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# Overview of the first year of the NEMO global 1/36° configuration (ORCA36) development

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# Global 1/36° (ORCA36): context

- Model configuration for future CMEMS/MOI global forecasting and reanalysis systems

- Based on NEMO 4

- Projects:

IMMERSE (EU H2020)

ESIWACE2 (EU H2020)

# ESiWACE2 - for future exascale climate and weather predictions

Projet objectives:

- improve efficiency and productivity of numerical weather and climate simulation and prepare them for future exascale systems
- prepares the European weather and climate community to make use of future exascale systems in a co-design effort involving modelling groups, computer scientists and HPC industry

**MOI involved in WP1.Task 1.1:**

- WP1.    : « Production runs at unprecedented resolution on pre-exascale supercomputers »
- Task 1.1: « Develop infrastructure for production-mode configurations »

  « *To enable production-mode simulations at the highest resolution possible, to be able to fill a significant fraction of a pre- exascale EuroHPC system, and to allow a scientific comparison of results some infrastructure needs to be developed.* »

⇒ **Provide NEMO-based global 1/36° ORCA36 configuration**

esiwace
CENTRE OF EXCELLENCE IN SIMULATION OF WEATHER AND CLIMATE IN EUROPE

EU Horizon 2020 grant agreements 823988

# IMMERSE: world-class marine modelling tools for its next generation systems

Projet objectives:

- *Develop a new, efficient, stable and scalable NEMO reference code with improved performances adapted to exploit future HPC technologies in the context of CMEMS systems.*
- *Develop NEMO for the challenges of delivering ocean state estimates and forecasts describing ocean dynamics and biogeochemistry at kilometric scale with improved accuracy*
- *Prepare the exploitation of the next generation of high resolution observing networks within CMEMS systems and in detailed, downstream modelling systems.*

IMMERSE-WP6: ORCA36= high resolution configuration used as a bench
For developped code in WP3 (numerics), WP4 (HPC) and WP5 (physics)

- Short simulations (operationnal objective: 7 days) to assess developments
- A first simulation (several months) to validate the configuration
- A long simulation with NEMO4/IMMERSE code to highlight IMMERSE developments

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# Global 1/36° (ORCA36): context

- Collaborations:

## CMEMS contract with BSC:

« 87-GLOBAL-CMEMS-NEMO: EVOLUTION AND OPTIMISATION OF THE NEMO CODE USED FOR THE MFC-GLO IN CMEMS » :

NEMO HPC performances, especially with global 1/36°

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

## CMEMS contract with CNRS/IGE/MEOM team:

« 2-GLO-HR Evolution of CMEMS Global High Resolution MFC »

IGE Institut des Géosciences de l'Environnement

- ➢ sensitivity of NEMO solutions to numerical and parametric choices in realistic configurations

an Atlantic (20S-81N) 1/12° configuration with AGRIF zooms (1/12° to 1/48° and 75 to 200 vertical levels)

- ➢ Definition of metrics to assess resolved fine-scale structures

Small scale vorticity variance, KE wavenumber spectra, regularity of resolved fields at the grid scale,submesoscale vertical buoyancy flux, fine scale horizontal gradient of surface buoyancy

# Model configuration

- Horizontal: tripolar ORCA grid, 1/36° résolution (2-3km)
- Vertical: 75 Z-levels, 1 meter at surface
- Bathymetrie: based on ETOPO1
- Runoff: climatology
- Atmospheric forcing: Era-interim (on-line interpolation)
- Initial condition: from MOI ¼° reanalysis (shorten model spinup)
- XIOS servers for outputs

# Model parametrizations

NEMO 4

**Variable volume**

**Forcing:**
Erainterim with NCAR bulk formulae and analytical diurnal cycle
Surface frequency frequency: every time-step
Atmospheric pressure gradient added in ocean & ice Eqs.
2 bands light penetration scheme

