GLO MFC CMEMS
Les systèmes globaux état des lieux,
évolution et collaborations

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Le Monitoring and Forecasting Center Global

1. Organisation et partenariats

2. Etat actuel des produits disponibles

3. Evolution dans les 2 prochaines années

4. Développement en cours pour une intégration plus long terme

1 Global
2 Arctic
3 Baltic
4 NWS
5 IBI
6 Med Sea
7 Black Sea
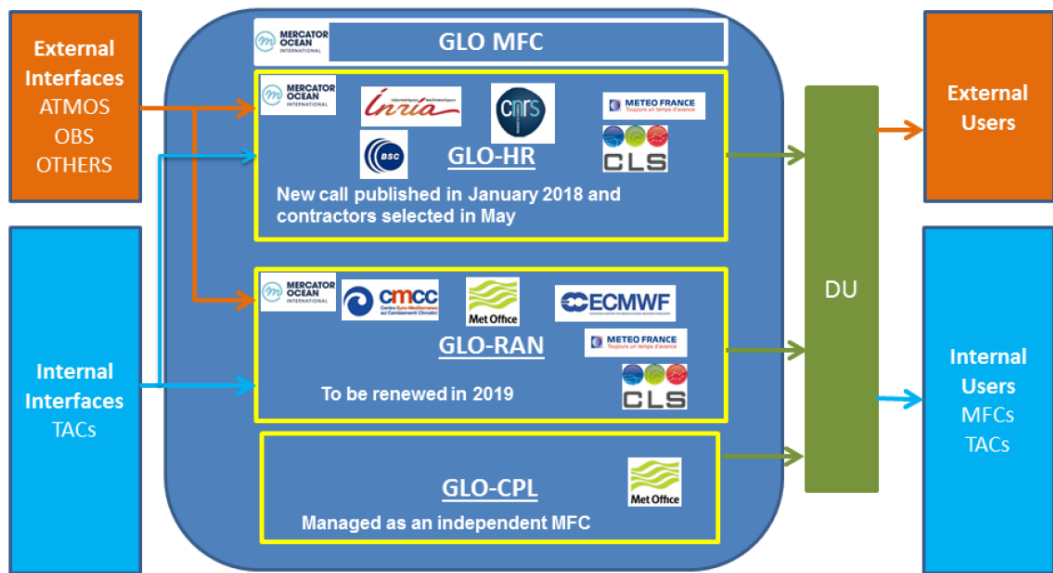
GLO-HR is the high resolution real time component producing global ocean analysis and forecasts from the surface to the bottom and for physical, biogeochemical, sea ice and waves variables.

GLO-RAN is the reanalysis component providing several reanalysis for physical, biogeochemical, sea ice and waves variables.

GLO-CPL is the real time ocean atmosphere coupled system providing analysis and forecast for the physical variables. These activities are managed in a dedicated contract by CMEMS coordination.

Etat actuel et evolution d'ici 2021

Evolutions/quality improvements (NRT products)

system	model	Data assimilation	observations	forcing	forecast	products
GLO12v3 (PSY4V3R1) *Current*	**NEMO3.1, 1/12°, orca grid, 50L**	**SAM2, 3Dvar bias correction**	**MDT,SLA,T/S,SST,SIC**	**IFS ECMWF 3h**	**Daily 10-d forecast**	**024** **Regular 1/12° daily, monthly, surface hourly, 3D 6-hourly (available in 2019)**
GLO12v4	**NEMO3.6, 1/12°, eorca grid, 75L, LIM3, vvl**	**SAM2, 3Dvar bias correction, 4D SEEK analysis**	**MDT,SLA,T/S,SST,SIC** **New MDT, L3 SST**	**IFS ECMWF 3h** **WAVEv2**	**Daily 10-d forecast**	**034** **Reg1/12° daily, monthly, surf hourly, 3D 6-hourly**
BIO4v1 (BIOMER4V1R2) *Current*	**PISCES3.2** ¼°	**NO**	**NO**	**GLO12v3**	**Weekly 1 week forecast**	**014** **Regular ¼° weekly**
BIO4v3 *July 2019*	**PISCES3.6** **¼°, 75L**	**SAM2V1**	**Ocean Color L4**	**GLO12v4**	**Weekly** **10-d forecast**	**040** **Regular ¼° daily**
BIO4v2	**PISCES3.6** ¼°	**SAM2V1**	**Ocean Color L4**	**GLO12v3**	**Weekly** **10-d forecast**	**028** **Regular ¼° daily**
WAVEv2 *Current*	MFWAM 1/10°	OI	SIW	IFS ECMWF 3h GLO12v3	Daily 5-d forecast	027 Regular 1/12°, 3 hourly
WAVEv3	MFWAM 1/10° Dir and freq from 24 to 36	OI	SIW and spectra, CFOSAT, sentinel3b	IFS ECMWF 3h GLO12v3	Daily 10-d forecast	035 Regular 1/12°, 3 hourly

Commission

OC data*

Assim model

Free model

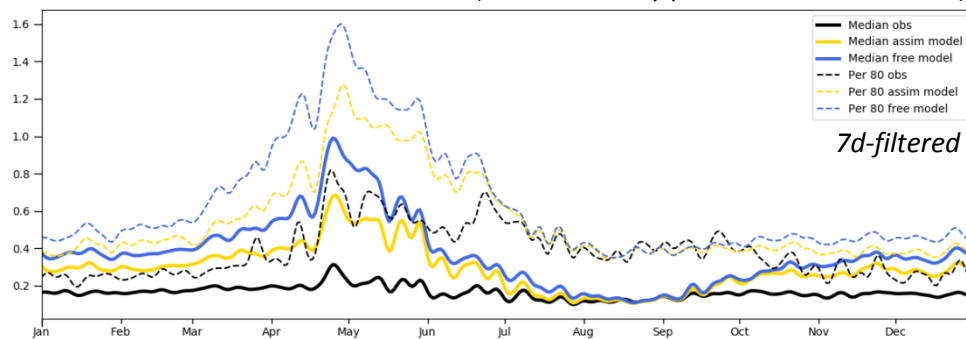* CMEMS L4 monthly product – not assimilated

Global surface CHL 2009-2018 mean

➔ **Significant impact at large scale**
➔ **Better extension/amplitude of oligotrophic gyres**
➔ **Still too productive in Southern Ocean (wrt OC data…)**

