HYCOM developments and tests in the MOUTON project

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Objective of the project :

Develop and validate a model able to represent the ocean dynamics (=currents, temperature and salinity fields) in both deep and shallow regions at high resolution (1 km)

Operational needs :

Under water warfare (navig., acoustics in coastal areas)

Mine warfare (mine drift + burial)

Special operations (commandos, amphibious ops)

Police operations at sea

(rescue at sea, drift of objects, pollutions, …).

Launched 2001, finish 2008/9

Numerical Modeling :

•Include tide in OGCMs

•« Clean » river run-off

• Deal with the cont. shelf

•…

=> based on HYCOM

Data Assimilation :

•Observations (Altimetry, RHF, …)

•« filters » dev.

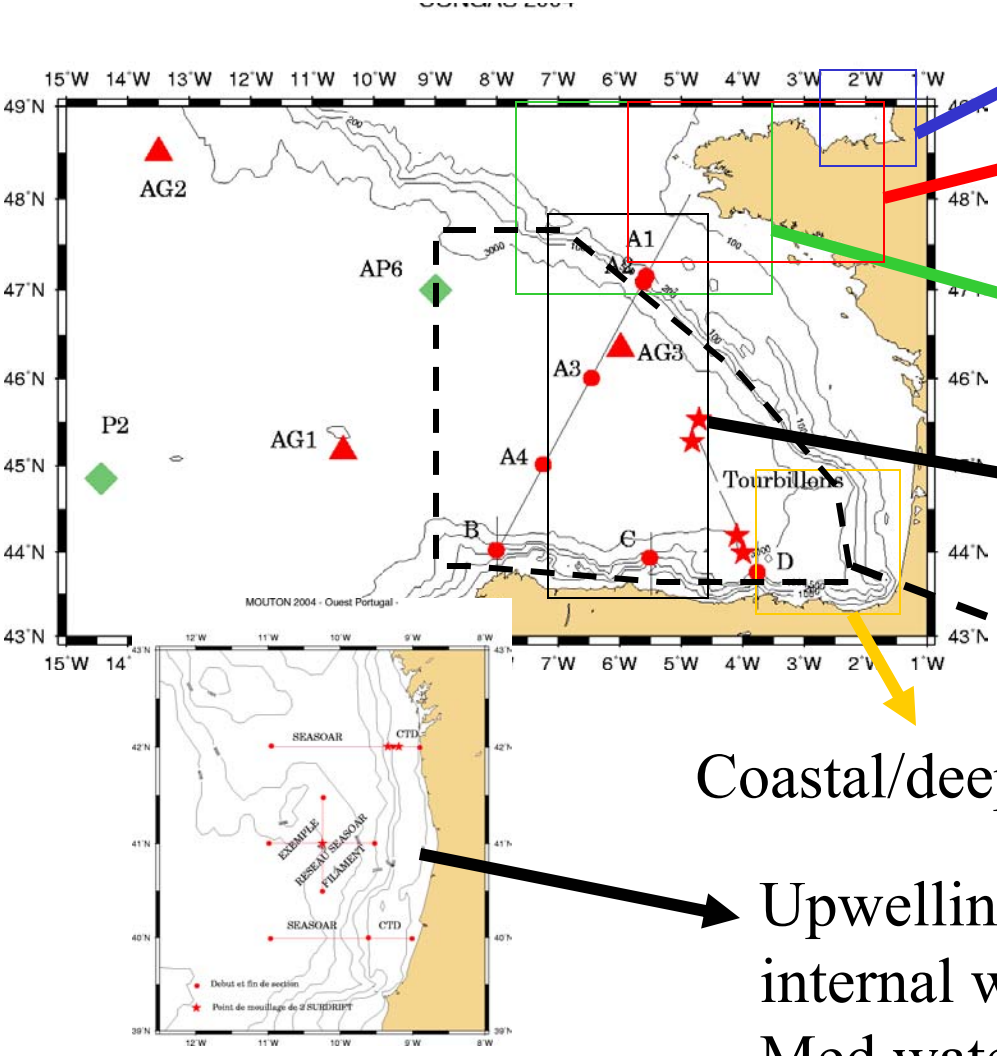
•…

Validation :

Campaigns at sea

CONGAS/MOUTON campaign 2004->2009

CHOICE OF THE AREA : Process studies



Wetting/drying tide

O/A intercations (HF)

Tide + internal tide
Current + drift

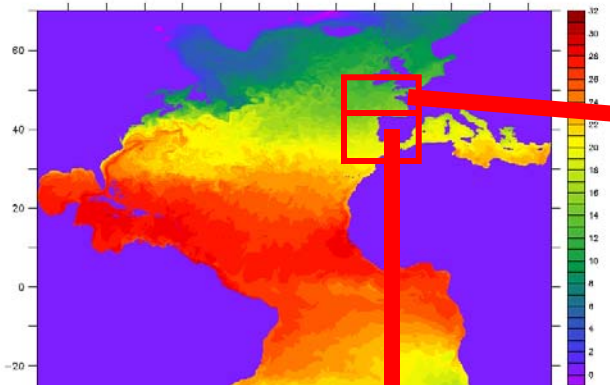
Seasonal stratification
(formation of thermocline)

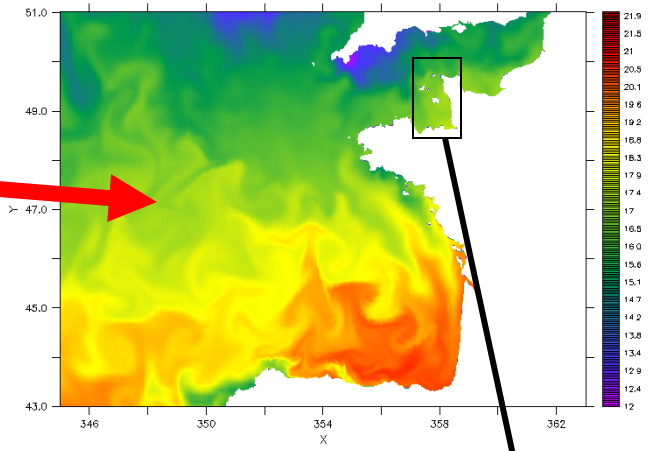
Vortices/Eddies

Coastal/deep ocean exchanges

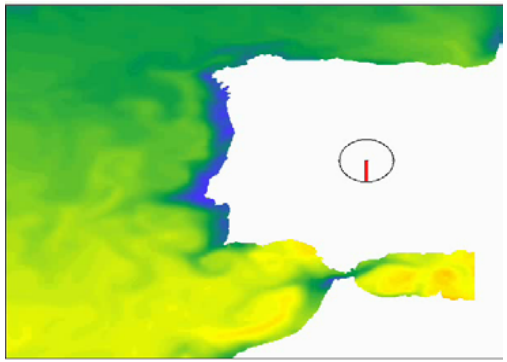
Upwelling
internal waves (solitons)
Med waters

Characteristics of the demonstration models





V 1 : basin model – Resolution 1/12°
assimilation of altimetry (RSMAS+COAPS)

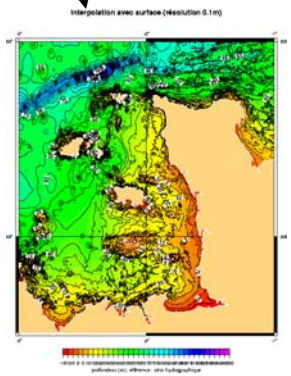


V 2.2 : local model – Resolution 1,7 km

V 2.1 : local model – Resolution 1,7 km
33 levels

Initial state and boundary conditions forced by
•MERCATOR
•MOG2D (tide – Le Provost and Lyard)

Atmospheric forcings: ARPEGE (METEO-France)



150 m (only tid

Numerical developments and results

Wetting drying version of HYCOM (modified barotp)
⇒ tides

New time stepping for the slow part of barotropic fields (slight modif main and momtur
⇒ to deal with strong currents in shallow areas (tides)

