



**MERCATOR  
OCEAN**  
INTERNATIONAL

# Mercator Ocean International

Yann Drillet and Mercator team

- European context and Mercator Ocean International leadership
  - Copernicus Marine
  - European Digital Twin Ocean
- Current status of Global and regional forecasting and reanalysis systems
  - Global Monitoring and Forecasting Center
  - Iberian Biscay and Irish seas Monitoring and Forecasting Center
- Main evolutions under development
  - Daily analysis
  - Assimilation of SWOT
  - Ensemble analysis and forecast, monthly and seasonal forecast
  - Global high resolution at 1/36°
  - Global reanalysis
  - Marine ecosystems modeling
  - Machine learning for ocean modeling and forecasting

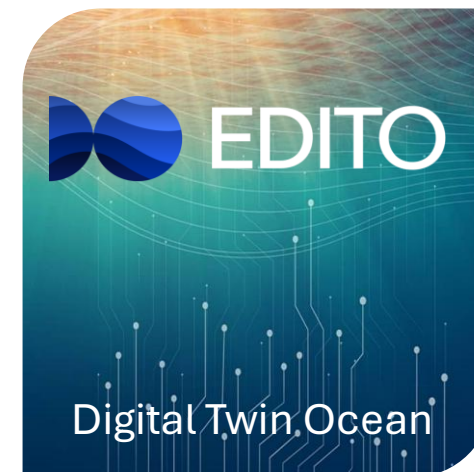
# European programmes & International mandates



DEFIS



DEFIS



RTD / MARE



RTD



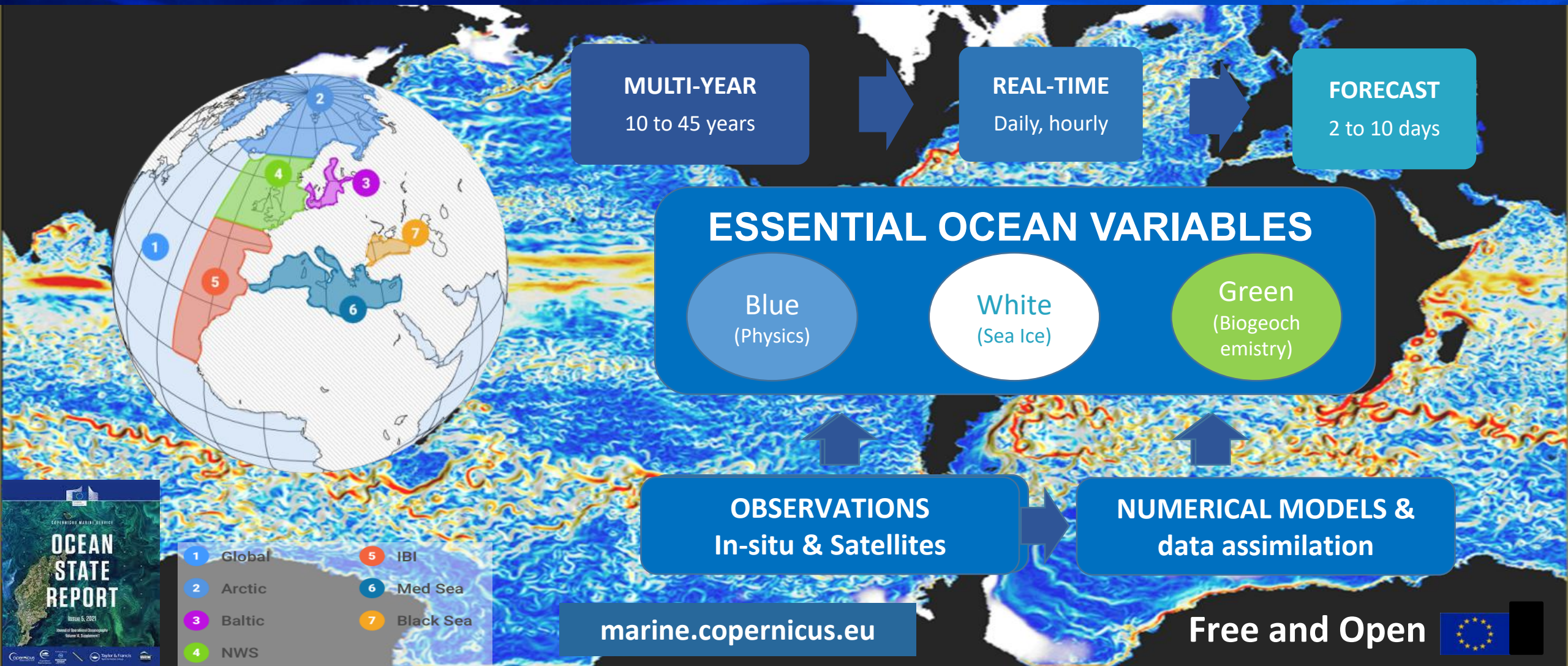
UNESCO



INTPA

# The EU Copernicus Marine Service

## Global & Regional Ocean Monitoring and Forecasting

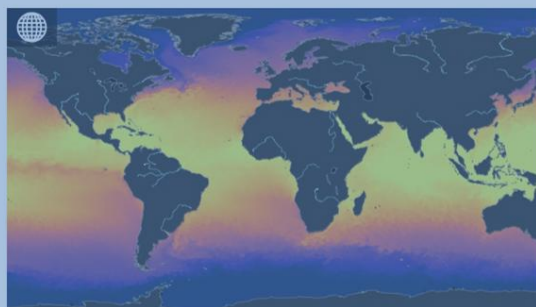


# EDITO is the core infrastructure platform of the European Digital Twin Ocean

Our mission is to make ocean knowledge available to all



## Blue Ocean



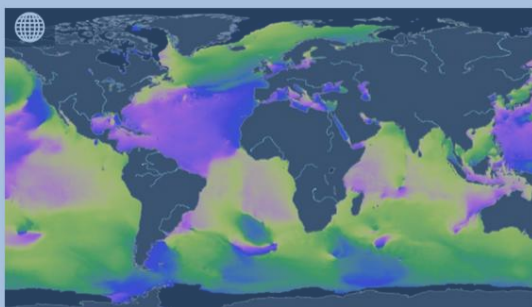
### Global Ocean Physics Analysis and Forecast

