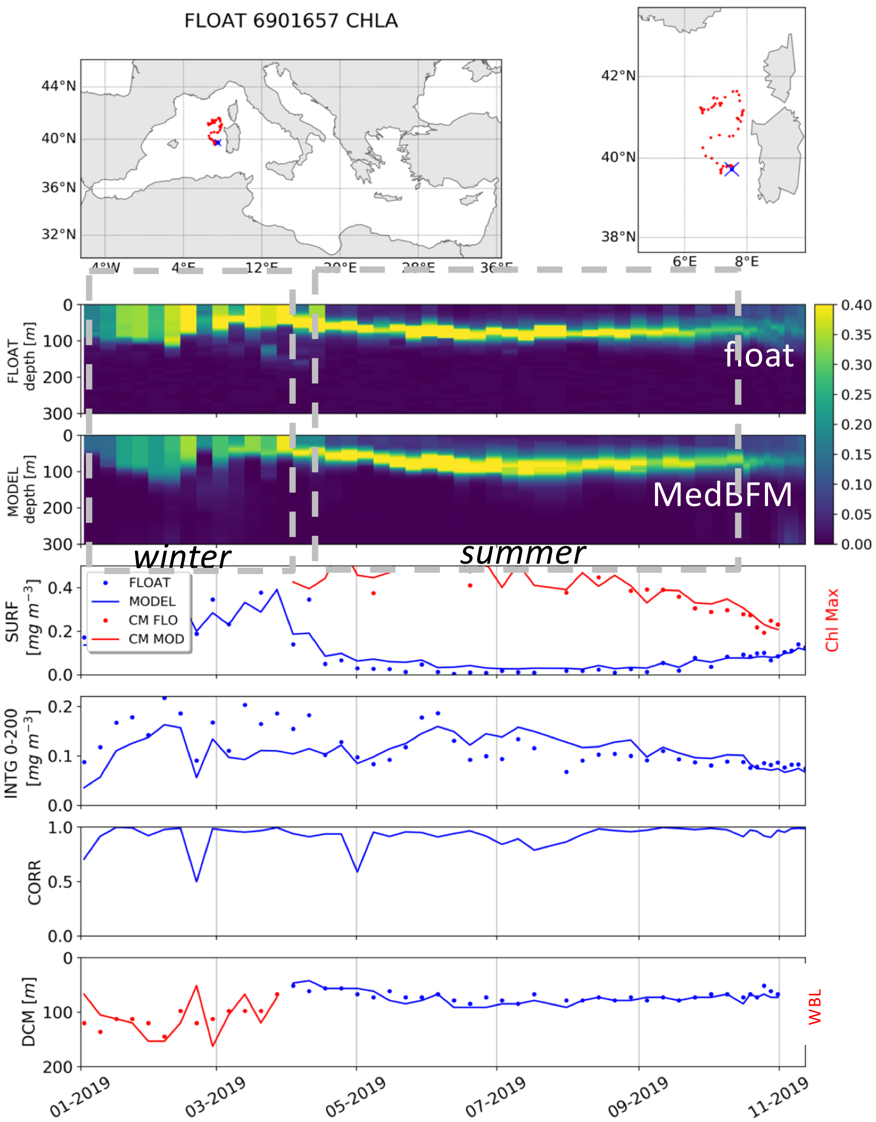
Validation Framework (PART 1): CHLA



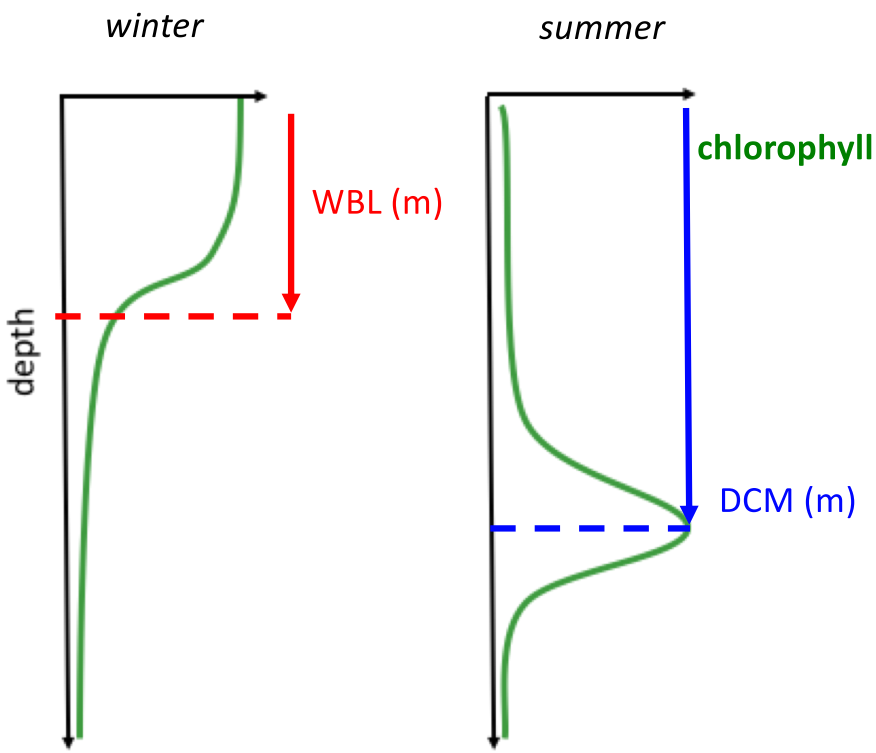
Metrics on vertical shape of **chlorophyll** profiles