Time varying stratification characteristics (new subroutine)
⇒ manage seasonal thermocline

New boundary conditions for BT mode (new subroutine)
⇒ clean forcing of the tide and rivers

Original data assimilation method
⇒Adaptive filter (adjoint)

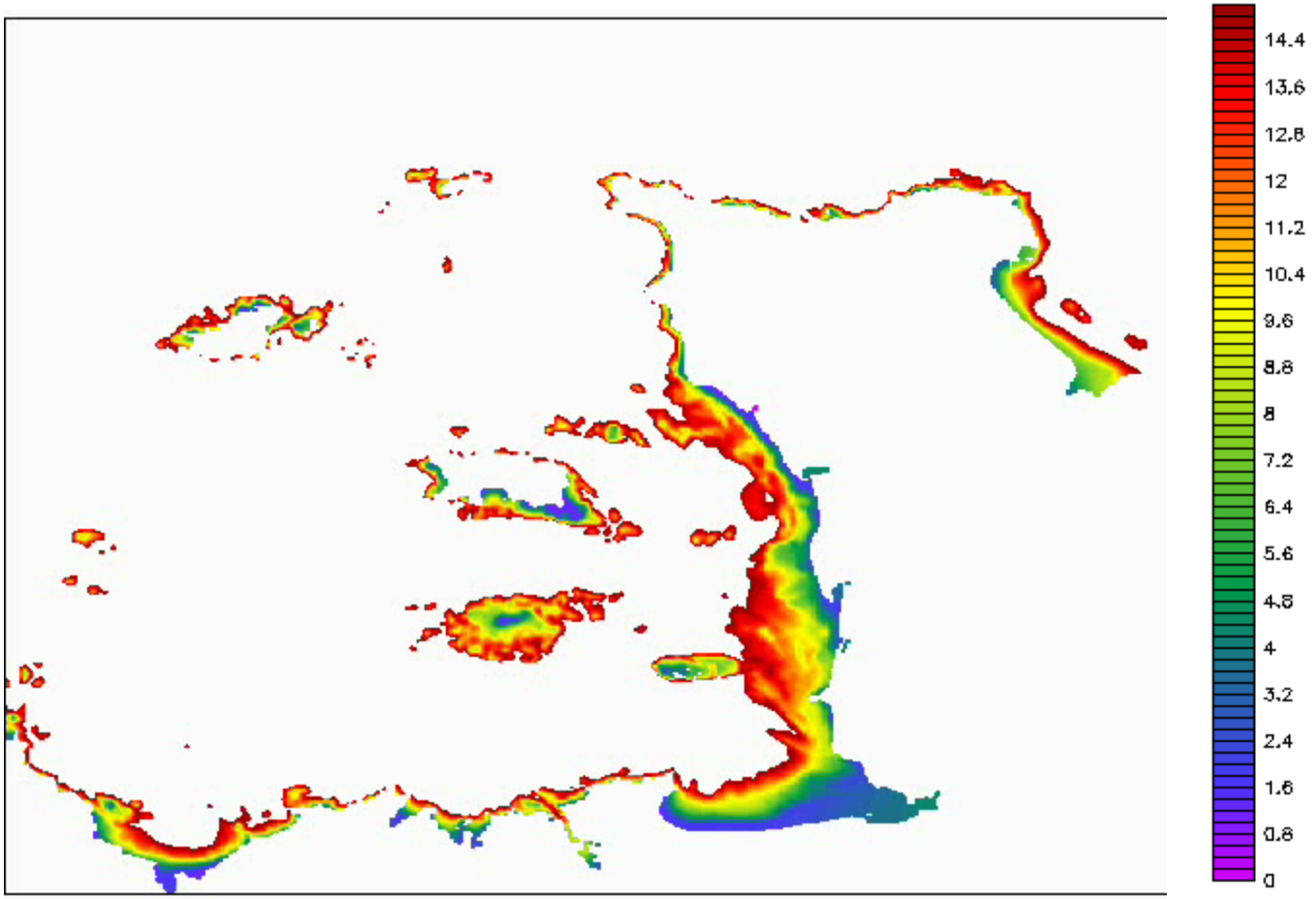
4th order advection scheme for momentum (new momtum)
⇒ more efficient than 2nd order scheme at high resolution

Wetting/Drying

Non-linear terms
included in barotropic
Mode (no approximations)

Drastic modification
Of the numerical
Schemes (but based
On the schemes used
In HYCOM for
Baroclinic mode)

⇒ Has a cost ! (but only
for barotropic mode)



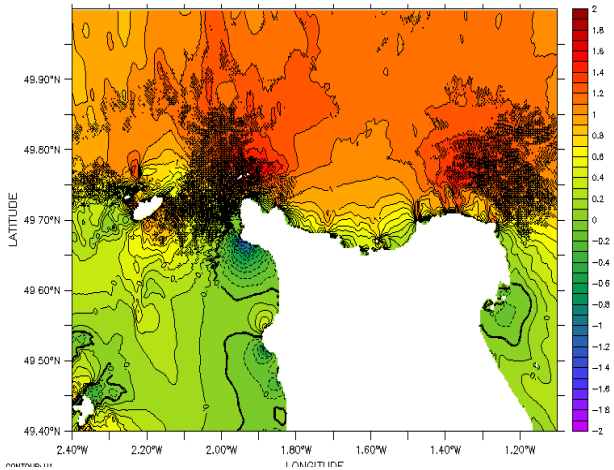
20-25 september 1997

Water depth

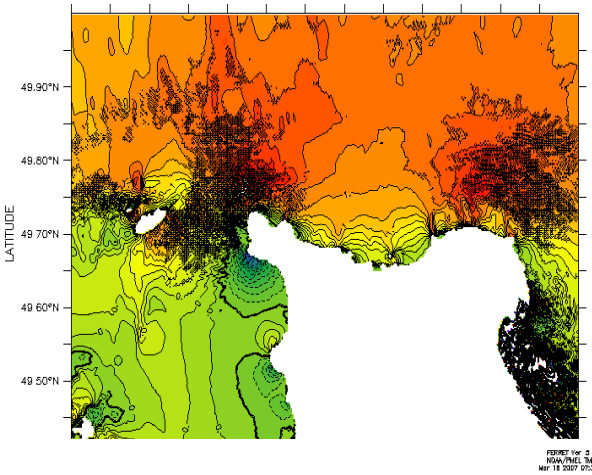
New time stepping for BT mode

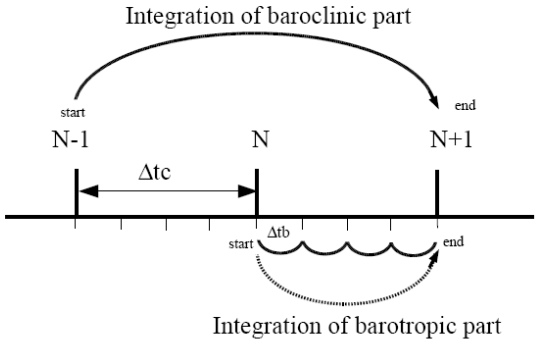
Slow evolution of Btropic mode : original code is unstable (CFL) !

