Ocean Response to the Klaus storm (24/25 Jan 2009) in the Bay of Biscay as modelled by Symphonie

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Objectives

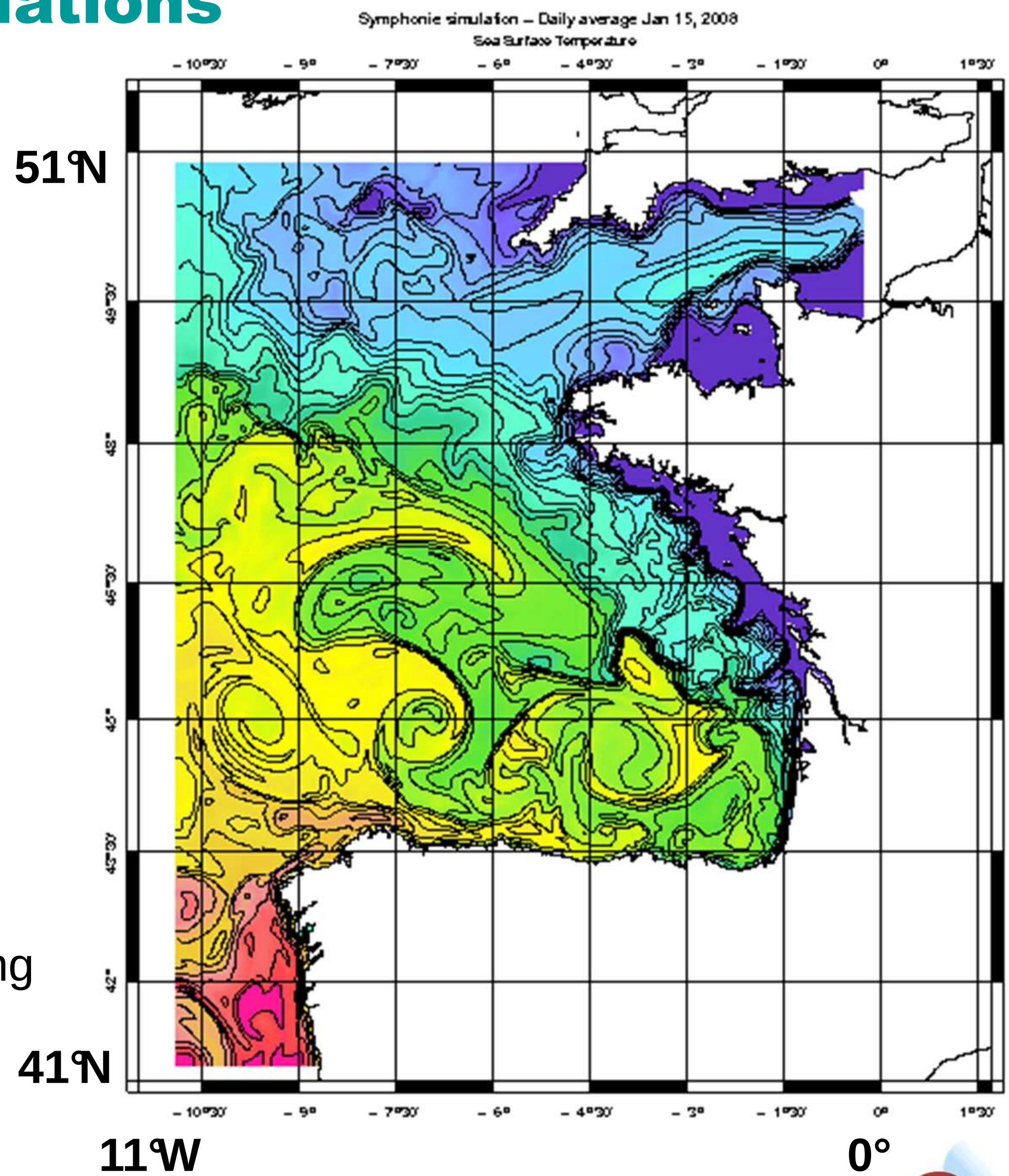
Document and understand the upper ocean's response to the Klaus storm from a numerical simulation

- What are the dynamical and thermal responses of the upper ocean during and just after the passage of the storm Klaus ?
- What are the characteristics of the mixed layer depth and its variability ?
- Is the model able to provide a realistic representation of the upper ocean's response to the storm ?