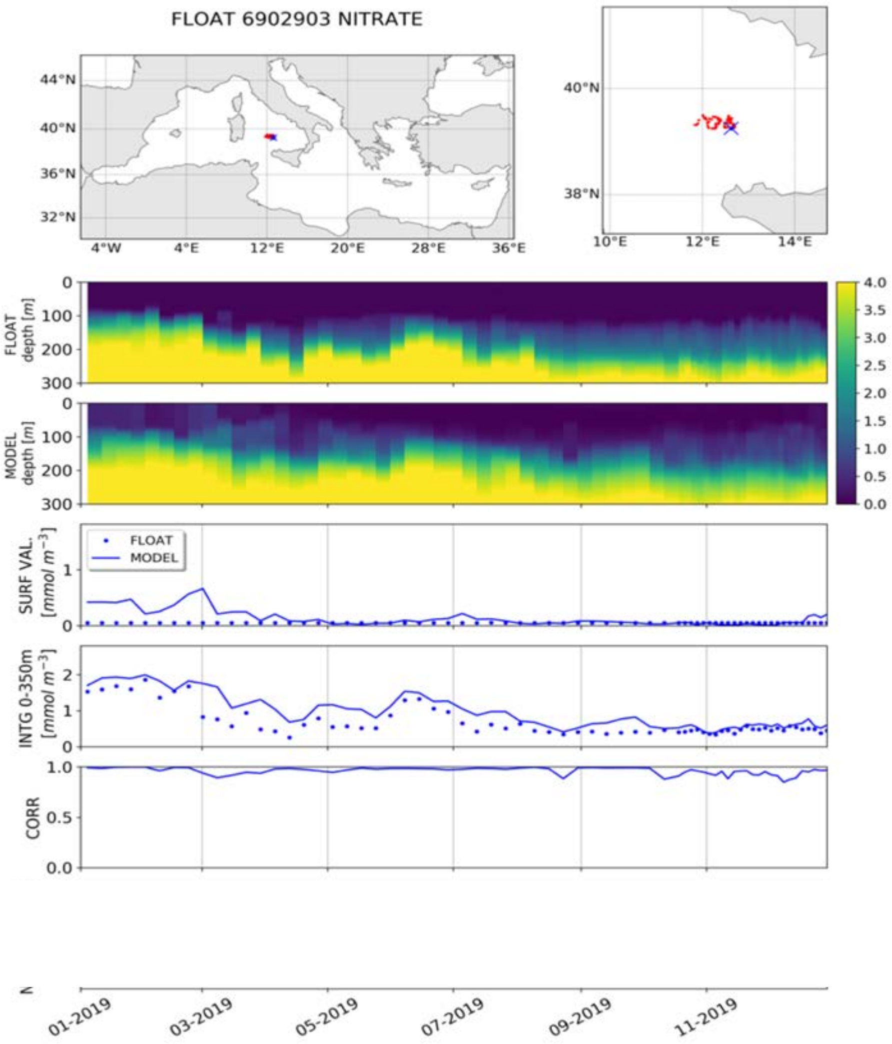
Validation Framework (PART 1): CHLA



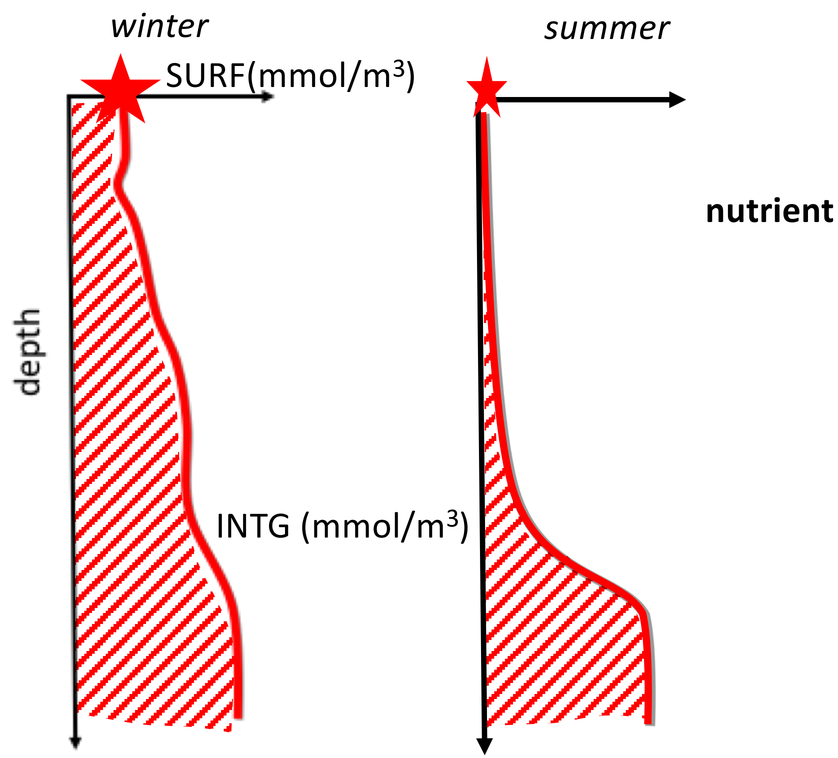
Metrics on vertical shape of **chlorophyll** profiles