GLOBAL\_ANALYSISFORECAST\_PHY\_001\_024

#### Models

Global, 0.083° × 0.083° × 50 levels

1 Nov 2020 to 27 Jan 2025, hourly, daily, monthly  
Temperature, salinity, sea surface height, velocity, mixed layer thickness, wave, sea ice



### Global Ocean Waves Analysis and Forecast

GLOBAL\_ANALYSISFORECAST\_WAV\_001\_027

#### Models

Global, 0.083° × 0.083°

1 Nov 2022 to 27 Jan 2025, hourly  
Velocity, wave

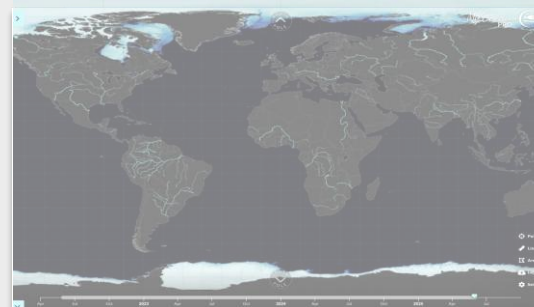
Temperature, Salinity,  
velocities, sea surface  
height,...

6-9 km Resolution  
10-days daily forecast  
1993-now reanalysis

Waves height, period,  
directions,...

9-25 km Resolution  
10-days twice daily forecast  
1993-now reanalysis

## White Ocean



### Global Ocean Physics Analysis and Forecast

GLOBAL\_ANALYSISFORECAST\_PHY\_001\_024

#### Models

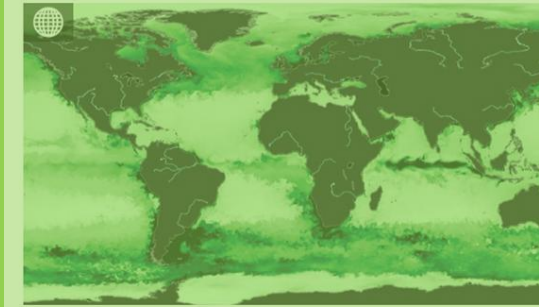
Global, 0.083° × 0.083° × 50 levels

1 Nov 2020 to 27 Jan 2025, hourly, daily, monthly  
Temperature, salinity, sea surface height, velocity, mixed layer thickness, wave, sea ice

Sea ice concentration,  
thickness, velocities,...

6-9 km Resolution  
10-days daily forecast  
1993-now reanalysis

## Green Ocean



### Global Ocean Biogeochemistry Analysis and Forecast

GLOBAL\_ANALYSISFORECAST\_BGC\_001\_028

#### Models

Global, 0.25° × 0.25° × 50 levels

1 Oct 2021 to 24 Jan 2025, daily, monthly  
Plankton, nutrients, oxygen, carbonate system, optics

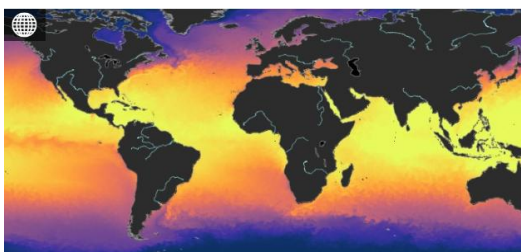
Carbon chemistry variables,  
CHL, nutrients,...

20-25 km Resolution  
10-days daily forecast  
1993-now reanalysis

## 1/12° ORCA NEMO3.6

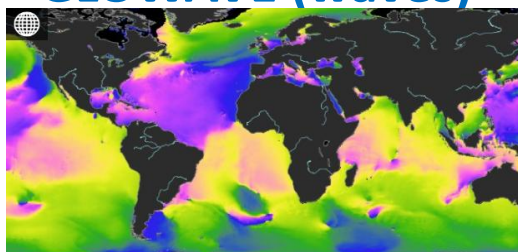
- Forced by 1h IFS forecasts
- IFS Bulk, GLS vertical model, 5 bands light penetration scheme, etc.
- Assimilates
  - in situ T,S
  - Alti SLA alti
  - Odysea SST
  - OSISAF sea ice

## GLO12 (ocean)



$U_o, V_o$  ocean  
current  
components

## GLOWAVE (waves)



$C_{d wave}^N, \frac{\tau_{oc}}{\tau_a}$  → wave-induced Surface stress  
 $\phi_{oc}, H_{swv}$  → wave-induced Surface mixing  
 $U_{sd}, V_{sd}, W_{sd}$  → wave-induced Stokes drift interactions