Estimate the model's sensivity to atmospheric forcing

Model setup and simulations

Symphonie model
3km x 3km,
43 levels (coord. σ generalized)
OB et IC : Mercator PSY2V3
Atm. forcing: Aladin (3h)
Tidal and pressure forcing
3 rivers (Loire, Garonne, Adour)



Two simulations analyzed:
- S1 from Jun. 2007 to Mar. 2009
- S2 from Dec. 2008 to Mar. 2009

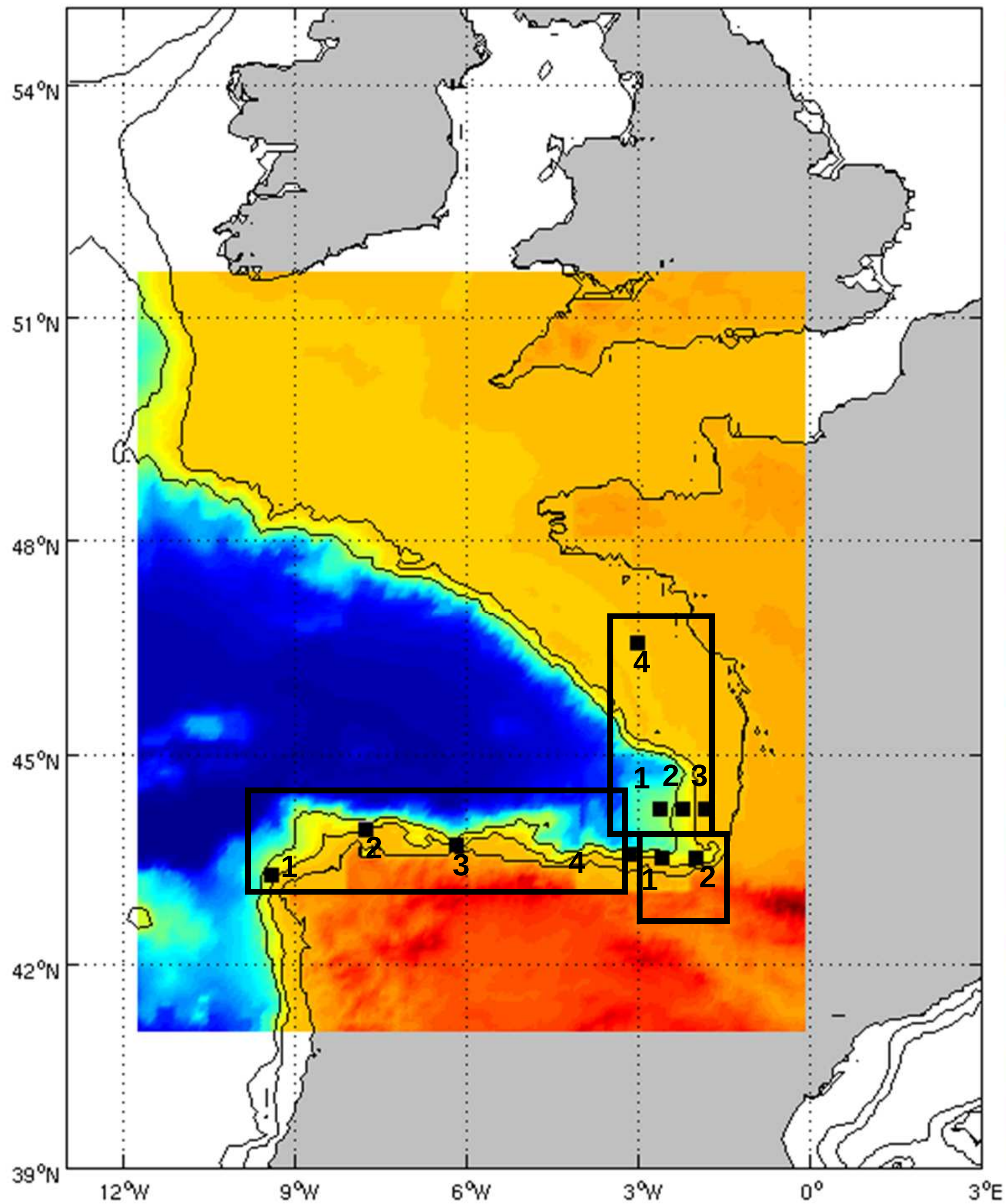
Different state equations
Different parameters for vertical mixing