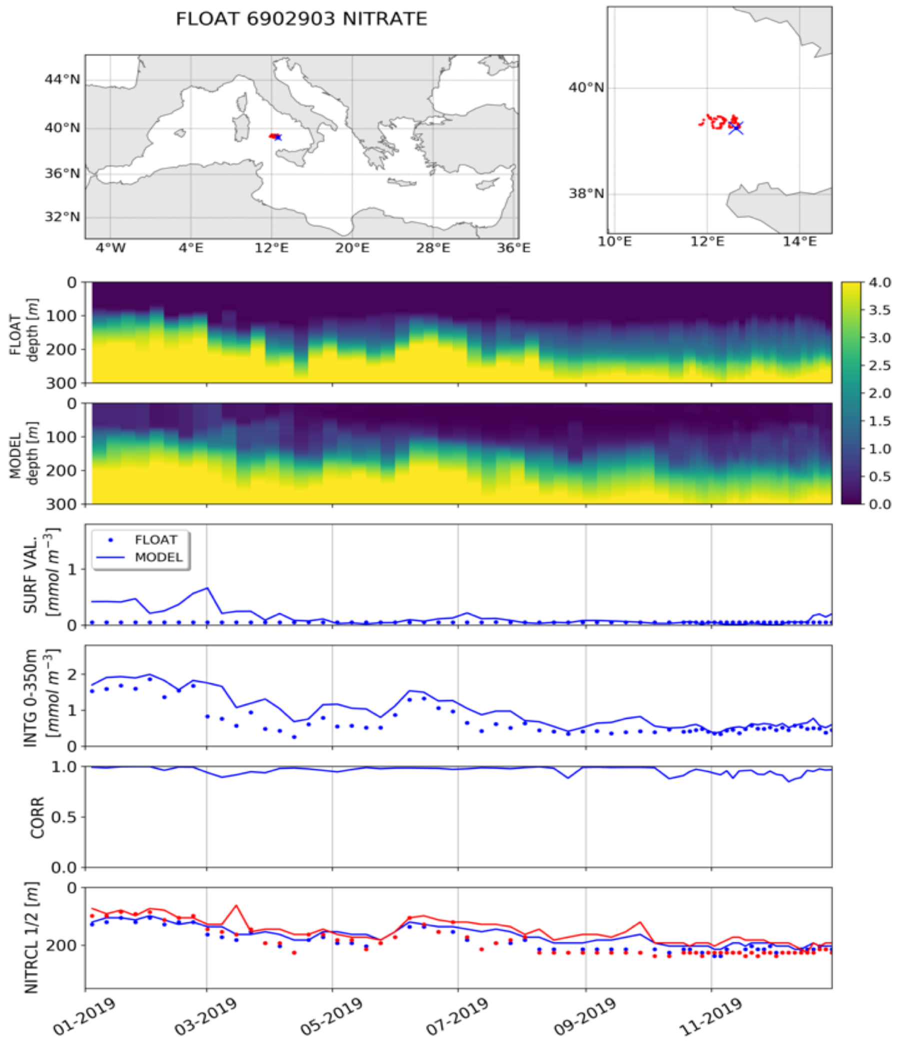
Validation Framework (PART 1): NO3



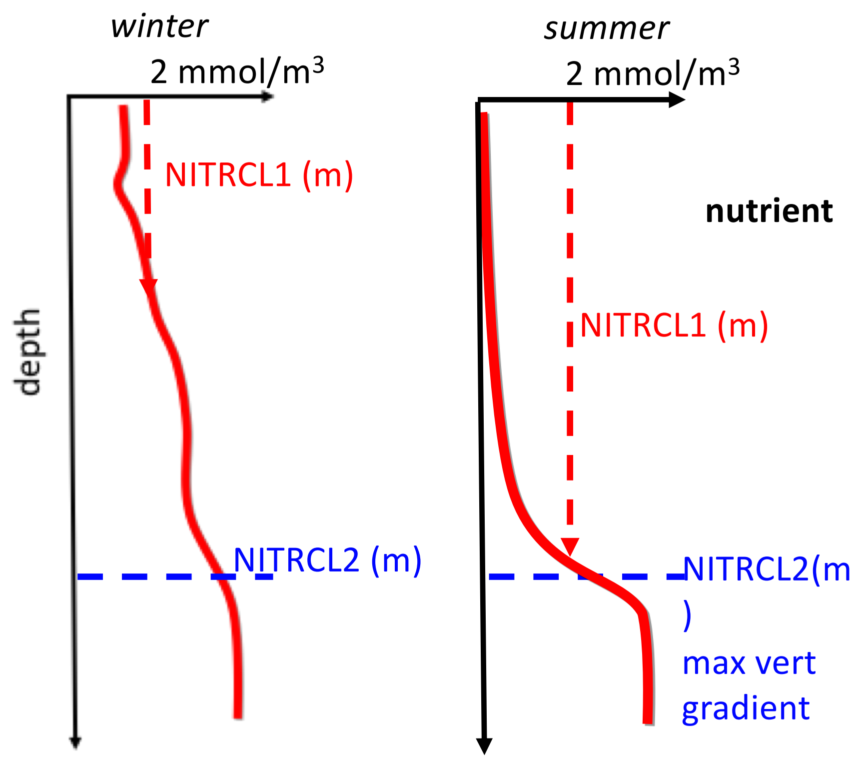
Metrics on vertical shape of **nitrate** profiles



