Overview of HYCOM activities at SHOM

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French operational system that provides open ocean forecast

Development of regional and coastal models

Range : from research to operational systems

Purpose : to have a forecast system that provides oceanographic data for both civil and military uses

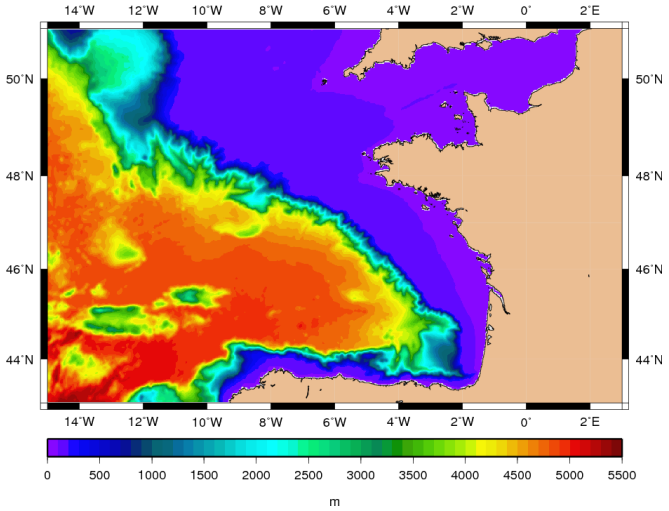
Outline

1- Areas of interest

2- HYCOM developments

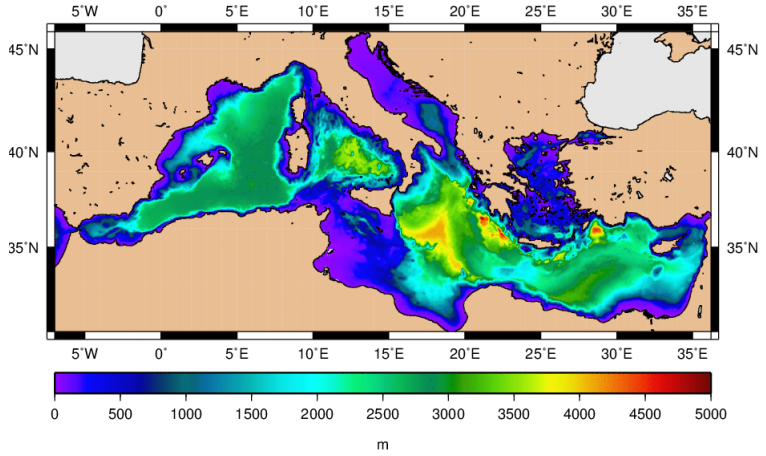
3- Operational systems

Bay of Biscay model
1’, 40 layers



- ✓ Thermal fronts,
- ✓ Surges,
- ✓ Tide and internal tide,
- ✓ Solitons,
- ✓ Eddies dynamics,
- ✓ Slope currents,
- ✓ River plumes, …

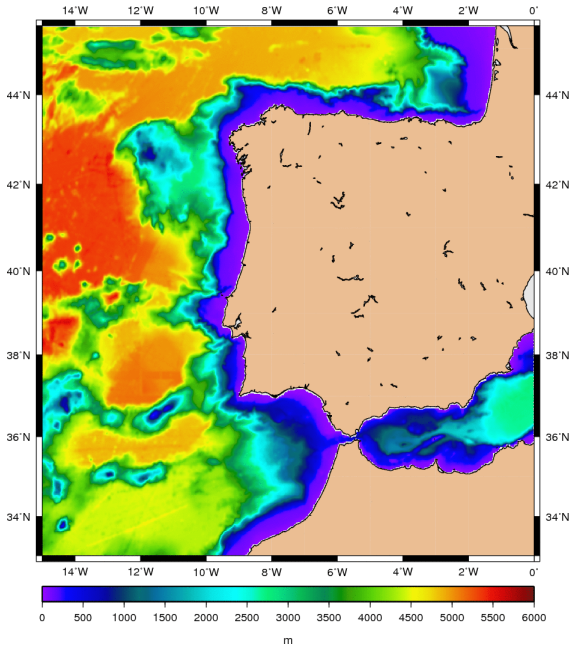
Mediterranean model
1’, 32 layers



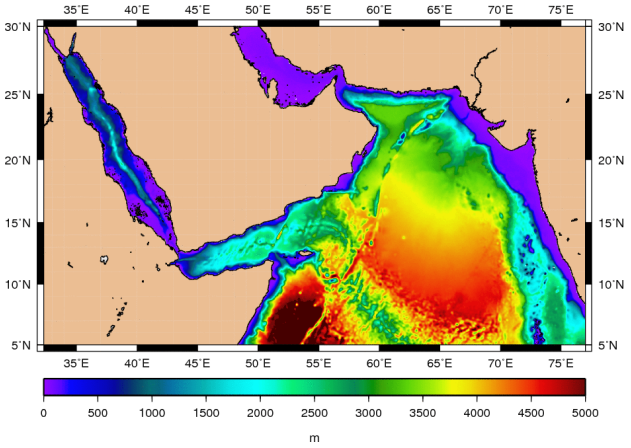
- ✓ Mediterranean Northern Current,
- ✓ Surges,
- ✓ Deep convection,
- ✓ Eddies dynamics,
- ✓ River plumes …

