Contact : theo.brivoal.gmail.com / theo.brivoal@meteo.fr

# *A kilometric scale nested configuration over the Iberian - Biscay - Ireland area: assessment and impact on ocean dynamics*

Demonstrating impact on CMEMS systems

**Théo Brivoal, Jérome Chanut, Emmanuella Clementi, Michele Giurato, Romain Bourdallé-Badie**

**Mercator Océan / CMCC**

# Introduction

**How ocean models can benefit from an increase of the resolution?**

- Currently, the highest resolution of Mercator configurations is 1/36° (2-3km) (e.g : IBI36)

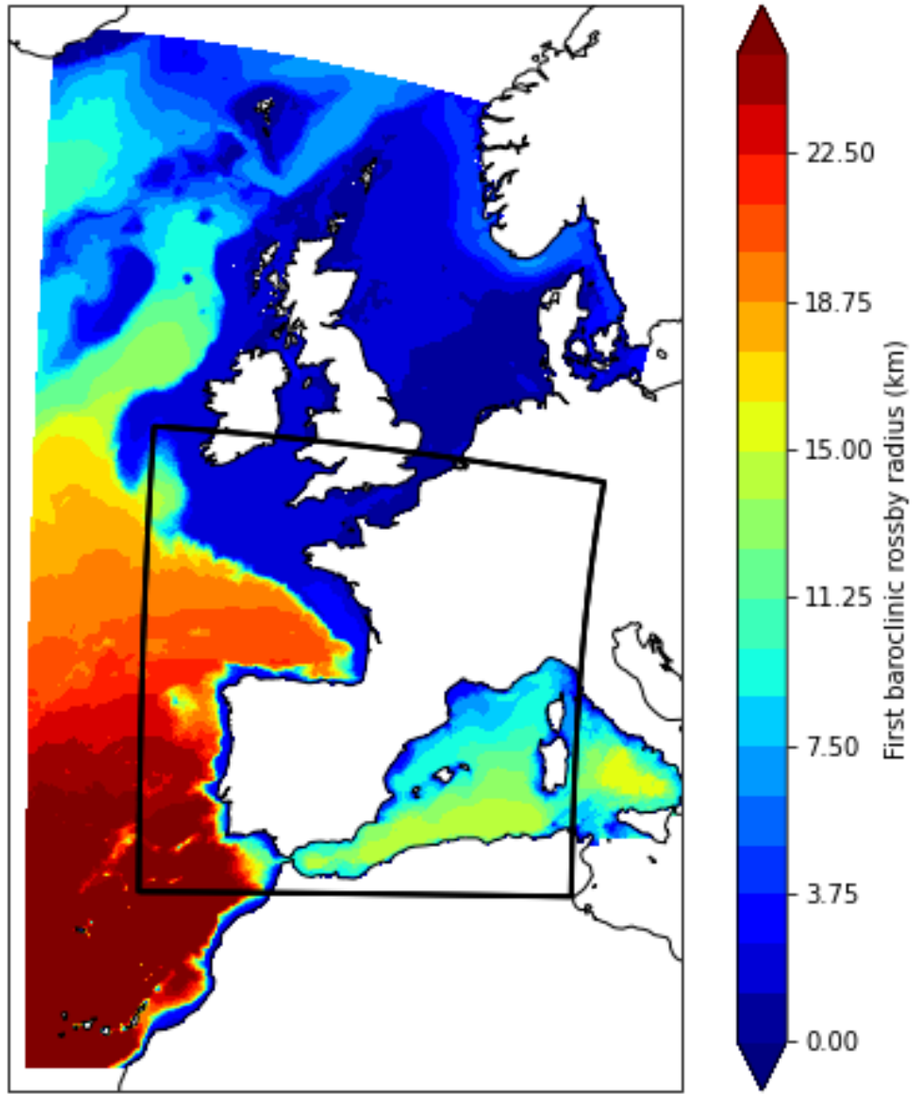
- 1st baroclinic Rossby radius ≃ scale of mesoscale eddies

- Mediterranean sea : mesoscale structures are poorly resolved at a 1/36° (only 2 to 3 points per eddy)

- Continental shelf: eddies are not resolved

- Also:
  - Resolving higher baroclinic modes = better representation of internal wave-driven mixing processes

  - Better representation of geometric constraints (e.g: Gibraltar)