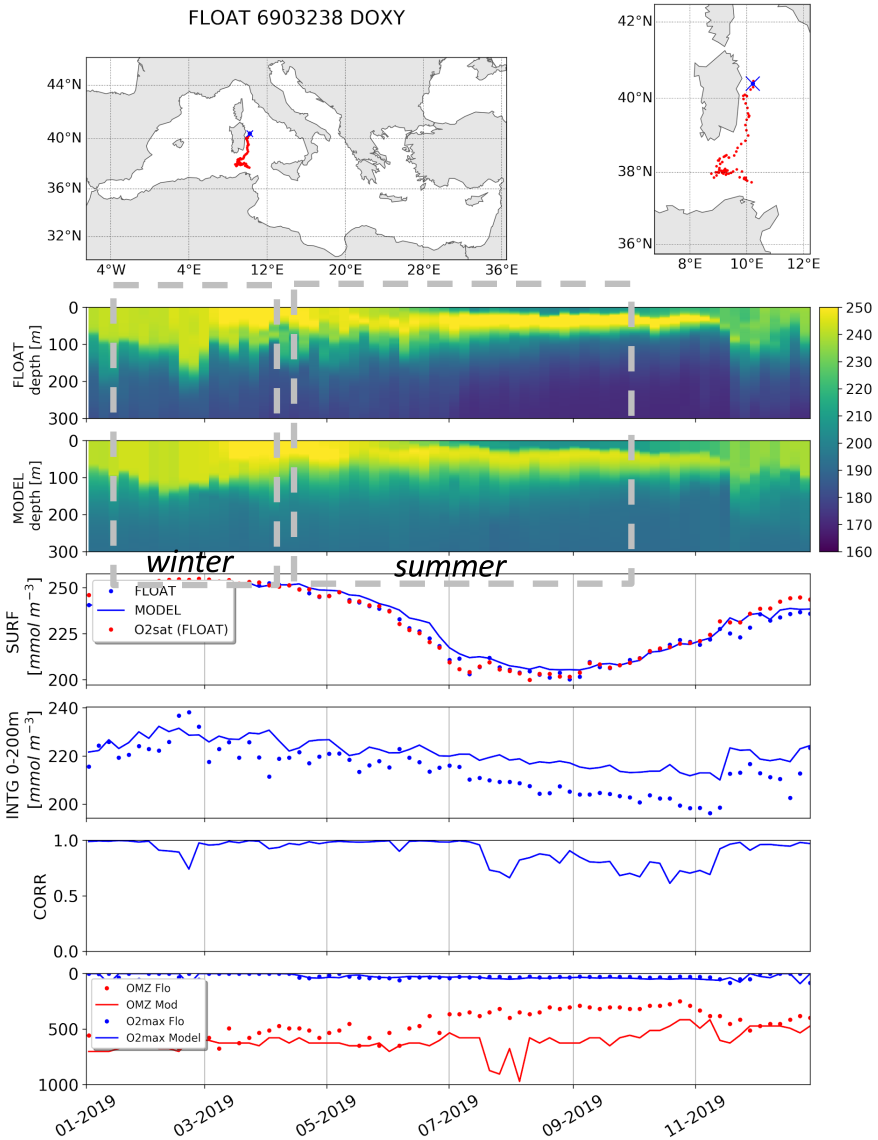
Validation Framework (PART 1): NO3



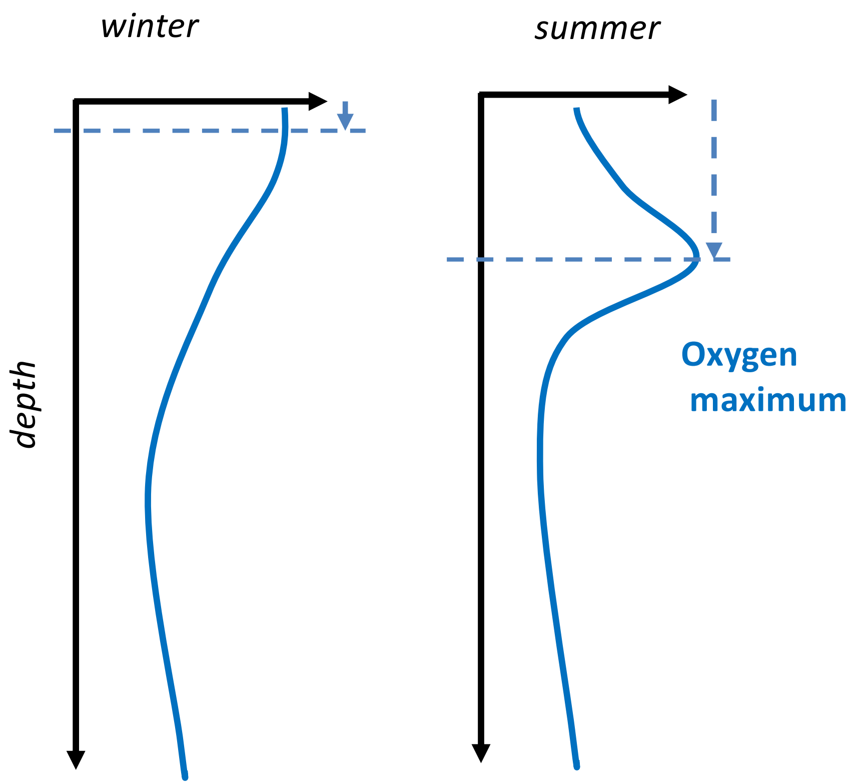
Metrics on vertical shape of **nitrate** profiles