1- Areas of interest

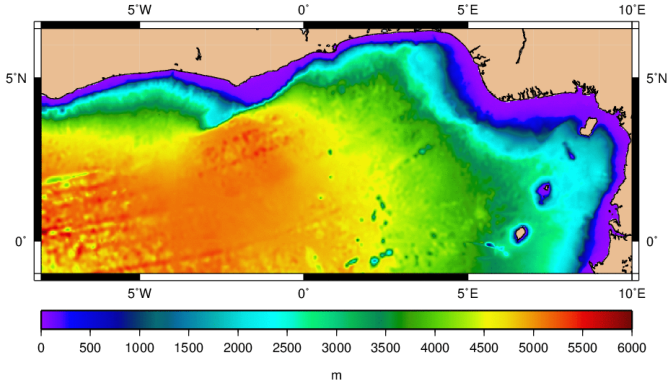
Iberian model 1', 32 layers	Northwestern Indian model 1/20°, 40 layers	Gulf of Guinea model Academic configuration



- ✓ Thermal fronts,
- ✓ Tide and internal tide,
- ✓ Solitons
- ✓ Density current,
- ✓ …

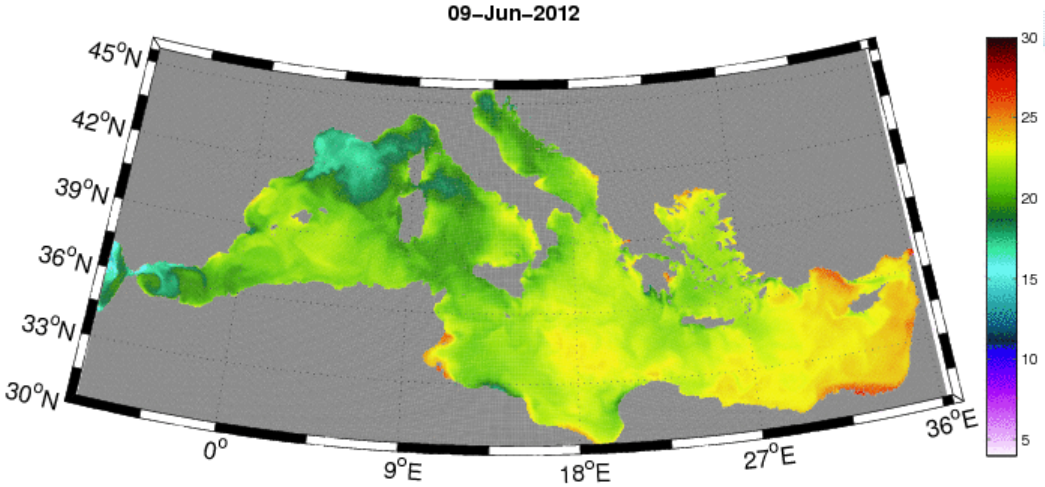


- ✓ Density currents,
- ✓ Eddies dynamics,
- ✓ …

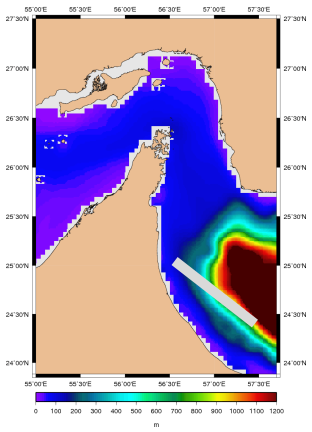


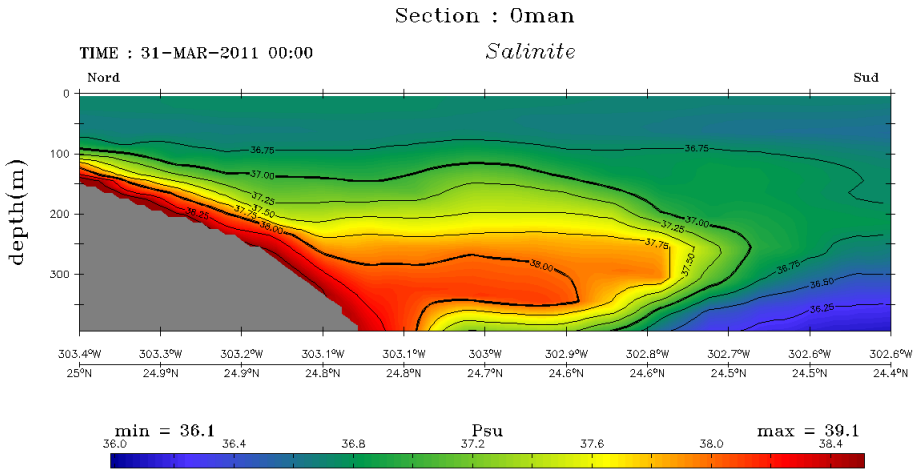
- ✓ River plumes,
- ✓ Tide and internal tide,
- ✓ Solitons
- ✓ …

Mediterranean model
SST



Indian model
Salinity vertical distribution





Mesh refinement

Applications : coastal modeling (surges,…)