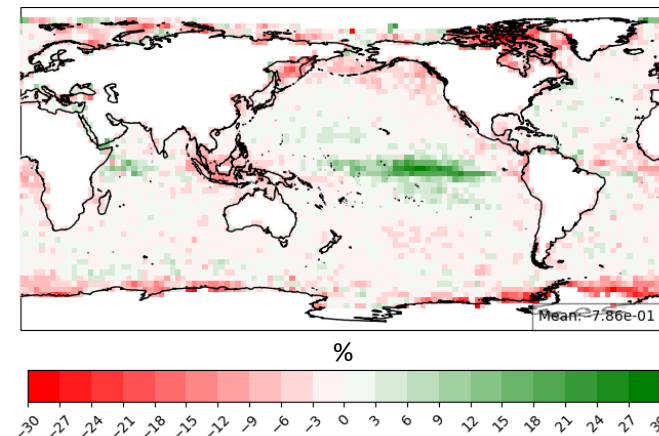
## 1/10° MF-WAM

- Forced by 1h IFS atmospheric/ice
- Forced by GLO12 daily currents
- ST4 physics + in house parameterizations
- Assimilates
  - Alti Hs
  - Wave Spectra (Sentinel, CFOSAT)

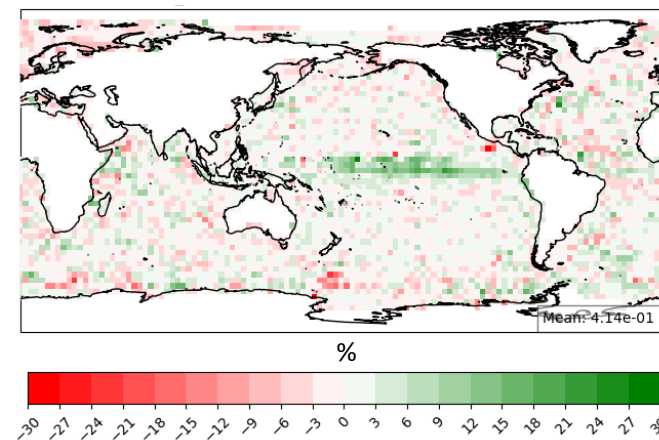
## RMSE % Score WAVES

Green : improvement  
 Red : degradation  
 Hatched : > obs error

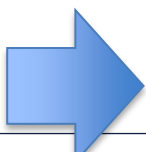
### SST



### SSH



**Main positive impact in analysis and forecast in tropical pacific**



# The MOI/CMEMS IBI real-time and reanalysis system

## Blue Ocean



### Atlantic-Iberian Biscay Irish- Ocean Physics Analysis and Forecast

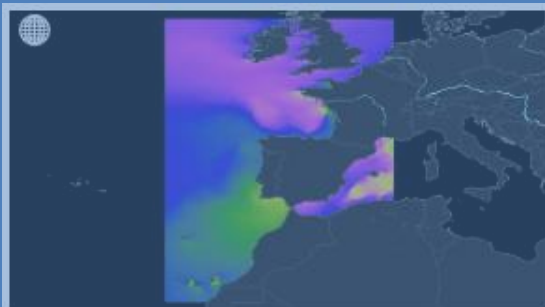
IBI\_ANALYSISFORECAST\_PHY\_005\_001

Models

Multi-area,  $0.028^\circ \times 0.028^\circ \times 50$  levels

22 Nov 2022 to 16 Apr 2026, sub-hourly, hourly,...

Temperature, salinity, sea surface height, velocity,  
mixed layer thickness



### Atlantic-Iberian Biscay Irish- Ocean Wave Analysis and Forecast

IBI\_ANALYSISFORECAST\_WAV\_005\_005

Models

Multi-area,  $0.0278^\circ \times 0.0278^\circ$

26 Nov 2022 to 15 Apr 2026, hourly

Velocity, wave

Temperature, Salinity,  
velocities, sea surface  
height,...

Waves height, period,  
directions,...

2-3 km Resolution  
10-days daily forecast  
1993-now reanalysis

2-3 km Resolution  
10-days twice daily forecast  
1993-now reanalysis

## White Ocean

## Green Ocean



### Atlantic-Iberian Biscay Irish- Ocean Biogeochemical Analysis and...

IBI\_ANALYSISFORECAST\_BGC\_005\_004

Models

Multi-area,  $0.028^\circ \times 0.028^\circ \times 50$  levels

23 Nov 2022 to 11 Apr 2026, daily, monthly

Plankton, nutrients, oxygen, carbonate system,  
optics

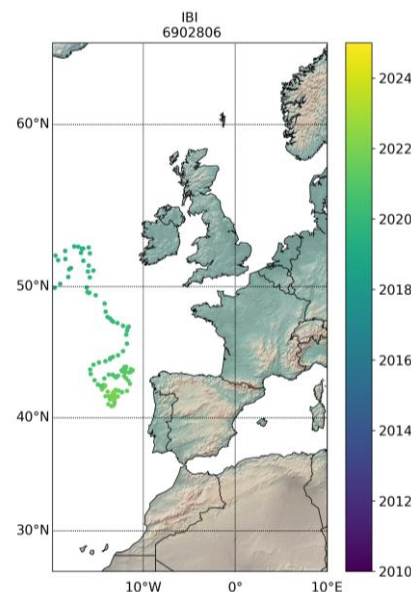
Carbon chemistry variables,  
CHL, nutrients,...