**Sea Ice model :**
SI3
Levitating sea ice
5 categories

**EOS80 for equation of state**

**Hydrostatic pressure gradient:** s-coordinate (standard jacobian formulation)

**BC:**
Lateral friction: free slip
logarithmic top/bottom drag coefficient

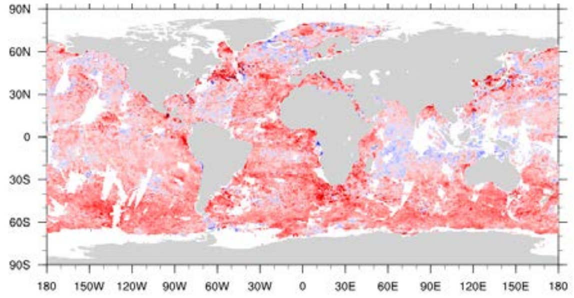
**Tracers transport:**
TVD advection scheme 4th order on horizontal and vertical
Explicite diffusion with triad iso-neutral operator
No damping

**Dynamic:**
Advection: flux form - 3rd order UBS
No explicit diffusion
EEN energy & enstrophy scheme (with masked averaging of e3t divided by the sum of mask)

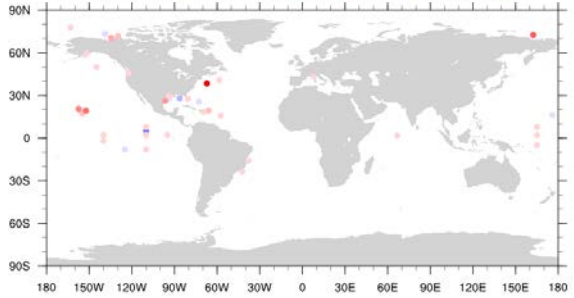
**Vertical physic:**
Vertical mixing: GLS
adaptive-implicit vertical advection (Shchepetkin 2015)

# Activate NEMO observations operator

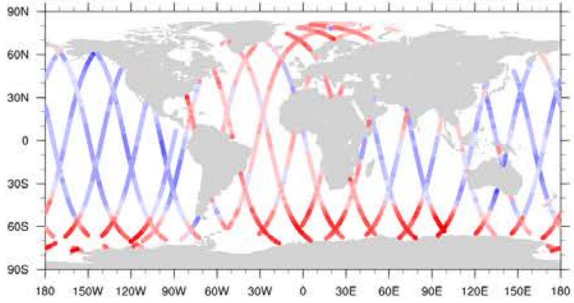
SST:
ODYSEA
L3S 0,1°




In situ :
Coriolis




SLA:
S3A,C2,J3,
ALT,H2Y




Good way to provide model-observations comparison

But… out of memory….

- **Why?** Each processor:

load the **data on all the domain**: -
select which observations are inside its MPI sub-domain
make the colocalisation

An example of data volume for the first week:
SST (1Gb) + SLA (100Mb) + INSITU (3.5 Gb) : 4.5G for each processor

- **Consequence:** Peak of memory during initialisation => Need to depopulate : 1 proc on 2

- **Solution to avoid this problem ?**

✓ Don't need to read observation data itself, positions are enough (but need to concatenate after)
✓ Preprocess obs dataset: split on MPP sub-domains
✓ Read obs day per day instead loading all the full run period dataset at initialisation

# Run setup

- Run starts at 20170101
- 3 full months of simulation

- Time step: 120s

- Twin runs with global ¼° (ORCA025) and global 1/12° (ORCA12) performed

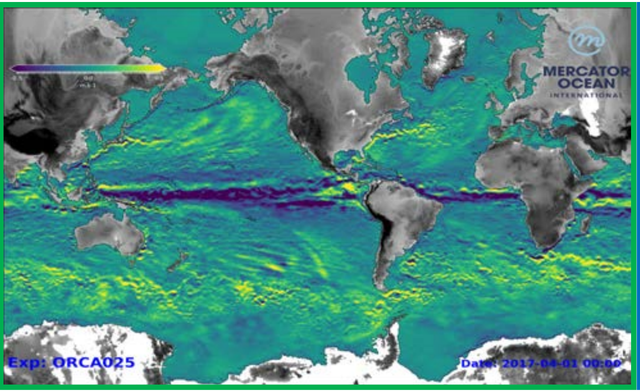
- Computer: ECMWF CRAY CCA ( Lustre file system, One node: 36 cores , 128 Gb memory)

