Impact of high-resolution atmospheric and riverine boundary conditions on Mediterranean Sea biogeochemical dynamics

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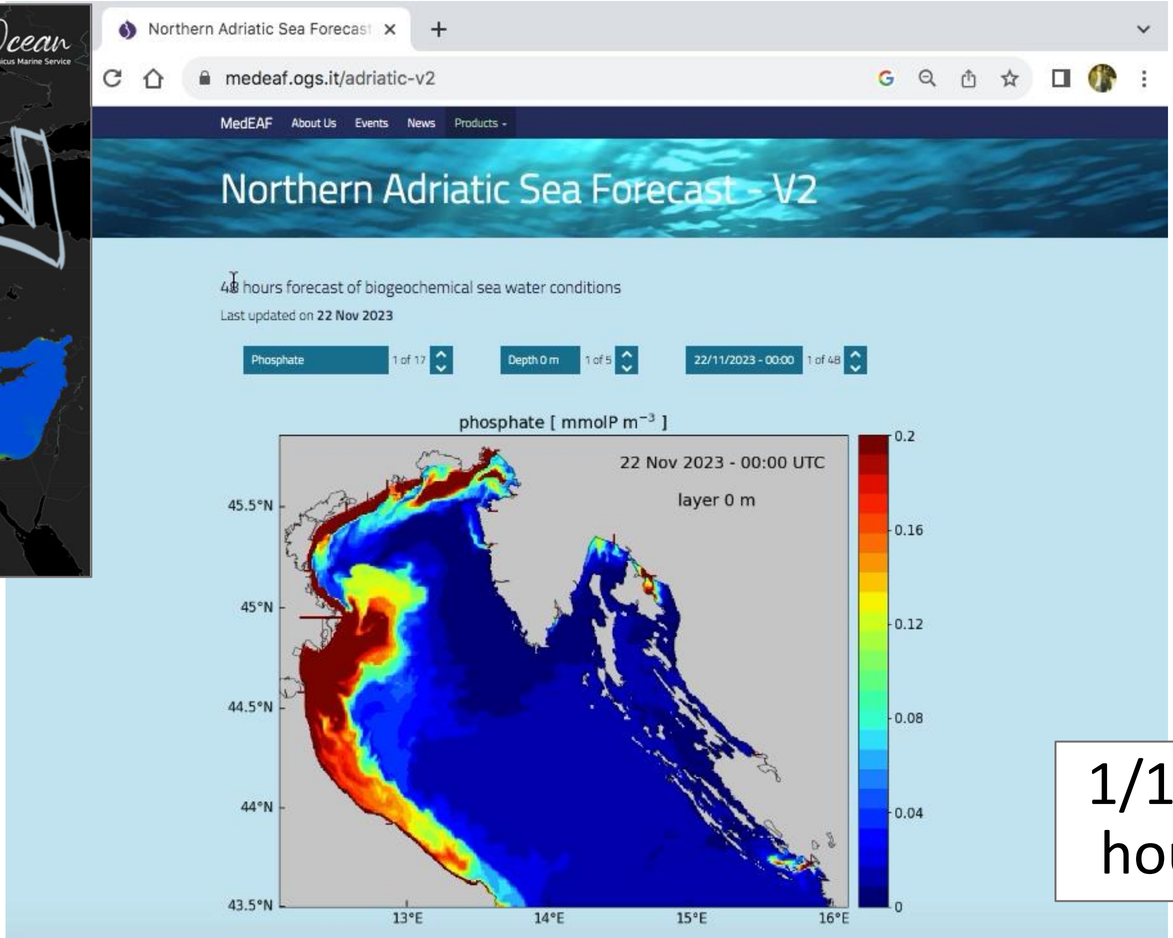
Overview

- Coastal marine ecosystems: spatial and temporal variability
- Copernicus EU BCs for Mediterranean Sea BGC: EFAS and CAMS
- Setup of simulations implementing high resolution BCs
- Preliminary results
- Conclusions and future work

