MERCATOR OCEAN INTERNATIONAL

IMMERSE Meeting – Sept 2021

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Introduction : Actual status of IBI in IMMERSE

- **eNEATL36 is functional on NEMO4.0-HEAD and NEMO4.2-RC versions**
  - Over the 2017/08/23 – 2018/12/31 period
  - A few remaining bugs have been identified

- Functional with the new EMODNET bathymetry
  - Adjustment on tide parameters needed?

- **AGRIF zoom :** area has to be defined (based on cost estimation)

outline

1. **Comparison of NEMO pre (4.0) and post (4.2) IMMERSE versions**
   a) Twin simulations over the 2017/08/23 - 2018/12/31 period with similar physics
   b) Scalability tests
   c) Remaining issues

2. **Using the new EMODNET Bathymetry**

3. **What NEMO4.2_RC physics for IBI**

4. **AGRIF ZOOM : Area definition and cost estimations**

1) Comparison of NEMO pre and post IMMERSE versions

Comparison of NEMO pre and post IMMERSE versions

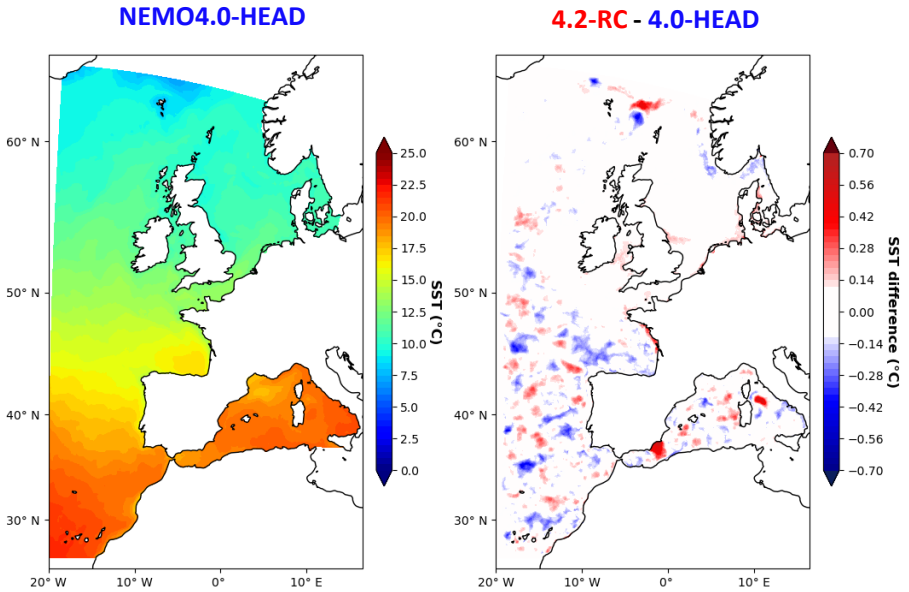
a) Twin simulations over the 2017/08/23 - 2018/12/31 period with similar parameters

- **Objective : estimate the differences between NEMO4.0 and NEMO4.2** :
  - similar setup:
    - Period
    - atmospheric forcing (IFS)
    - boundary (PSY4V3R1)
    - initial conditions (PSY4V3R1)
  - parameterizations

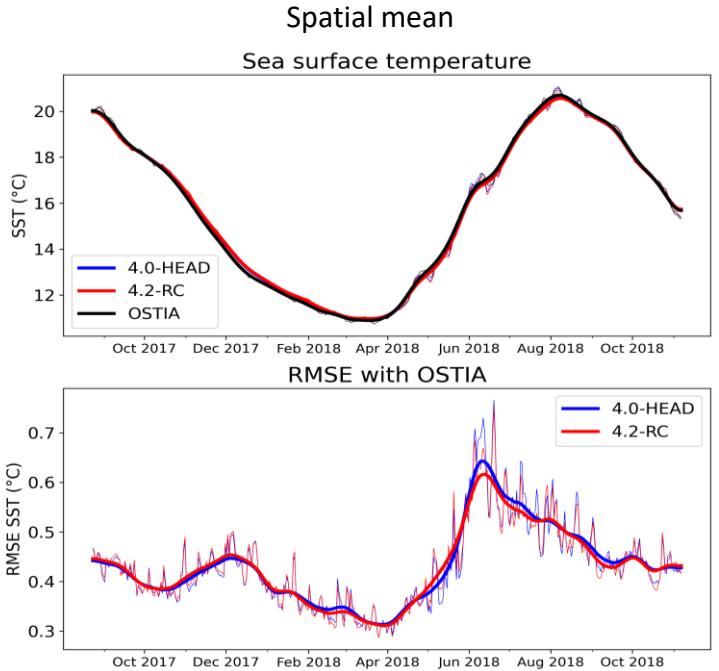
- The only difference between the two runs is the use of VVL or QCO
  - **NEMO4.0-HEAD** – Variable Volume Level VVL (pre-IMMERSE)
  - **NEMO4.2-RC** – Quasi-eulerian Coordinate QCO (post-IMMERSE)

  -> Note that VVL is currently not working in the 4.2-RC version

Comparison of NEMO pre and post IMMERSE versions: SST



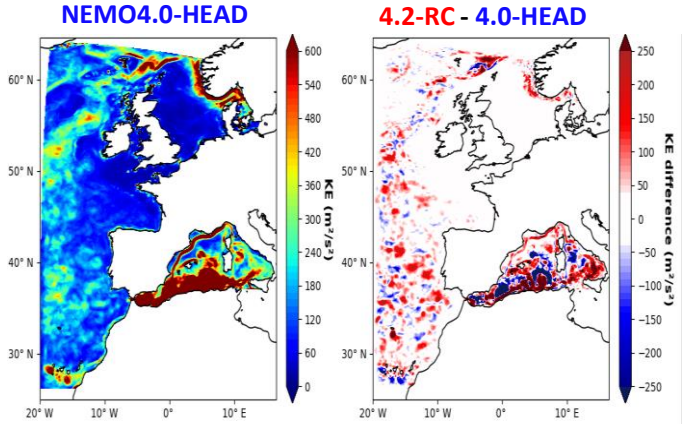
SST (°C) averaged over 2018

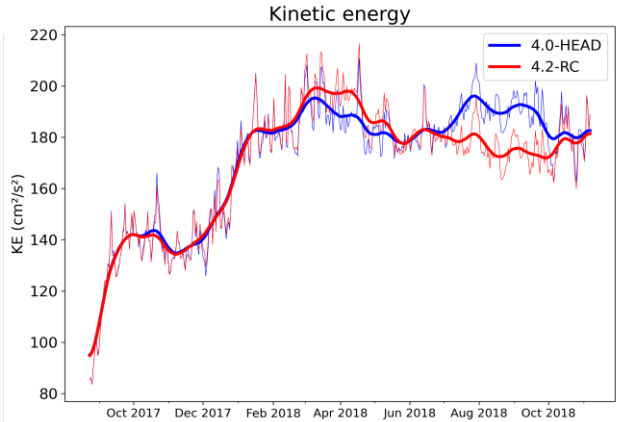


- Small local differences between NEMO4.2 and NEMO4.0
- Related to qco ?