Baclin = 12 s batrop = 1,5s

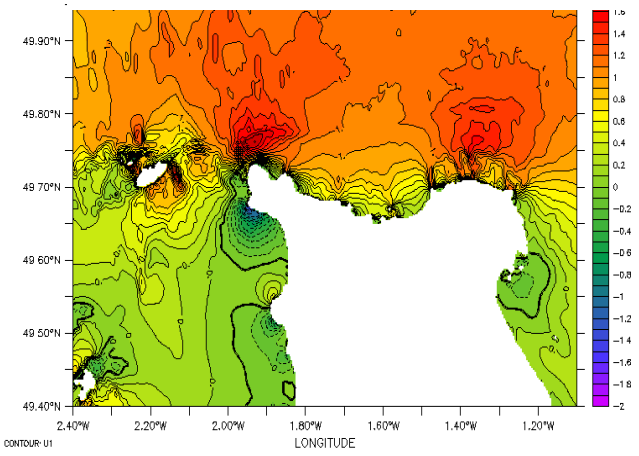


Baclin = 12 s batrop = 0,5s



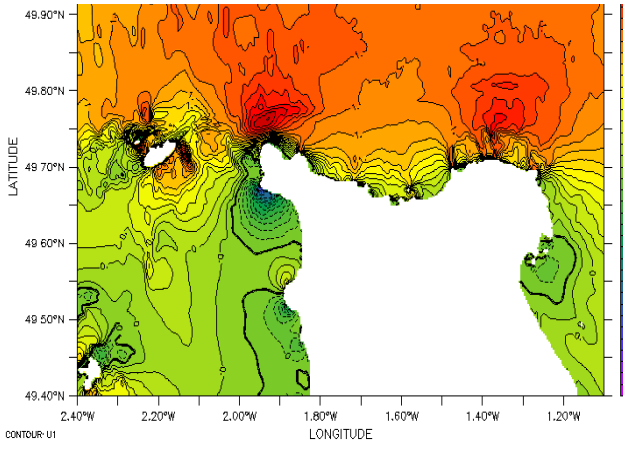


Baclin = 6 s batrop = 1,5s



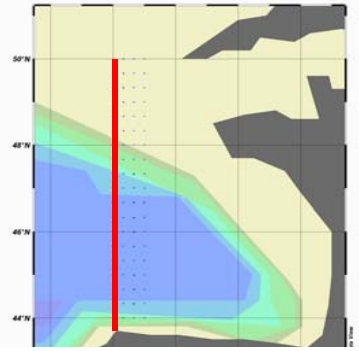
U1

Baclin = 12 s batrop = 1,5s LSBM

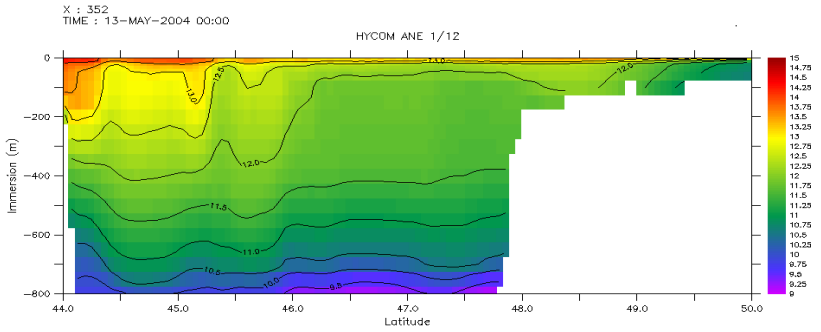


U1

Time evolution of stratification characteristics

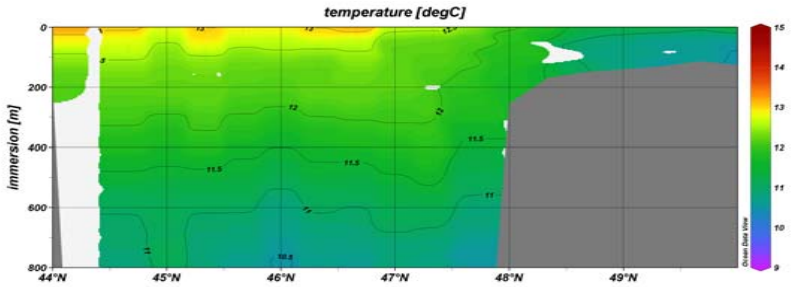


AXBT MOUTON – MAY 20

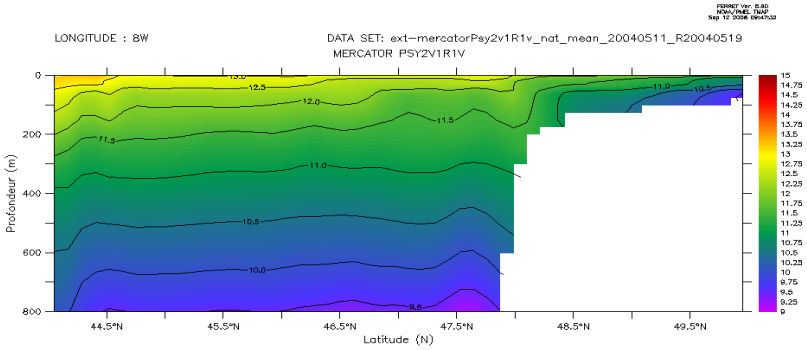


Radiale de Temperature – 8W – 05/2004

HYCOM ATL 1/12°

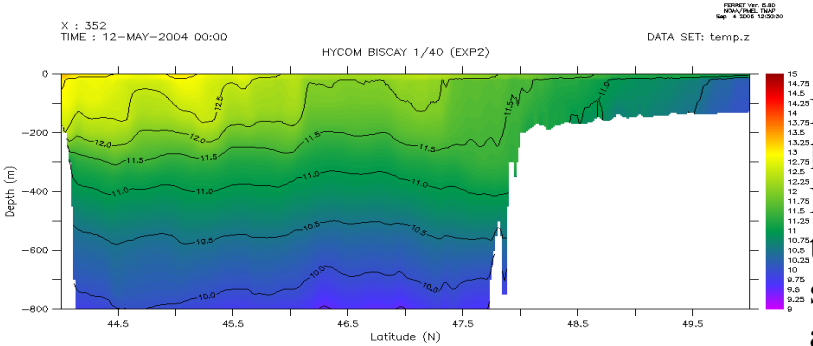


AXBT



Temperature (C),section meridienne 8.00W

MERCATOR

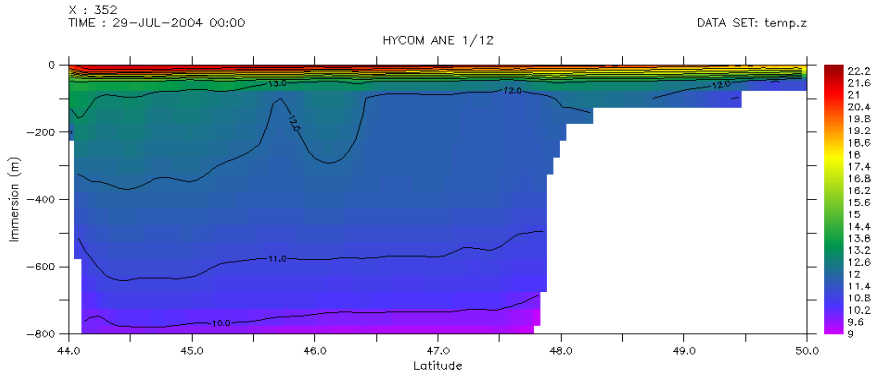


Temperature (C), meridian section 8.00W

HYCOM GASC-MOUTON

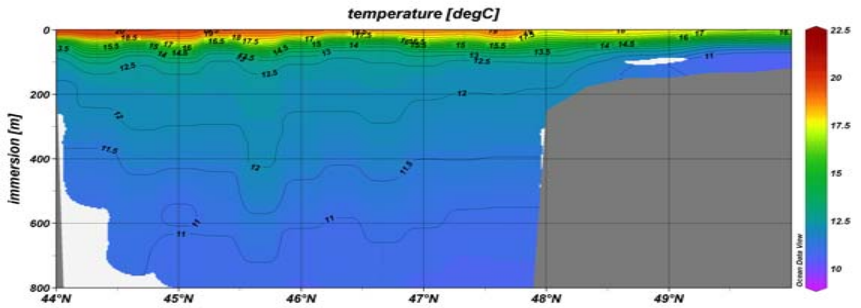
Position of geop. levels is evolved Monthly accordin to the averaged stratification in th area from climato