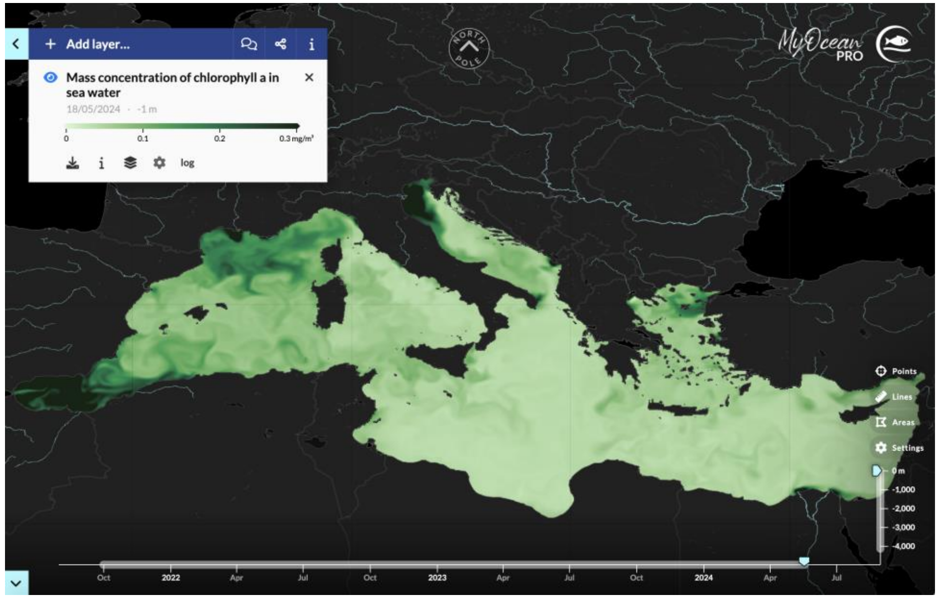
Variability of coastal marine ecosystems: northern Adriatic Sea case study



1/128° resolution, hourly frequency

How can we reproduce such a high variability?

- **BGC Med-MFC** products of **Copernicus EU Marine Service**: **1/24° (ca. 4 km)** horizontal resolution

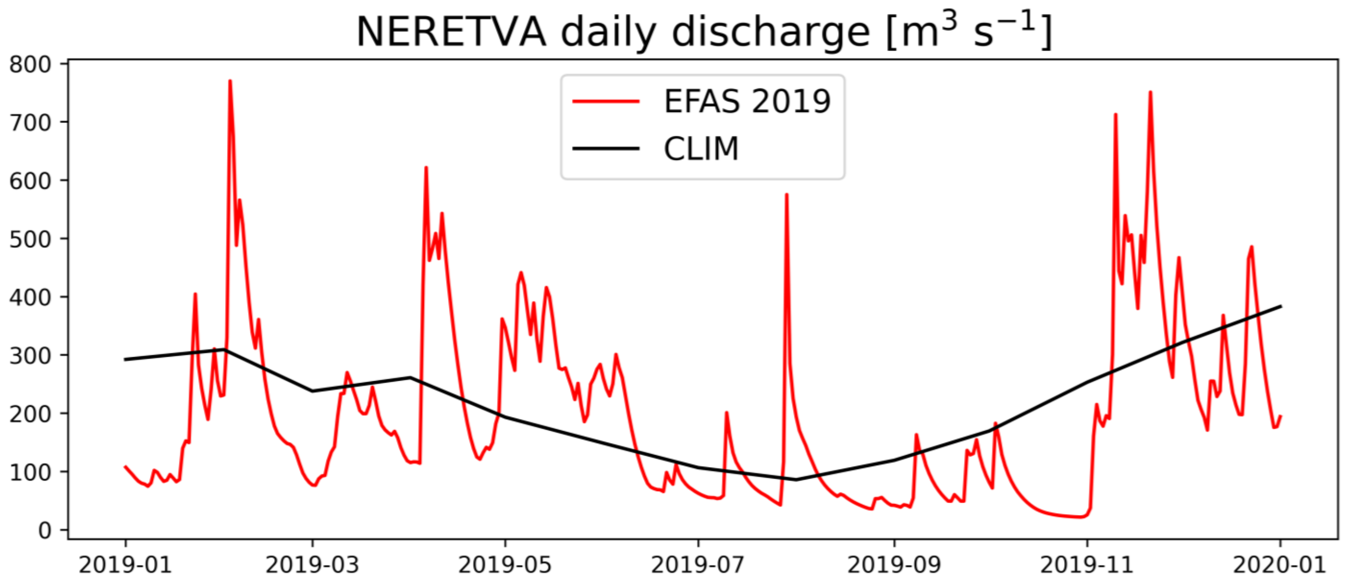


- **State-of-the-art coupled system:**
  - Transport model OGSTM v4.0;
  - BGC model BFM v5;
  - 3DVAR-BIO v3.4: surf chl from OCTAC + chl, nitrate and oxy profiles from BGC-Argo floats + convolutional NN for nitrate from Argo and BGC-Argo floats;

  including nutrients, dissolved gases, carbonatic system and plankton

- **Coastal dynamics** of marine ecosystems also require to:
  - Include **benthos** (under development in NECCTON project);
  - **Solve coastal processes** at <u>high spatio-temporal resolution</u>