2-3 km Resolution  
10-days daily forecast  
1993-now reanalysis

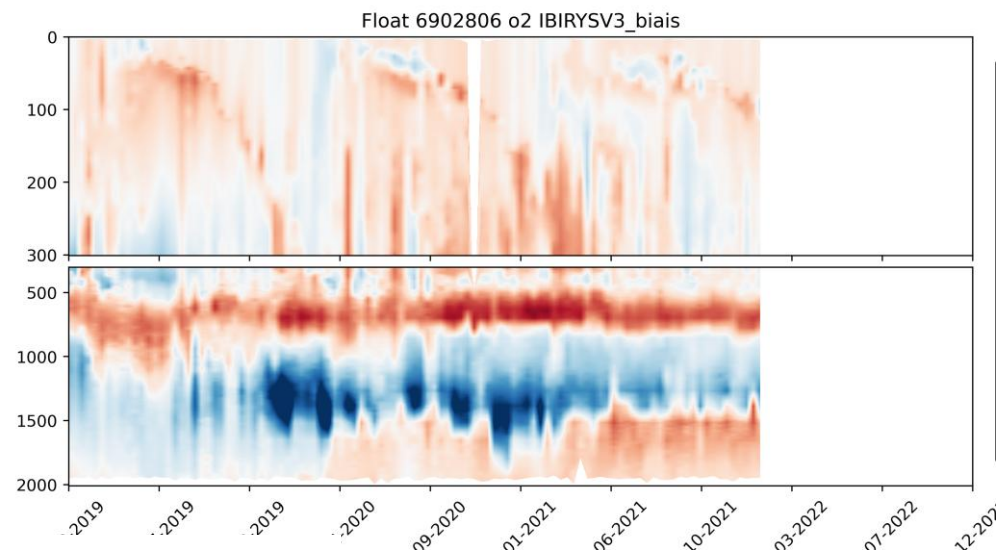
## IBIRYS 1993-2026 reanalysis main evolutions

- Resolution at **1/36°**
- **Interannual** Atmospheric forcing for CO2 and Dust
- **Daily** river flow

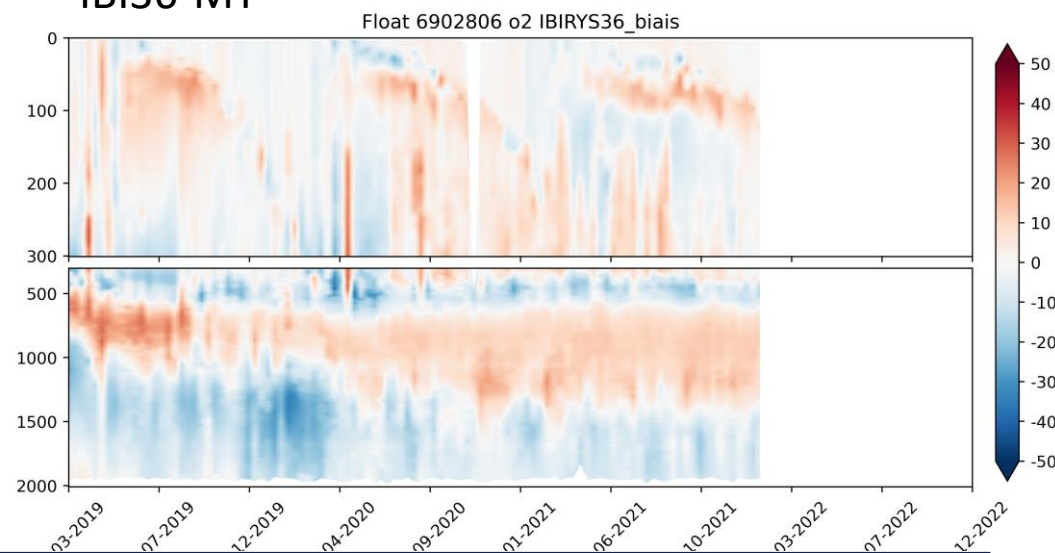
**Main positive impact  
for Oxygen in open  
ocean and on the shelf**



IBI12-MY



IBI36-MY

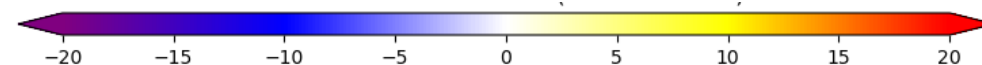


**New operational production scenario daily analysis and daily forecast. Analysis cycle ranging from 3 to 6 days during the week.**

**Improved initial state and forecast score for all physical variables**

**Ready for integration in the operational suite by end of 2026**

| SLA [0m]          |        |        |        |        |        |
|-------------------|--------|--------|--------|--------|--------|
| GLO12V4           | 0.055  | 0.058  | 0.061  | 0.065  | 0.067  |
| GLO12V4_NEW       | -18.2% | -15.5% | -13.1% | -12.3% | -10.4% |
|                   | 1      | 3      | 5      | 7      | 10     |
| Lead time [days]  |        |        |        |        |        |
| uo filtered [15m] |        |        |        |        |        |
| GLO12V4           | 0.150  | 0.154  | 0.159  | 0.163  | 0.167  |
| GLO12V4_NEW       | -6.0%  | -5.2%  | -5.0%  | -4.3%  | -3.6%  |
|                   | 1      | 3      | 5      | 7      | 10     |
| Lead time [days]  |        |        |        |        |        |
| vo_filtered [15m] |        |        |        |        |        |
| GLO12V4           | 0.144  | 0.148  | 0.151  | 0.155  | 0.160  |
| GLO12V4_NEW       | -10.4% | -8.8%  | -6.6%  | -5.2%  | -5.6%  |
|                   | 1      | 3      | 5      | 7      | 10     |
| Lead time [days]  |        |        |        |        |        |