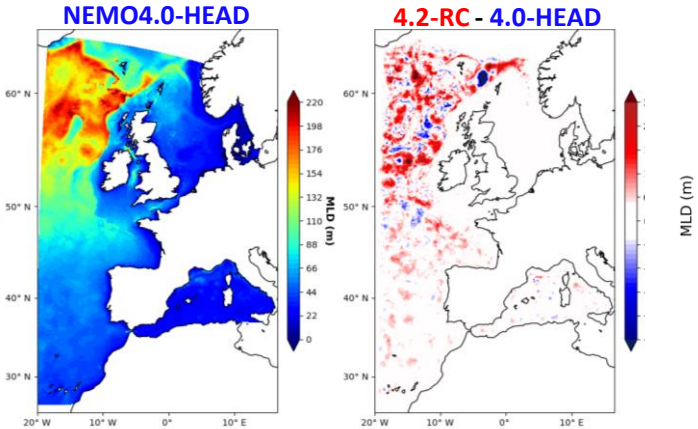
Comparison of NEMO pre and post IMMERSE versions: KE & MLD

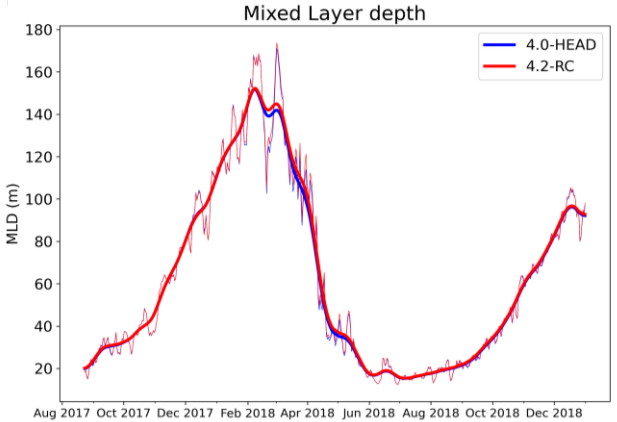
KE





MLD



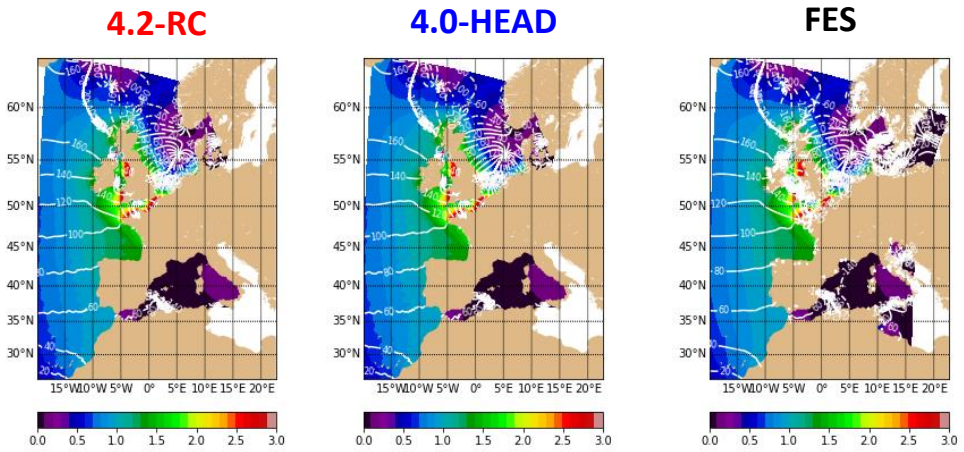


KE and MLD averaged over 2018

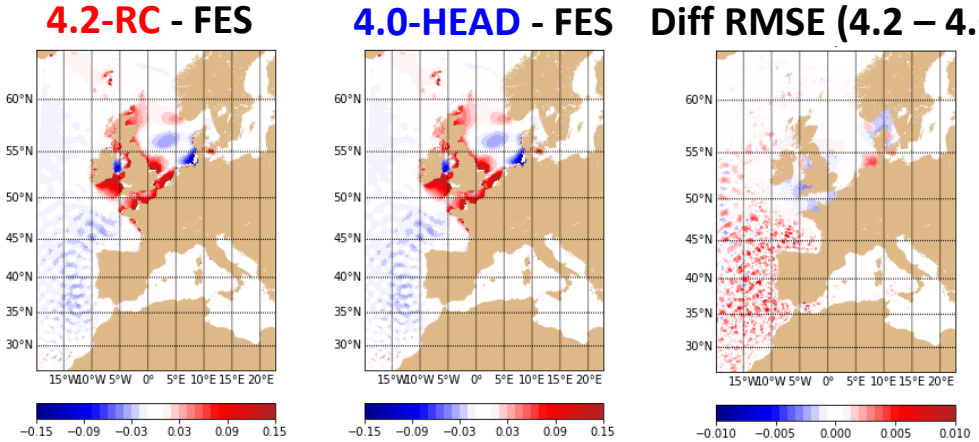
- Kinetic energy and MLD : Changes at mesoscales
- Higher KE level in 4.0-HEAD
- Weak positive MLD difference (4.2_RC deeper)
- Perhaps related to qco vs vvl ?

Comparison of NEMO pre and post IMMERSE versions : Tides

M2 Amplitude (m) & phase



M2 Amplitude difference (m)



- Offline harmonic analysis
- Amplitude differences with FES < +- 15cm
  -> Consistent with Maraldi et al. 2013
- Small changes in internal waves signature between the 2 NEMO versions
  -> Internal waves are closer to FES in 4.0

Comparison of NEMO pre and post IMMERSE versions

b) Scalability tests

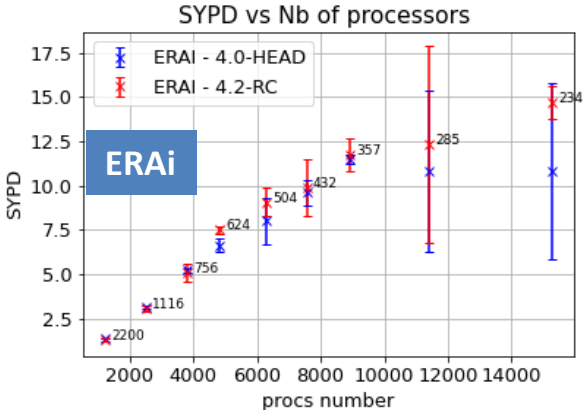
- **Objective :** show differences between HPC cost of NEMO4.2 versus NEMO4.0
- **Setup :**
  - **NEMO4.0-HEAD** – jpni*jpnj = Nprocs (no procs suppression over land)
  - **NEMO4.2-RC** – jpni*jpnj = Nprocs (no procs suppression over land)
- As VVL does not work in actual NEMO4.2 version, these runs are performed using a linear free surface (linssh).