Copernicus EU EFAS river discharges



HIGH FREQUENCY DYNAMICS

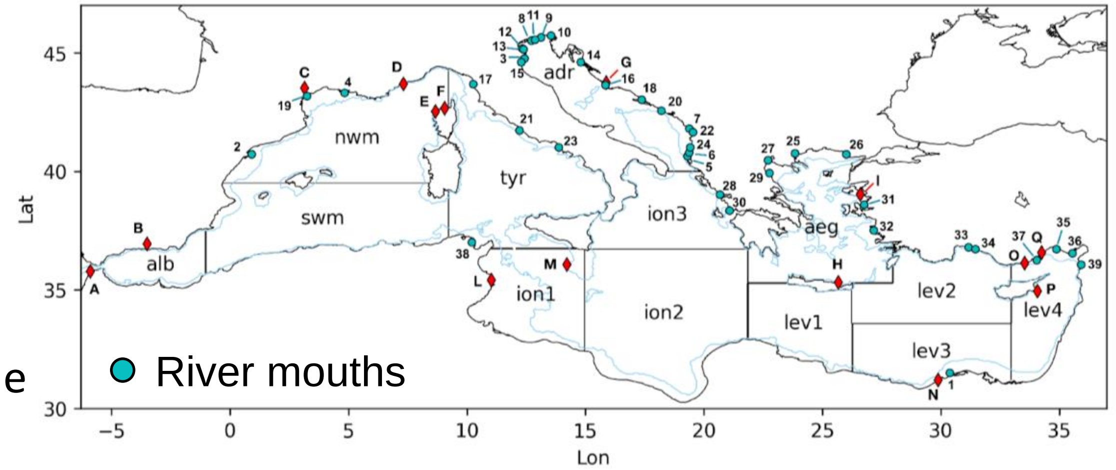
Emergency Management

- **6-hourly river discharges** for **historical and forecast** products;
- **EFAS v5**: LISFLOOD hydrological model forced with gridded observational data of precipitation and temperature (ca. **1.5 km resolution**), with outputs available since 1992;
- Fig: **example of daily discharge** of Neretva river in 2019, superimposed to PERSEUS (FP7-287600 project, D4.6) climatological estimate.

Nutrient and carbon loads associated with EFAS river discharges

load = river discharge x conc.

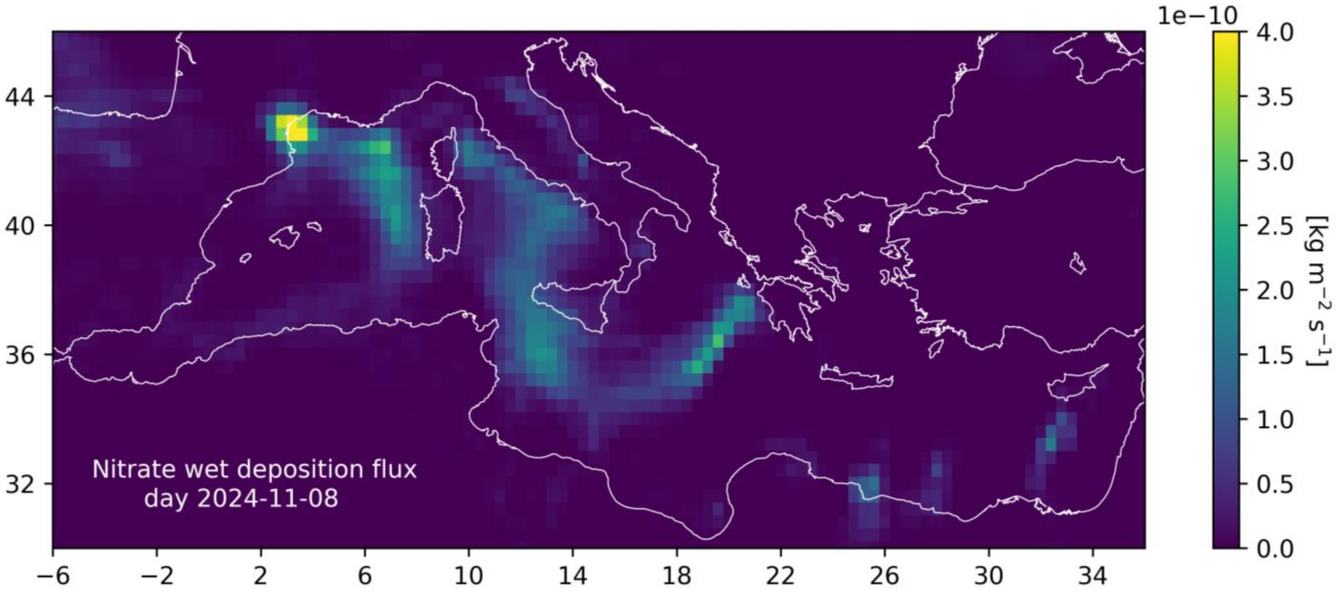
- EFAS **daily discharges** of **38 rivers** flowing into Med Sea;
- **Conc**. from **updated literature**:
  1) for each river: conc. = load/discharge
  2) for each sub-basin: conc. = mean of the conc. of all rivers in the sub-basin weighted by their discharges



	nwm	tyr	adr+ion	aeg	lev	Nile	Medjerda
Nitrate [gN/m^3]	1,61	2,23	1,74	1,71	2,06	12,88	2,56
Phosfate [gP/m^3]	0,096	0,283	0,060	0,379	0,083	0,492	0,172
DIC [gC/m^3]	30,04	52,96	36,08	34,41	32,23	35,33	57,81
POC [gC/m^3]	1,84	1,68	1,52	1,68	1,68	1,68	1,68
DOC [gC/m^3]	1,72	3,24	2,29	2,01	2,01	2,01	2,01
Alkalinity [mol/m^3]	2,87	5,16	3,00	2,62	2,52	2,41	5,73