3 approaches :

- ✓ HYCOM-AGRIF
  - nested grids,
  - the software AGRIF is included in HYCOM,
  - a single executable code

- ✓ Curvilinear grid

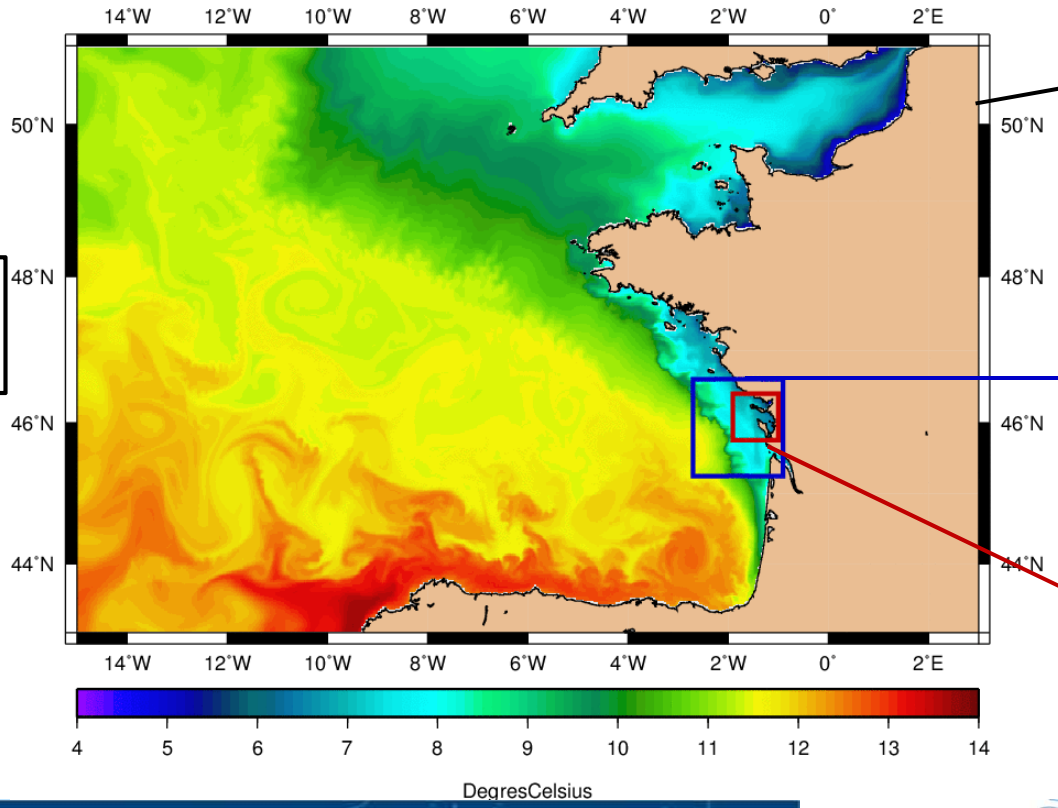
- ✓ Using the coupler Oasis (also used for wave coupling)
  - nested grids,
  - the Oasis coupler is outside HYCOM,
  - as many executable codes as grids

Mesh refinement

HYCOM-AGRIF

AGRIF
Adaptive Grid Refinement In Fortran
Free software governed by the CeCILL license
Contact : Laurent Debreu, http://www-ljk.imag.fr/MOISE/AGRIF/