***First baroclinic rossby radius on the eNEATL36 domain***
***Nest area is indicated in black***

# Configuration description

**Configuration : eNEATL36 + BIzoo (Biscay zoom) ("IBI prototype like")**

- **NEMO 4.2 (post-IMMERSE)**

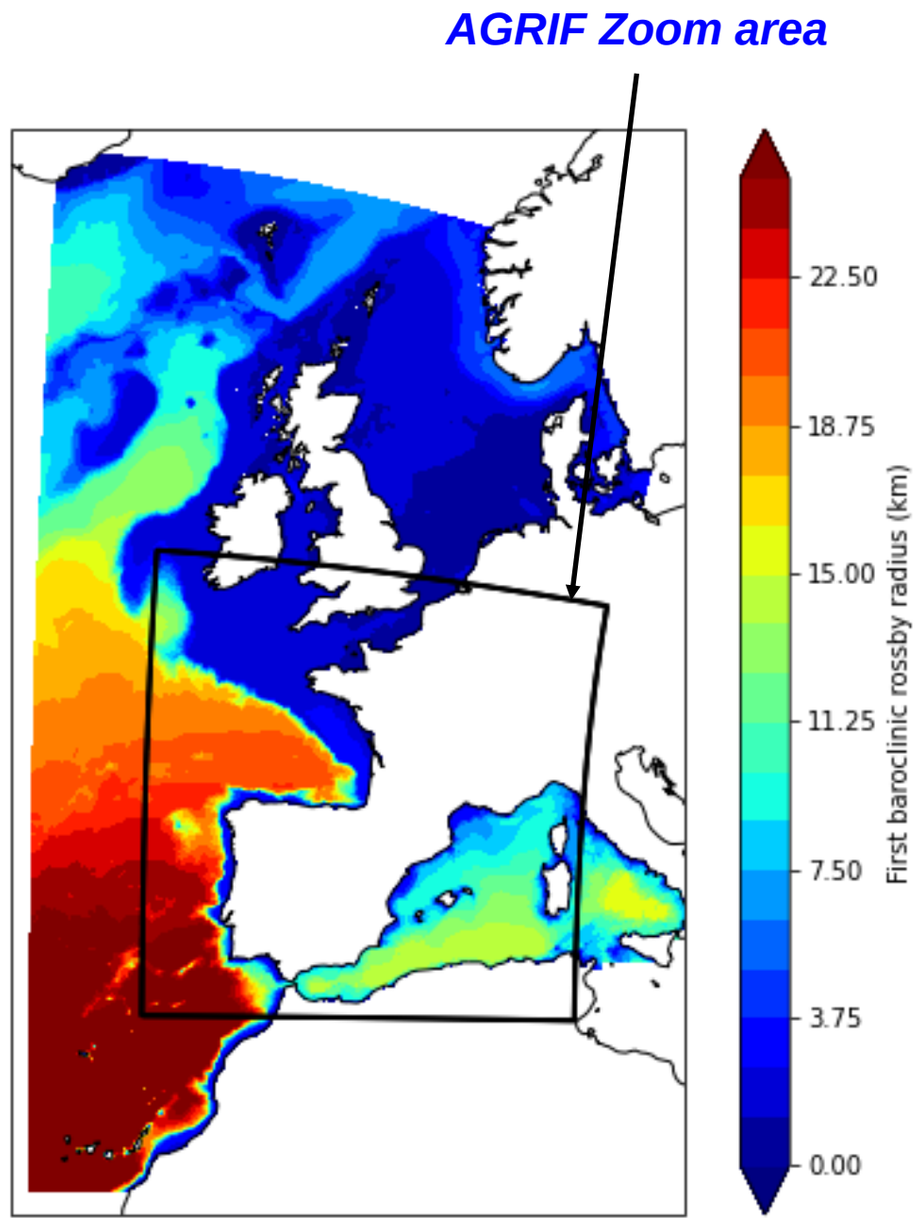
- **Parent configuration : eNEATL36**
  - 1/36° resolution (~2-3km)
  - 150s time step

- **High resolution nest (BIzoo) :**
  - based on AGRIF code
  - 1/108° resolution (~1km)
  - 50s time-step

- **Two-way nesting between the parent and the child configuration**

- **Forcing :**
  - Atmospheric : IFS
  - Initial & lateral boundary condition : 1/12° CMEMS operational product (PSY4V3R1)
  - Tides : FES2014

- **Bathymetry :** Emodnet 2018

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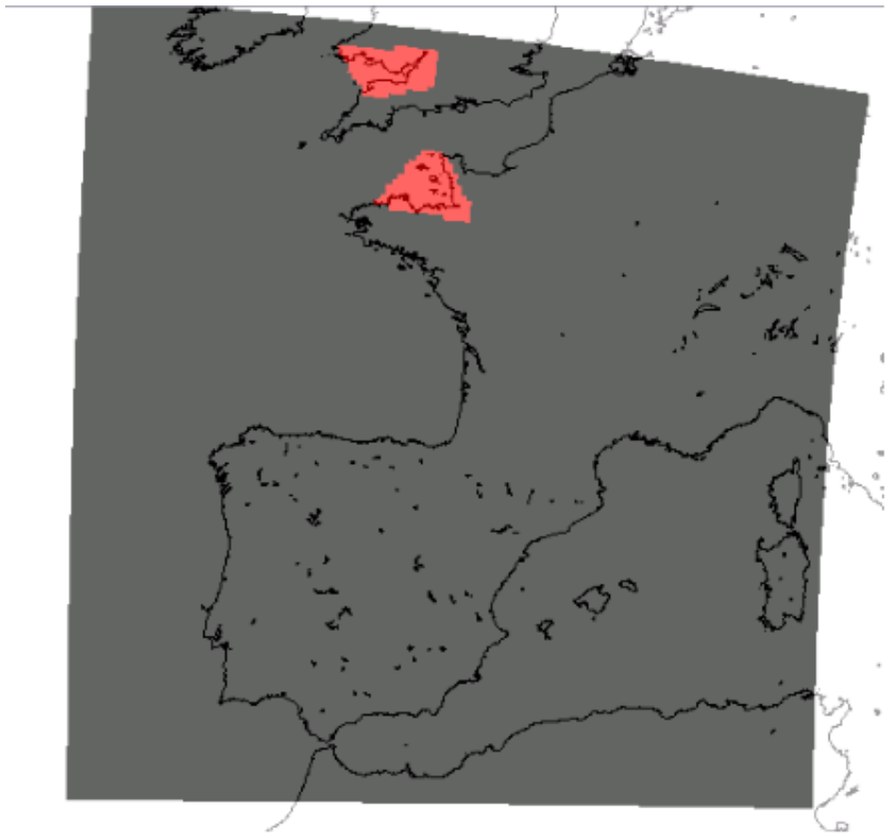
# Simulation design

- **Objectives:**
  - present a validation of the configuration from a dynamic point of view (SSH, tides, currents).
  - Impact of the nest on the ocean dynamics