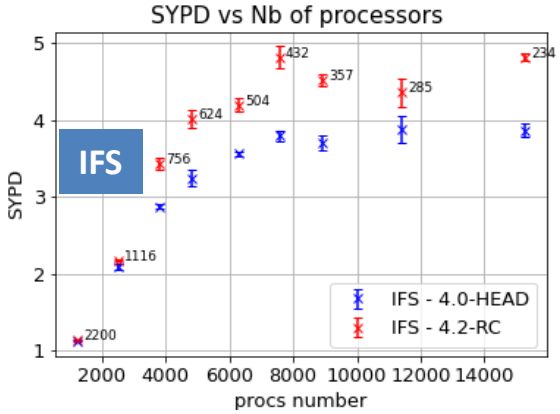
Comparison of NEMO pre and post IMMERSE versions

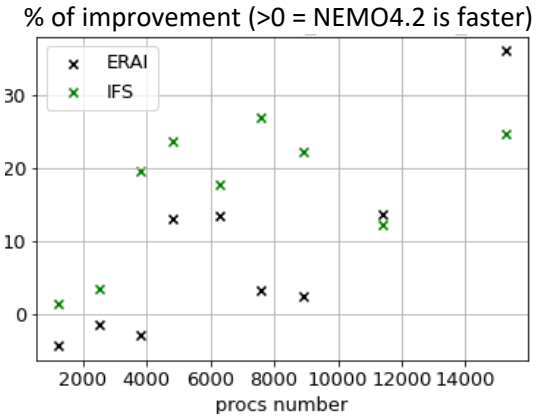
No removal of earth processors (i.e : force Nprocs = jpni * jpnj)

Experimental setup :

- **NEMO 4.0-HEAD & NEMO 4.2-RC**
- **5 runs of 7 days per procs number**
- Tests with ERAI (3h) and IFS (1h)
- No outputs, linear SSH







- **10% to 35% of improvement in NEMO4.2 for high number of processors**
- Note: huge variability related to the Meteo-France supercomputer (belenos)

Comparison of NEMO pre and post IMMERSE versions

No removal of earth processors (i.e : force Nprocs = jpni * jpnj)

Experimental setup :

- **NEMO 4.0-HEAD & NEMO 4.2-RC**
- **5 runs of 7 days per procs number**
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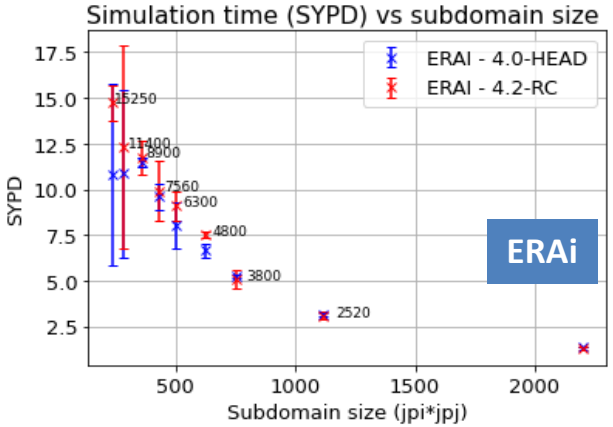

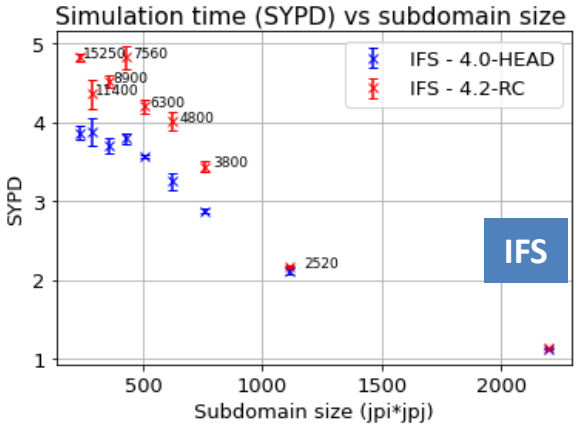

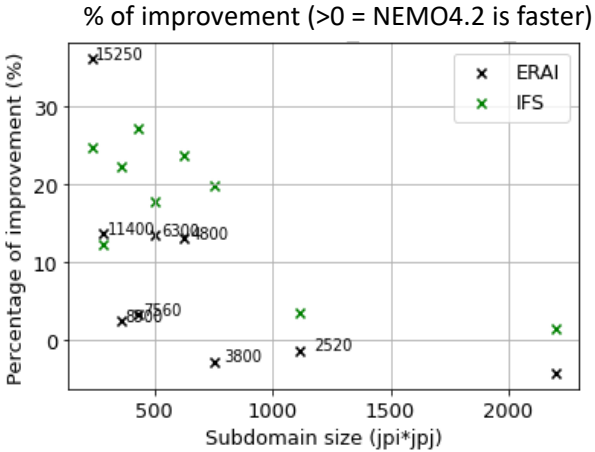

- **10% to 35% of improvement in NEMO4.2**
- Improvement for all subdomain size but **better results for subdomain smaller than 1000 points**

Comparison of NEMO pre and post IMMERSE versions

No removal of earth processors (i.e : force Nprocs = jpni * jpnj)

Experimental setup :

- **NEMO 4.0-HEAD & NEMO 4.2-RC**
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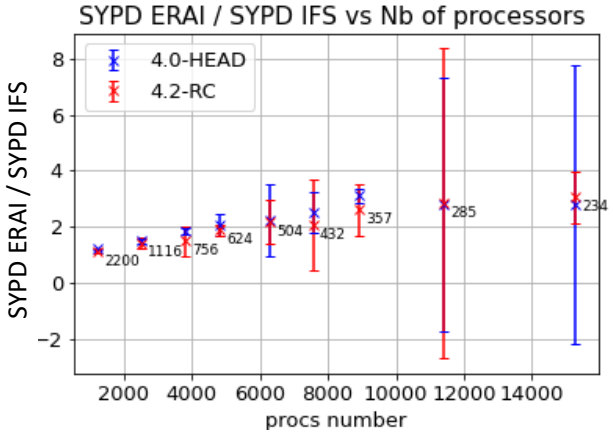


- **NEMO is 2 to 3 times faster with ERA-Interim**

- Perhaps the results can be improved for IFS by selecting only the IBI area with ncks (preprocessing) ? (e.g: ~4Mo for 1day of 3h ERAI Tair data ; ~648Mo for 1day of 1h IFS Tair data)

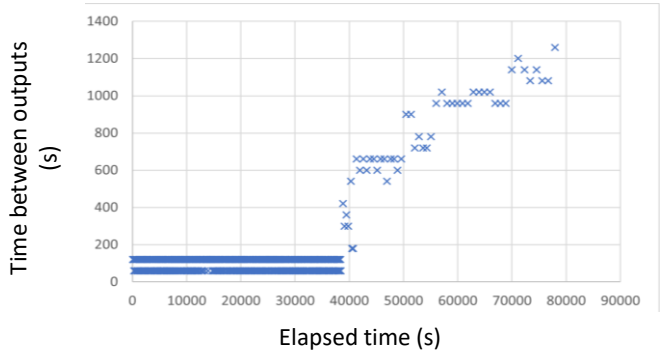
Comparing NEMO pre and post IMMERSE versions

Issues with 4.2-RC :

- Halos : systematic buffer size problem when jpni & jpnj = 0 -> **related to BDYs**

Fatal error in MPI_Recv: Message truncated, error stack:
MPI_Recv(224).....: MPI_Recv(buf=0x90b6480, count=192, MPI_DOUBLE_PRECISION, src=9, tag=2, comm=0xc4000003, status=0x1) failed
MPIDI_CH3U_Request_unpack_uebuf(618): Message truncated; 3072 bytes received but buffer size is 1536

- Increase of the time step duration for very long simulations in NEMO4.2-RC: possible memory leak ?