North ATL CHL median/percentile 80

(CMEMS L3 daily product – not assimilated)

7d-filtered

➔ **Median&Perc80 reduced from 30-50%**

➔ **Overall positive impact of OC data assimilation on CHL.** Overall no NO3 degradation+Other components not constrained (not shown)

- New version under developement, specification done, precise design need sensitivity experiments

- Main component of the system :

  - New horizontal and vertical grid, new version of the NEMO (V3.6) and Sea Ice (LIM3 multi categories) models

  - 4D version of the assimilation scheme and assimilation of new MDT, L3 high resolution SST

  - Offline coupling with waves (surface stress, mixing, stokes/coriolis)

WAVES

ALL: SST RMSE improvement

4D & SST L3
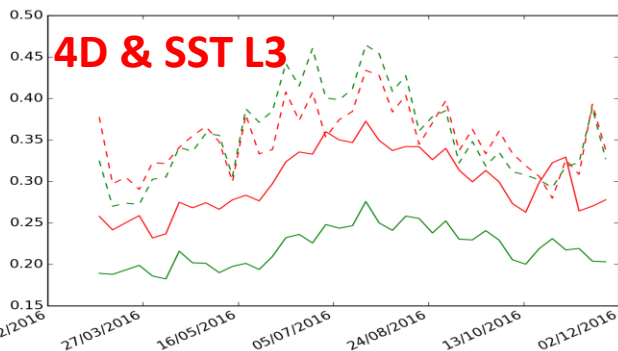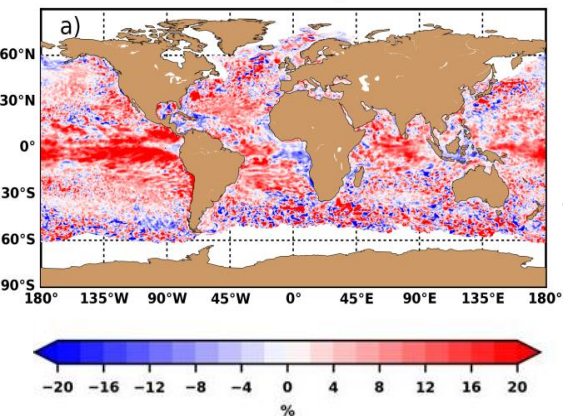
Evolution of the RMS forecast errors compared to the L4 (dashed) and L3s observations (plain line) for the experiments **OSE_L4** *et* **OSE_L3s**.
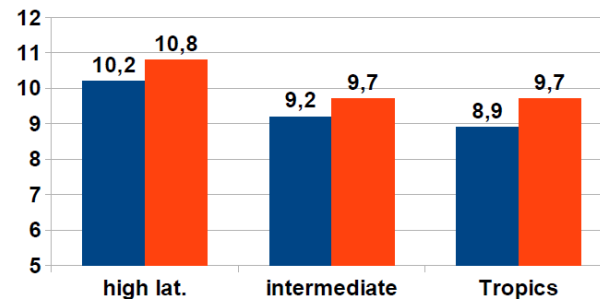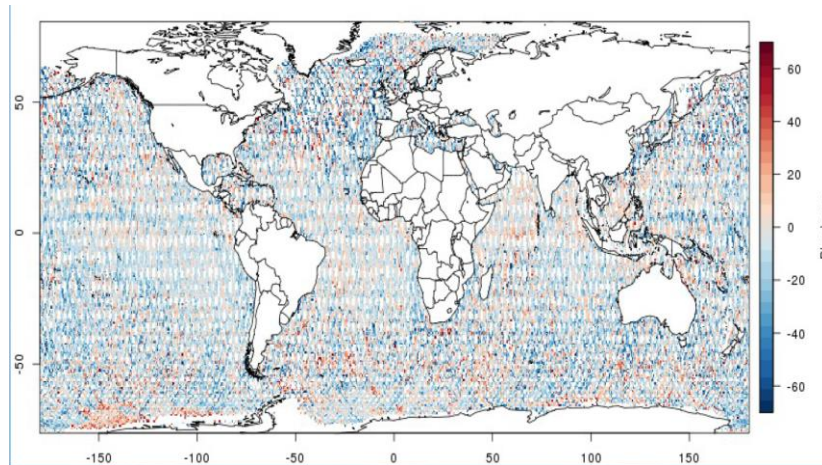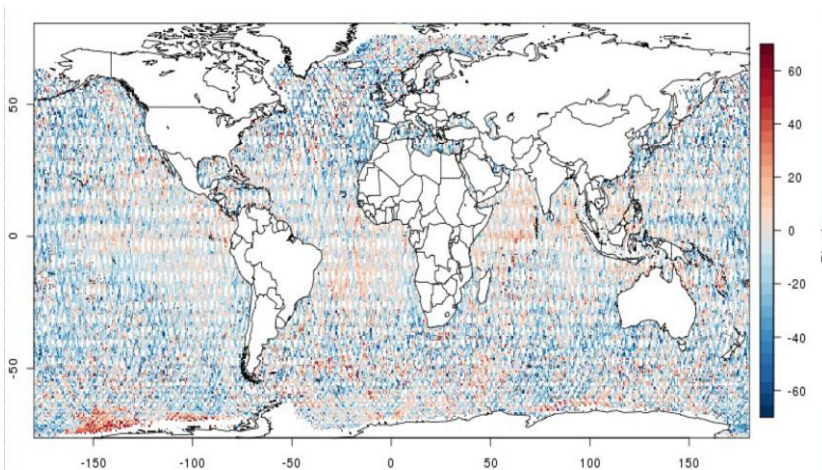

MDT
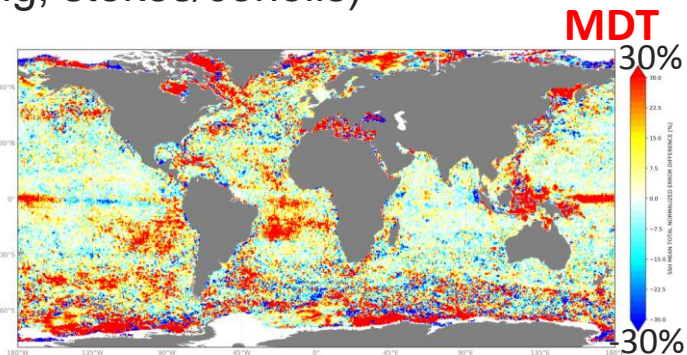
Diff of normalized error (by ocean variability) between OSE_MDTv3 and OSE_MDTv4