OBSERVATIONS

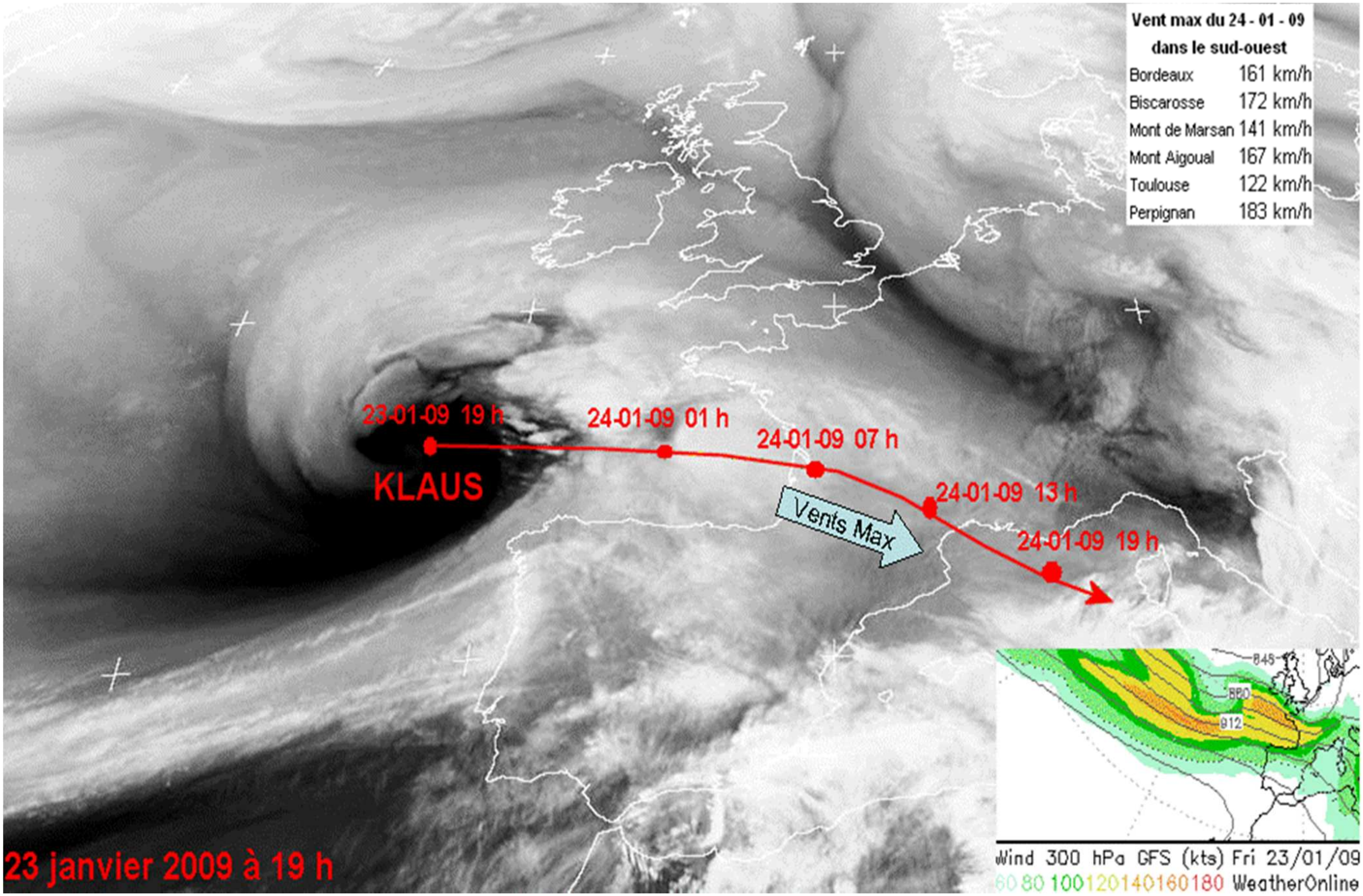
- ***Puertos del Estado***
  1: Villano Sisargas
  2: Cabo de Peñas
  3: Estaca de Bares
  4: Bilbao Vizcaya

- **Mouillages AZTI**
  Coll. A. Rubio, J. Mader
  1: Matxitxako
  2: Donostia

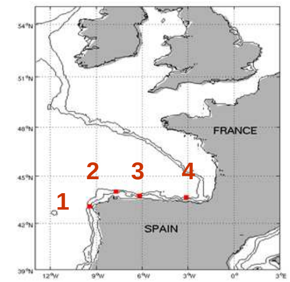
- **ASTEX**
  Coll. L. Marié
  1: ASTEX1
  2: ASTEX2
  3: ASTEX3
  4: ASTEX4