11783 NEMO subdomains => **18 processus per node ( depopulate)** => 655 nodes
240 Xios servers => 2 processus per node ( depopulate) => 120 nodes
Total => 775 nodes

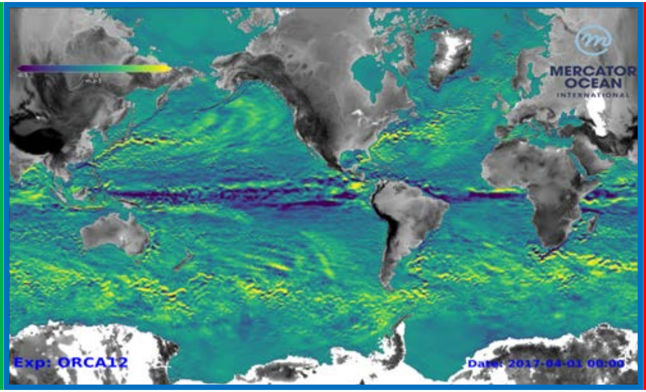
30 minutes to simulate one day

# Results

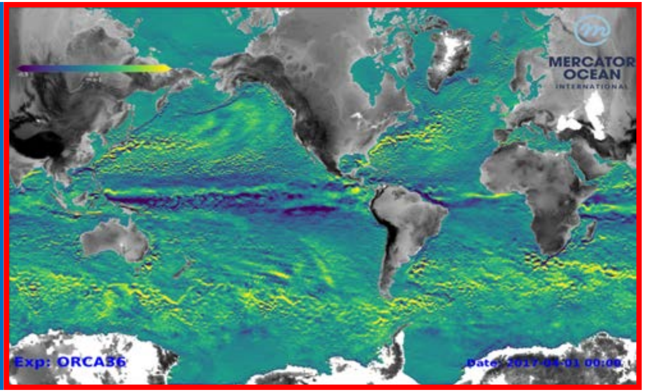
## 1 hour sea surface velocities after 3 months