- **NEMO4.2 Reproducibility issue** : After 1week of simulation, 4th digit differences on SSH, S, T & U between a run with 2520 procs and 11400 procs (Note that the results are reproducible when using the same number of processors)

Summary

Summary :

- **No significant differences** in mean state for T, S, U & V between pre and post IMMERSE versions (when the same parameterisations are used)
- NEMO computational cost is **reduced** in the new version with high number of resources
- Remaining issues (halos, reproducibility)

Remaining issues

What remains to be done :

- Comparison with a twin NEMO3.6 experiment (Not IMMERSE task)
- More comparison with observations : SSH, HF radar currents … (collaboration with IMEDEA, PdE, CMMC)… but **the validation should be statistic** because it's free runs !
- Bugfixes (halos, reproducibility, vvl)
- Estimate the contribution of new 4.2 parameterisations / schemes

-> does the new physical schemes / parameterisations implemented in 4.2-RC improves or deteriorates the results ?

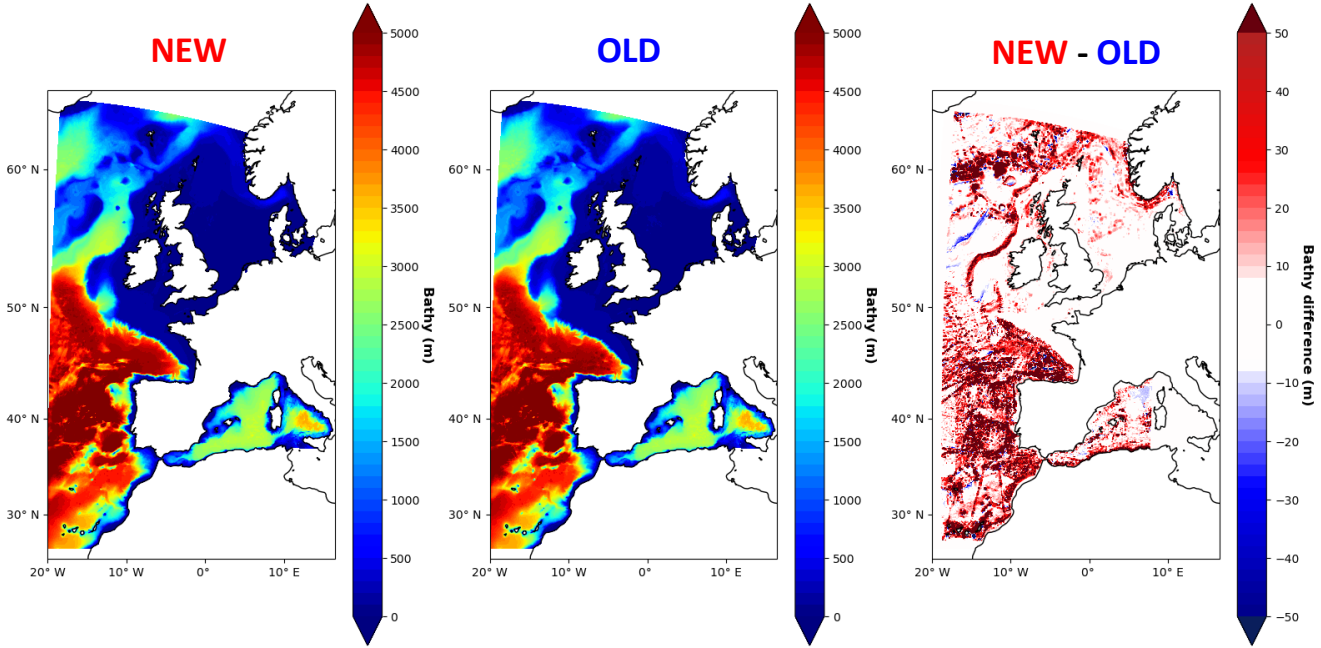
2) Using the new EMODNET BATHYMETRY

Using the new EMODNET bathymetry

Twin experiments over the 2017/08/23 - 2018/12/31 period (with the same namelist parameters):

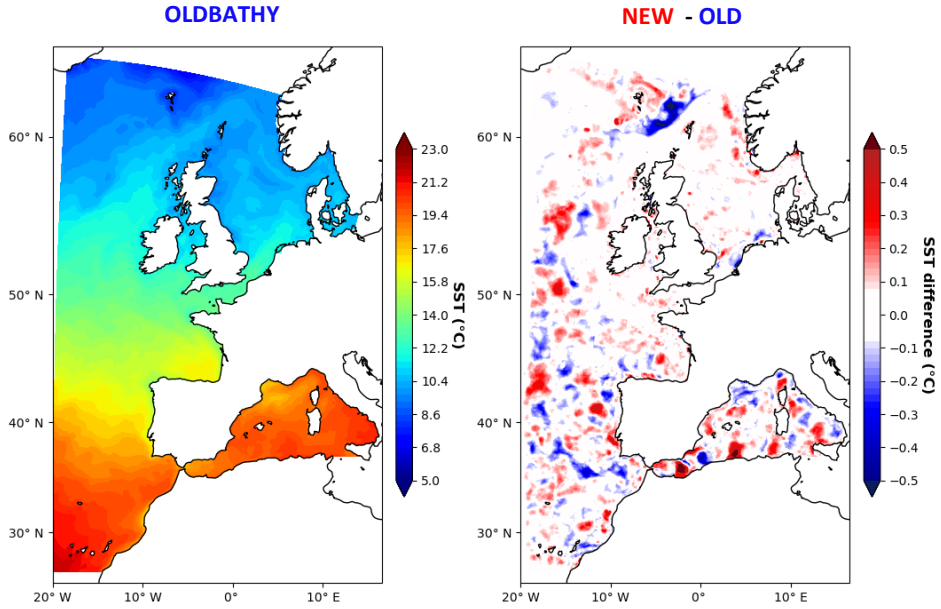
- **NEMO4.2-RC** – QCO – **OLD** BATHY based on GEBCO data (~1km resolution)
- **NEMO4.2-RC** – QCO – **NEW** BATHY based on EMODNET data (~100m resolution)

Objective : show the impact of the new bathymetry on the results

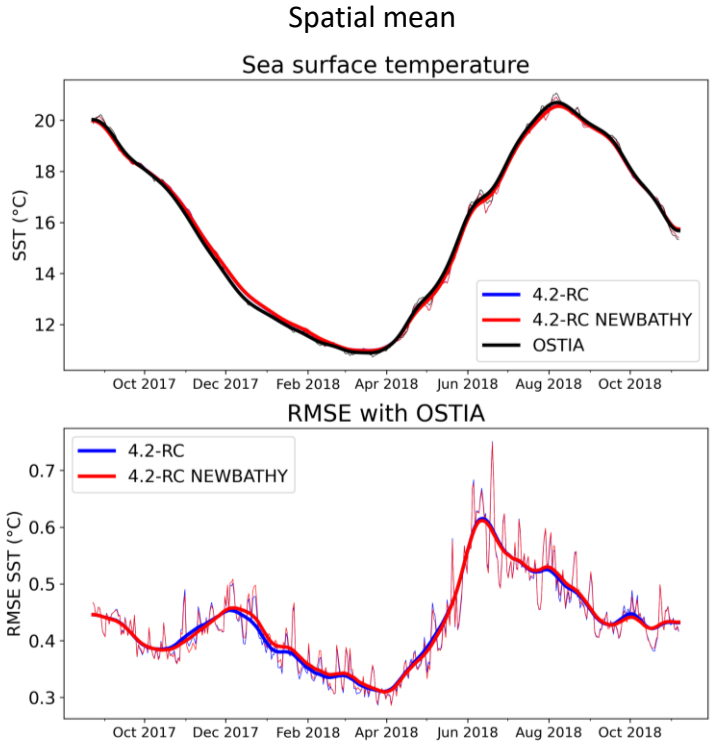


Bathymetry and differences between NEW and OLD bathy (m)