improvement

degradation

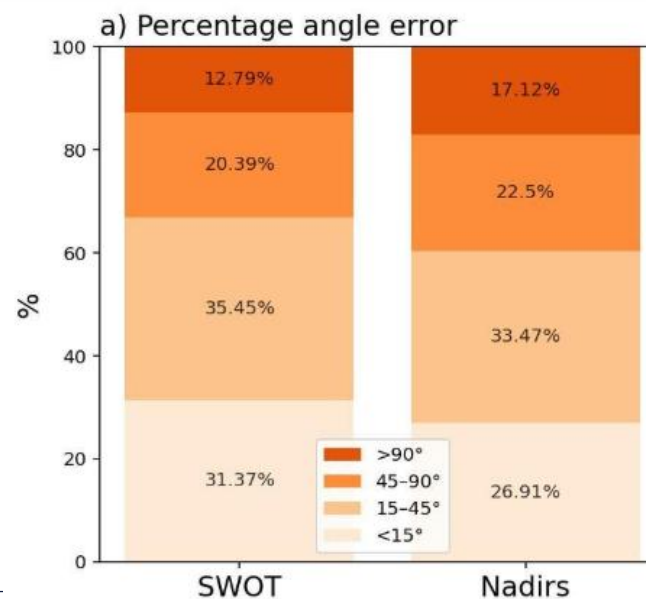
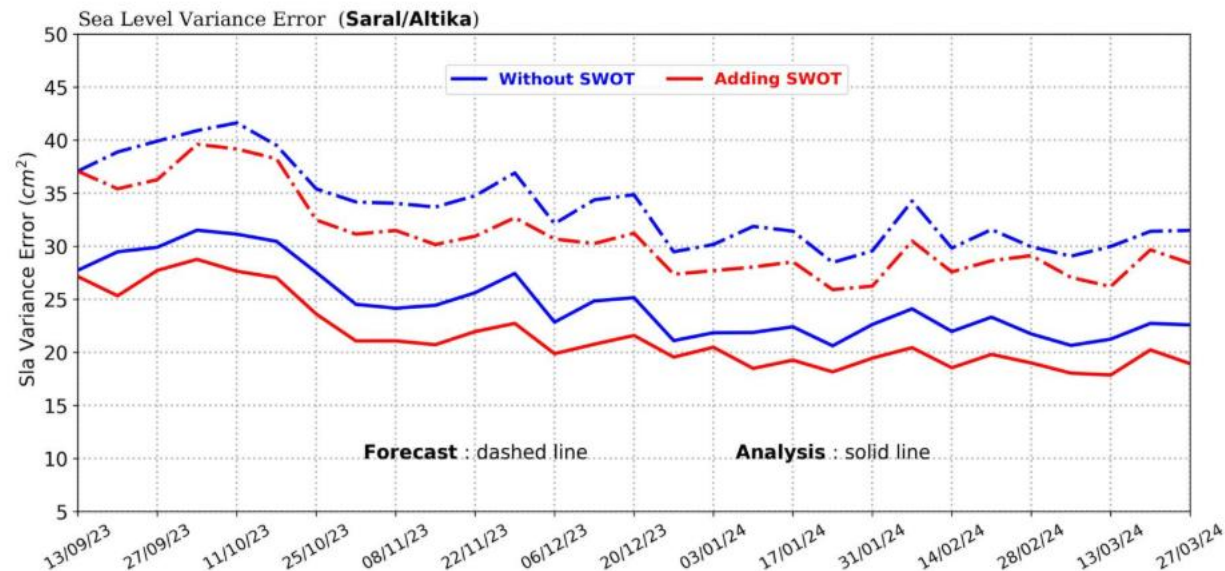
**Preliminary results**

*2-month of daily forecast not using the final scenario*

## Assimilation of SWOT observation in global 1/12°

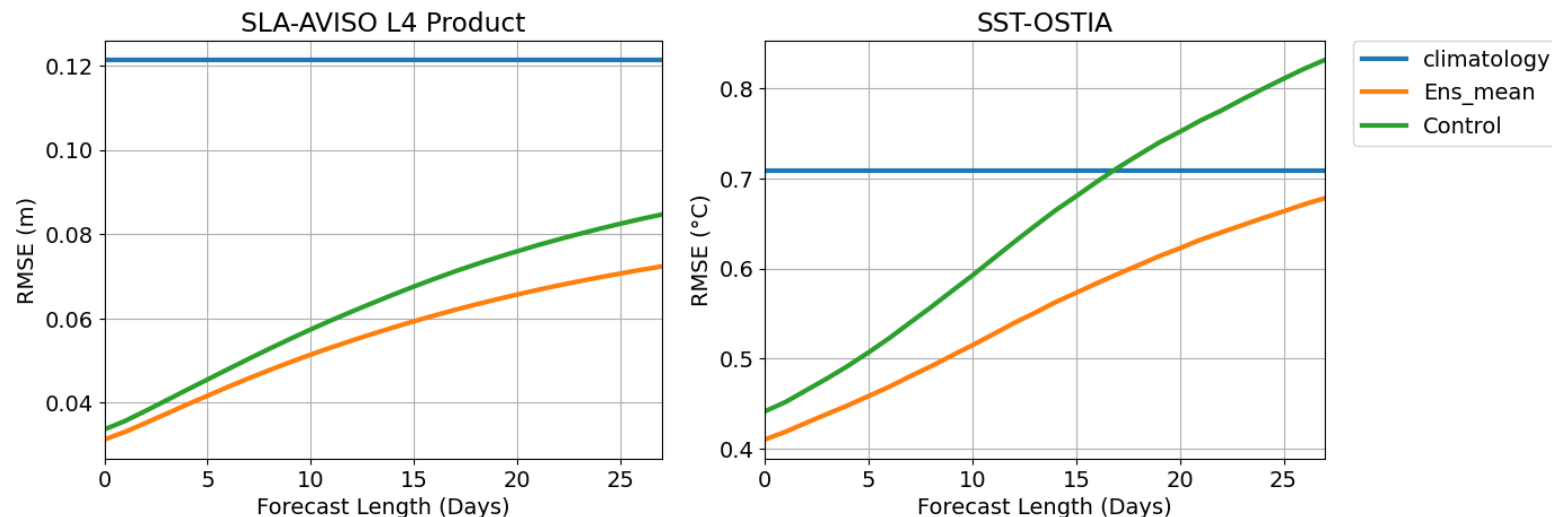
**Improvement of skill  
score in analysis and  
forecast**