BIAS Feb 2019

WAVEv2

Bias reduction

Assim SWH CFOSAT and S3b

Blue : with S3B and CFOSAT
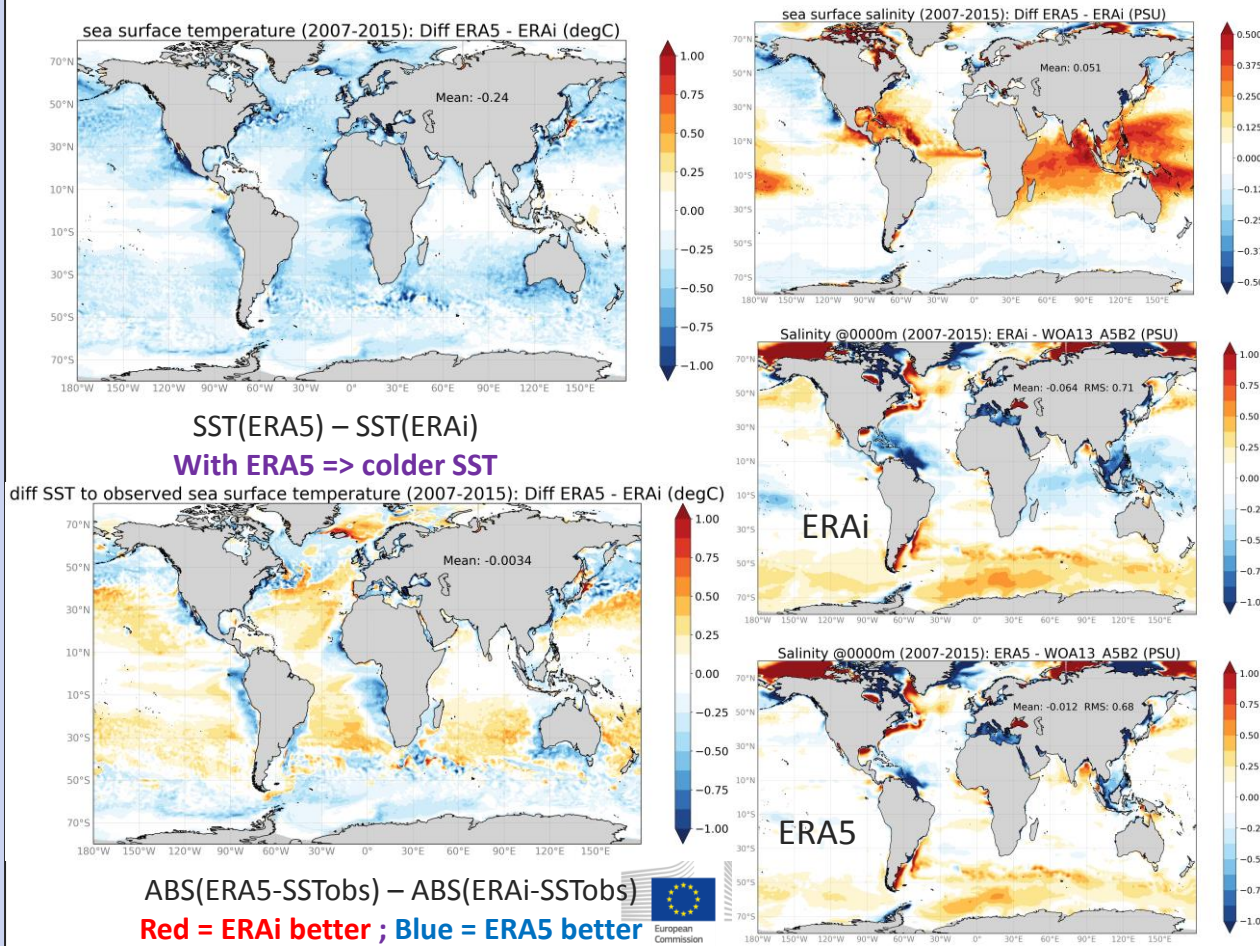**Red : current wave system**

Evolutions/quality improvements (Multi Year products)

system	model	Data assimilation	observations	forcing	period	products
GLORYS2v4	NEMO3.1 1/4°, orca grid, 75L	SAM2 3Dvar bias correction	MDT,SLA,T/S,SST,SIC	ERAinterim 3h	1993-2017 …	025 Regular 1/4° daily, monthly
GLORYS12v1	NEMO3.1 1/12°, orca grid, 50L	SAM2 3Dvar bias correction	MDT,SLA,T/S,SST,SIC	ERAinterim 3h	1993-2017 …	030 Regular 1/12° daily, monthly
GLORYS12v2	NEMO3.6 1/12°, eorca grid, 75L	SAM2 4D SEEK analysis 3Dvar bias correction	MDT,SLA,T/S,SST,SIC	ERA5	1993-2019 …	038 Regular 1/12° daily, monthly
GREPv1	NEMO 1/4°, orca grid, 75L	4 systems	MDT,SLA,T/S,SST,SIC	ERAinterim 3h	1993-2017 …	026 Regular 1° monthly. Mean, Std and individual member
GREPv2	NEMO 1/4°, orca grid, 75L	4 systems	MDT,SLA,T/S,SST,SIC	ERAinterim 3h	1993-2017 …	031 Regular 1/4° daily and monthly. Mean, Std and individual member

Current

Current

July 2019

First global (1/4°) interannual simulations performed with ERA5.