Using the new EMODNET bathymetry: SST



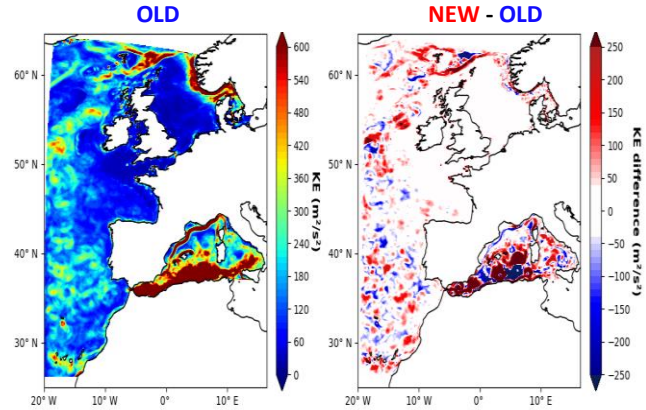
SST (°C) averaged over 2018

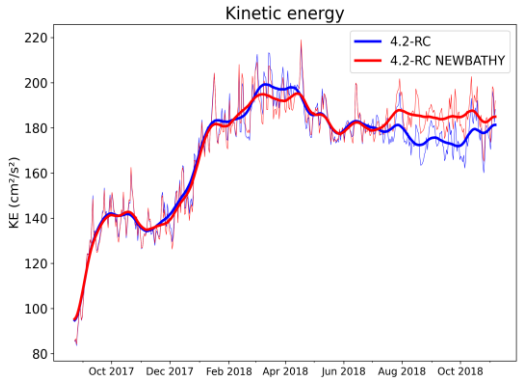


- Changes in mesoscale SST
- No change in the mean state

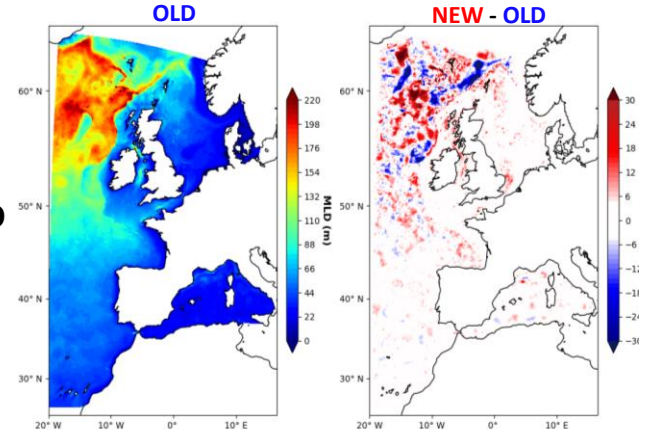
Using the new EMODNET bathymetry: KE & MLD

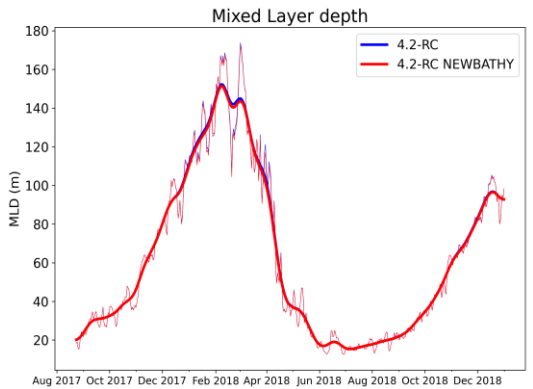
KE





MLD





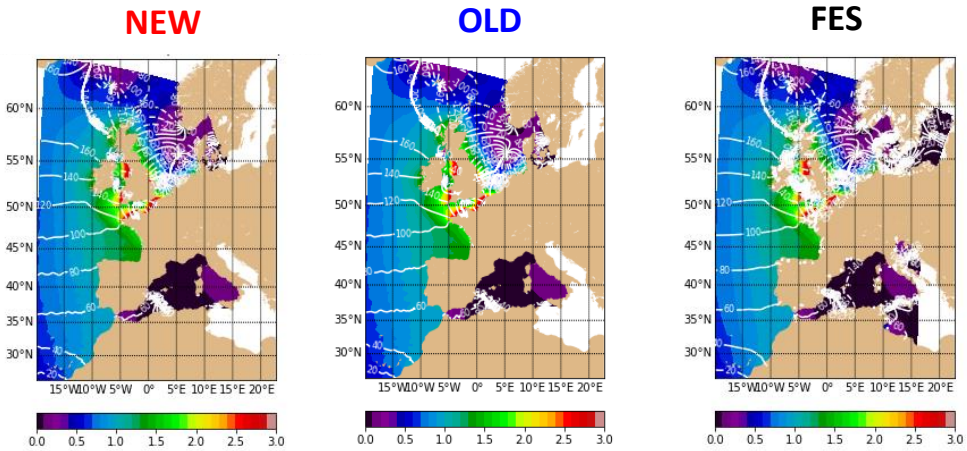
KE and MLD averaged over the simulation period

- Strong local changes in MLD and KE
- Small increase in mean KE
- No change in MLD
- No major impact => however, the new bathy is based on a higher resolution product and is therefore **more suitable** for an AGRIF zoom

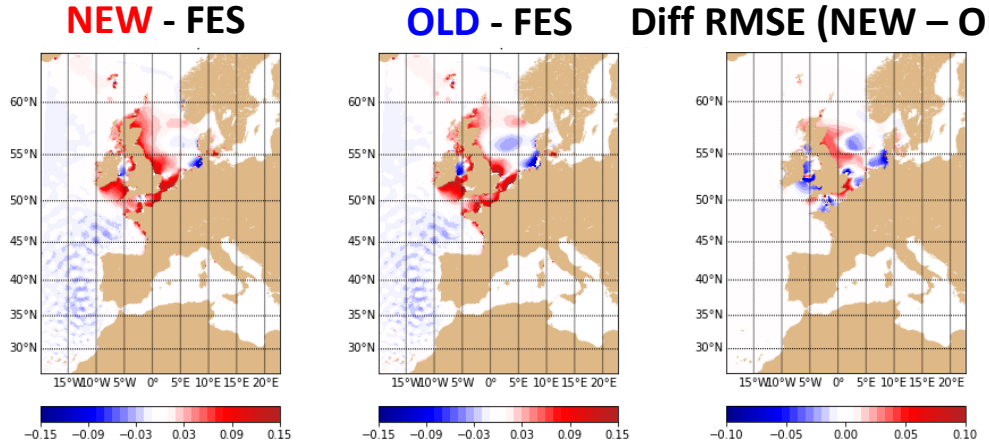
Using the new EMODNET bathymetry

Tides

M2 Amplitude (m) & phase



M2 Amplitude difference (m)



- Significant differences around the english channel (not surprising)
- It is however impossible to tell which bathymetry gives the better results :
  -> **OLD** is closer to FES near the eastern english coast
  -> **NEW** gives better results in the north sea (offshore)

Using the new EMODNET bathymetry

Flow across gibraltar :

	INFLOW (Sv)	OUTFLOW (Sv)	NETFLOW (Sv)
OLD BATHY	1.13	-1.03	0.11
NEW BATHY	1.07	-0.97	0.10
Litterature	0.7 to 0.9	-0.4 to -1.0	0.02 to 0.08

- New bathymetry reduces inflow, outflow and netflow across gibraltar
- All flows are overestimated -> NEW BATHY improves the results
- Mostly because the strait is smaller in the new bathymetry (7.82 km² in OLD 7.00 km² in new)
- Nb : In operational versions = noslip lateral boundary within the strait

Summary

Summary :

- **No significant differences** in mean state for T, S, U & V between new and old bathy

What remains to be done :

- More comparison with observations : SSH, HF radar currents … (collaboration with IMEDEA, PdE, CMMC)… but **validation should be statistic** because it’s free runs !