**Ready to be integrated  
in the operational suite  
end of 2026**



*Benkiran et al, 2026*

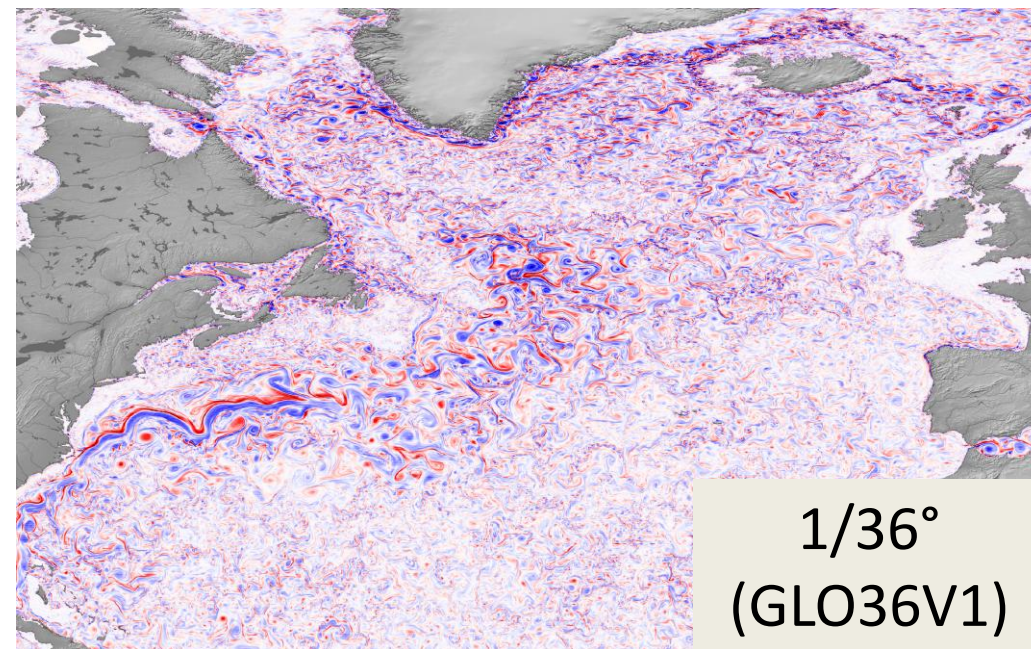
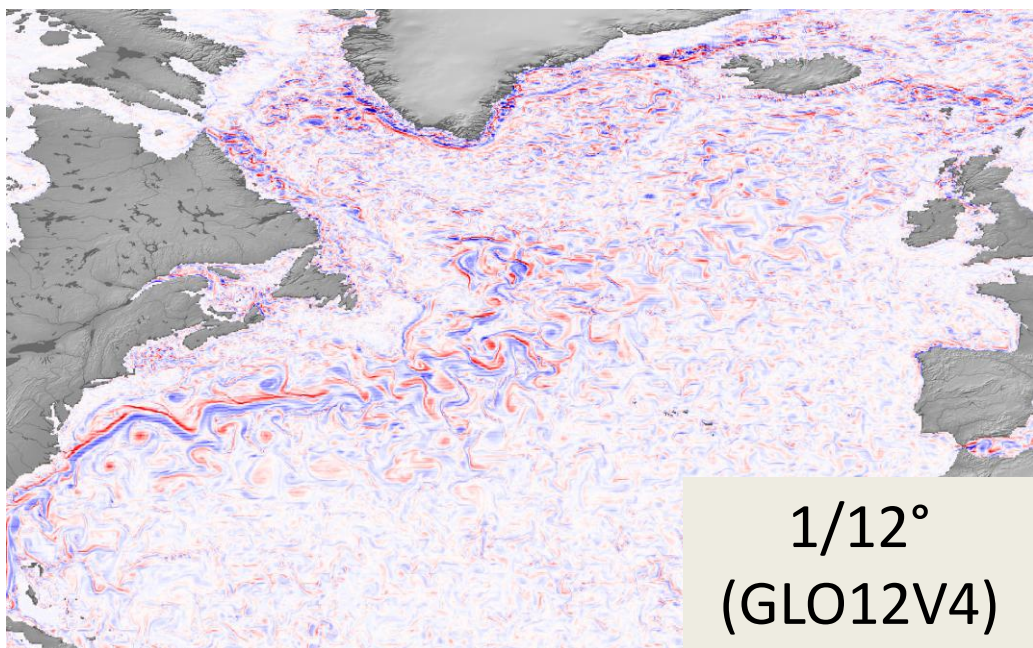
- Global  $\frac{1}{4}^\circ$  physic and sea ice
- 50 members + unperturbed control run for 28-days. Running weekly
- 10 members for 7-month with Sargassum model. Running monthly
- Stochastic perturbations of model parameters
- Data assimilation based on Ensemble Kalman Filter (LETKF – Hunt et al., 2007)