SST on Biscay area
Grid 0



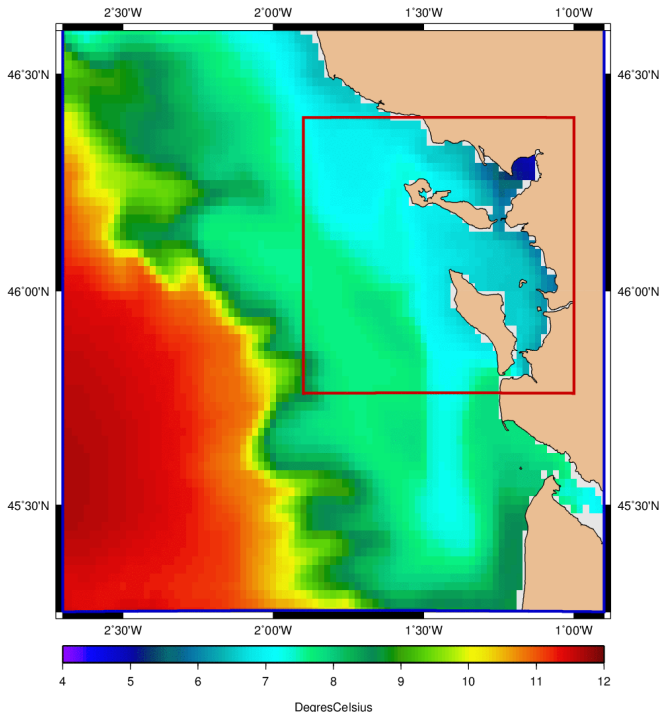
Biscay area
Grid 0 at 1800 m

Aquitain area
Grid 1 at 600 m

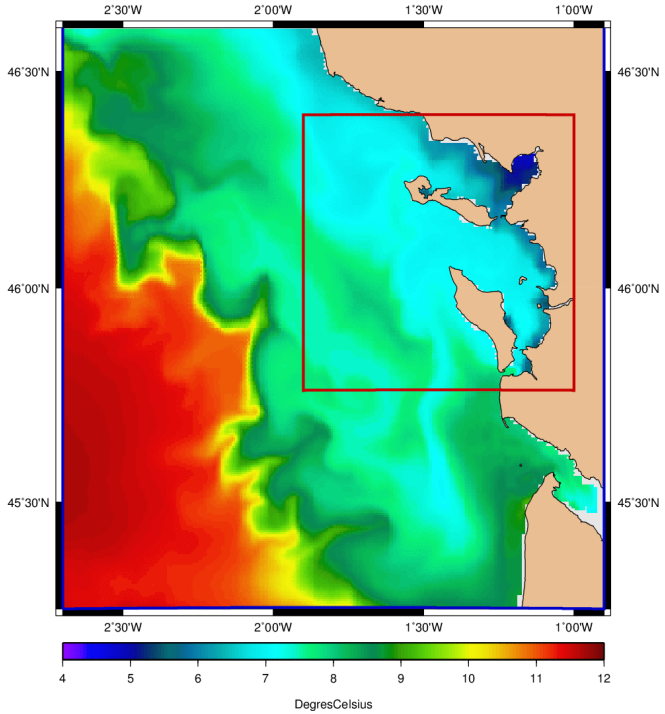
Xynthia area
Grid 2 at 200 m

Mesh refinement

HYCOM-AGRIF



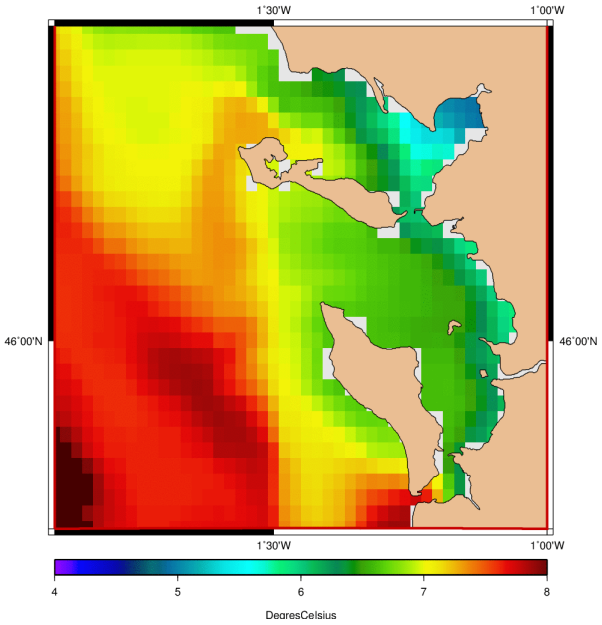
SST on Aquitain area
Grid 0



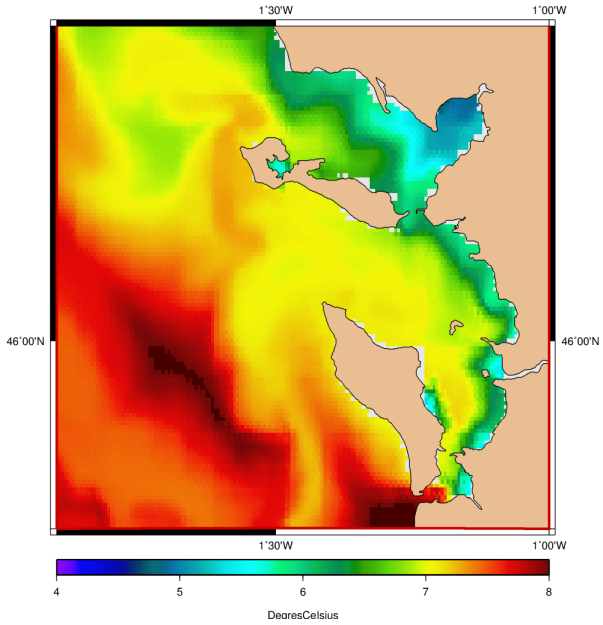
SST on Aquitain area
Grid 1

Mesh refinement

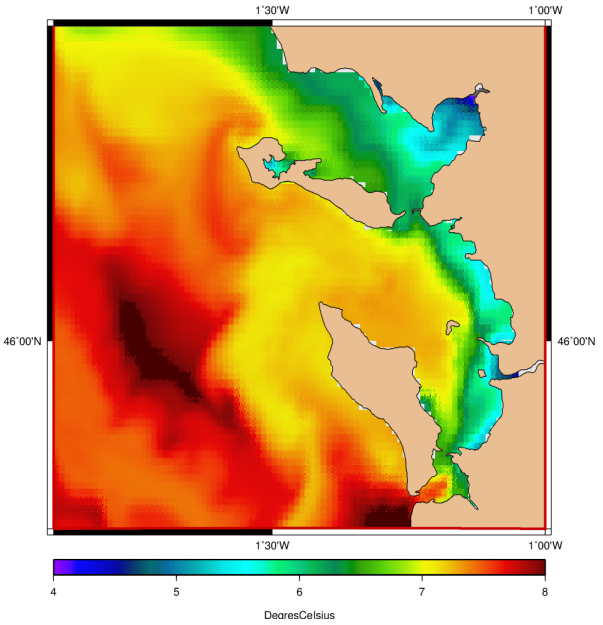
HYCOM-AGRIF



SST on Xynthia area
Grid 0



SST on Xynthia area
Grid 1



SST on Xynthia area
Grid 2

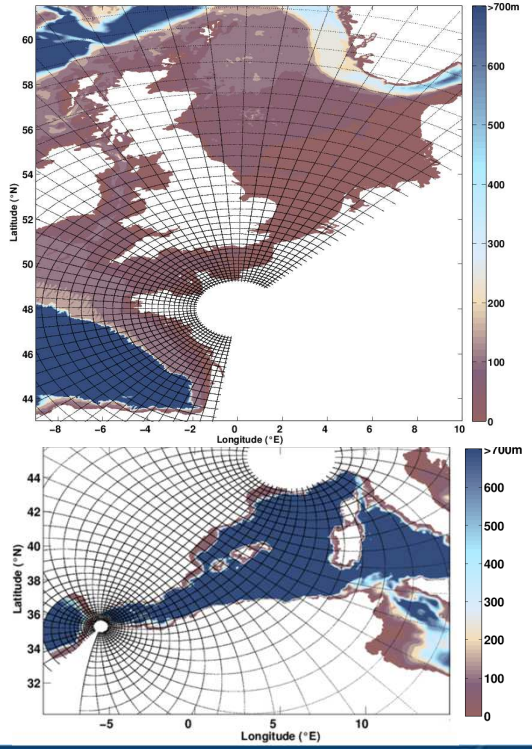
Mesh refinement

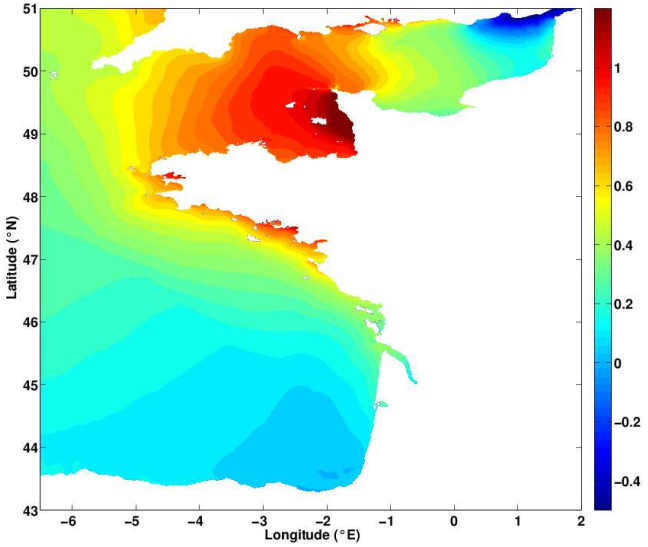