3) What NEMO4.2_RC physics for IBI

What NEMO4.2_RC physics

Objectives: Estimate the contribution of new 4.2 parameterisations / schemes

-> does the new physical schemes / parameterisations implemented in 4.2-RC improves or deteriorates the results ?

- **Comparing two runs :**
  - **NEMO4.2-RC** (with NEMO4.0 physical parameterisations and scheme)
  - **NEMO4.2-RC – NEW IMMERSE PHYSICS**

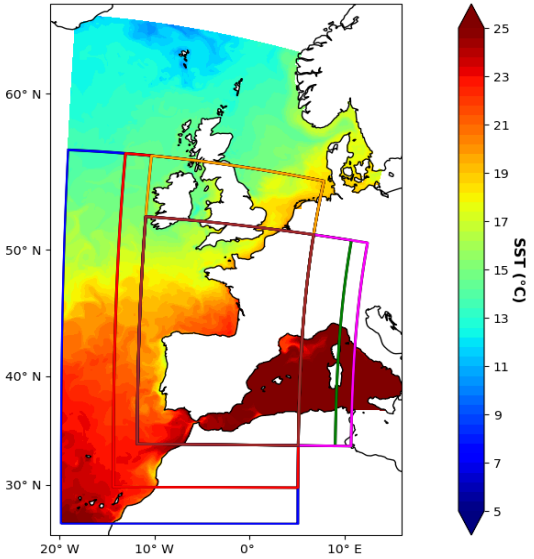
- **Which new physical scheme and parameterisation should be added in this run ? Propositions :**
  - New 4th order advection scheme
  - Current feedback param (Renault et al. 2017)
  - Cool skin param
  - Mass-flux Convection

- **Should we make sensibility tests ?**

4) AGRIF ZOOM : Area definition and cost estimations

AGRIF ZOOM : Area definition and cost estimations

Zoom proposals

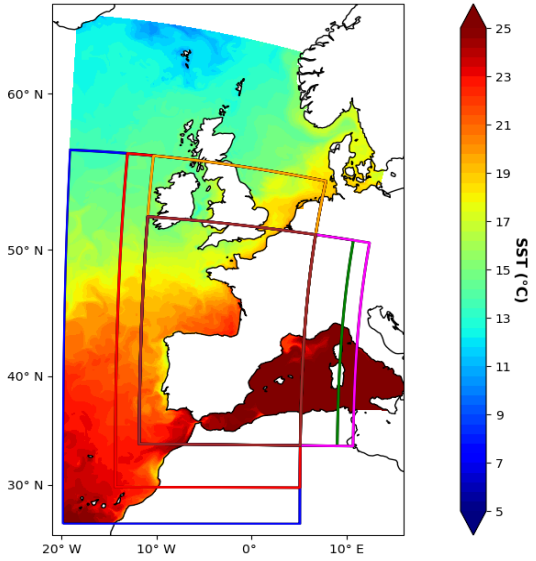


- **eNEATL36 :** 1894 * 1294 points; (= 2450836 points)
- **Computational cost (eNEATL36):**
  - *~1h on 3800 processors (for 1 month simulation)*
  - *~15h on 3800 processors (for 1 year and 3 month simulation)*
- **Data storage (eNEATL36):**
  - ***Standard outputs*** *= 2D hourly surface data (SSH, SST, SSS, MLD, surface currents) + 3D daily data (T°, S, 3D currents) =* ***2.8To*** *for 1 year and 3 months (182Go/month)*
  - ***Standard + additionnal 3D hourly outputs*** *(T, S, 3D currents) =* ***~29,2To*** *(1.9 To/month)*

-> 3D hourly fields = 10 times more storage !!!! (However, only ~+1% of computational cost)

AGRIF ZOOM : Area definition and cost estimations

Zoom proposals



- **Computational cost of an AGRIF zoom:**

$$Cost_{zoom} = Cost_{eNEATL36} * \left(\frac{N_{pts}(AGRIF)}{N_{pts}(eNEATL36)}\right) * 3$$

$$Cost_{suppl\ AGRIF} = Cost_{zoom} + Cost_{interp\ \&\ updates}$$

Avec : $Cost_{interp\ \&\ updates} \approx 10\% * Cost_{zoom}$

$$\boldsymbol{Cost_{total} = Cost_{zoom} + Cost_{eNEATL36} + Cost_{interp\ \&\ updates}}$$

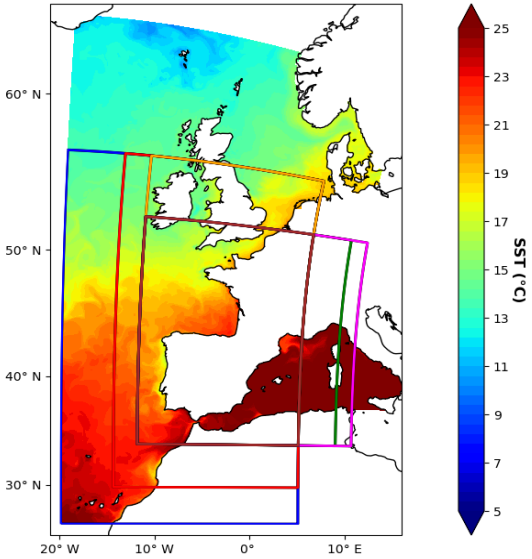
- **Supplementary information :**
  - $Cost_{interp\ \&\ updates}$ is an estimation from previous AGRIF zooms -> needs to be estimated over the future zooms in eNEATL36
  - A smaller zoom (over bay of Biscay) will be used first to set up a first AGRIF configuration over eNEATL36

AGRIF ZOOM : Area definition and cost estimations

eNEATL36 : 1894 * 1294 points; (= 2450836 points)

- *~15h on 3800 processors (for 1 year and 3 month simulation)*
- *2.8 To storage (standard outputs for 1year 3 months)*