¼°



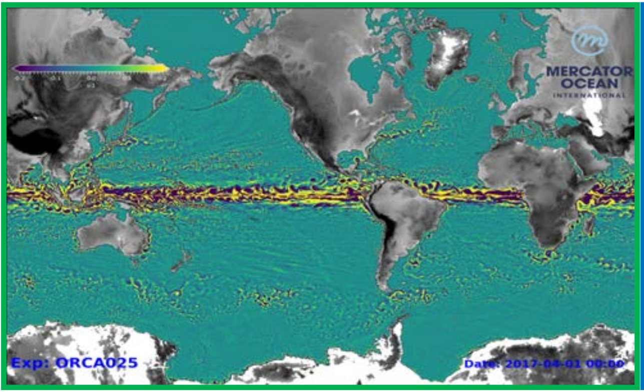

1/12°

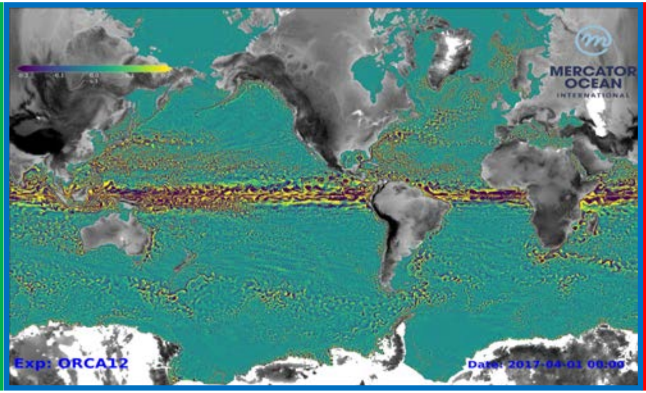


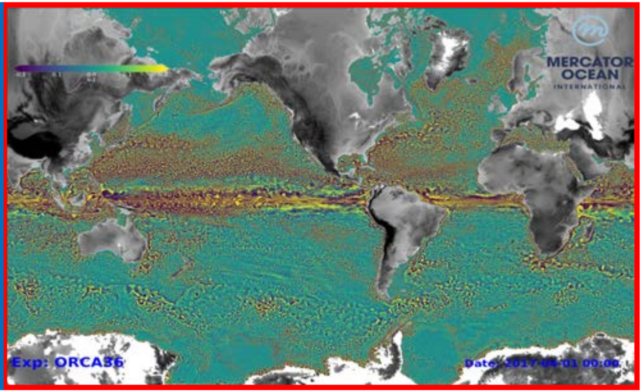

1/36°

# Results

**1 hour sea surface relative