SYMPOSIUM OP'24 — ADVANCING OCEAN PREDICTION SCIENCE FOR SOCIETAL BENEFITS

cmcc Centro Euro-Mediterraneo sui Cambiamenti Climatici

OGS Istituto Nazionale di Oceanografia e di Geofisica Sperimentale

Theme #5:

B

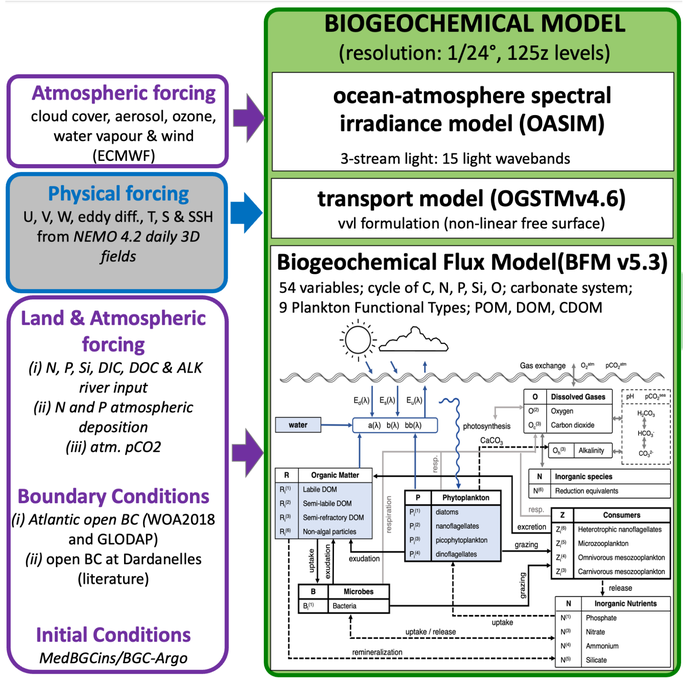
Sensitivity of a 3D-model biogeochemistry to ocean physics forcing frequency

Introduction

The influence of the **time frequency** of ocean **physics (PHY) forcing** (currents, temperature, salinity and vertical diffusivity) on an operational transport **biogeochemical (BGC) model** is investigated and discussed measuring the impact on some meaningful biogeochemical indicators and on product quality.

Method

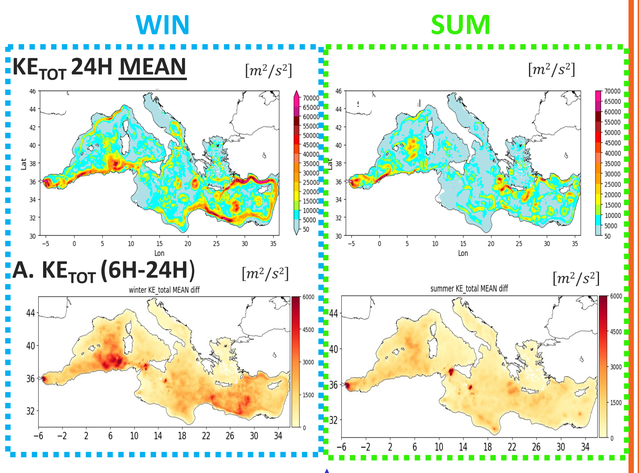
- The model system of the Copernicus Marine Service for the Mediterranean Sea consists of NEMO-WWIII physical model (**MED-PHY**) and the OGSTM-BFM transport-biogeochemical model (**MED-BGC**) at 1/24° horizontal resolution. The two components are separately coupled to a data assimilation schemes: ocean 3DVar (Dobricic and Pinardi, 2008) for physics, and 3DVarBio (Teruzzi et al., 2014; 2021) for biogeochemistry.
- **SET-UP**: two experiments off-line coupling for year 2019:
  - 24h frequency physical forcings from MED-PHY (Low Freq run, **24H**)
  - 6h frequency physical forcings from MED-PHY (High Freq run, **6H**)
- Results are analyzed in terms of differences **6H-24H**

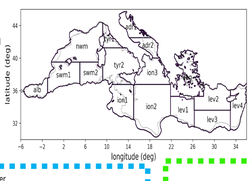


Physics

We propose some evaluating metrics which combine physical variables to spot possible differences in the energetics, hydrodynamics and circulation patterns that can have impacts on the biogeochemical dynamics; the metrics reduce the fields from 3D to 2D.