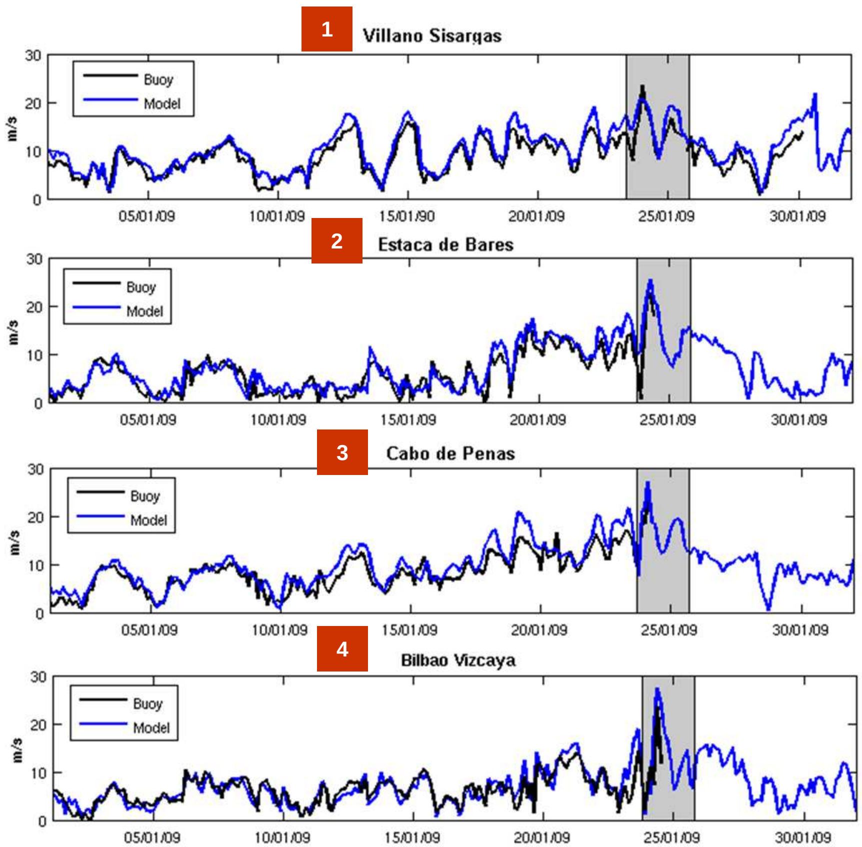
METEOROLOGICAL CONTEXT



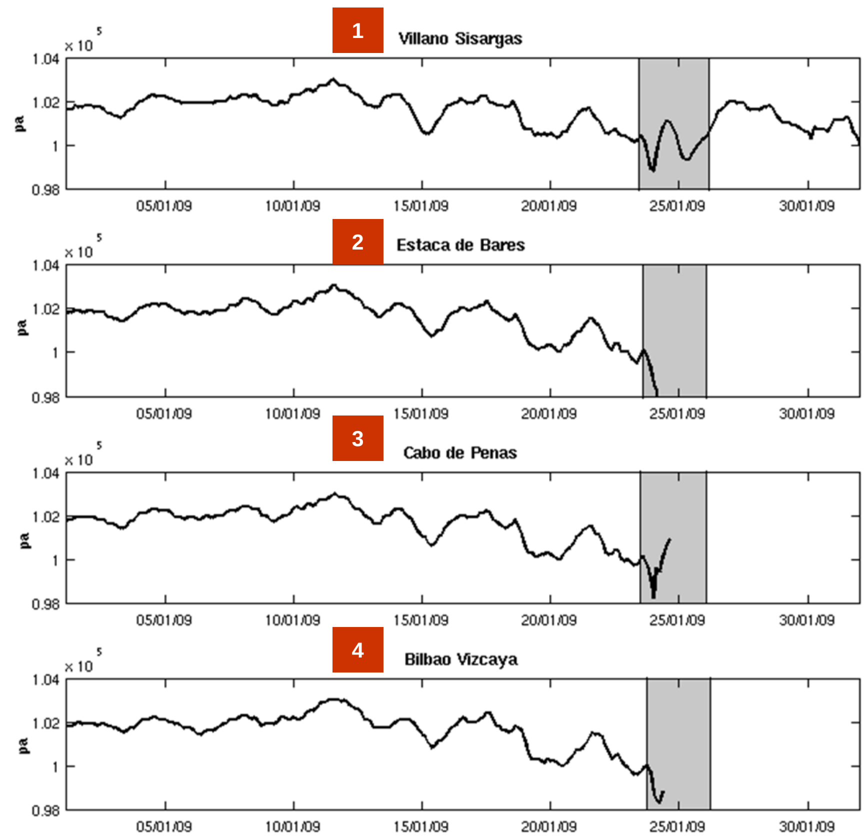
KLAUS: extreme event characterised by low pressure (~988hPa) and strong winds (~28m/s)