- **2 simulations from Jan 2017 to July 2018**

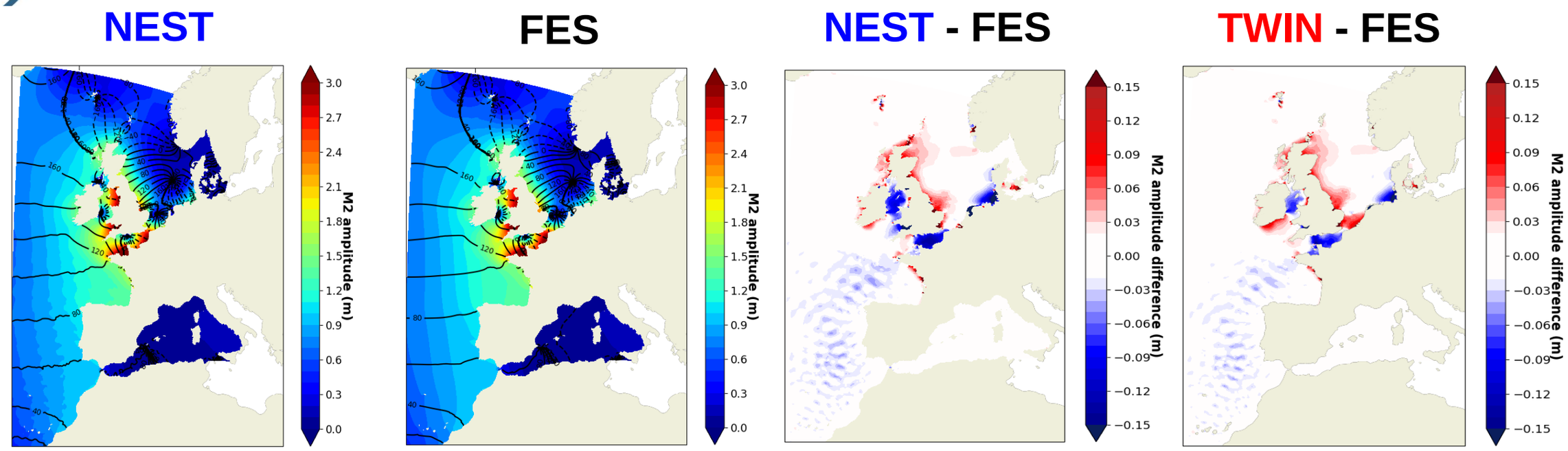
- **NEST** :
– 2 way AGRIF zoom
– drag Boost (Cd X2) in the bay of Mt saint Michel, and in the bay of bristol

- **TWIN** : Same simulation as NEST, but with no zoom ( = eNEATL36 simulation) :



***Areas (in red) where a X2 Cd boost is applied***

# Macroscopic validation



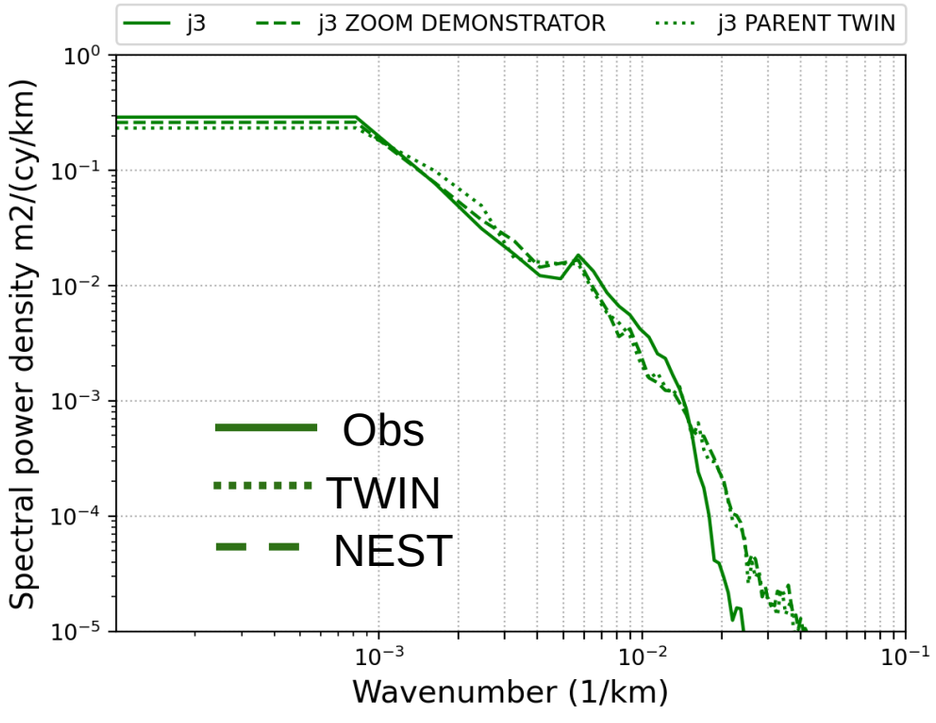

***M2 amplitude, comparison with FES2014***

## ➢ Tides : validation with FES2014 (Lyard et al 2021)

- NEST : Good agreement with FES (differences < 15cm)
- Underestimation in NEST, overestimation in TWIN = bathymetry change
- **Two-way nesting : Continuous tidal solution across the nest boundaries**

## ➢ SLA along satellite tracks (Jason 3)

- SLA data unfiltered from tides
- Good agreement with satellite SLA for scales > 100km (=satellite effective resolution)
- Small scales filtered by on-track interpolations