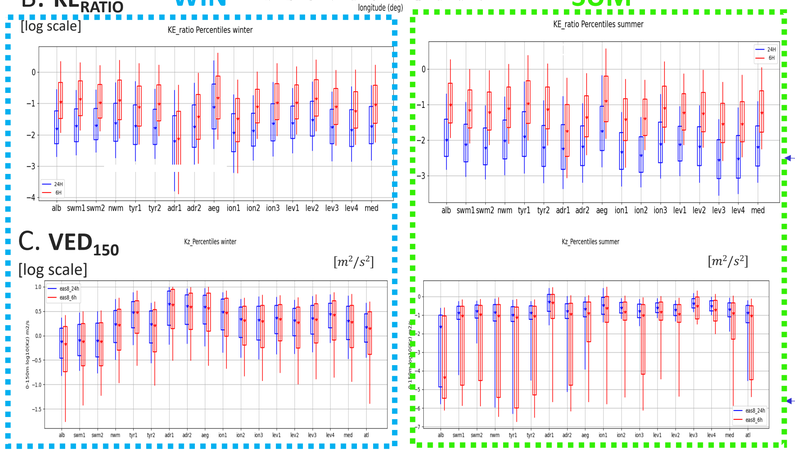
metrics	units	formula
A. Total Kinetic Energy: **KE_{TOT}**	$[m^2/s^2]$	$\int_0^{200} \frac{1}{2}(U^2+V^2+W^2)$
B. Ratio of Vertical Kinetic Energy: **KE_{RATIO}**	[-]	$\int_0^{200} \frac{\frac{1}{2}W^2}{\frac{1}{2}(U^2+V^2)}$
C. Vertical Eddy Diffusivity: **VED_{150}**	$[m^2/s]$	$\int_0^{150} VED(x,y,z)dz$





A. Increase in the system of ~15% of KE_{TOT} (more intense in winter than summer)

B. KE_{RATIO} [log scale]



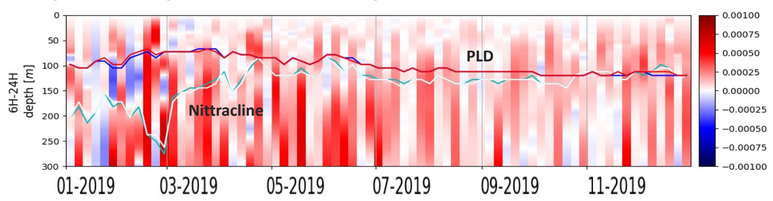
B. Increase of KE_{ratio} almost everywhere: the vertical component increases proportionally more than the horizontal one

C. VED_{150} [log scale]

C. Larger range of variability of VED150 towards lower values: low impact on vertical transport

Example: **FLOAT 6903249**

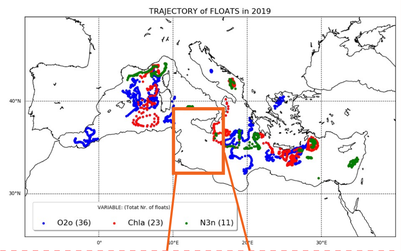
Daily variability of Vertical Velocity [m/s]



Higher forcing time frequency affects the most the vertical component of velocity: larger vertical velocity variability may favour injection of nutrients from bottom towards the surface and moves phytoplankton vertically toward (or away from) light.

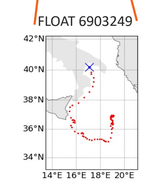
Biogeochemistry

The BGC dynamics are greatly dependent by vertical processes. Impact of different PHY frequencies evaluated by comparing evolution of variables along vertical (Hovmoeller plots).

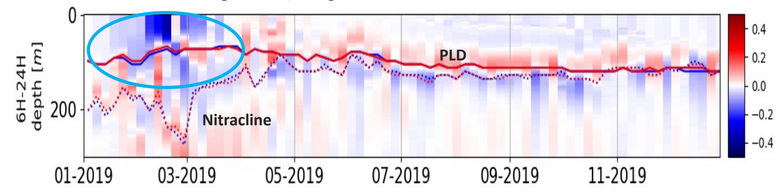


6H-24H

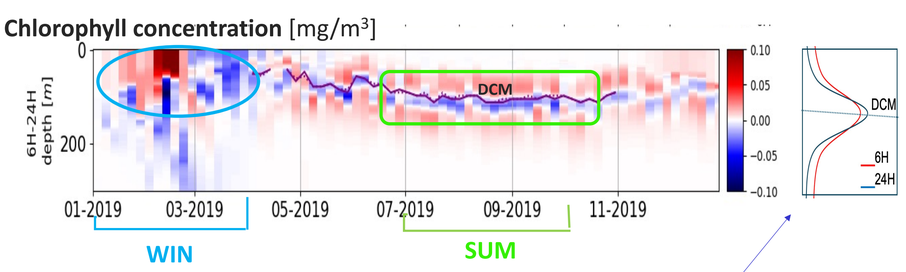
Example: **FLOAT 6903249**



Nitrate concentration [mmol/m³]