Wind amplitude every 3 hours

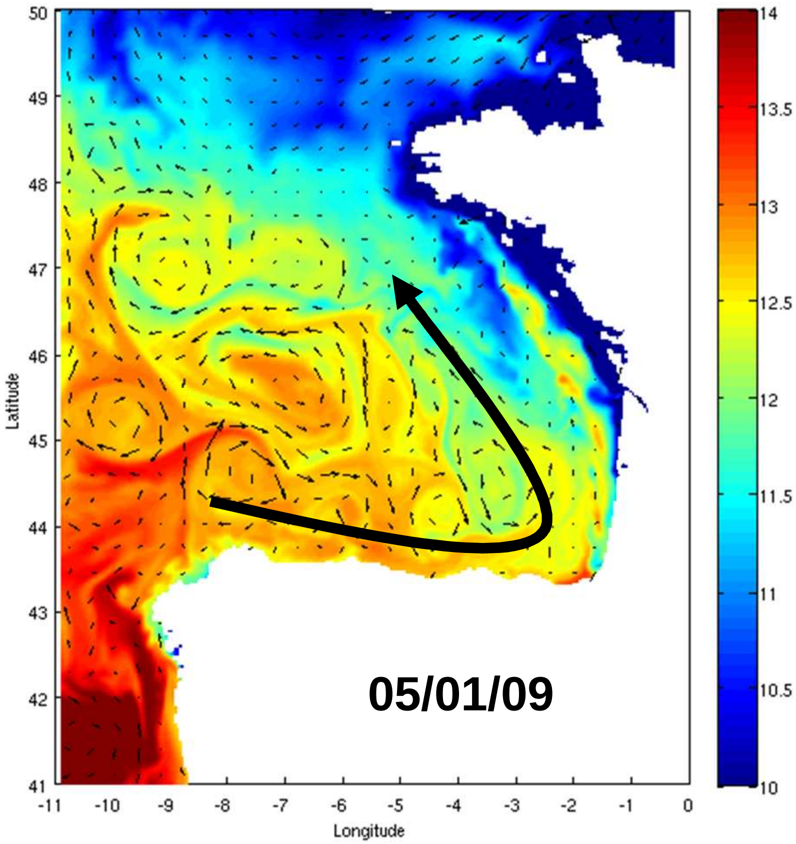


Atmospheric pressure (Pa) 24h-average

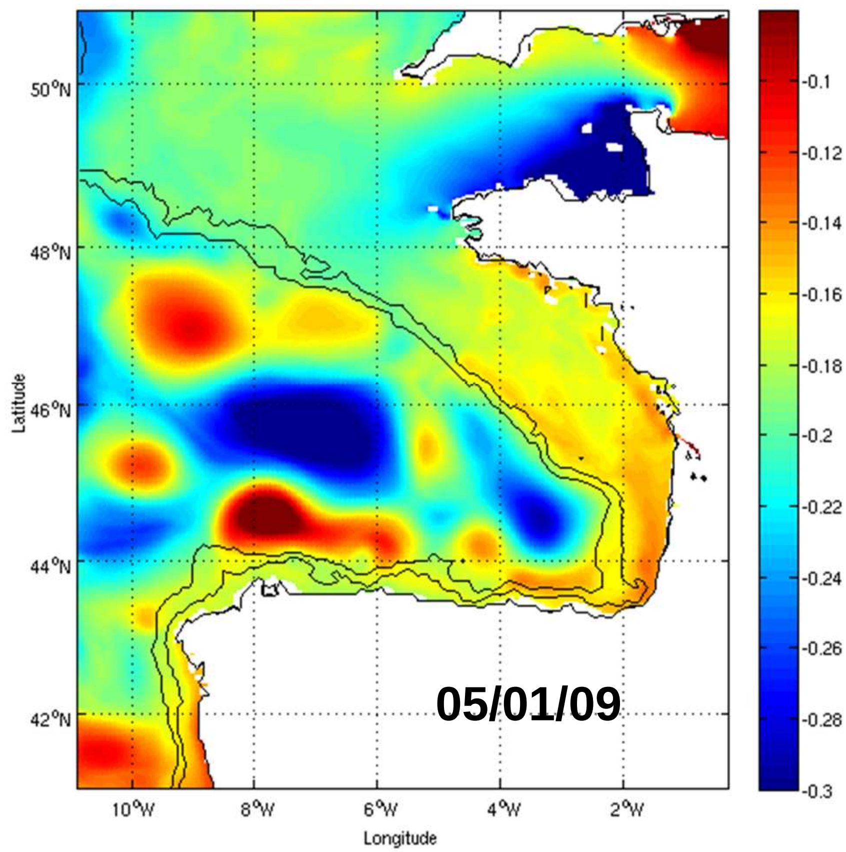


OCEANIC CIRCULATION BEFORE THE STORM

SST (ºC) and surface currents (m/s)



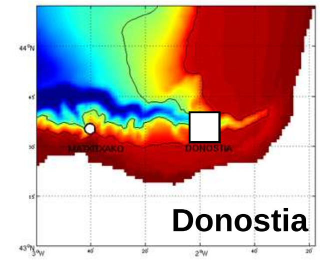
SSH (m)