- **Simulation forced by ERA5 better in subpolar gyre and upwelling area**
- **Simulation forced by ERA5 too cold in subtropical gyres**
- **Simulation forced by ERA5 good in the tropical band**
- **Higher EKE level in simulation forced by ERA5 (not shown)**
- **Open question on the need of correction for ERA5**
- **Other planned and on going tests :**
  - **Simulation with ERA5 correction to evaluate mean state, biases and trends**
  - **GLORYS ¼° and GLORYS1/12° in 2017 to quantify discontinuity on OMI and other diagnostics**

sea surface temperature (2007-2015): Diff ERA5 - ERAi (degC)
Mean: -0.24

SST(ERA5) – SST(ERAi)
With ERA5 => colder SST

diff SST to observed sea surface temperature (2007-2015): Diff ERA5 - ERAi (degC)
Mean: -0.0034

ABS(ERA5-SSTobs) – ABS(ERAi-SSTobs)
Red = ERAi better ; **Blue = ERA5 better**

sea surface salinity (2007-2015): Diff ERA5 - ERAi (PSU)
Mean: 0.051

Salinity @0000m (2007-2015): ERAi - WOA13_A5B2 (PSU)
Mean: -0.064 RMS: 0.71
ERAi

Salinity @0000m (2007-2015): ERA5 - WOA13_A5B2 (PSU)
Mean: -0.012 RMS: 0.68
ERA5

system	model	Data assimilation	observations	forcing	period	products
BIORYS4v3	**PISCES3.2** **¼°**	**NO**	**NO**	**freeGLORYS2v4 offline**	**1998-2016**	**018** **Regular ¼° monthly**
BIORYS4v4	**PISCES3.6** **¼°**	**NO**	**NO**	**freeGLORYS2v4 offline**	**1993-2018 …**	**029** **Regular ¼° monthly**
BIORYS4v5	**PISCES3.6** **¼°**	**SAM2V1**	**Ocean Color L4**	**GLORYS12**	**1993-2019 …**	**036** **Regular ¼° daily**
MICRORYSv1	**Seapodym**	**NO**	**NO**	**GLORYS**	**1993-2016 …**	**033** **Regular ¼°** **weekly**
MICRORYSv2	**Seapodym**	**NO**	**NO**	**GLORYS12** **BIORYS4**	**1993-2019 …**	**037** **Regular 1/12°** **daily**

Current

July 2019

GLOBAL_REANALYSIS_BIO_001_033
Biomass of Low and Mid-Trophicl Levels (**LMTL**)
Developed by CLS

- 1 functional group of zooplankton
- 6 functional groups of epi and mesopelagic micronekton
- 1st reanalysis (1998-2016); ¼° x 7d
- Forcing:
  - Free GLORYS2v4 (as in BIORYS), temperature and horizontal velocity
  - CMEMS derived Primary production:
    - FREEBIORYS
    - GLOBCOLOUR chlorophyll_a with PAR (INTERIM) and SST (OSTIA)
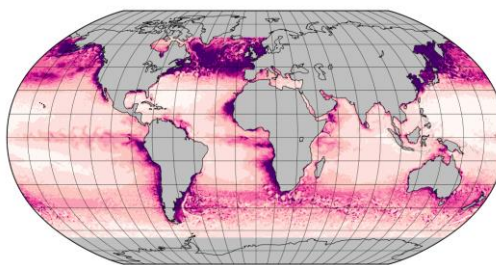- Data gaps: high latitudes / winter => relaxation to PISCES values

Improvement for the next version 2021 :
Consistency of the forcing
Improvement of the resolution

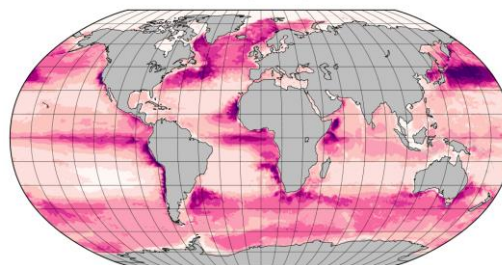PP PISCES – 1st week of May 1998   PP VGPM – 1st week May 1998
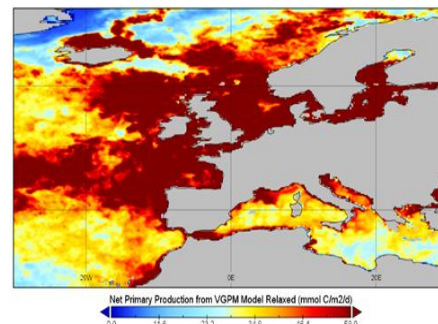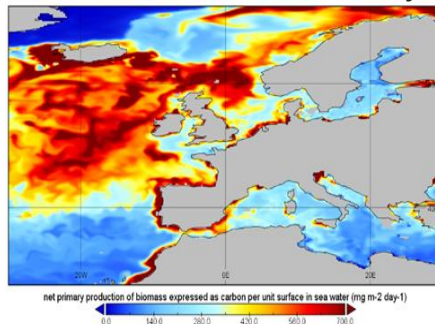
Comparisons of Primary Production predicted from the biogeochemical model (FREEBIORYS) and from VGPM satellite-based products.

meso-zooplankton biomass SEAPODYM-LMTL

Mesozooplankton biomass PISCES

system	model	Data assimilation	observations	forcing	period	products
Nov 2019 → WAVERYSv1	**MFWAM** **1/5°**	**OI**	**SIW**	**ERA5** **GLORYS12v1**	**1993-2017**	**032** **Regular 1/4°** **3 hourly**
WAVERYSv2	**MFWAM** **1/5°**	**OI**	**SIW, wave spectra**	**ERA5** **GLORYS12**	**1993-2019**	**039** **Regular 1/4°** **hourly**

Time period	1993-2018 with 3h outputs
Grid	Global 1/5° grid with 30 frequencies distributed over 24 directions
Physics	Same than the GLO MFC NRT wave system
Input data	• ERA5 3h winds and sea ice • GLORYS12 1/12° 3 h currents for current refraction • Assimilation of 3h satellite Hs: ERS1-2, ENVISAT, TOPEX, JASON1, GFO, JASON2, CRYOSAT, SARAL + TAC wave spectra data (from 2016)

Scores for October 2013

Scatter Index of SWH (%)

ERA5 — WAVERYS

	High	Intermed	Tropics
ERA5	10,4	10,5	9,6
WAVERYS	10	8,7	8,4

Collected data :   17577   35373   26280
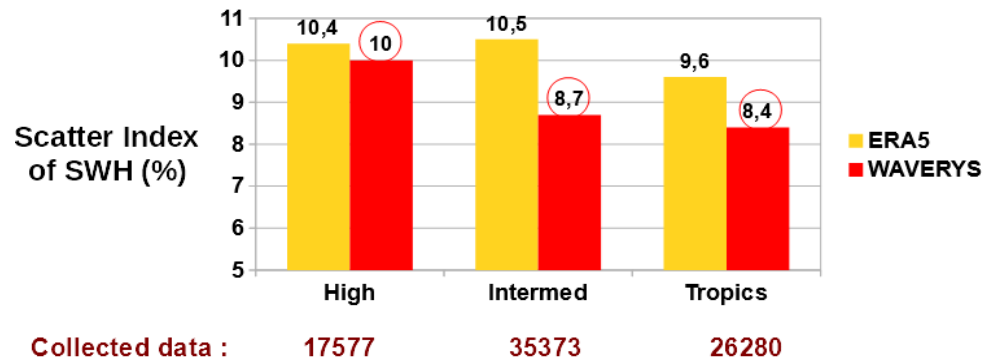
**Good performance for WAVERYS
Better than ERA5 on all ocean basins**