Brogi et al., 2020; Cozzi & Giani, 2011; Dai et al., 2012; Giani et al., 2023; Gómez-Gutiérrez et al., 2006; Higueras et al., 2014; Kaiser et al., 2004; Ludwig et al., 2009; Malagó et al., 2019; Many et al., 2021; Panagiotopoulos et al., 2012; Pitta et al., 2014; Strobl et al., 2009; Tamše et al., 2015; UNEP/MAP/MED POL, 2003; Van Apeldoorn & Bouwman, 2014; Volf et al., 2013.

Copernicus EU CAMS atmospheric deposition fluxes



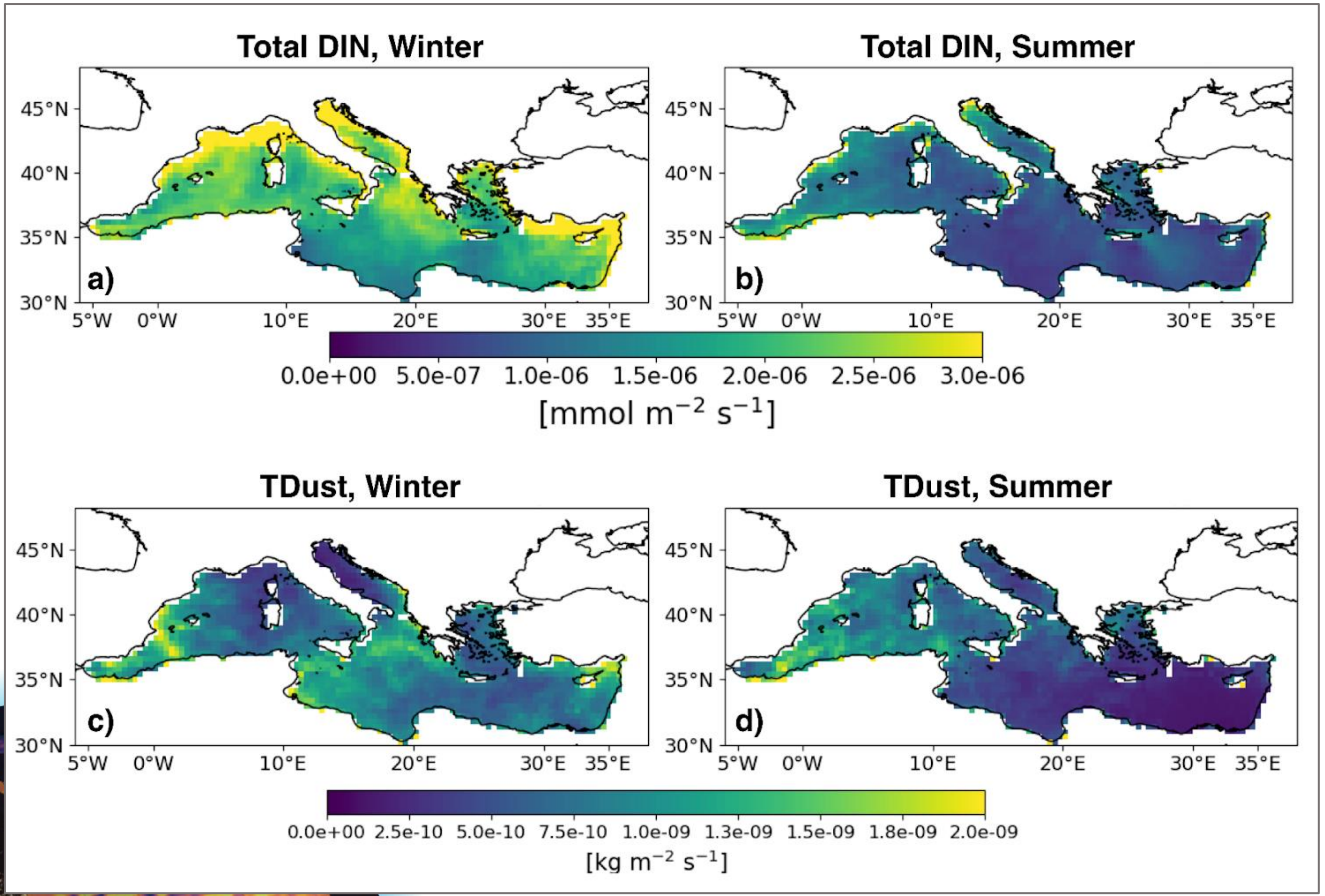
SPATIAL AND TEMPORAL PATTERNS

Atmosphere Monitoring Service

atmosphere.copernicus.eu

- 12-hourly **Global Atmospheric Composition Forecasts** product at 0.4° horizontal resolution;
- **Wet and dry deposition of nitrate, ammonium and dust aerosol** since mid-2019 onwards;
- Fig: **example of daily wet deposition** (i.e., both from convective and large-scale precipitation) of fine and coarse **nitrate** particles.

Seasonal atmospheric deposition of nitrogen and phosphorus (1/2)



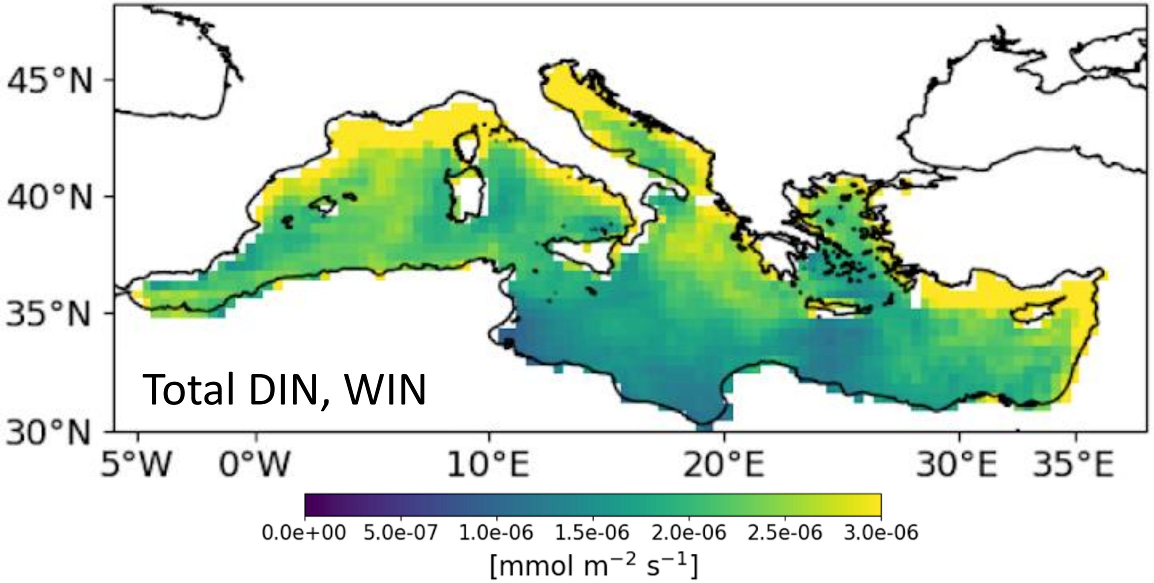
- **CAMS Total DIN** includes ammonium and fine/coarse nitrate particles;
- **CAMS Total Dust** includes all CAMS size classes of dust particles (i.e., 0.03-0.55 um, 0.55-9 um, 9-20 um);