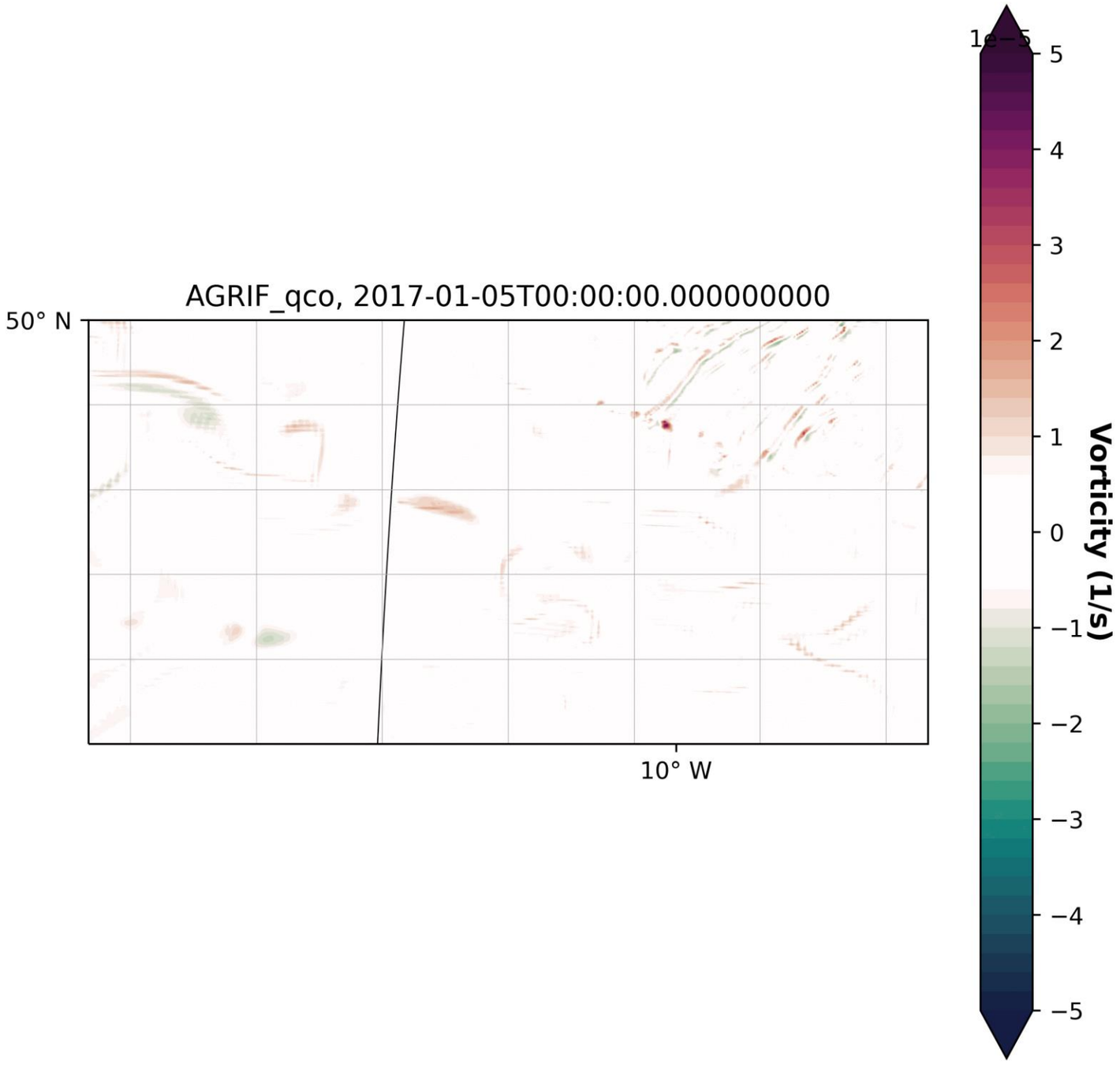



***SLA spectrums over the zoom area***

# Two-way nesting

**Nest boundaries**

- We need to check if the structures are consistent inside and outside the nest
- Vorticity structures crossing the nest boundary
- Vorticity structures are consistent inside and outside the AGRIF domain
- Balanced motions are transmitted through the nest boundaries