vorticity after 3 months**



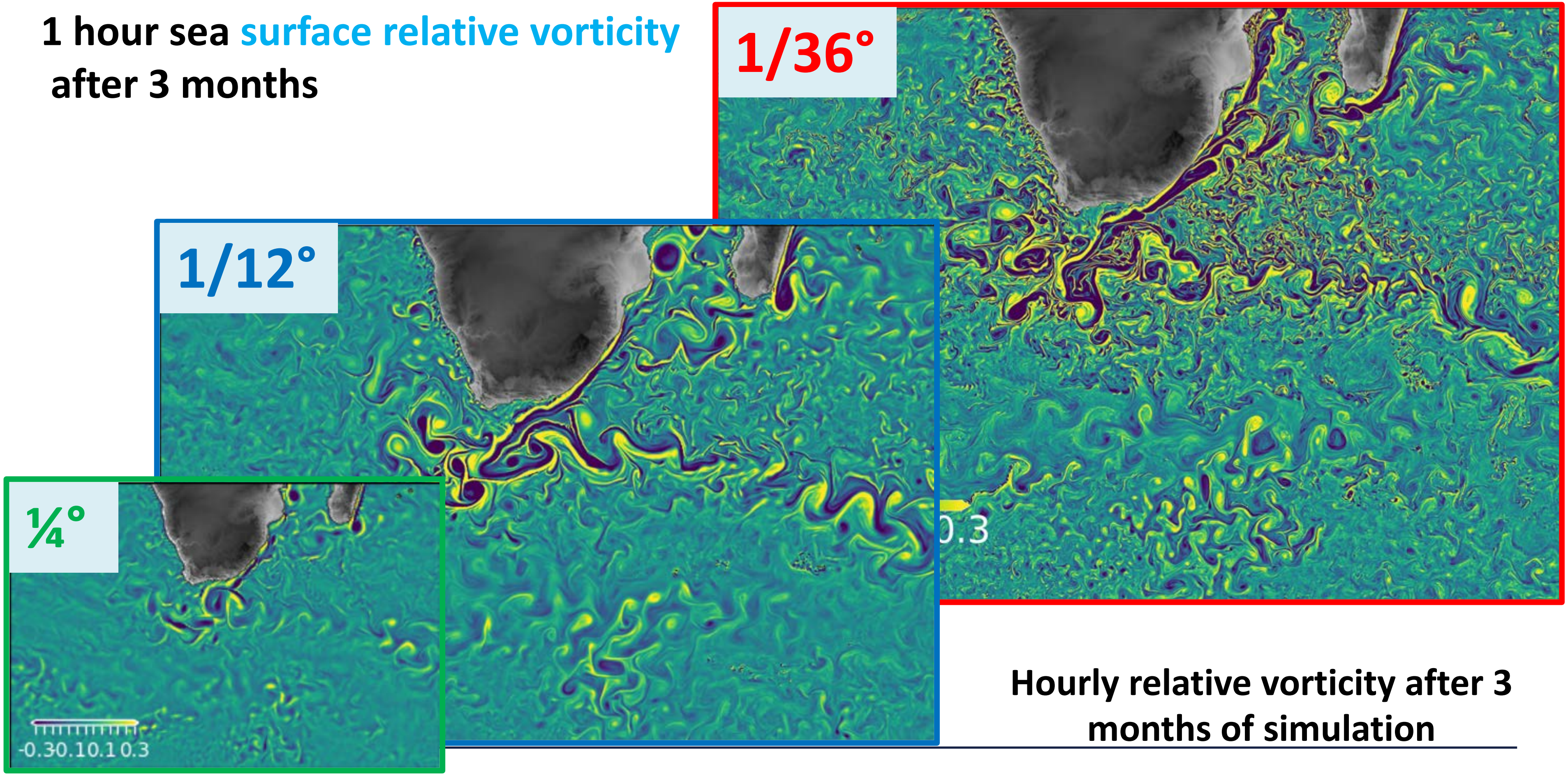




¼° 1/12° 1/36°

# Results

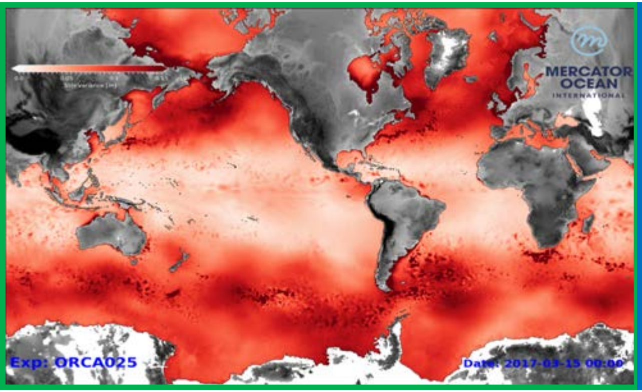
1 hour sea surface relative vorticity
after 3 months