**High Lat |Φ|> 50°
Intermediate lat 20°<|Φ|<50°
Tropics |Φ|<20°**

Bref apperçu des développements en cours et état des lieux

Développement en cours

Other improvements of the global system

R&D started but not yet available, postponed for integration in operational system after 2021

- Data assimilation smoother scheme
- Ensemble forecast
- Ensemble analysis
- Tides
- Atmospheric Boundary Layer
- Assimilation of In Situ biogeochemistry profiles
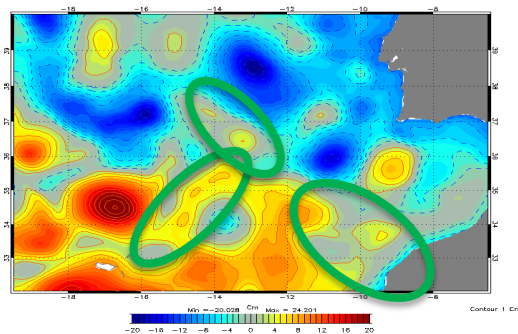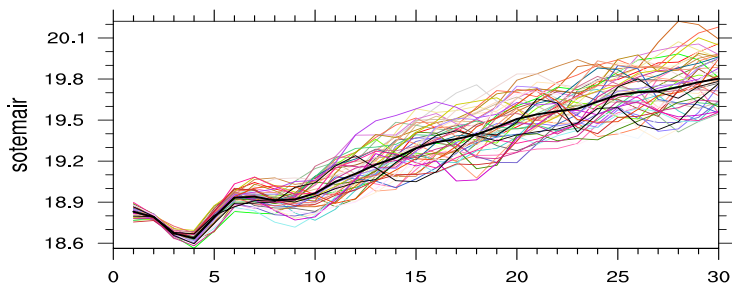- Higher resolution global configuration
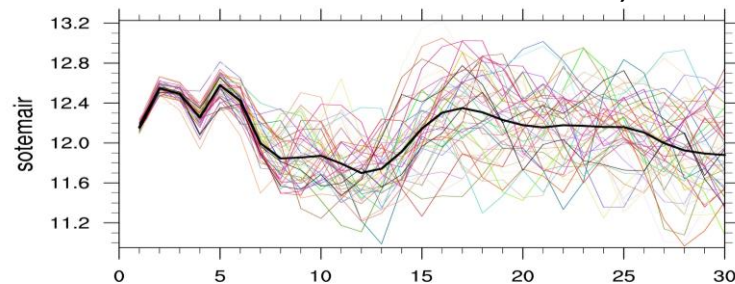
Nature run
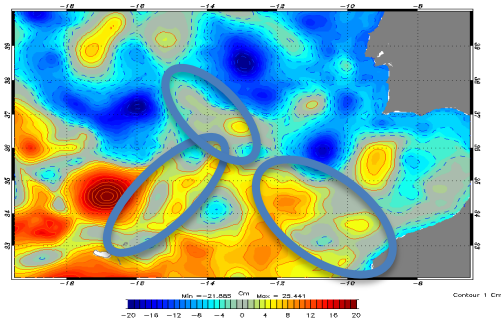
Standard scheme
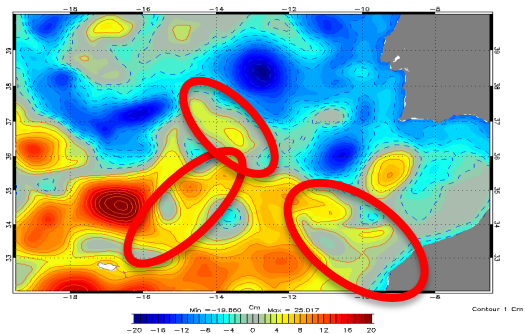
Smoother scheme

Concept tested in SAM2 data assimilation scheme and validated in OSSE experiments. Need developement and transfer in global system
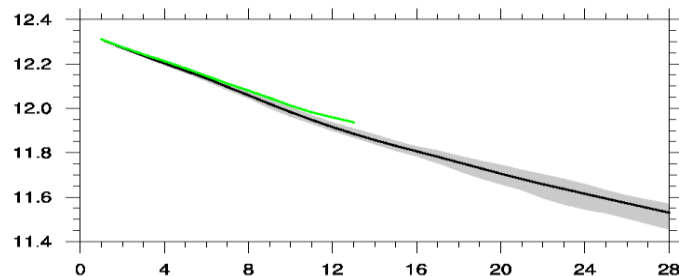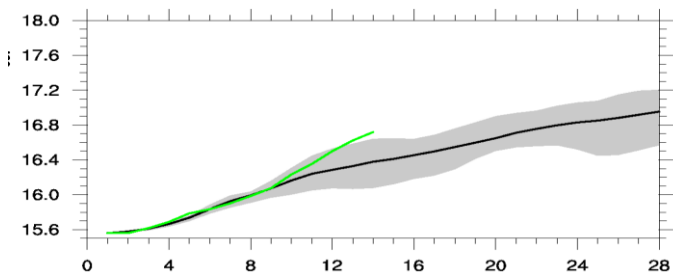
C. Dubois

Summer season (July)   **Winter season (January)**

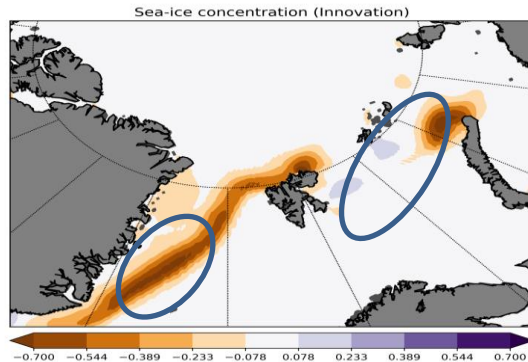ECMWF Atmospheric air temperature (North Atlantic for the 50 members)