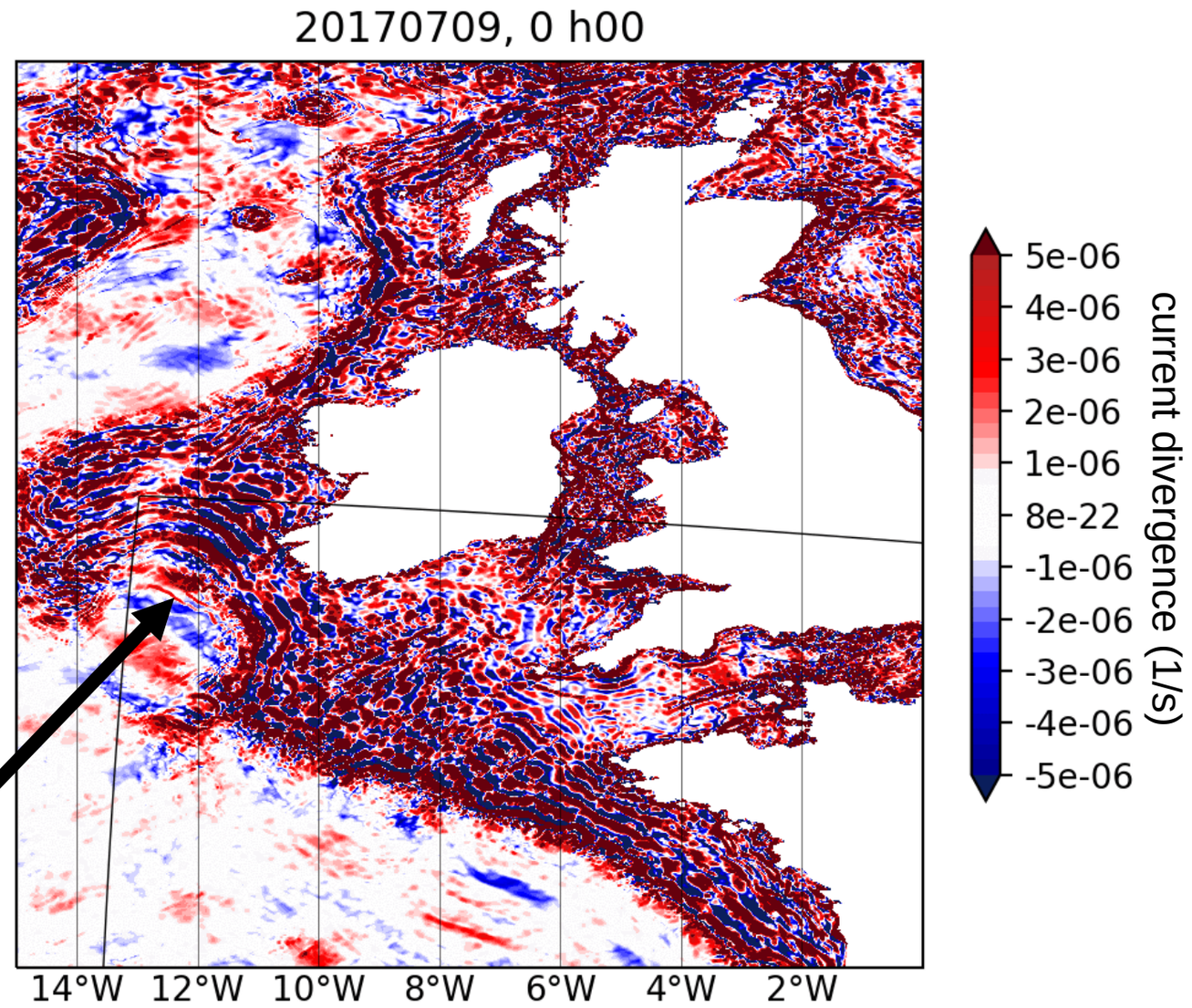


# Two-way nesting

## Internal waves (ITW) crossing the nest boundaries

- A well known issue in nested configurations :
  - ITW information should be transmitted across the nest boundaries
  - ITW should not be reflected by the boundaries

**ITWs propagate on the shelf and across the nest boundaries**

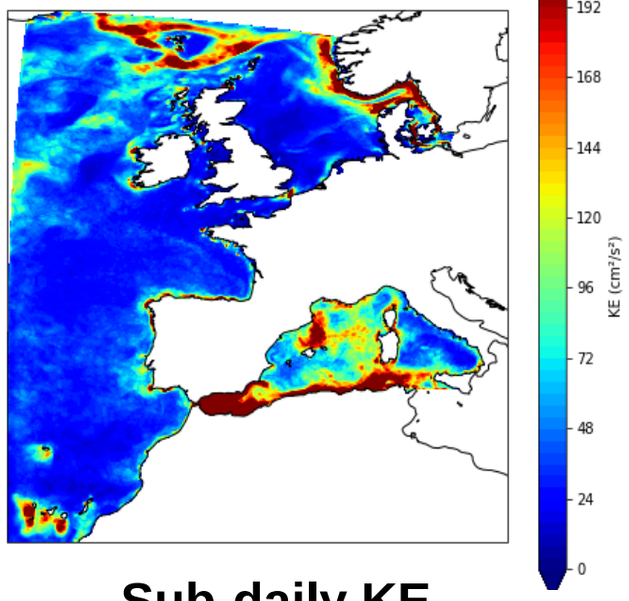



***1st baroclinic mode current divergence (1/s)***

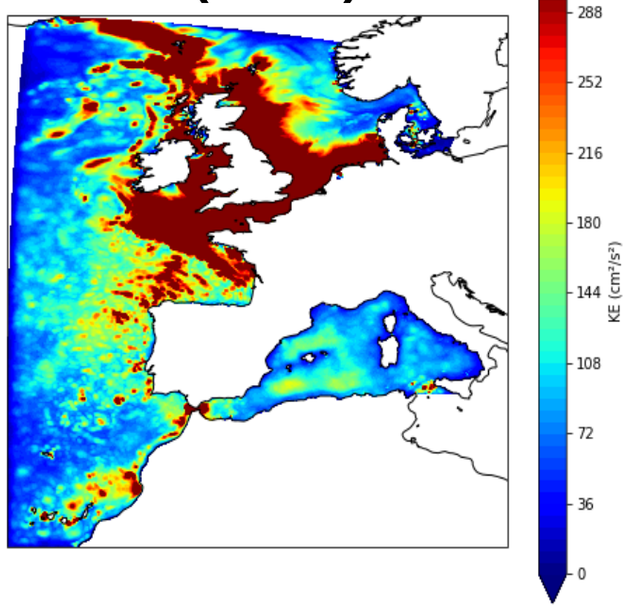
**Two way nesting enables internal wave information & balanced motions to be transmitted across the nest boundaries**