Curvilinear grid

Barotropic configurations for **Météo-France** operational surge forecast systems

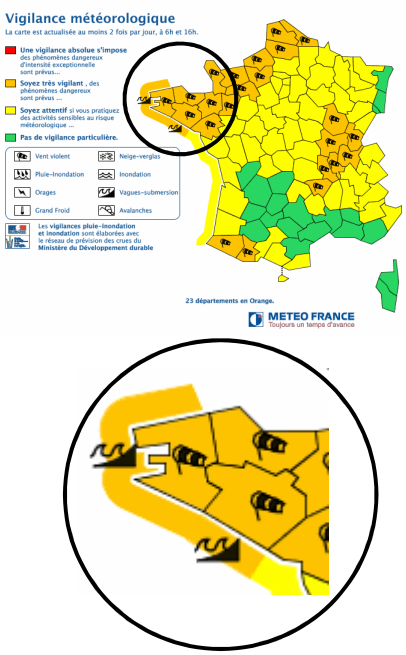
Northeast Atlantic grid from 400 m to 2 km

Mediterranean grid from 800 m to 5 km





Storm surge (m) on 12.24.2013, 01 UTC (Dirk Storm)



Météo-France weather warning map

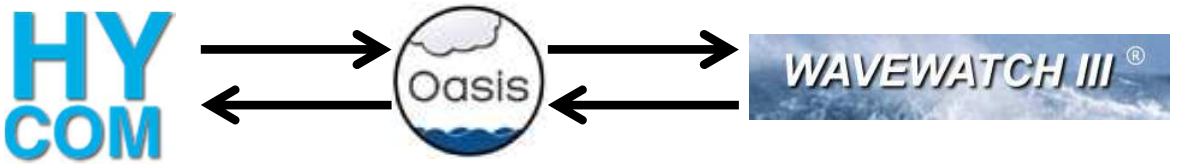
Wave coupling

Applications : coastal modeling (surges,…)

Additional terms due to wave effects in :

- Continuity equation with Stokes drift terms
- Barotropic equation with Stokes drift terms
- Momentum equation with Vortex force and wave induced non conservative forces (wave breaking,…)