Zoom proposals



	Npoints (zoom)	Computational cost (* eNEATL36 cost)	Standard outputs* (Zoom + eNEATL36) (To)	Standard + 3D hourly outputs (Zoom + eNEATL36) (To)
ALL IBI (1/108°)	22057524	27	25.2	262.8 (17.1 To/month)
IBI service (full)	11745000	16.8	16.2	140 (9.1 To/month)
Atlantic French coasts and Ireland	8190000	12	12.2	98 (6.3 To/month)
Atlantic French coasts and Ireland (reduced)	6176250	9.3	9.9	74 (4.8 To/month)
All french coasts (exept corsica)	6075000	9.2	9.7	72 (4.7 To/month)
All french coasts (with corsica)	6561000	9.8	10.3	78 (5 To/month)
Atlantic French coasts + IMEDEA	4941000	7.7	8.4	59 (3.8 To/month)

** Standard output = 2D hourly fields + 3D daily fields*

4) Overall summary and work plan

Overall summary and work plan

- **Evaluate the improvements of NEMO4.2**
  - Scalability tests : Comparison between 4.0-HEAD and 4.2-RC ✓
    -> Improvements in 4.2
  - Comparison between two long runs in 4.0-HEAD and 4.2-RC with the same physical characteristics
    -> No significative changes between 4.0 and 4.2 for T, S, U & V.
  - Contribution of new parameterisations ?
    -> to be done

- **New bathymetry**
  - Comparison between the new and old bathymetry
    -> No significative changes between OLD and NEW for T, S, U & V.
  - Next step : comparison new 4.2 physics + new bathymetry vs new 4.2 physics + old bathymetry
    -> to be done

- **AGRIF zoom**
  - Cost estimation ✓
  - Choosing the area of the zoom *To be done*
  - First AGRIF runs *To be done*

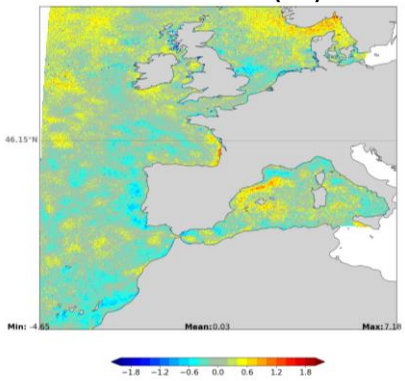
Additionnal slides

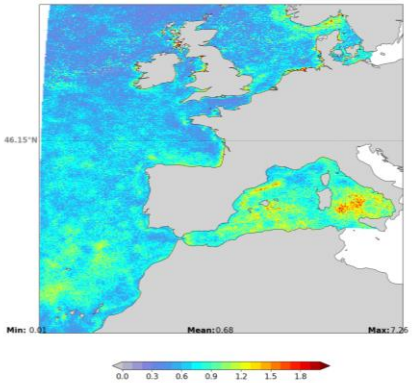
Comparing NEMO pre and post IMMERSE versions

Innovation (°C)

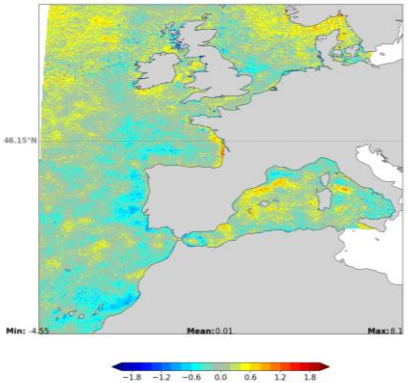
Forecast error (°C)

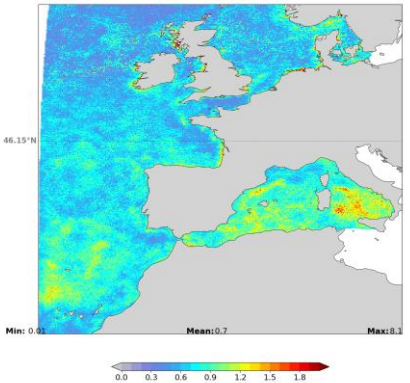
4.2-RC





4.0-HEAD





- **Validation with NOOBS (observation operator)**
- ODYSSEA SST
- Innovation = OBS – MODEL
- Forecast error = abs(Innovation)

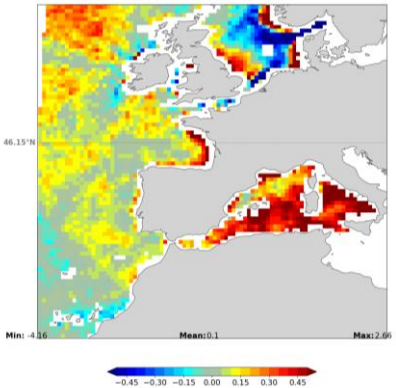
Comparing NEMO pre and post IMMERSE versions

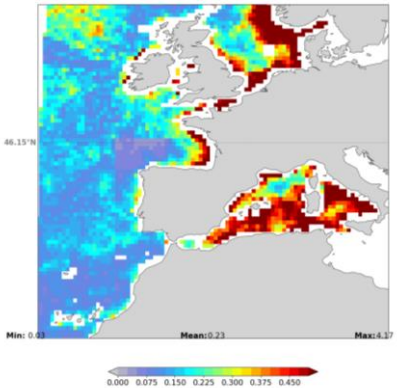
Salinity

Innovation (psu)

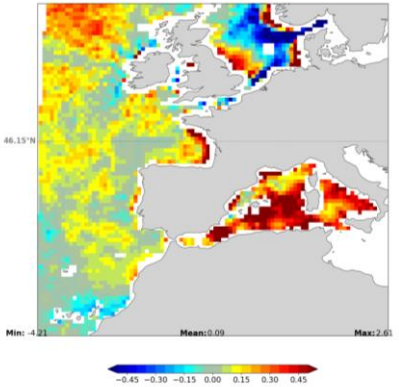
Forecast error (psu)