**New uncertainty products  
Improvement of forecast score  
Ready to be integrated in the  
operational suite in 2027**

Spectral nudging technic to maintain mean state and large mesoscale features

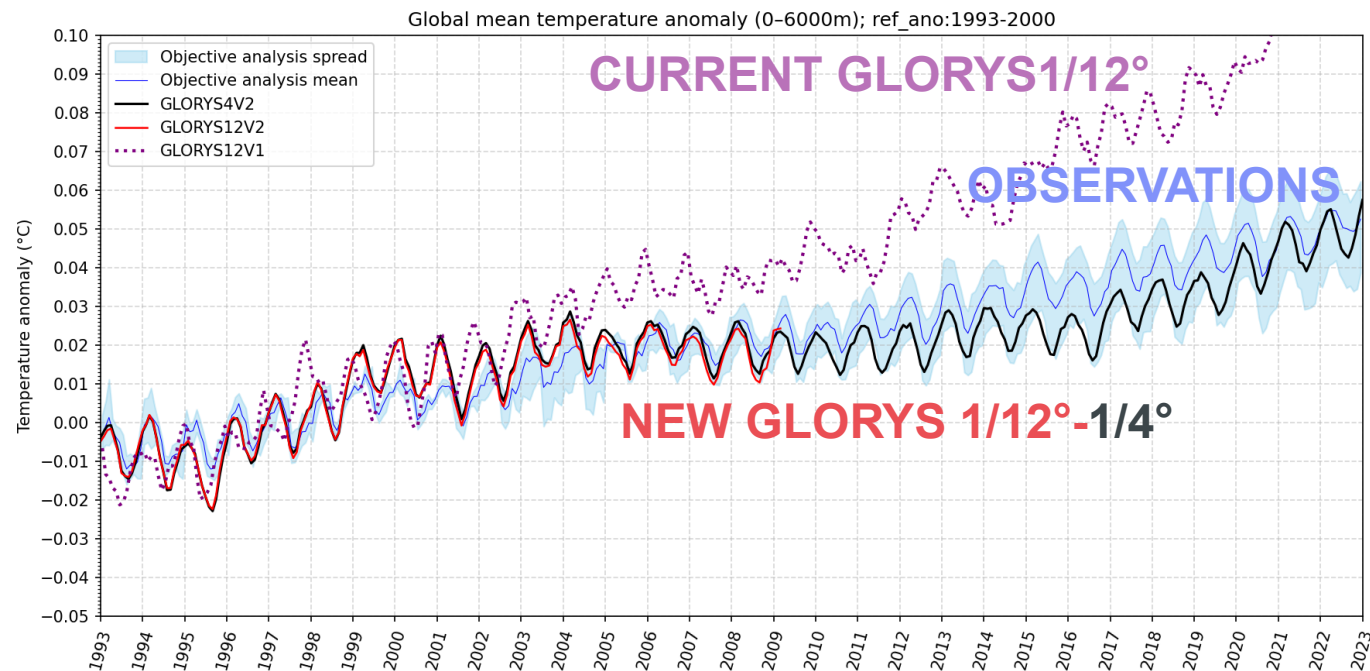
**Energy, meso, submesoscale, high frequency processes  
(tides and storm surge) improved in high resolution forecast  
Demonstration and sample available in EDITO**



## GLORYS12v2

Production on going (1993-2008 produced)