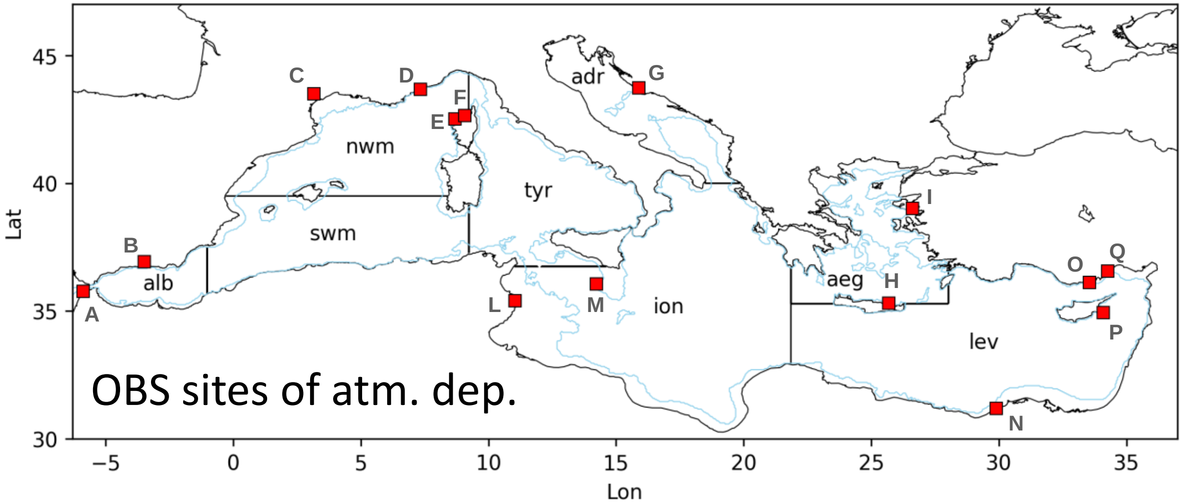
⇩

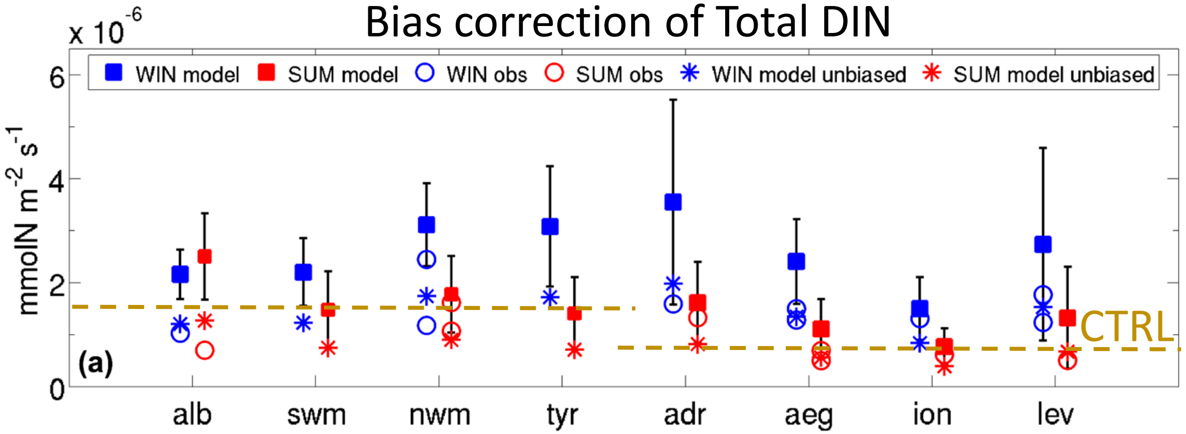
- **Total P** = 735 ppm of Total Dust (Richon et al., 2018);

We computed «winter» (ONDJFM) and «summer» (AMJJAS) averages of 2020-2022 **CAMS** forecasts of **atmospheric wet+dry deposition fluxes** for Total DIN and Total Dust and estimated Total P.