# Resolution impact on kinetic energy temporal scales

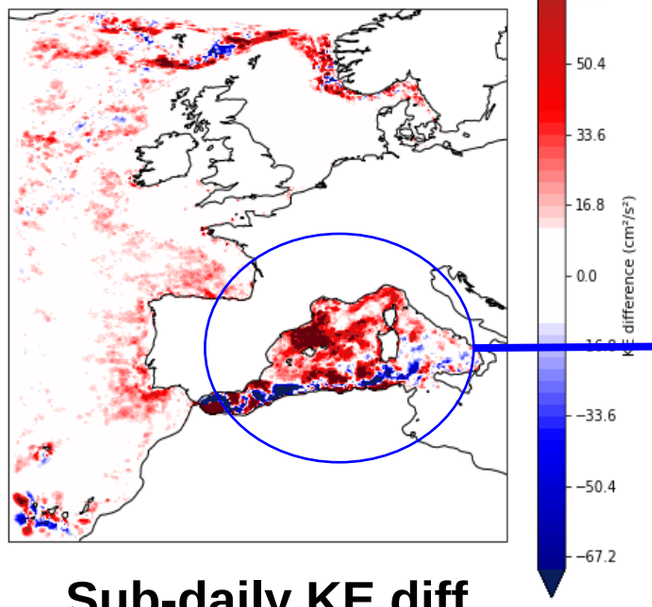
**1 day -> 1 month KE (NEST)**




**Sub-daily KE (NEST)**




**1 day -> 1 month KE diff (NEST - TWIN)**

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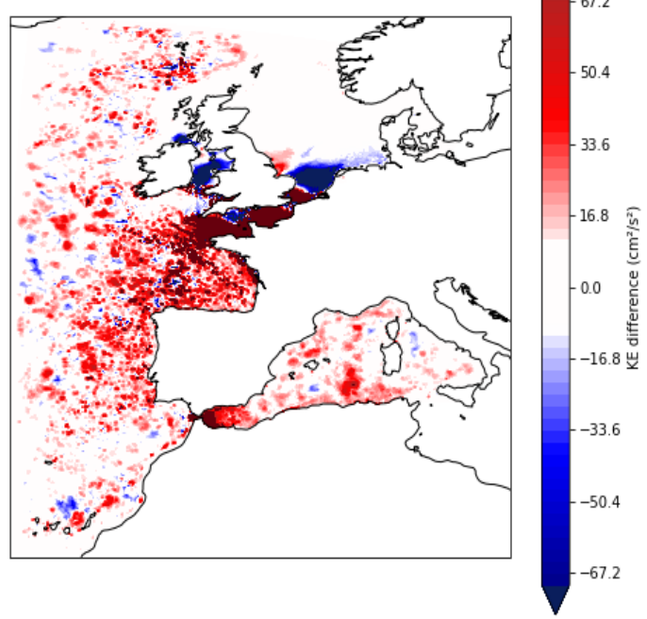


Small Rossby radius: better resolved mesoscale structures in NEST

***KE (left) and KE differences (right, NEST – TWIN) averaged over 2017.***

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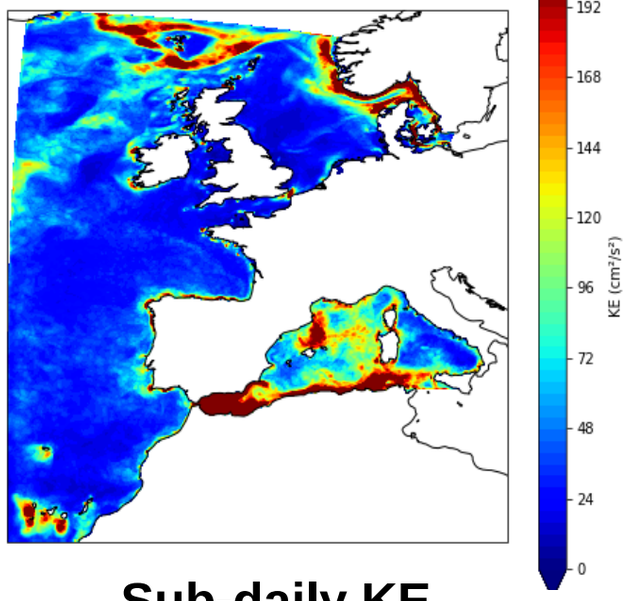


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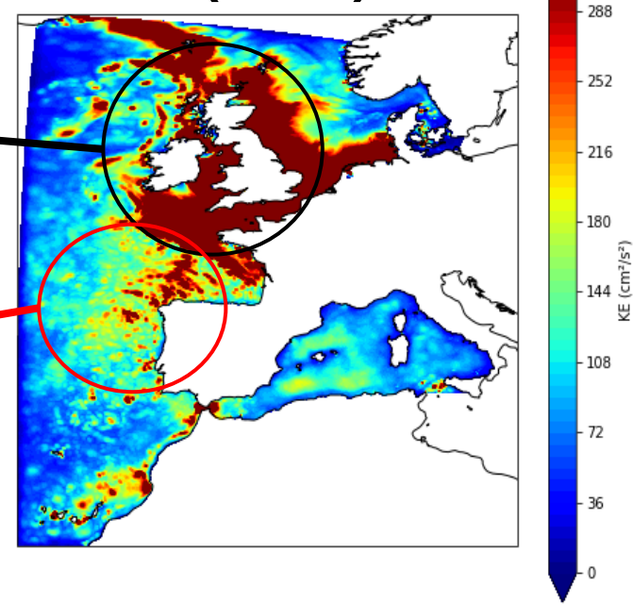
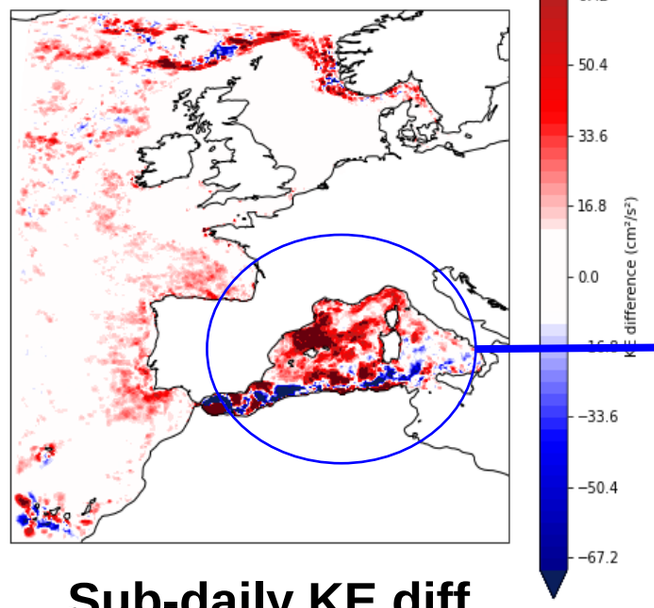