Validation Framework (PART 1): O2



Metrics on vertical shape of **oxygen** profiles



Validation Framework (PART 1)

Skill statistics (BIAS and **RMSD**) can be computed for each metrics, grouping profiles in large sub-basins for robust statistics

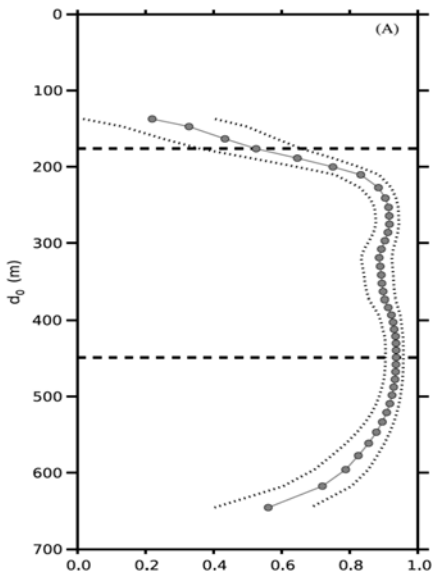
	Chl			PhyC	NO_3		OXY	
	RMSD 0-200m mean [mg/m^3]	RMSD DCM depth [m]	RMSD WBL depth [m]	RMSD 0-200m mean [mgC/m^3]	RMSD 0-200m mean [mmol/m^3]	RMSD NITRCL1 depth [m]	RMSD 0-200m mean [mmol/m^3]	RMSD max O2 depth [m]
SWM	0.04	9	42	1.70	-	-	8.48	10
NWM	0.04	10	30	1.07	0.46	9	7.27	9
ION	0.03	27	18	0.52	0.26	11	3.18	25
LEV	0.02	17	17	0.43	0.32	36	7.93	5

Validation Framework (PART 2): density|NO3

Previous studies: e.g. Ascani et al 2013 → **nitrate-density** relations emerge from profile correlation index

Omand & Mahadevan (2013),
Ascani et al. (2013)

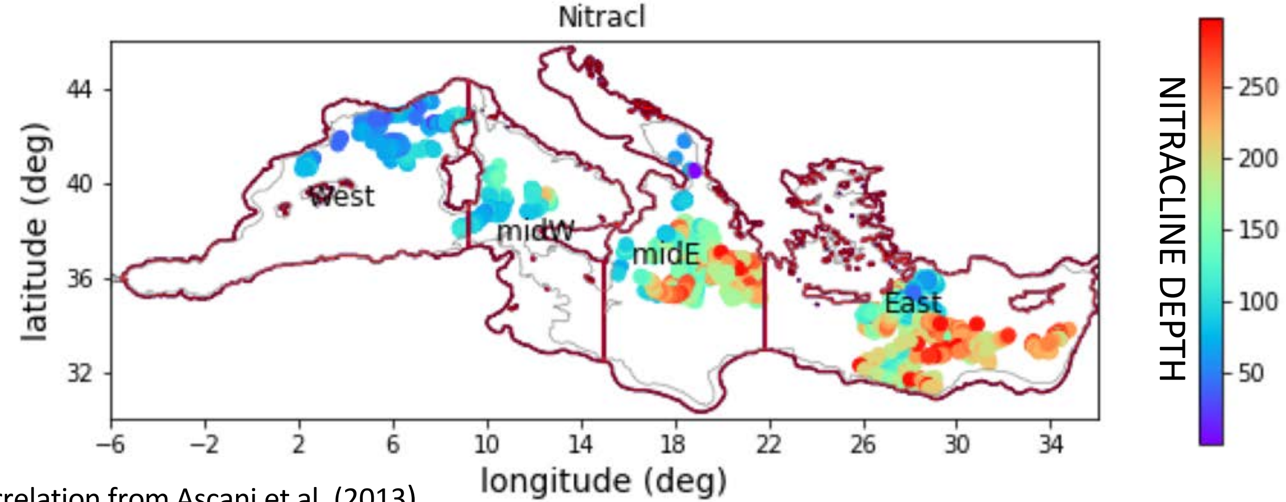
Correlation from Ascani et al. (2013)