Time evolution of stratification characteristics

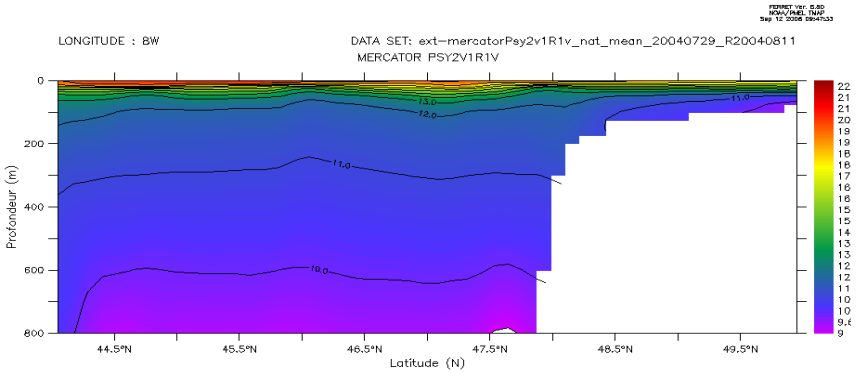


Radiale de Temperature – 8W – 07/2004

HYCOM ATL 1/12°

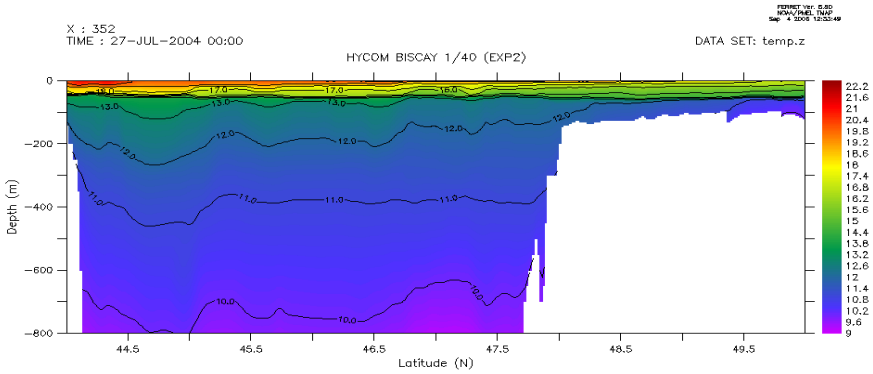


AXBT



Temperature (C), section meridienne 8.00W

MERCATOR



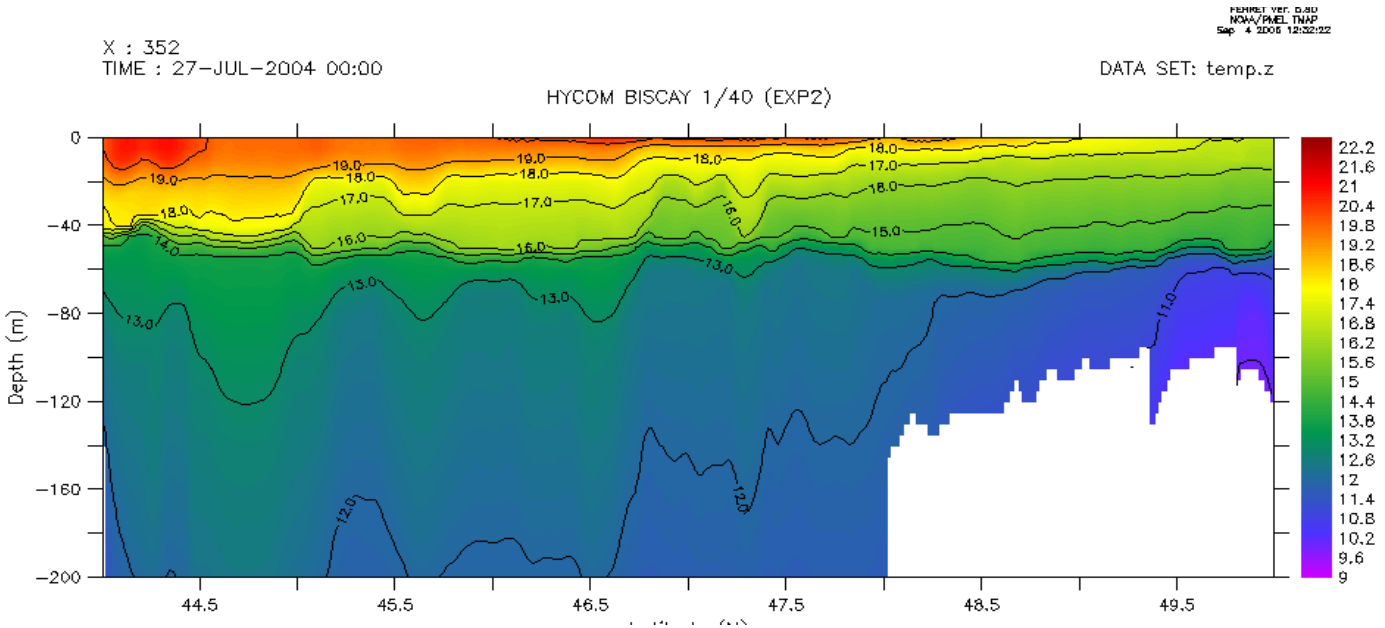
Temperature (C), meridian section 8.00W

HYCOM GASC-M

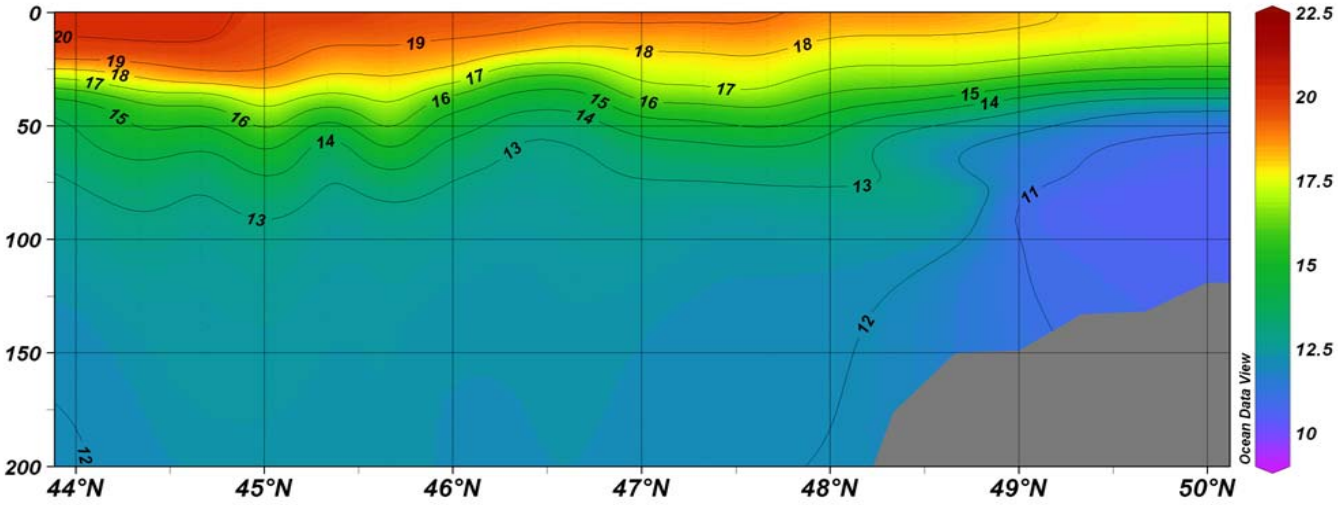
AXBT MOUTON – JULY 2004

AXBT MOUTON JULY 2004 (zoom 0-200m)