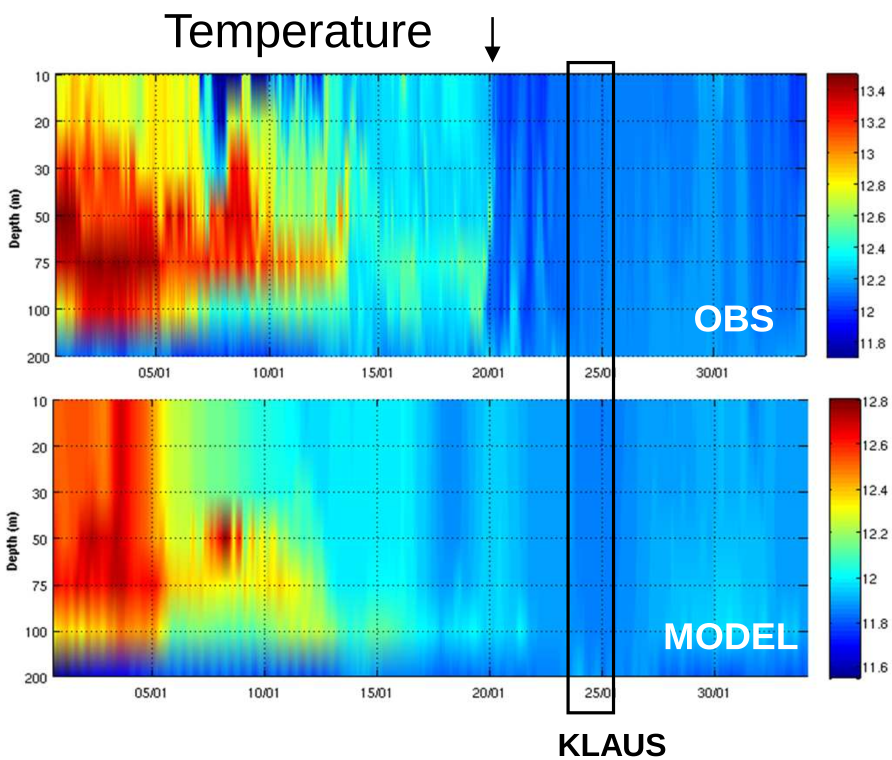
- Cyclonic general circulation

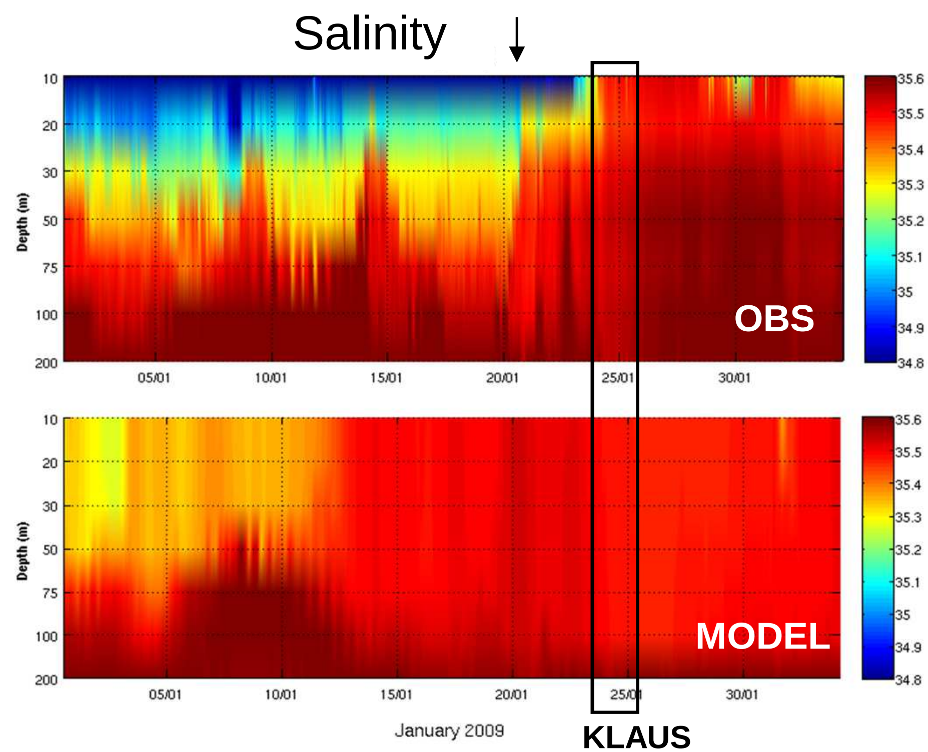
- Anticyclonic and cyclonic eddies

T/S RESPONSE IN THE UPPER 200 m
COMPARISON WITH IN SITU PROFILES



Weak SST and salinity response at Donostia



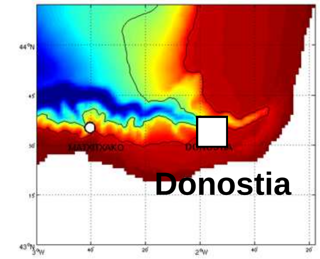


- Slight temperature decrease (<=0.1℃)