NITRATE-DENSITY CORRELATION

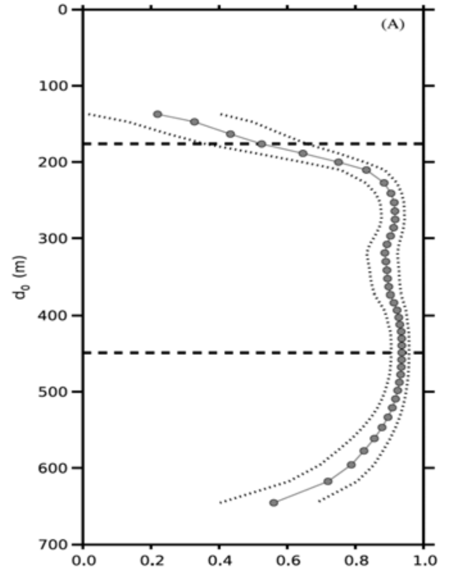
Validation Framework (PART 2): density|NO3

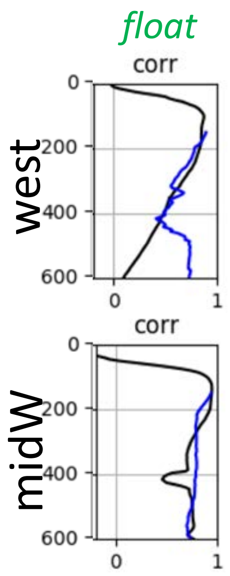
2013-2021 float equipped with CTD sensors and NO3 sensors → **nitrate-density** relations emerges from profile correlation index in different «sub-regions»

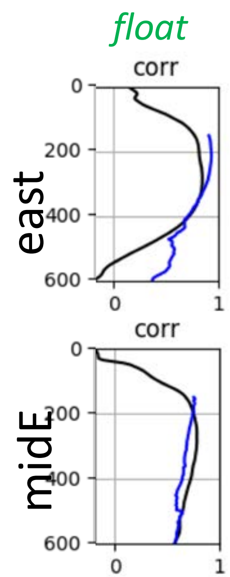


SUMMER SEASON

Correlation from Ascani et al. (2013)