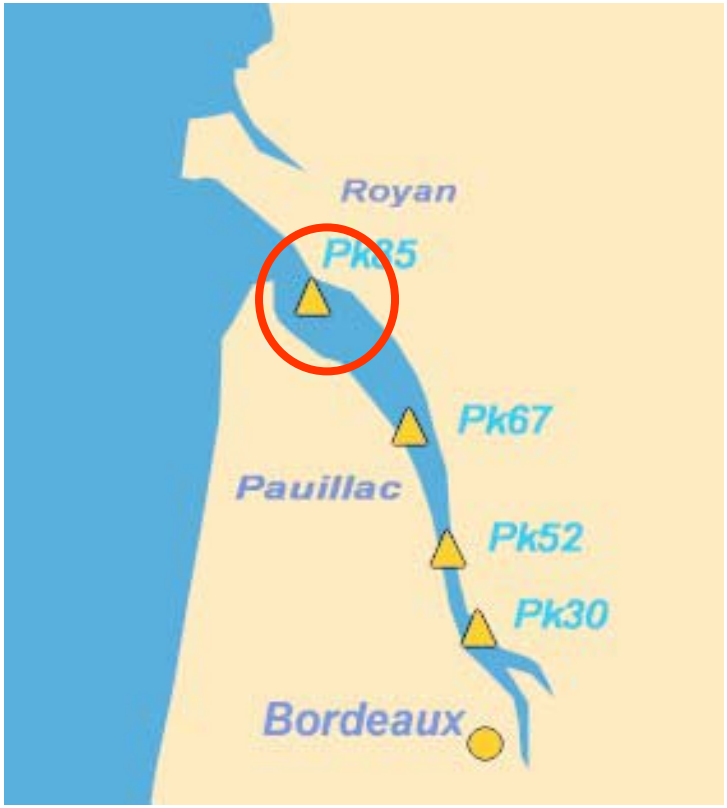
HYCOM
GASC-M

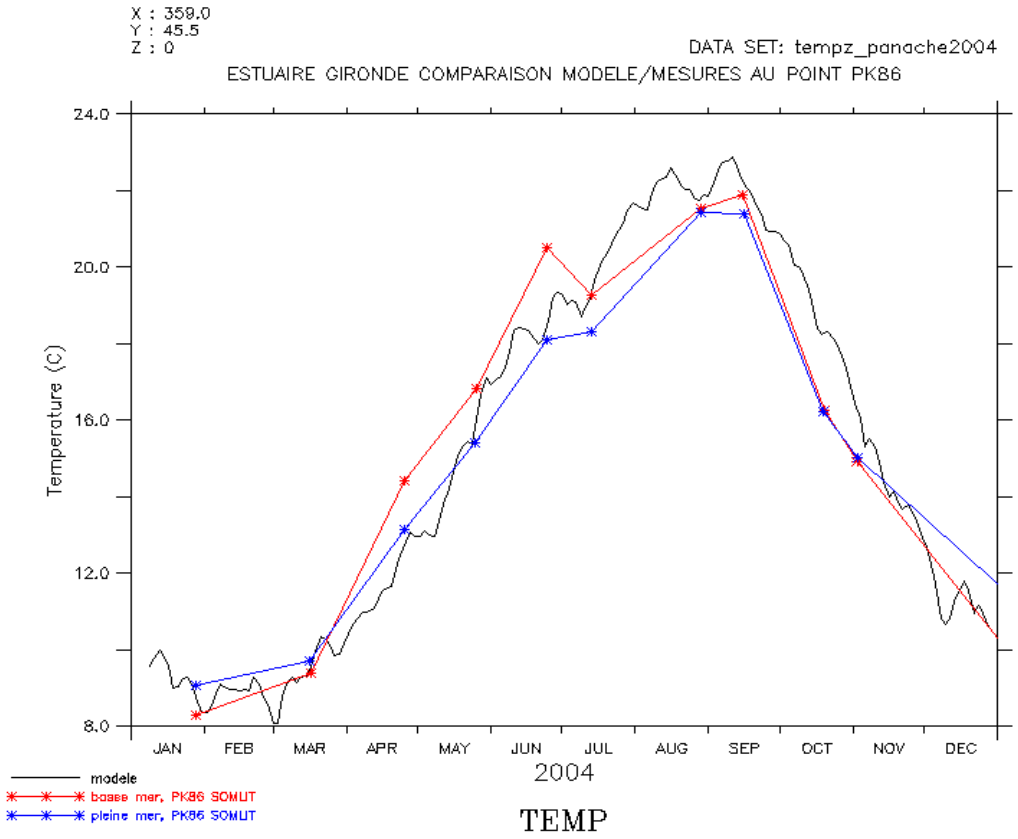


OBS



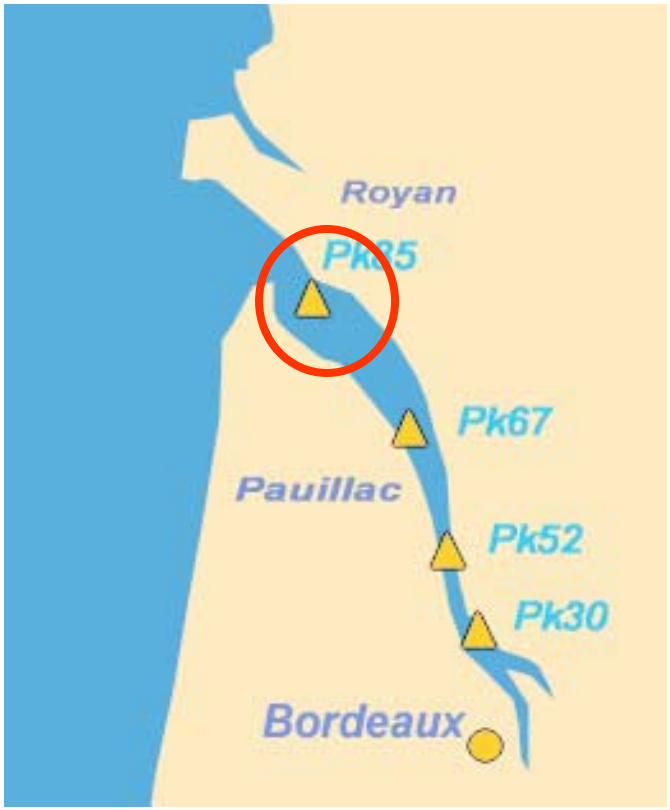
Boundary conditions : rivers

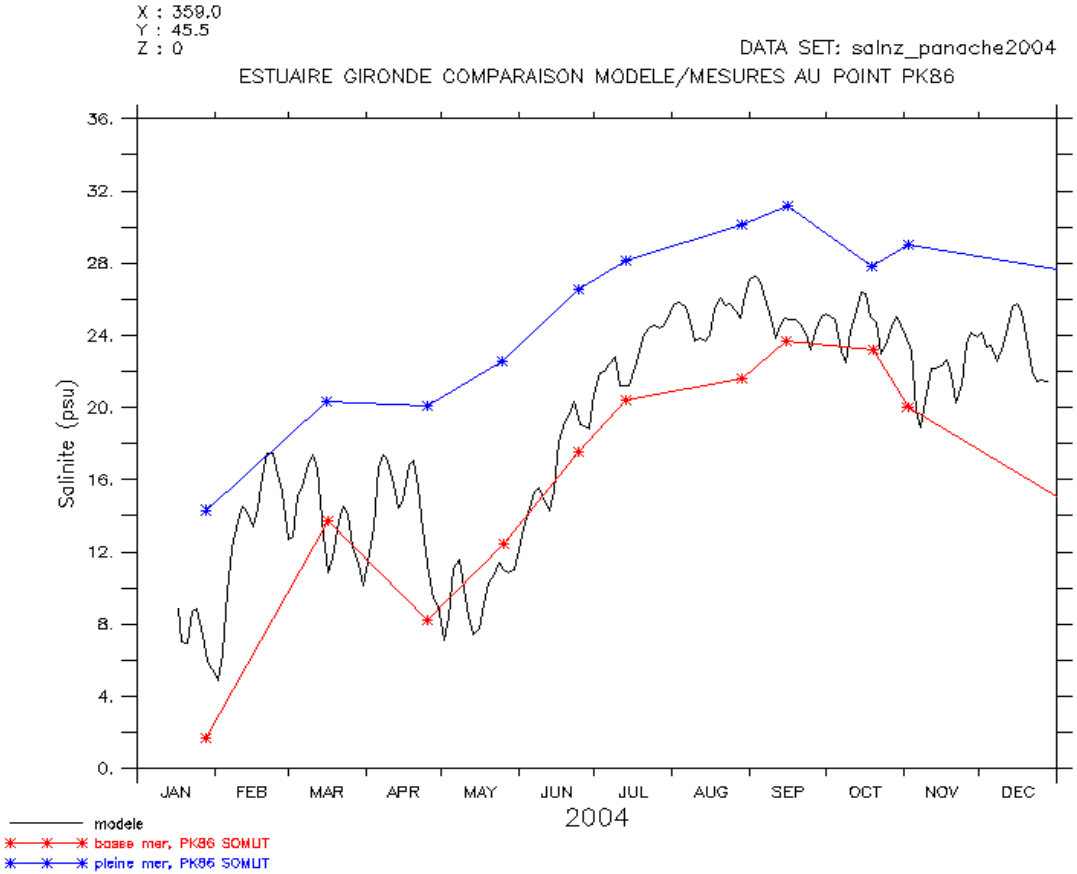




Temperature : comparison between observations (- -) and model (-) (data source : SOMLIT + EPOC)

Boundary conditions : rivers