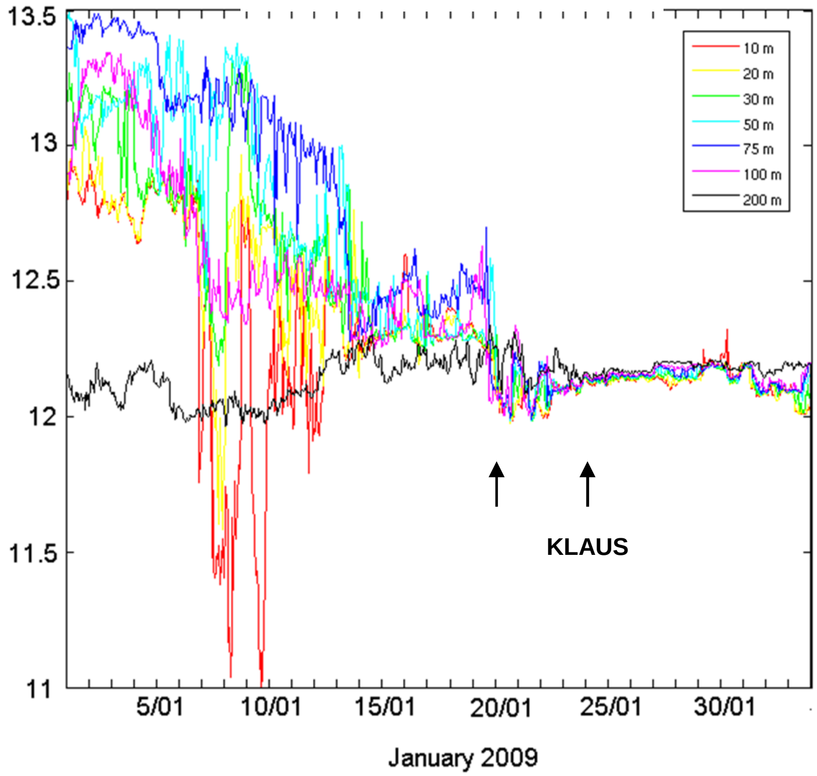
- Slight salinity increase (+0.02psu)

→ Role of earlier mixing event (e.g gale of Jan. 19) ?

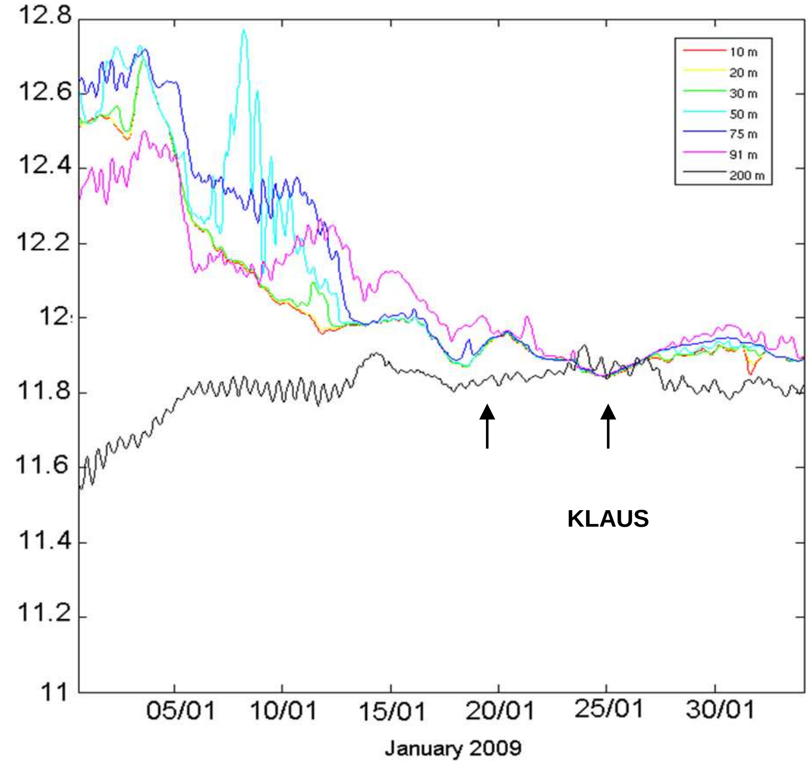
Tightening of isotherms at Donostia during the storm