Strong tides on the shelf

Internal waves & balanced motions

**1 day -> 1 month KE diff (NEST - TWIN)**

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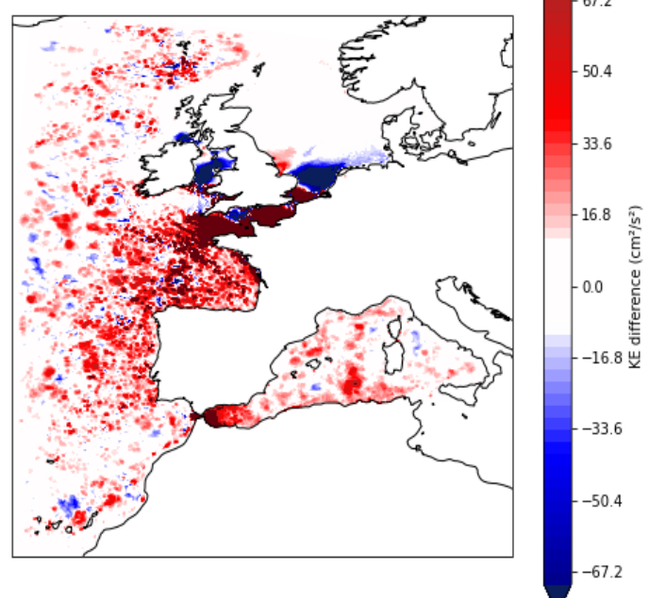


Small Rossby radius: better resolved mesoscale structures in NEST

***KE (left) and KE differences (right, NEST – TWIN) averaged over 2017.***

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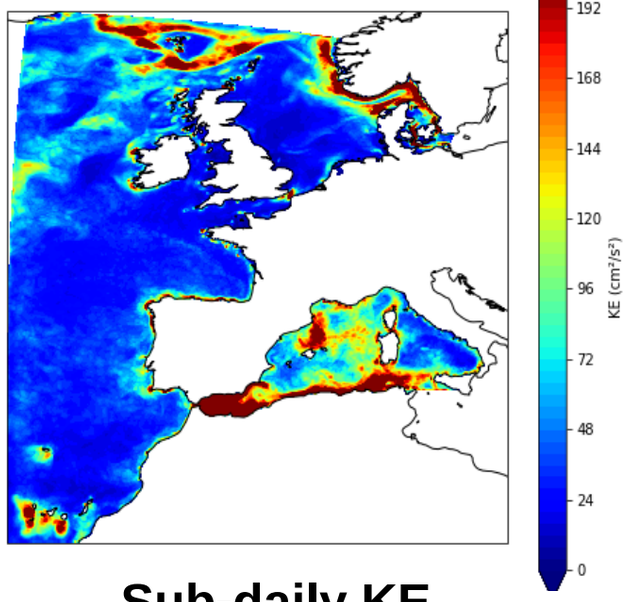


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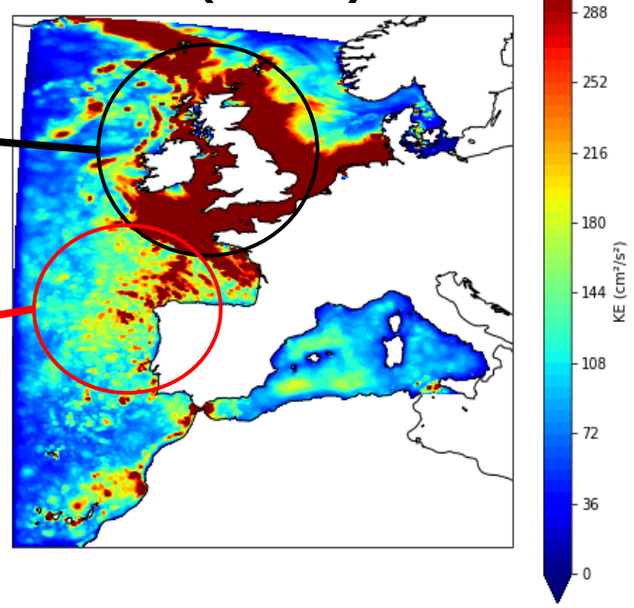


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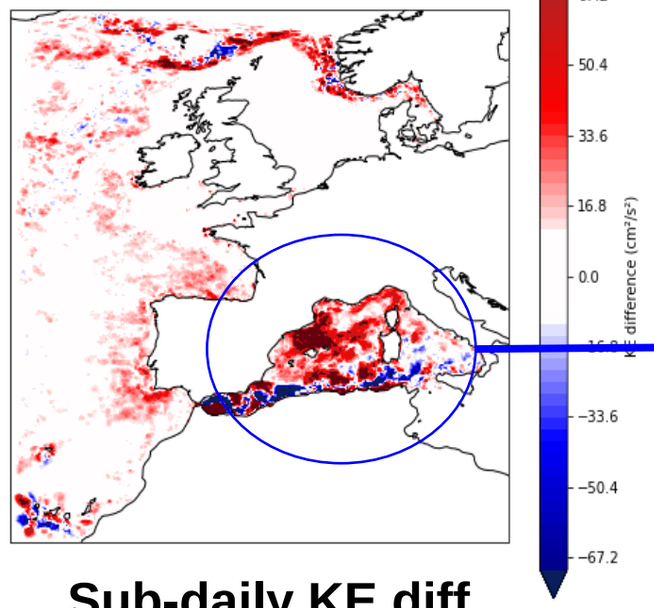


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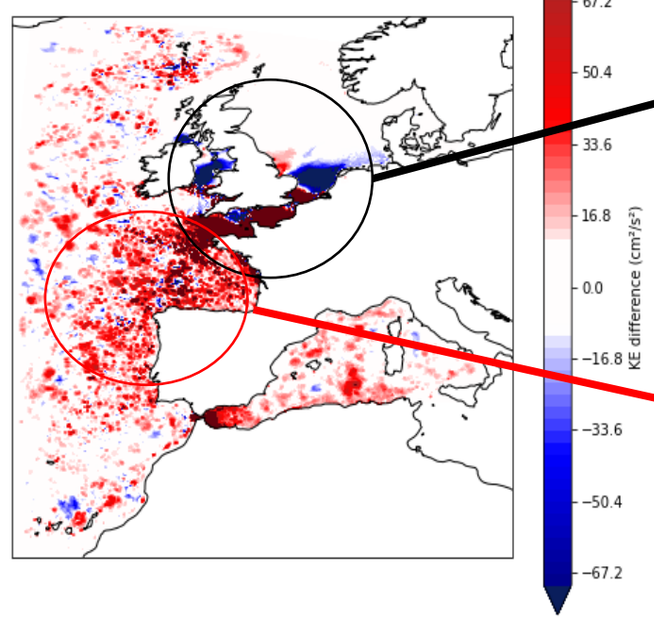