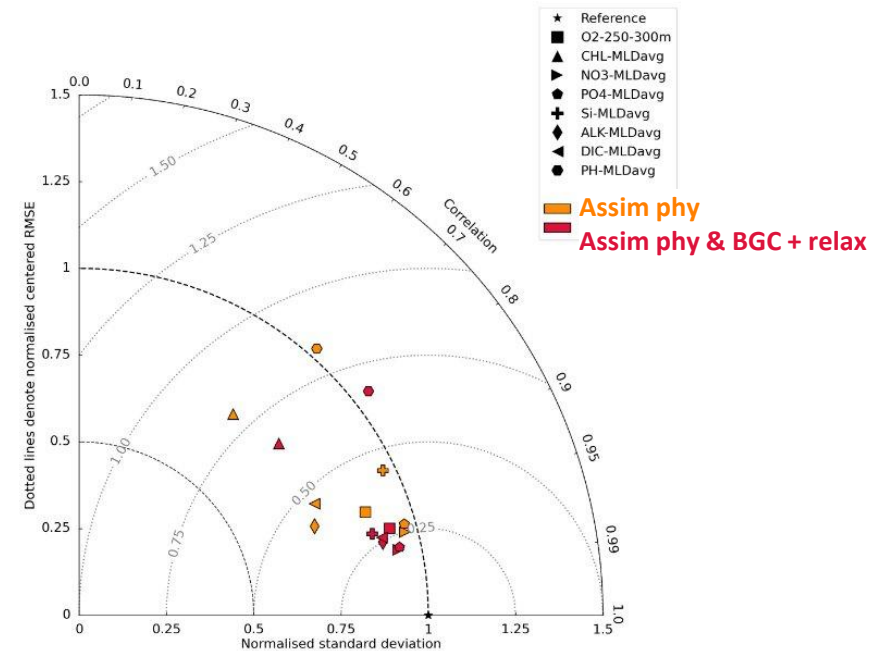
**Improvement of biaiis and trend**



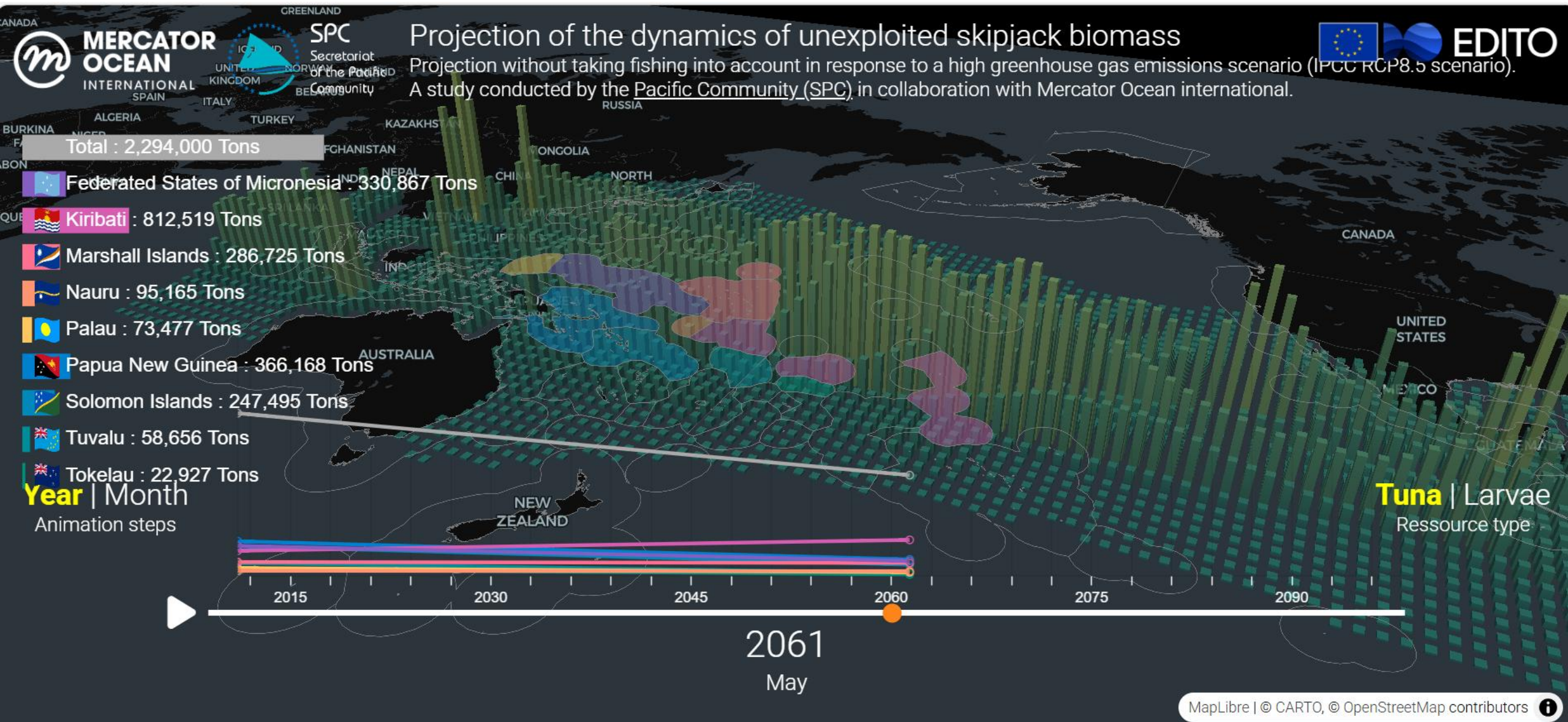
## BIORYS4V2

Assimilation of Ocean Color and Carbonate system

**Improvement in comparison to bgc argo dataset**



# Fish and marine species modeling



GLONET

[Search](#)

GLONET

Context and conception

Abstract

Architecture

Effective resolution

Citation

Forecasts

Latest forecast

Currents

Temperature

Sea surface height

Salinity

All daily forecasts

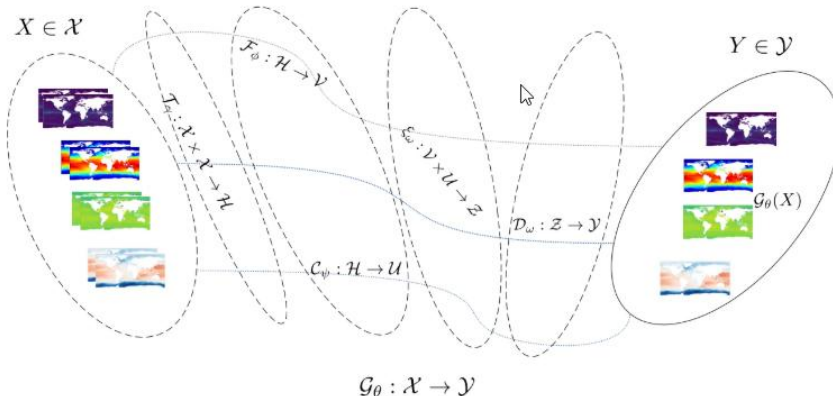
On-demand forecasts

Contact

and ocean currents.

GLONET's experimental daily forecast are accessible through the European Digital Twin Ocean platform EDITO.

## Architecture



Overview of GLONET's architecture containing different modules, particularly time-block designed to learn feature maps encapsulating initial conditions along with forcings. A spatial module architected to learn multi-scale dynamics, and finally an encoder-decoder to fuse multi-scale circulations into a unified latent space.

## Effective resolution

GLONET outputs data at 1/4 degree resolution, but it was trained on [GLORYS12](#), a dataset at 1/12 degree resolution. Hence, GLONET output represents a 1/12 degree resolution dynamics, which we call its **effective resolution**.

It is possible to obtain good results, depending on the use cases, by interpolating GLONET output to 1/12 degree resolution. This interpolation can be done on-the-fly while only keeping GLONET 1/4 degree output in your storage, which is significantly lighter than 1/12 degree resolution datasets.

The following figures illustrate this but more details can be found in the [scientific paper](#).