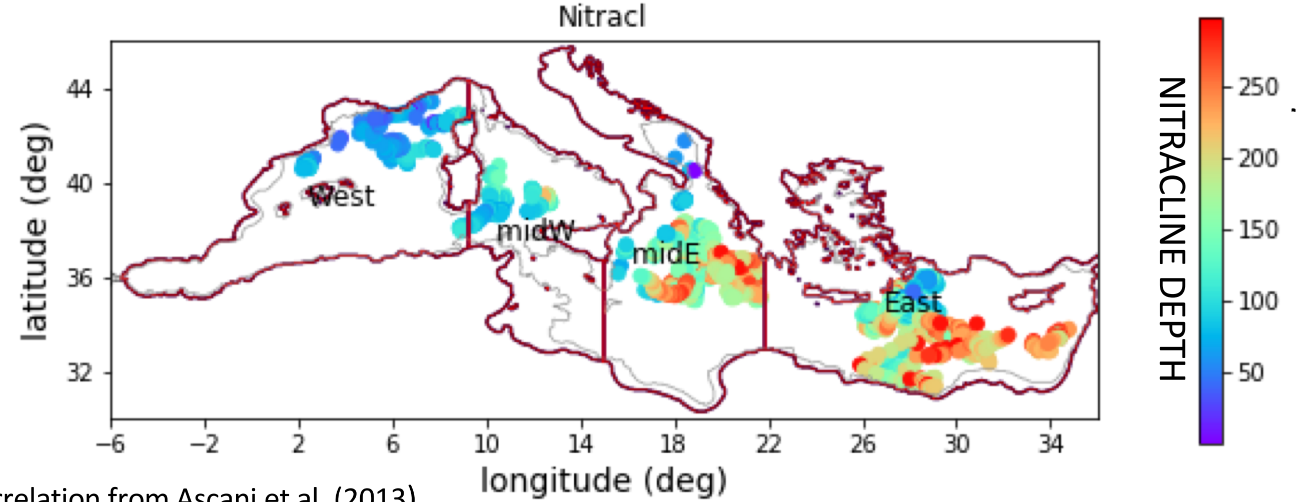




Different regions host different robust dens/nitr vertical relationships

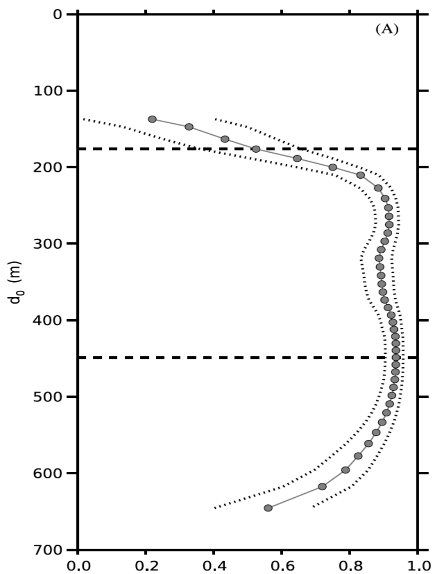
Validation Framework (PART 2): density|NO3

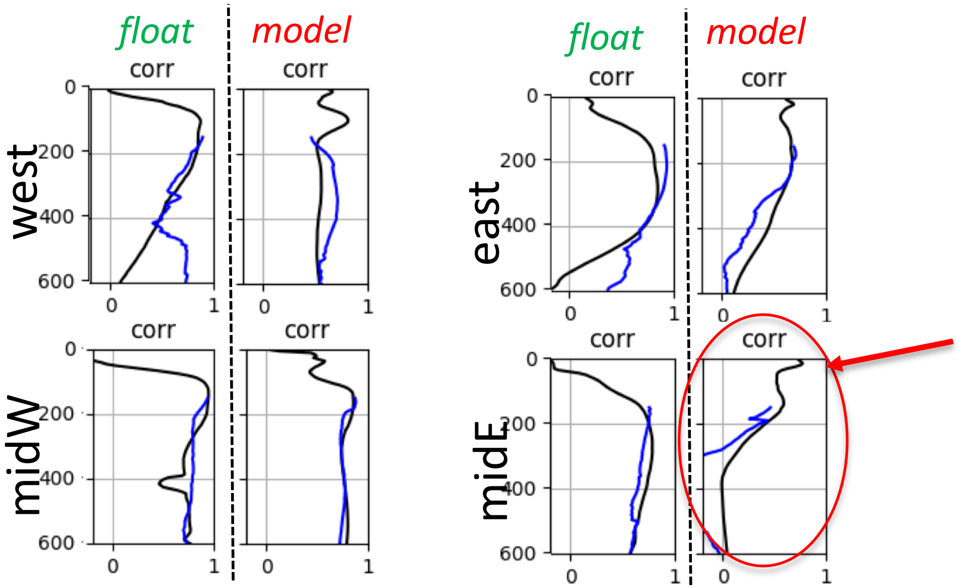
2013-2021 float equipped with CTD sensors and NO3 sensors → **nitrate-density** relations emerges from profile correlation index in different «sub-regions»



SUMMER SEASON

Correlation from Ascani et al. (2013)





Different regions host different robust dens/nitr vertical relationships

Model is consistently reproducing the physical biogeochemical coupled dynamics in all sub-regions but mid-East

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CONCLUSIONS:

AIM: to highlight the **benefits** of the introduction of the **high quality level dataset** of the **BGC-Argo** network into the NRT MedBFM

- **NRT MedBFM** is a continually evolving and improving system (Cossarini et al. 2019, Lazzari et al. 2021, Teruzzi et al 2021 – submitted to BG)

- **New SKILL METRICS framework** (with respect to Salon et al. 2019) helps to track the model quality improvements:
  - NRT BGC Argo profiles QC at OGS;
  - a novel metrics framework is defined to evaluate emerging properties in BGC;
  - evaluation of the **quality** of the BGC variables values and the **consistency** of physical and BGC processes;
  - **correlation metrics** between **nitrate and density** at particular depths can be a promising validation technique in order to capture **the nature of the physical processes** which may influence the evolution of BGC processes as well

- **PERSPECTIVES:**
  - **regional validation website MEDEAF (**http://medeaf.inogs.it/), complementing the CMEMS PRODUCT QUALITY DASHBOARD, as reliable monitoring system for quality checked forecast products
  - identification of ***relationship*** between **density** and **nitrate** distribution in the vertical corroborated by previous studies