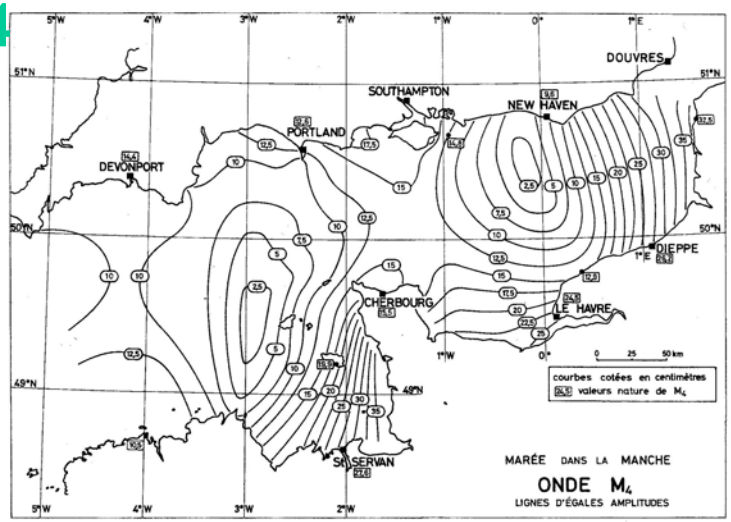
Salinity : comparison observations (- -) model (-)

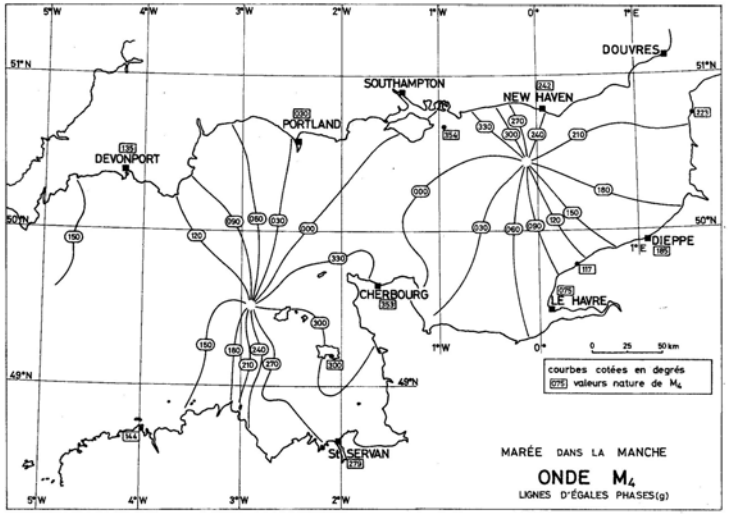
(data source : SOMLIT + EPOC)

TIDES IN THE MANCHE (CHANEL)

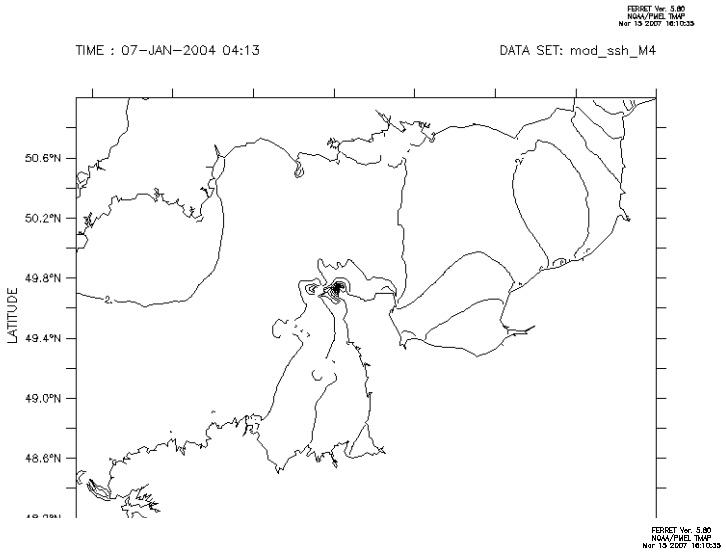
model includes all modifications (all are important)

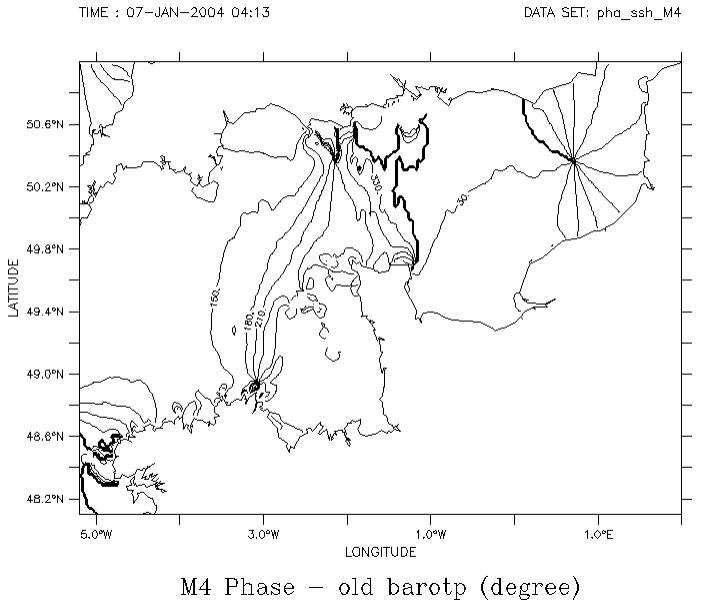
TIDE M4





Observations (Le Provost/Chabert d'Hières)