Model SST forecast

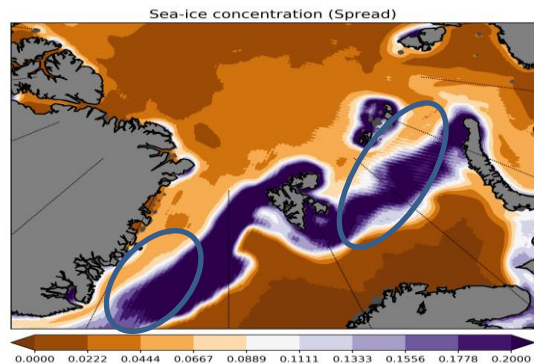**SST spread, ensemble mean, determinist forecast**

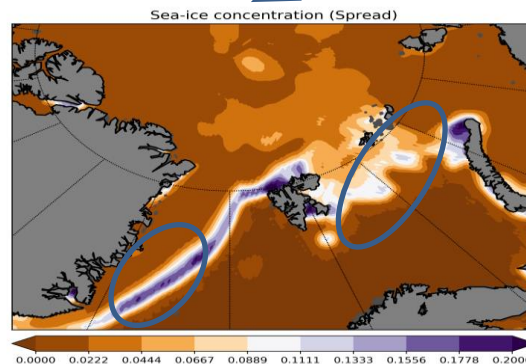**New ensemble will be produced, including perturbation of forcing and initial state**

G. Ruggiero

MERCATOR OCEAN INTERNATIONAL

Sea-ice concentration (Innovation)

Climatological Analysis error Covariance

Ensemble Analysis error Covariance

Sea-ice concentration (Spread)
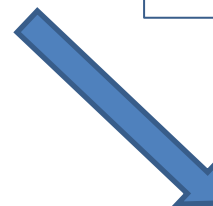
Ensemble produces reliable estimates of the state uncertainties

Sea-ice concentration (Spread)
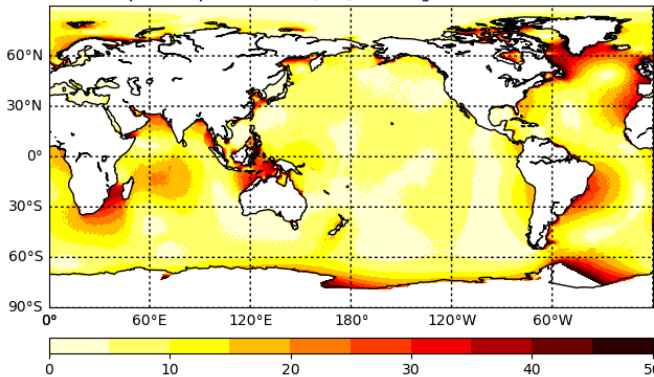
Need adaptation for multidata/multivariate and at global scale. Computation cost issue

Global simulations
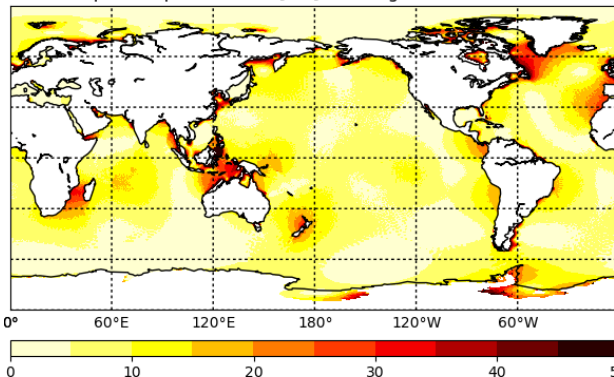- NEMO3.6 at ¼° and 1/12°
- Barotropic and 3D simulations
- Intercomparison with FES and HYCOM solutions
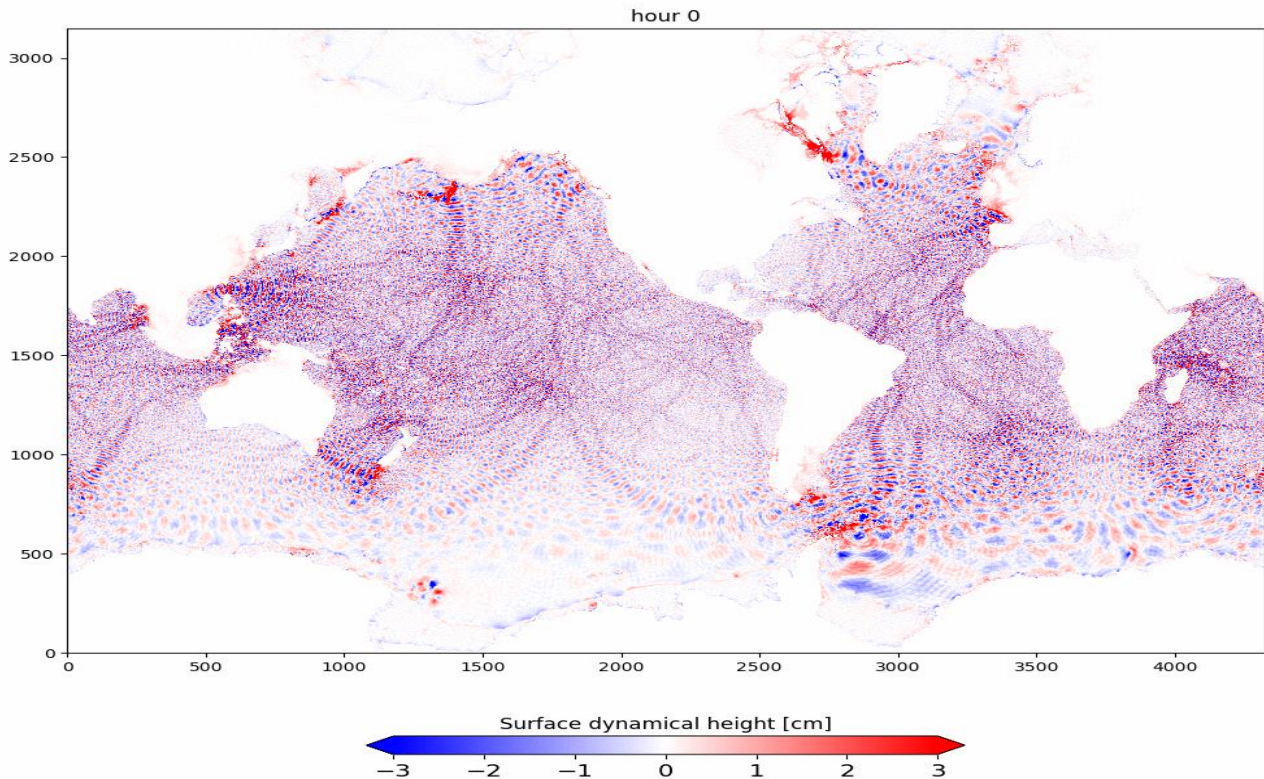
M2 complex amplitude error [cm] ; Average (h>1000m): 11.04 cm