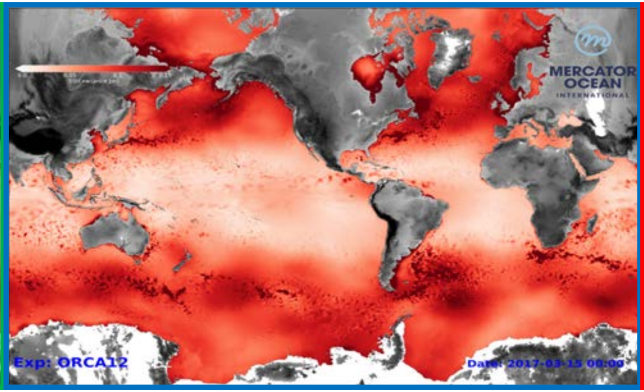


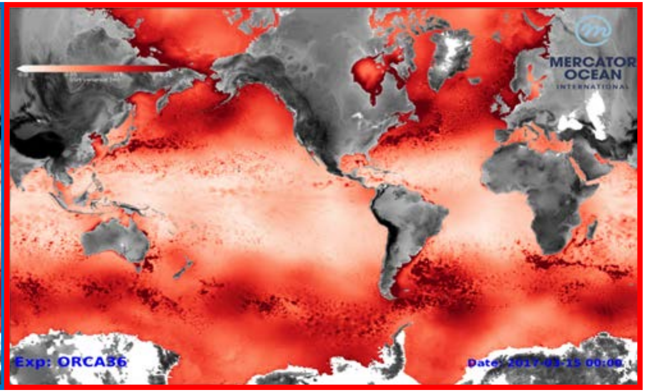

Hourly relative vorticity after 3 months of simulation

# Results

## Monthly SSH variance from hourly fields after 3 months




¼° 1/12° 1/36°

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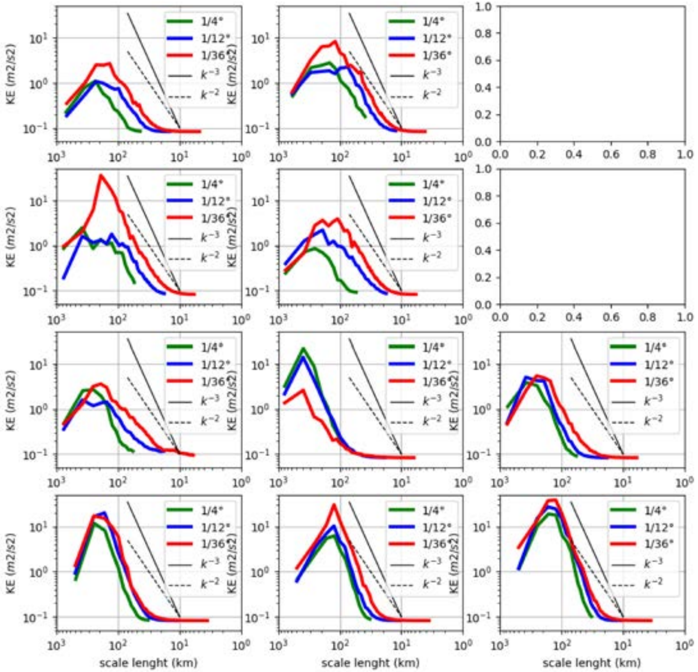
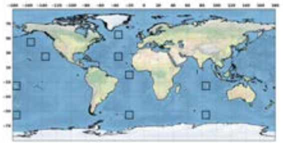
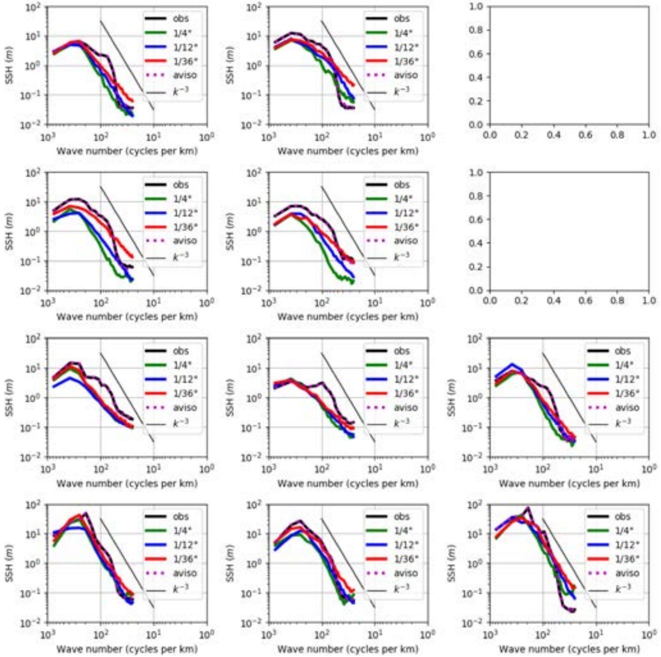
# Results

## 2017-01-15 to 2017-04-08
## KE power spectra



## 2017-01-15 to 2017-04-08
## SSH power spectra
## comparison to Jason3



# Summary

- A configuration is existing

- It is running with NEMO 4…

  with reasonable performance ( for development phase )

  with NEMO observations operator ( but need more memory)

- Right way to provide a configuration running with NEMO 4 for IMMERSE and ESIWACE2

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# What happens next?

- NEMO 4 version upgrade ( NEMO 4.1 « IMMERSE » version )
- Longer run (10/2012 => 2020)
- Forcing: ERAinterim => IFS

- Extension of domain southward: add under ice shelf seas
- Add tidal forcing ( for tidal internal waves)
- Uses Atmospheric Boundary Layer: dynamical downscalling of atmo data to model resolution
- Improve model parametrization tunning

- Increase ouput volume (1 hour 3D outputs)
- Increase MPI domain splitting
- Switch to new Meteo France BULL  and/or ECMWF computers
- Ask for a PRACE project ( 21th call) with IGE/Ocean-Next/CMCC/BSC on MARE NOSTRUM IV

End