Additional terms calculated in a separate module and activated with a CPP key



Coupling between HYCOM and WW3 is done via the Oasis coupler

Wave coupling

Oasis coupler

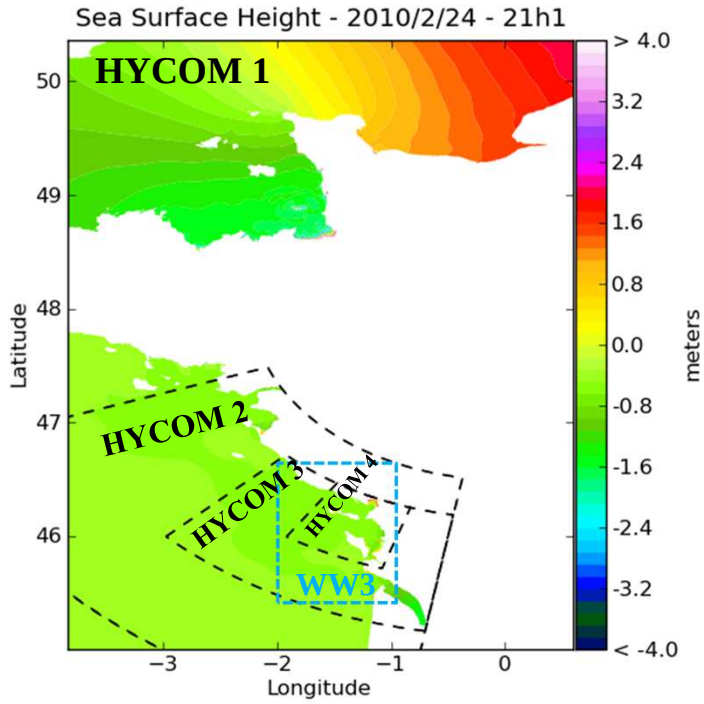
- ✓ Oasis facilitates the use of MCT (Model Coupling Toolkit from Argonne National Lab)
- ✓ Oasis is an open source under LGPL license
- ✓ In HYCOM, the main Oasis directives are computed in a separate module defining the initilization step, the grid and partition and the coupling variables
    - the exchange directives are non intrusive (oasis_put in hycom.F and oasis_get in forfun.F)
    - all coupling parameters are defined externally in a text file (oasis_info.input)
- ✓ Contacts: Sophie Valcke, Laure Coquart, https://verc.enes.org/oasis

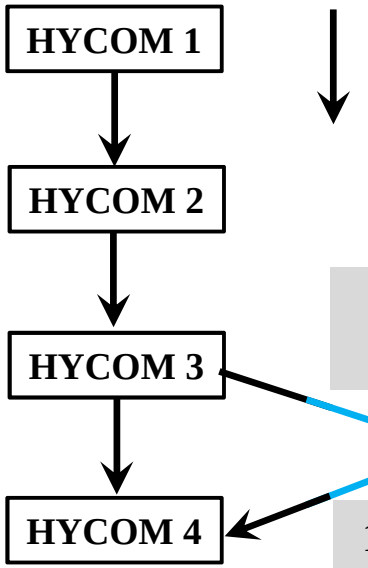
Wave coupling

Schematic coupling on the bay of Biscay with HYCOM and WW3 using Oasis3-mct

Objective : to improve Météo-France operational surge forecast system

Barotropic configuration with HYCOM curvilinear nested grids





1 way coupling at HYCOM's boundary
SSH and current

1 way coupling on WW3's whole domain
SSH, current, wetting and drying points mask

1 way coupling on HYCOM 4 's whole domain
Stokes drift, wave breaking, wave frequency and direction, wave significative height

Non-hydrostatic effects

Applications : internal tide and solitons

Methodology :

In each layer,

- z coordinate continuity equation is integrated from bottom layer to obtain w(z) in the layer
- z coordinate w equation is integrated from bottom layer to obtain P(z) in the layer
- P(z) is integrated over the whole layer to obtain P vertical average in the layer

⇩

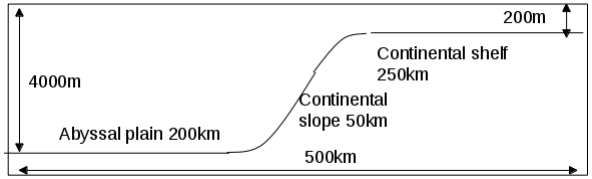
An addtional non hydrostatic pressure term is estimated and used in the horizontal momentum equations

Assumptions :