Seasonal atmospheric deposition of nitrogen and phosphorus (2/2)







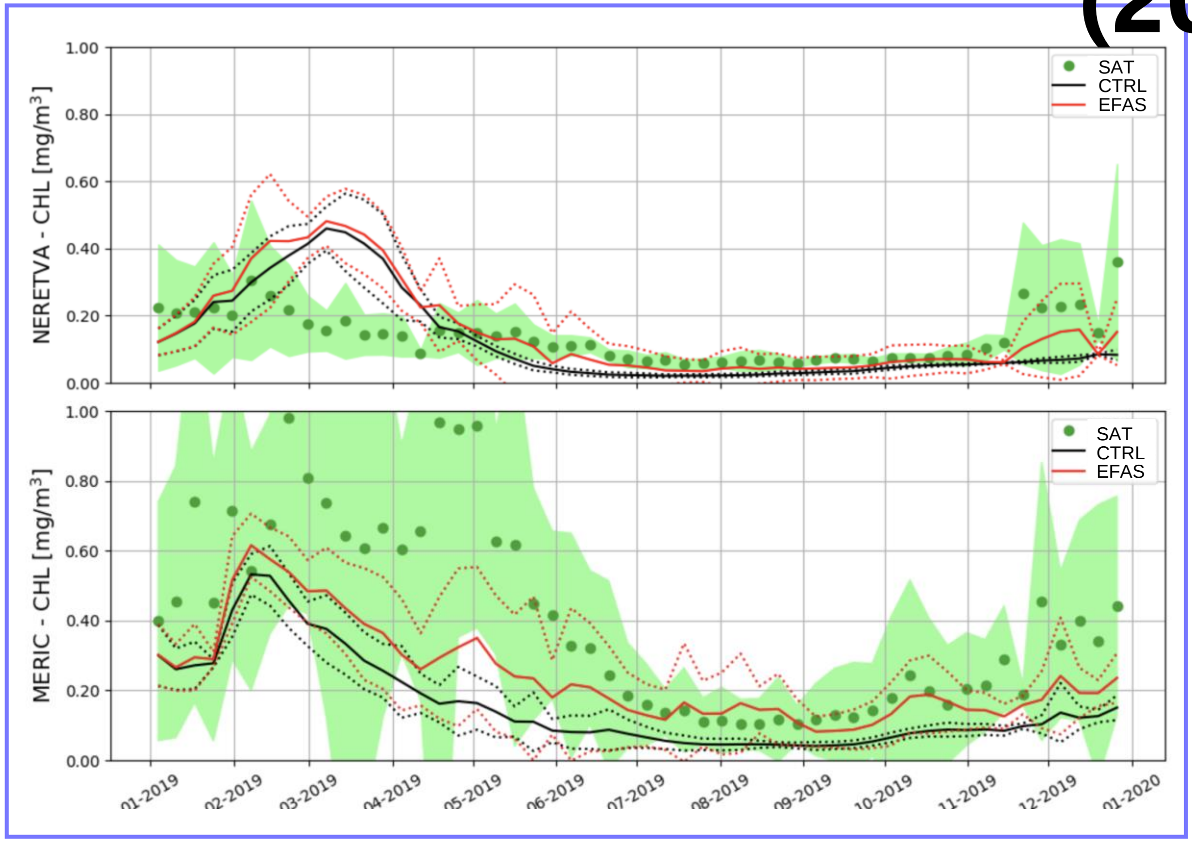
We estimated **mean (multiplicative) coefficients of bias correction** by **comparing** available observations and CAMS data averaged **in coastal sub-basins**.