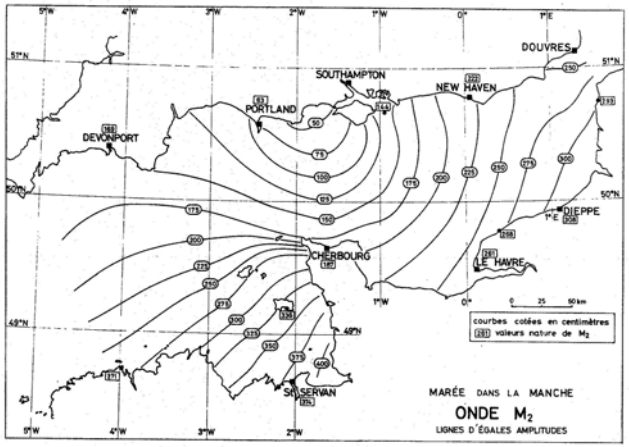


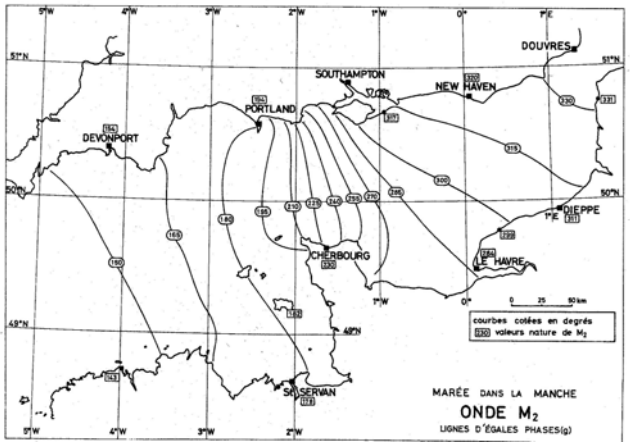


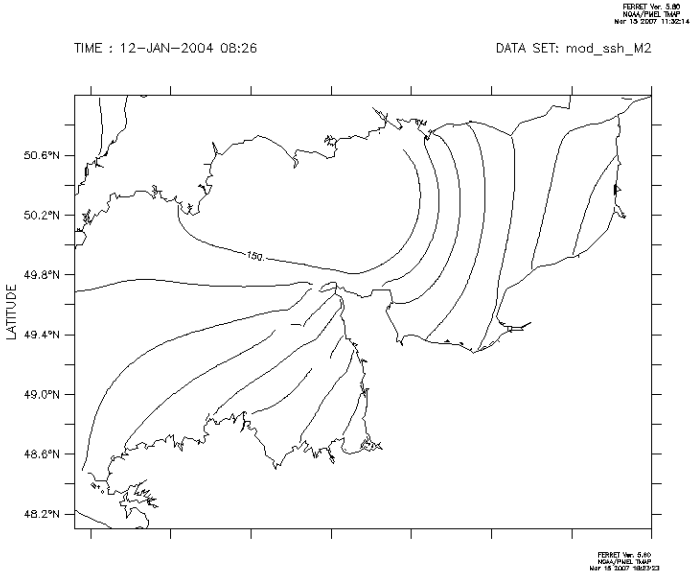
M4 Phase – old barotp (degree)

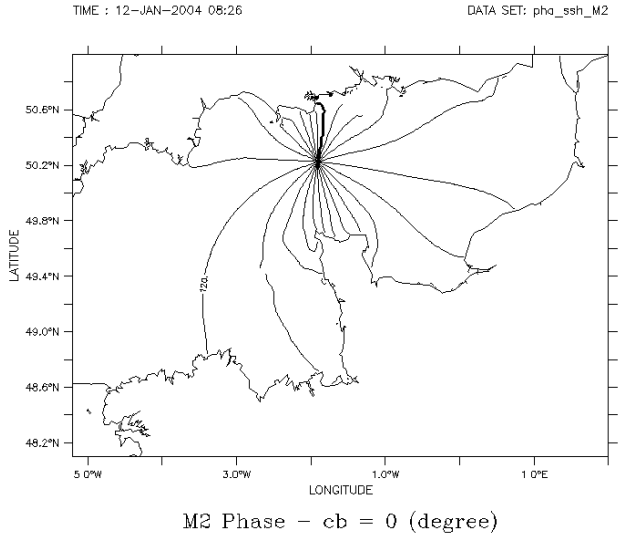
Model

TIDE M2



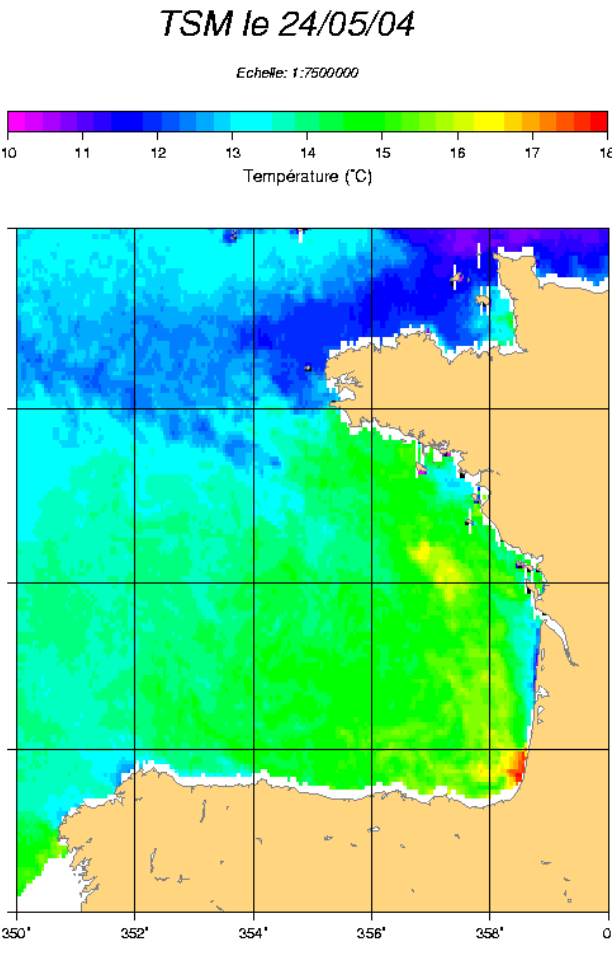


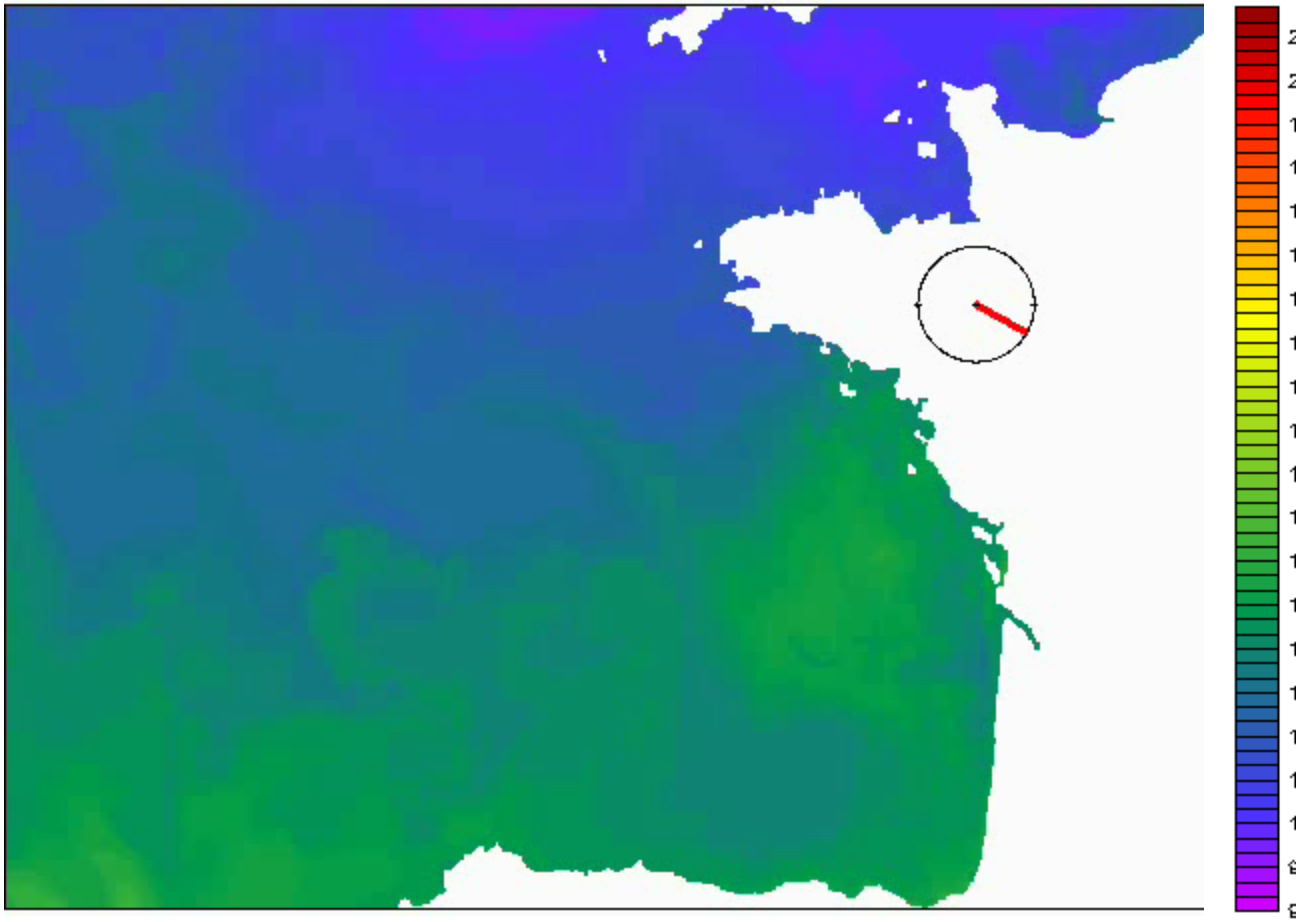




Observations (Le Provost/Chabert d'Hières)