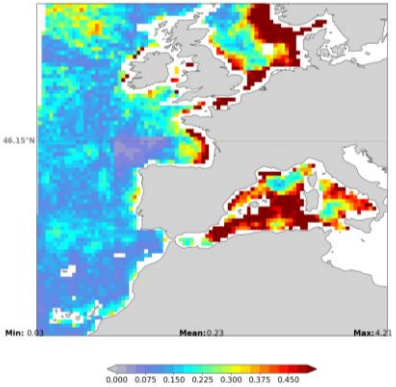
4.2-RC

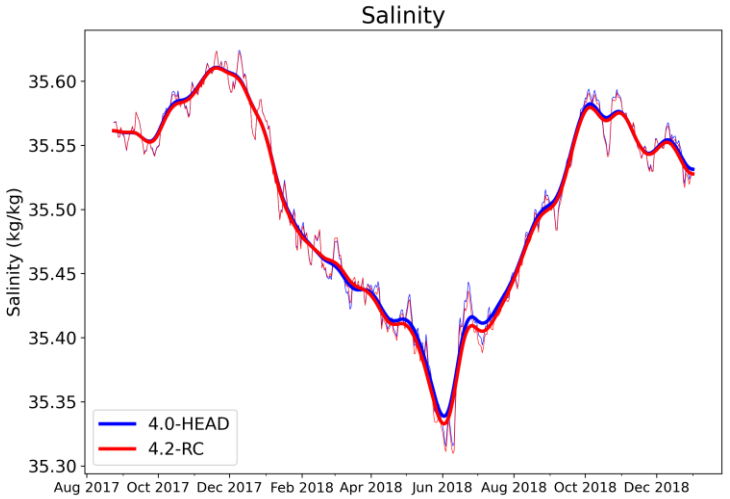




4.0-HEAD

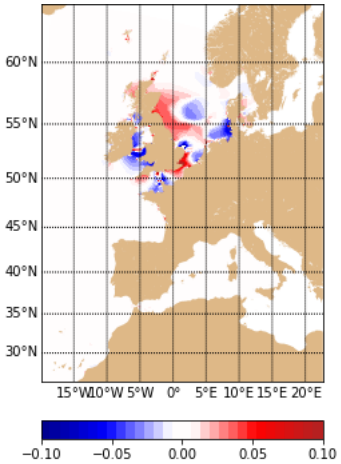




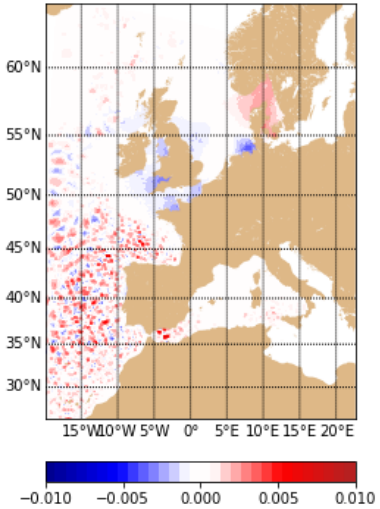


- Validation with NOOBS (observation operator)
- ESACCI SSS
- Stronger differences near coastlines

OLD - NEW



4.2-RC – 4.0-HEAD

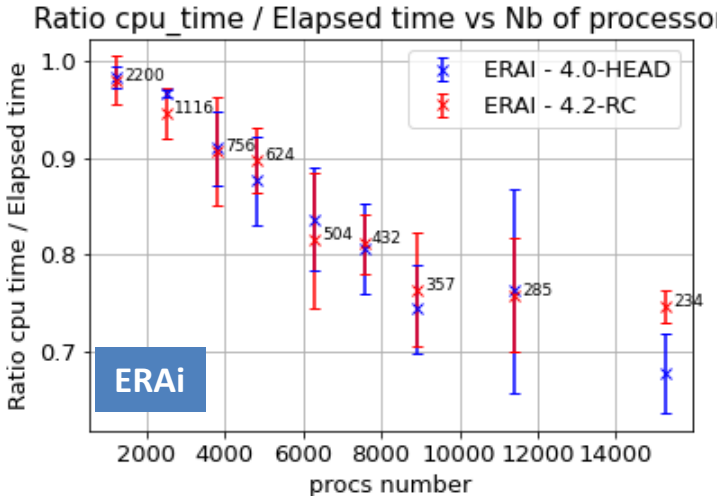


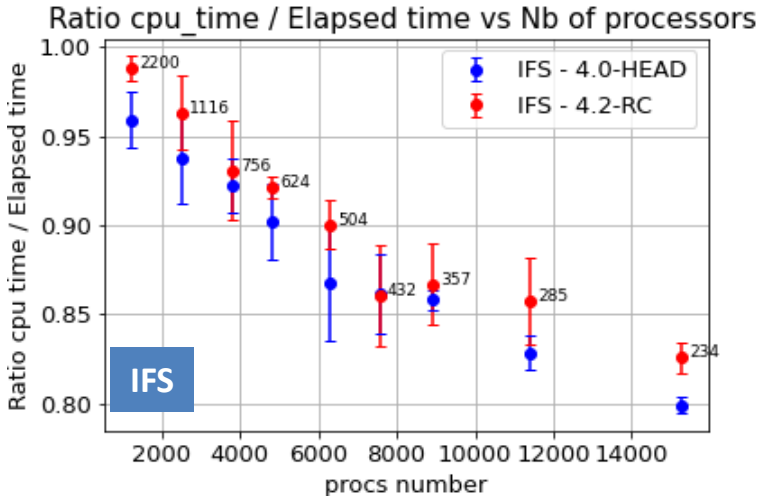
Comparison of NEMO pre and post IMMERSE versions

Step 1 : No removal of earth processors (i.e : force Nprocs = jpni * jpnj)

Experimental setup :

- **NEMO 4.0-HEAD & NEMO 4.2-RC**
- **5 runs of 7 days per procs number**
- Tests with ERAI (3h) and IFS (1h)
- No outputs, linear SSH

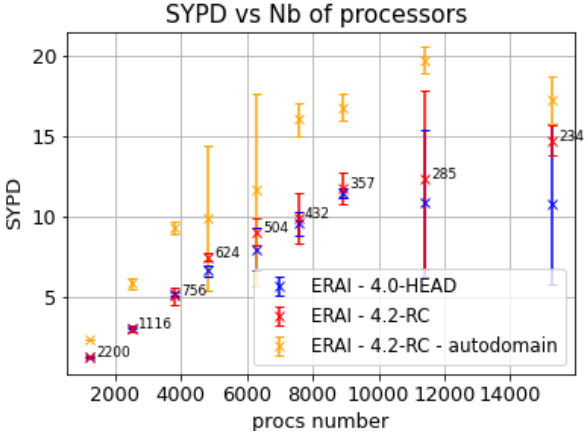


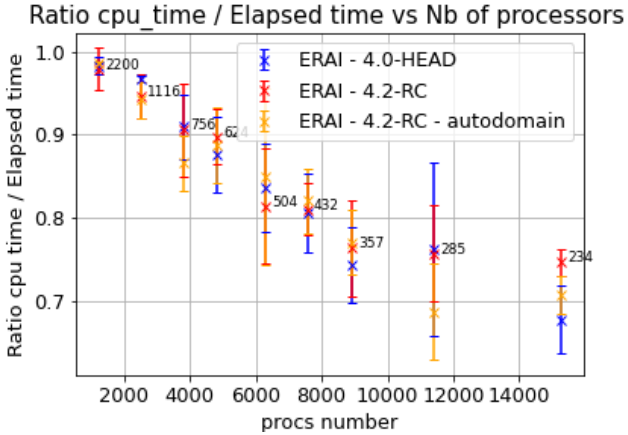


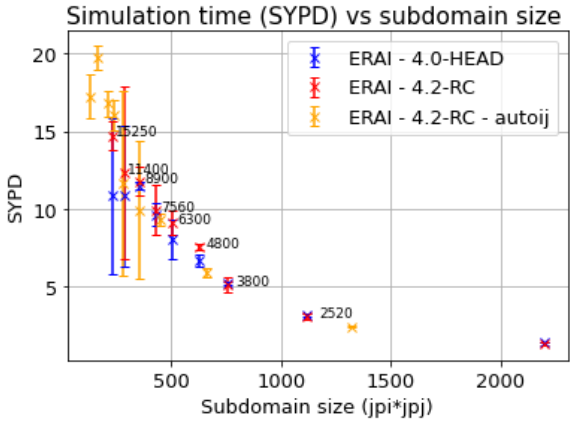
- Less waste of CPU with 4.2-RC with IFS

Comparing NEMO pre and post IMMERSE versions

Step 2 : NEMO determines the subdomain size (jpni & jpnj =0)







- **In orange** : NEMO (4.2-RC) select the best domain decomposition (for a given proc number)
- Note that NEMO 4.0-HEAD does not work with jpni=jpnj=0 when Nprocs>~2500 procs
- When NEMO automatically choose the domain decomposition :
  - Improvement of SYPD
  - No significant changes in ratio cpu / elapsed time