- Non-linear terms involving vertical velocity are neglected

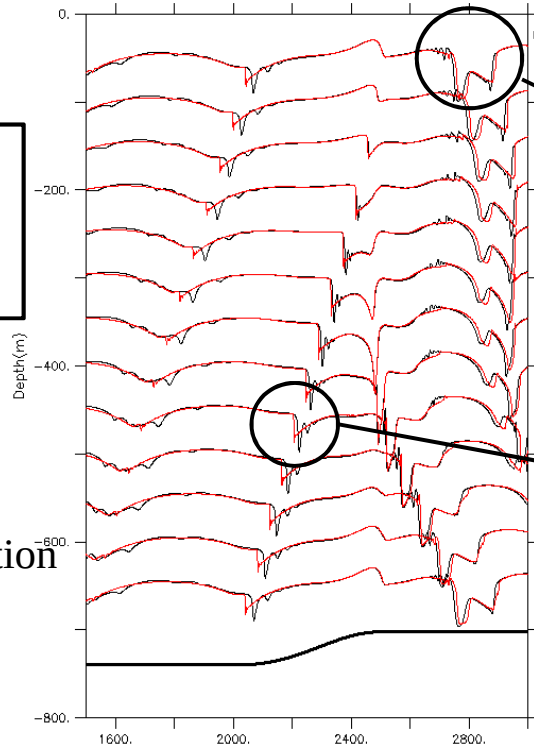
Non-hydrostatic effects

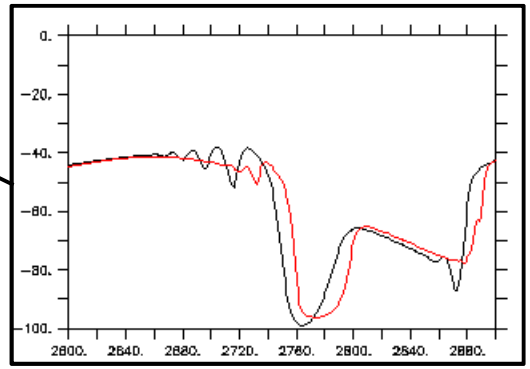
Academic study on a 2DV section in a 2 layer model



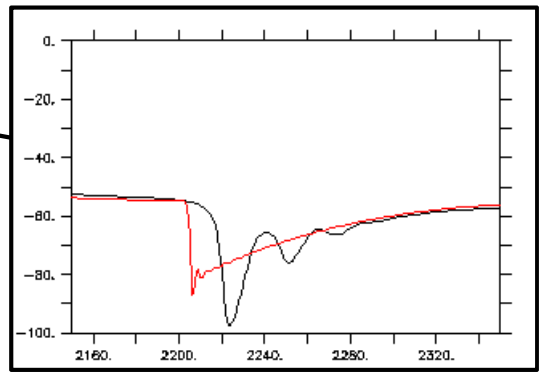
Forcing : M2 component
Initial conditions : ρ_1=1025.8 kg/m^3, ρ_2=1027 kg/m^3, H_1=50 m

Depth interface temporal evolution every tidal hour (gap : 50 m)





Continental shelf



Abyssal plain

Red : hydrostatic solution
Black : non-hydrostatic solution
Bold : topography

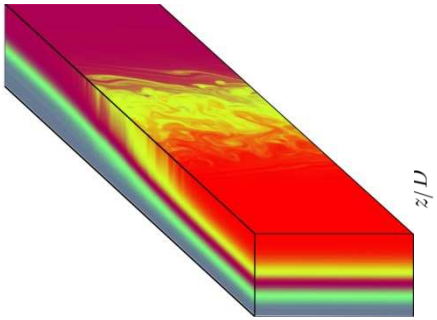
COMODO Project

Objective : Assessment of the numerical efficiency of ocean circulation model

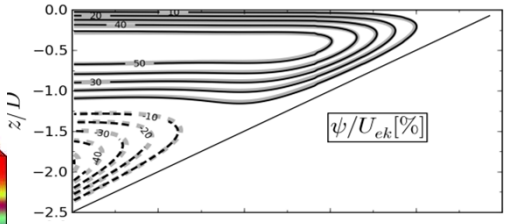
- ✓ 8 research labs
- ✓ 6 numerical ocean circulation models
- ✓ 10 test cases

Series of test cases

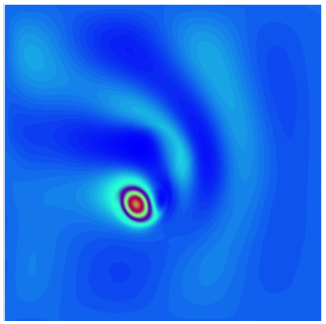
Idealized baroclinic jet



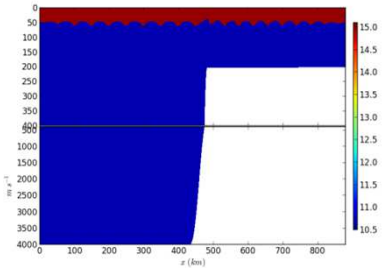
Idealized coastal upwelling



Idealized baroclinic vortex



Idealized shelf break



Operational systems developments

Pre-processing

- ✓ nesting
- ✓ meteorological forcing
- ✓ rivers outflows

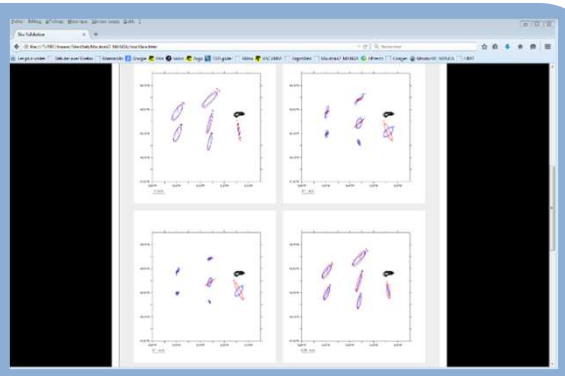
HYCOM-AGRIF run

« Quality control » outlier detection

Post-processing

- ✓ diagnostics
  - horizontal maps
  - vertical sections
  - processes detection
- ✓ observations/model comparisons
  - tide gauges
  - permanent moorings
  - in-situ profiles
  - HF radars data
  - satellite SST