Model


TSM le 24/05/04
Echelle: 1:7500000
10
11
12
13
14
15
16
17
Température (°C)
350'
352'
354'
356'
358'
0



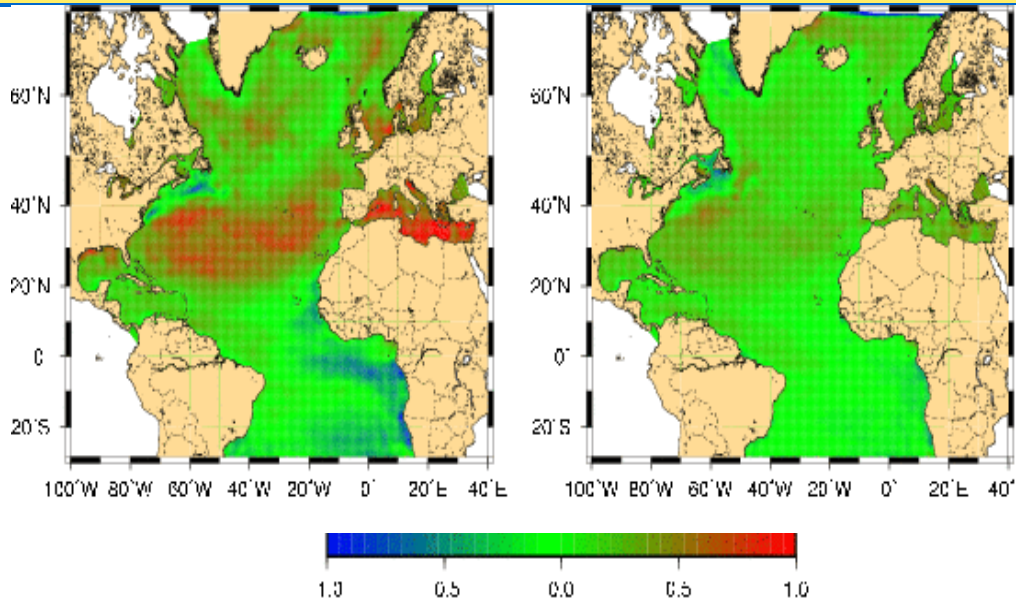
SST – May 2004

DATA ASSIMILATION

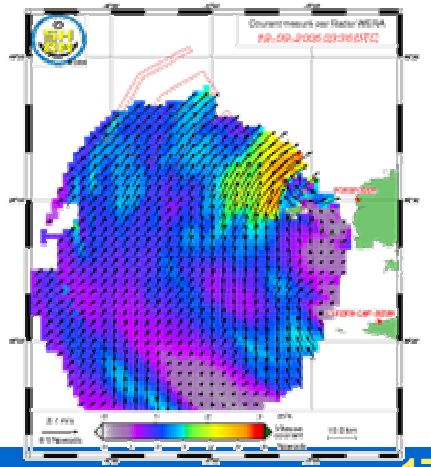
OI :
*applied to **bassin and regional** demonstration*
models

Adaptive filter :
applied to bassin demonstrator (Indian ocean)
⇒Adjoint of HYCOM

Used to deal with high frequency (tides) using HF radars



SST error (after 5 months) : free run and with assimilation (SSH, SST + in-situ)



Conclusion : ongoing and future developments

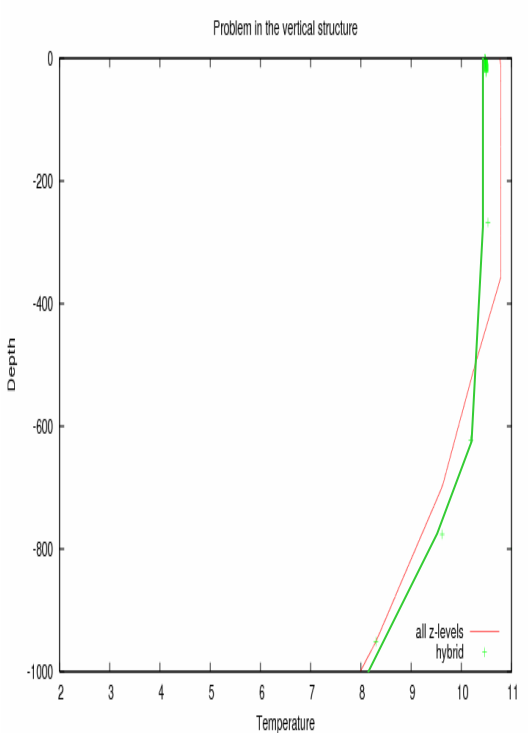
Locally adaptive stratification (modification of « hybgen »)
⇒ improve evolution of thermocline
and prepare coupling with atmospheric models (Cécile Renaudie – SHOM/MF)

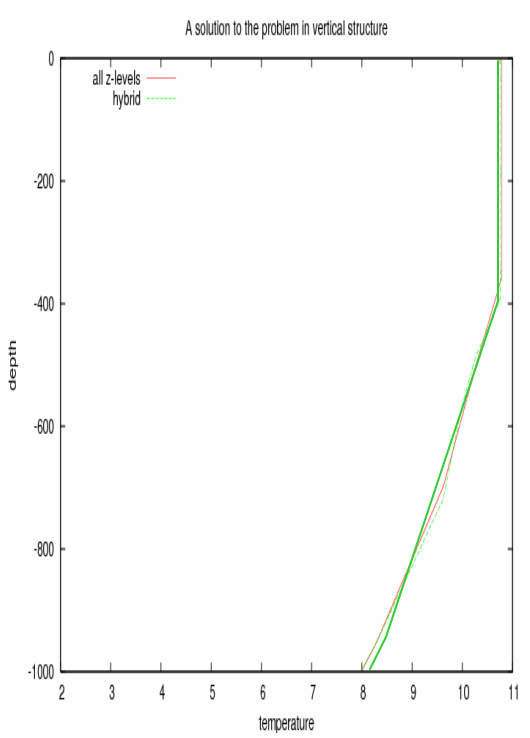
Simulation over 20 days, wind=20 m/s, air temperature=1°C, radiative flux=0W/m2 with 40 hybrid layers, in May (dp00=1.01m, dp00x=1.41m, dp00f=1.04) compared with an all z-levels solution (4476 layers of 1m each).

Alternative :

dp00f from the previous time step
geometrical series to calculate dp00 :

$$S = dp00\,\frac{1 - dp00\,f^{nbz}}{1 - dp00\,f}$$





Conclusion : ongoing and future developments

most important processes (coastal) are reproduced at least qualitatively **but need some modification of the code**

⇒confidence in model for coastal modeling

Data assimilation :
Deal with high/low frequency processes (tides)
Adapt « adaptive filter » to regional model

Pursue validation (test upwellings, gravity currents, internal tides)

AGRIF package (modification of « entire » code : look out for syntax in future release)
⇒ automatic 1-2 way nesting