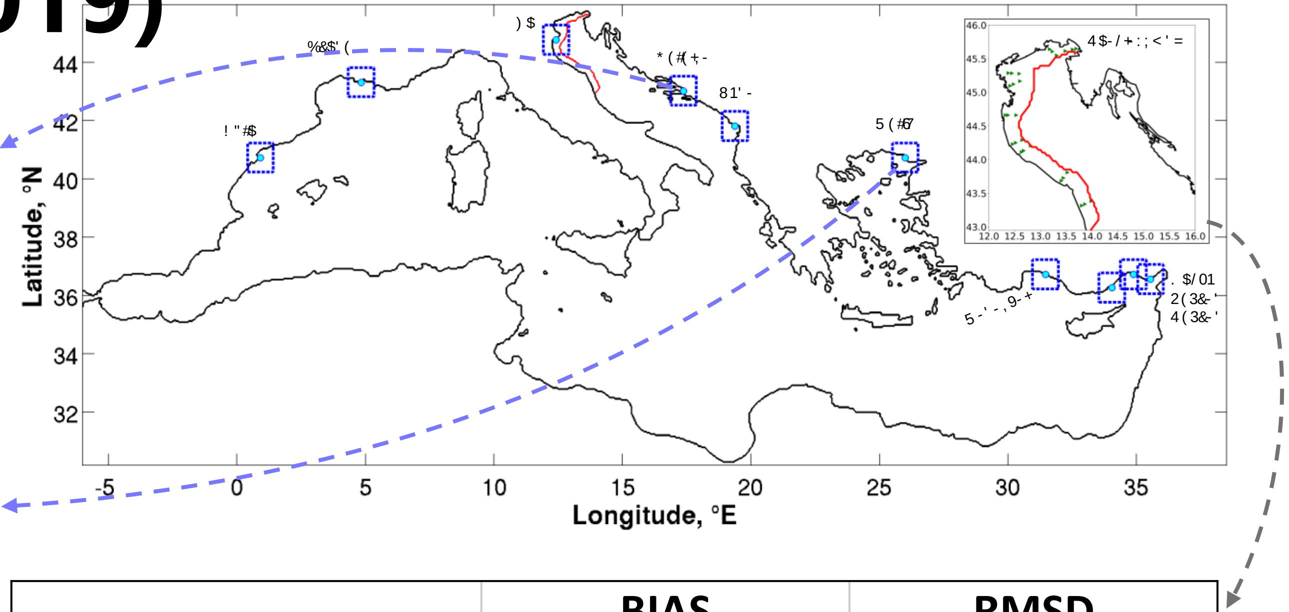
CTRL indicates the climatological values in West/East Med (Ribera D'Alcalà et al., 2003)

Run scheme for new BCs implementation

	BGC river loads	BGC atm. deposition fluxes
CTRL run	Monthly CLIM (PERSEUS D4.6)	CLIM (OBS, Ribera D'Alcalà et al., 2003): 2 values for N, P
EFAS run	EFAS daily discharges and updated BGC conc.	as in CTRL run
E+CA run	as in EFAS run	CAMS fields bias-corrected with OBS: 2 seasons, 16 sub-basins for N, P

Results: EFAS run validation (2019)