intranet web page



Current operational systems

Pre-processing

- ✓ nesting
- ✓ meteorological forcing
- ✓ rivers outflows

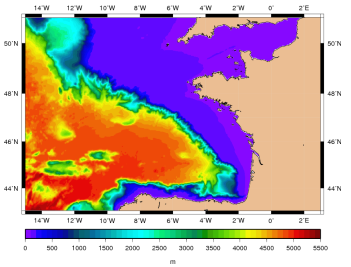
HYCOM run

SOAP

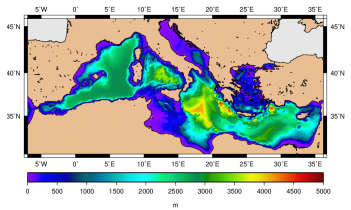
Defense products

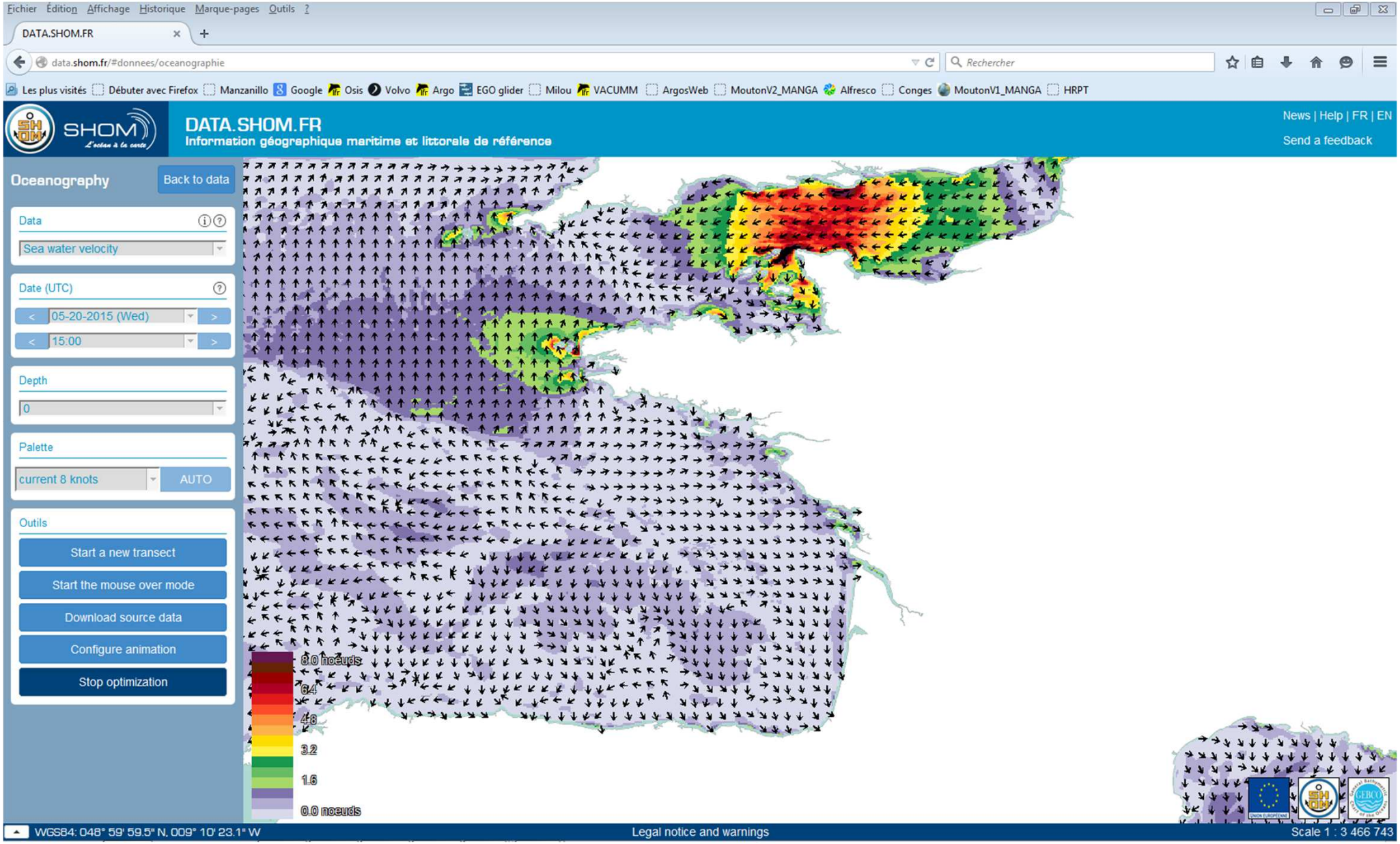
Internet website data.shom.fr

System 1 : Bay of Biscay area



System 2 : Mediterranean sea

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