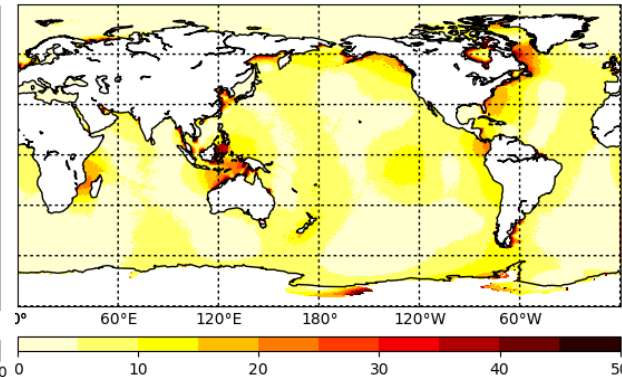M2 complex amplitude error [cm] ; Average (h>1000m): 8.21 cm

M2 complex amplitude error [cm] ; Average (h>1000m): 6.16 cm

Error= 11,0 cm

Error= 8,2 cm

Error= 6,2 cm

Resolving ice cavities

SAL from FES2014

Need tuning, parameterisation, bathymetry and constrain barotropic tides
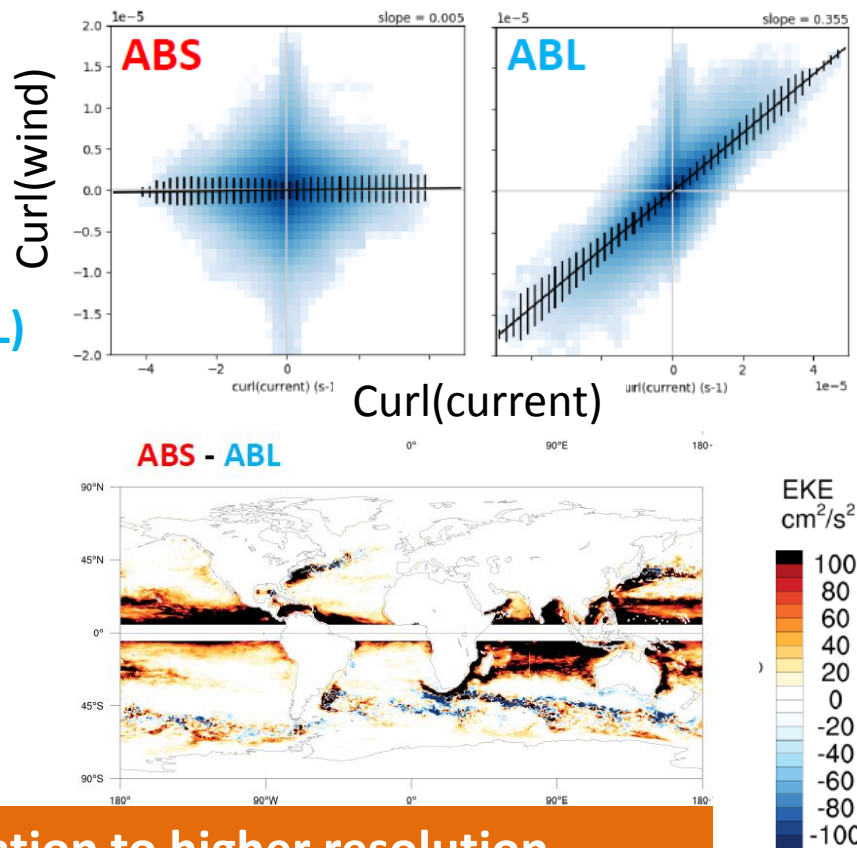
2 global ¼° simulations
NEMO3.6, LIM3, 75L, ERAinterim, 20132017
Forced with absolute winds (ABS)
Coupled ocean-ABL1D with relative winds (ABL)

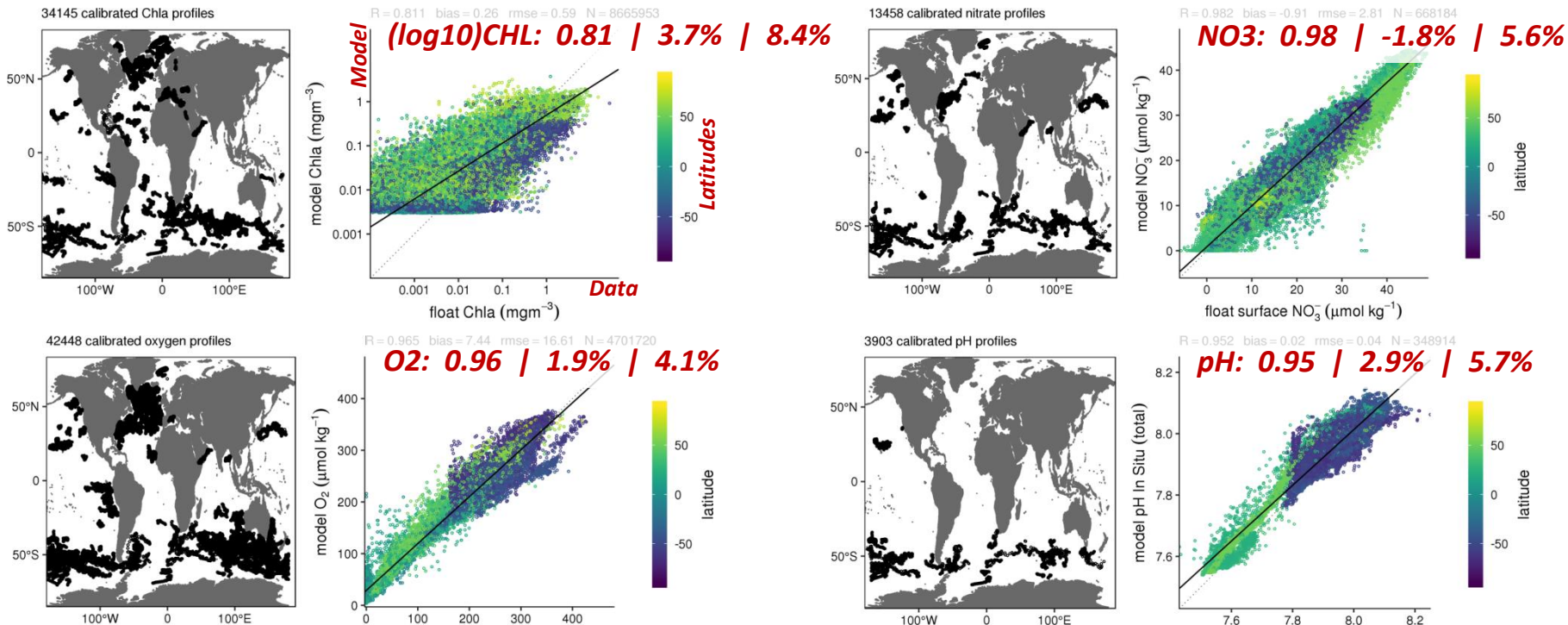Encouraging preliminary results
- SST-wind turbulent adjustement
- Eddy damping
- Low computational cost (+10%)