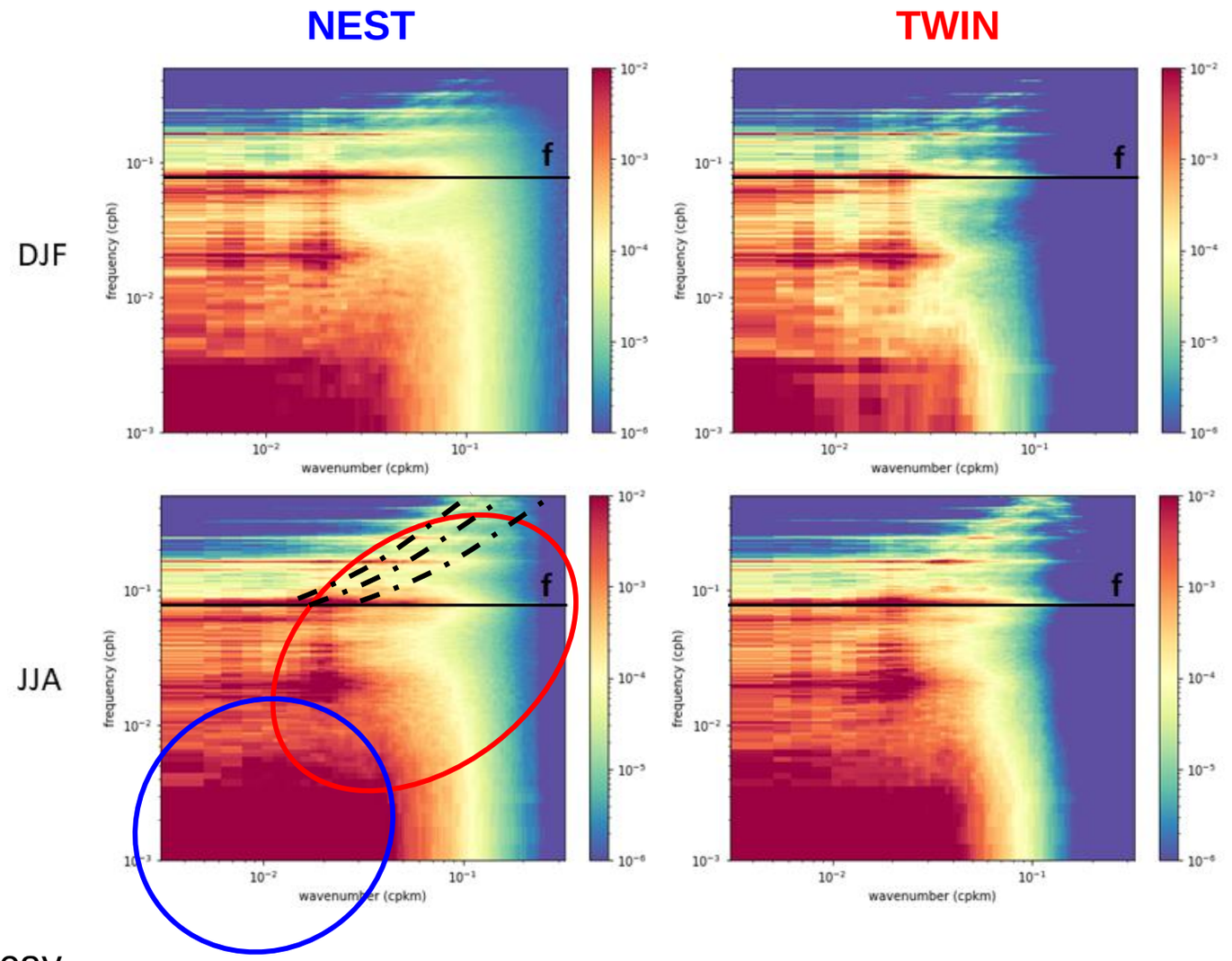

Difference in tidal amplitude (bathymetry change)

Increase of KE: Internal waves or meso/submesoscale motions ?

***KE (left) and KE differences (right, NEST – TWIN) averaged over 2017.***

# KE frequency-wavenumber analysis: Bay of Biscay

- Mesoscale motions
- Submesoscale motions
- Internal gravity waves




***Surface KE frequency-wavenumber spectra in the bay of Biscay for the DJF and JJA seasons***

- KE frequency-wavenumber spectrums in the Bay of Bicay
- Summer: stronger KE of IGW and submesoscale motions (enhanced stratification)
- **Increase of KE in NEST:**
  - Primarily due to more resolved submesoscale motions
  - Secondarily, to an increase of the KE of high baroclinic modes

# Conclusion & perspectives

**Conclusions :**

- Realistic oceanic solution for eNEATL36 + BIzoo

- Two-way nesting:
  - enables a continuous model solution across the nest boundaries
  - allow internal wave information and balanced motions to be transmitted across the nest boundaries

- Impact of the kilometric nest:
  - Increase the KE of submesoscale motions and high baroclinic modes in the Bay of Biscay
  - Increase the KE of mesoscale and submesoscale motions in the Mediterranean sea

**eNEAT36-BIZoo in the context of CMEMS:**

- Improvment of fine scales representation
- available pour IBI-MFC
- multi-grid assim under development at MOI ;
- Brexit consequence : change zoom position to include NWS (under test)

**Additionnal comments :**

- Configuration files and tutorials to reproduce the configuration are available on the IMMERSE github : https://github.com/immerse-project/eNEATL36-AGRIF_Demonstator

- The data is available on demand

# Thank you for your attention !