Chlorophyll concentration [mg/m³]

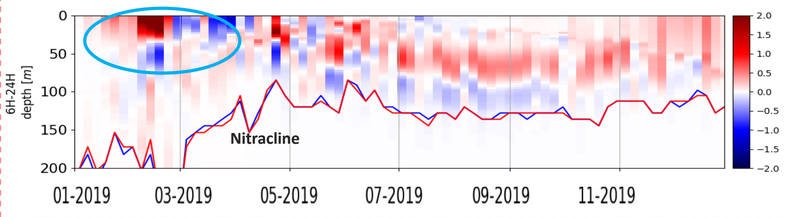


WIN: high PHY-forcing frequency induces early bloom and higher values of Chl-a concentration close to the surface

SUM: Maximum of Chl-a at DCM results lower in concentration and the DCM thickness is thicker: → dilution of Chl-a in the layer around the DCM.

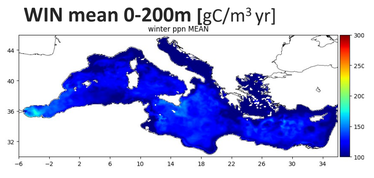
PLD= Photic Layer Depth
DCM= Depth of Chlorophyll Maximum
Nitracline=depth of 2mmol/m3 from the surface

Net Primary Production [gC/m³]

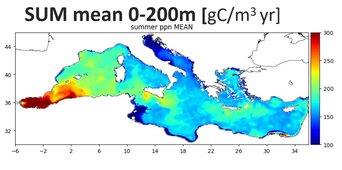


When the system is forced at higher frequency, phytoplankton **productivity** results enhanced: the net primary production increases closer to the surface and in winter a larger productivity occurs at an early stage.

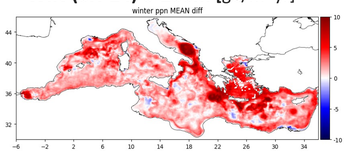
WIN mean 0-200m [gC/m³ yr]



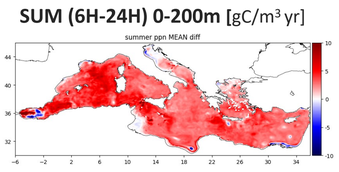
SUM mean 0-200m [gC/m³ yr]



WIN (6H-24) 0-200m [gC/m³ yr]



SUM (6H-24H) 0-200m [gC/m³ yr]



The mean Net Primary Production in the 0-200m layer shows an increase everywhere of approximately 2% in both seasons.

Validation with BGC Argo floats on year 2019

	RMSD 24H						RMSD 6H						
VARs	0-10m	10-30m	30-60m	60-100m	100-150m	CORR	0-10m	10-30m	30-60m	60-100m	100-150m	CORR	n. Tot Profiles.
Chl-a [mg/m³]	0.080	0.080	0.097	0.086	0.067	0.76	0.079	0.078	0.097	0.085	0.066	**0.77**	**1128**
Nitrate [mmol/m³]	0.722	0.668	0.620	0.972	1.230	0.93	0.718	0.664	0.624	0.978	1.266	**0.93**	**612**
Oxygen [mmol/m³]	5.71	7.64	12.34	11.31	10.81	0.81	5.36	7.26	10.71	11.54	11.01	**0.82**	**1980**

Root Mean Squared Difference (**RMSD**) between data and BGG Argo float:
BLUE = improvement; RED= worsening

The RMSD comparison shows that the performance of 6H generally increases close to the surface (0-30m layer).

Conclusions

By using 6H (vs 24H) frequency forcings:

- **increase of 15% of KE_{tot}** in the system (more intense in WINTER than SUMMER)
- increase of the **vertical component of KE** almost everywhere and in all the seasons (the increase of the variability of the vertical velocity plays a role)
- more injection of nutrients from bottom to the photic layer, **Net Primary Production** increases of 2% in both winter and summer
- **the quality of the simulated Chl-a, Nitrate and Oxygen improves**: comparison with BGC Argo floats demonstrates an improvement of the system in run 6H → the basin-scale model uncertainty (RMSD) diminishes of 2% in Chl-a concentration and of 1% in Nitrate concentration in the 0-30m vertical layer; of 6% in Oxygen concentration in the first 100m.

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