Need tuning of coupling coefficient, validation to higher resolution (1/12°) and atmospheric forcing pre processing in the operational chain .

Space-time integrated metrics - comparison to **full depth BGC-Argo** dataset (2008-2017)

34145 calibrated Chla profiles

R = 0.811   bias = 0.26   rmse = 0.59   N = 8665953

(log10)CHL: 0.81 | 3.7% | 8.4%

13458 calibrated nitrate profiles

R = 0.982   bias = -0.91   rmse = 2.81   N = 668184

NO3: 0.98 | -1.8% | 5.6%

42448 calibrated oxygen profiles

R = 0.965   bias = 7.44   rmse = 16.61   N = 4701720

O2: 0.96 | 1.9% | 4.1%

3903 calibrated pH profiles

R = 0.952   bias = 0.02   rmse = 0.04   N = 348914

pH: 0.95 | 2.9% | 5.7%

First comparison/validation, then model tuning/parameterisation and then assimilation. Still an issue on global coverage
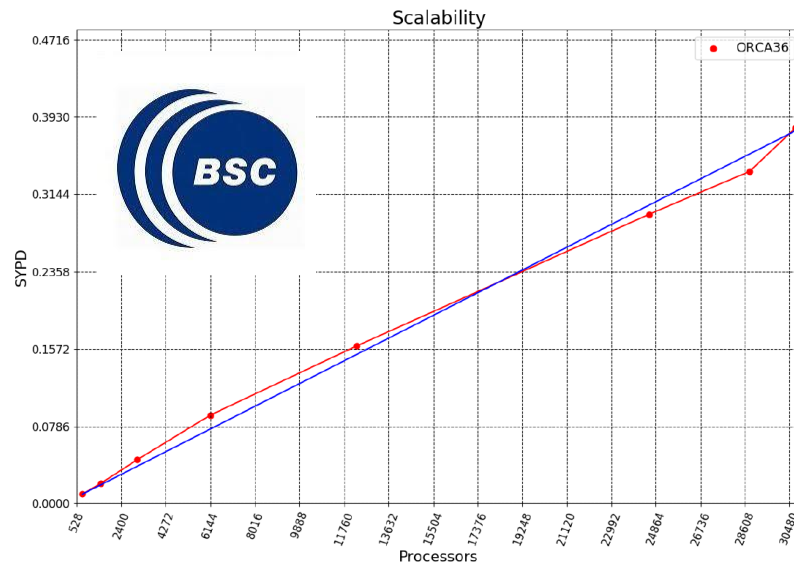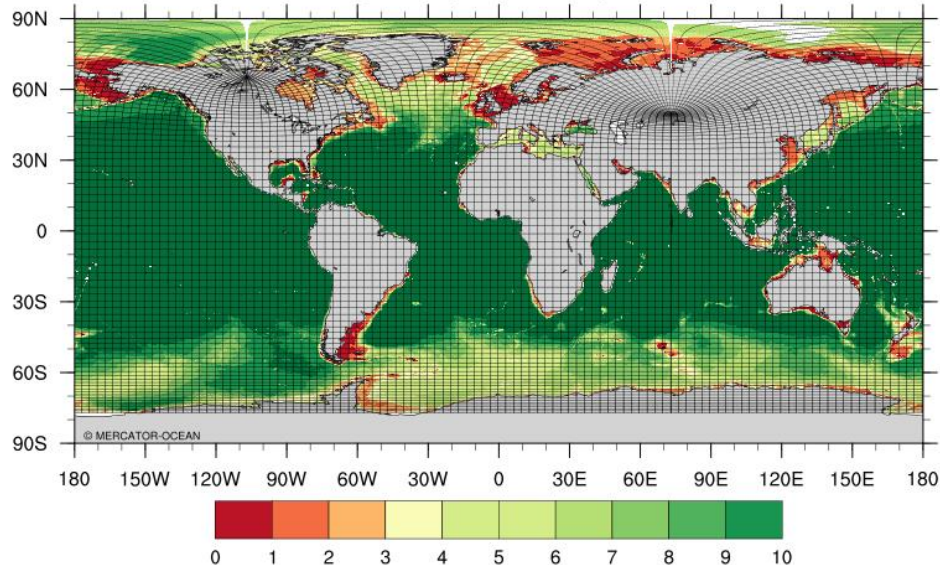
C. Bricaud

Fig 17: NEMO4 ORCA36 scalability in MareNostrum4

- Operational production is secured for BLUE, WHITE and GREEN global ocean

2019
- Biogeochemistry near real time and forecasting with ocean color assimilation
- Waves reanalysis

2020
- « Interim» production of the global reanalysis (physique, biogeochemistry, waves and micronekton)

2021
- New global 1/12° physical near real time and reanalysis systems

2021-2025
- Higher resolution
- Ensemble approach for analysis and forecast
- Coupling, retroaction/interaction between systems components (physics, biogeochemistry, waves, atmosphere, sea ice …) and multi variable/multi data assimilations