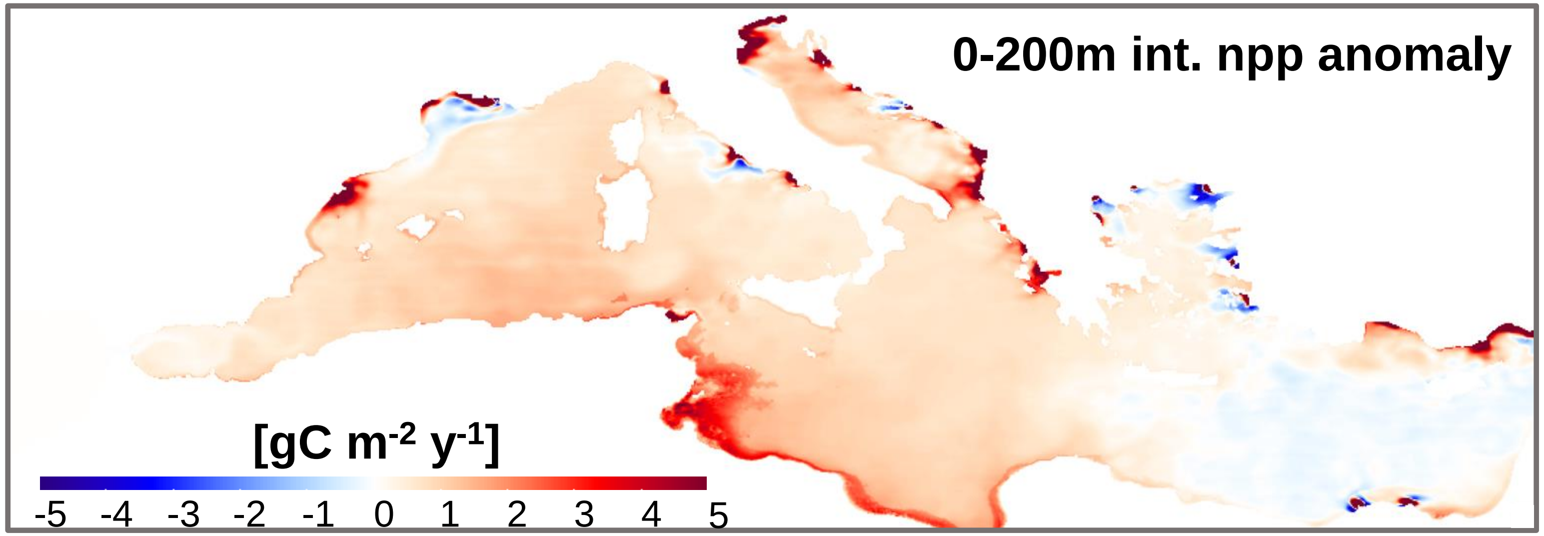
NAd coastal (12 nm)	BIAS		RMSD	
	CTRL	EFAS	CTRL	EFAS
Phosphate [mmol m^{-3}]	0.04	-0.002	0.11	0.065
Nitrate [mmol m^{-3}]	-2.52	-1.38	9.93	9.95

- **Chl** from Copernicus Marine Service OCTAC OCEANCOLOUR_MED_CHL_L3_NRT_OBSERVATIONS_009_040: better reproduction of coastal **blooms** and **high frequency variations** in coastal areas (**1°x1° boxes** around river mouths);
- Match-ups of modelled **nutrients** and a dedicated in situ dataset (MedBGCins, Di Biagio et al., 2024): improvements in spatial and temporal **distributions** in the northern Adriatic Sea Italian **territorial waters (12 nm)**

Results: E+CA run (2019)

- E+CA run shows a generally **higher coastal-offshore gradient** of npp wrto EFAS run;
- Coastal areas not influenced by rivers (i.e., central-southern Med) display higher npp (ca. 10%);
- **Open-sea productivity in Levantine Sea** slightly **decreased** (ca. 1%), due to lower input of Total P in summer (ca. 50%), thus enhancing the zonal gradient across the basin.

Δdeposition Total P [%]				
Sub-basin	Open-sea		Coast (0-200 m)	
	WIN	SUM	WIN	SUM
alb	106	79	158	162
swm	59	76	111	96
nwm	8	43	81	60
tyr	15	27	33	53
adr	90	25	18	47
aeg	67	9	94	46
ion	146	6	225	61
lev	101	-49	182	48



CTRL Total P: 1.95 10^{-8} (West Med) and 1.31 10^{-8} (East Med) mmolP m^{-2} s^{-1}

Conclusions and future work

- We implemented **BGC loads** associated to **EFAS** river daily discharges and **CAMS seasonal atmospheric deposition of N, P** on **Med sub-basins** in the Copernicus Med-MFC BGC model system;

- Preliminary **results** obtained from 1-year runs showed **improvements** in the simulation of phytoplankton **blooms** associated with high riverine discharges, and enhanced coastal-offshore and zonal **gradients of productivity** in the basin;

- We **plan** to estimate **P bioavailability** for marine organisms (by comparing longer simulations with the recently delivered Copernicus Marine EU product of npp) and to investigate the relationship between river discharge and nutrient and carbon concentrations (by using AI methods, e.g., MLP) in presence of observational datasets (e.g., for Po river).

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