OBSERVATIONS

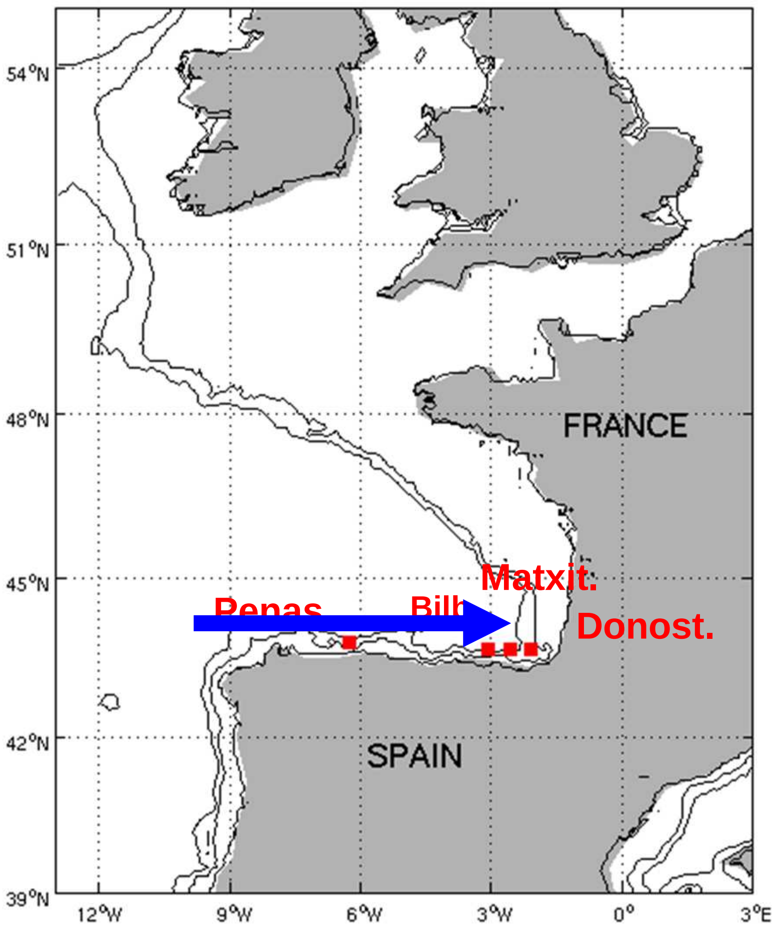


MODEL

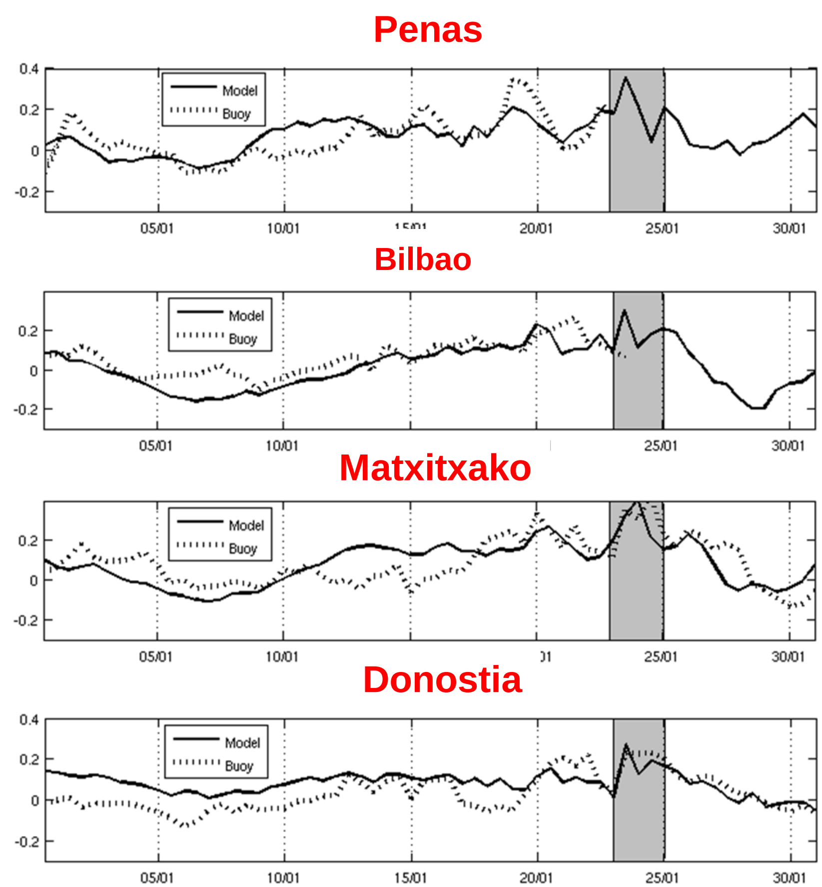


→ Homogenization of the water column

Strong Eastward current (~0.4m/s) along northern Spanish coast

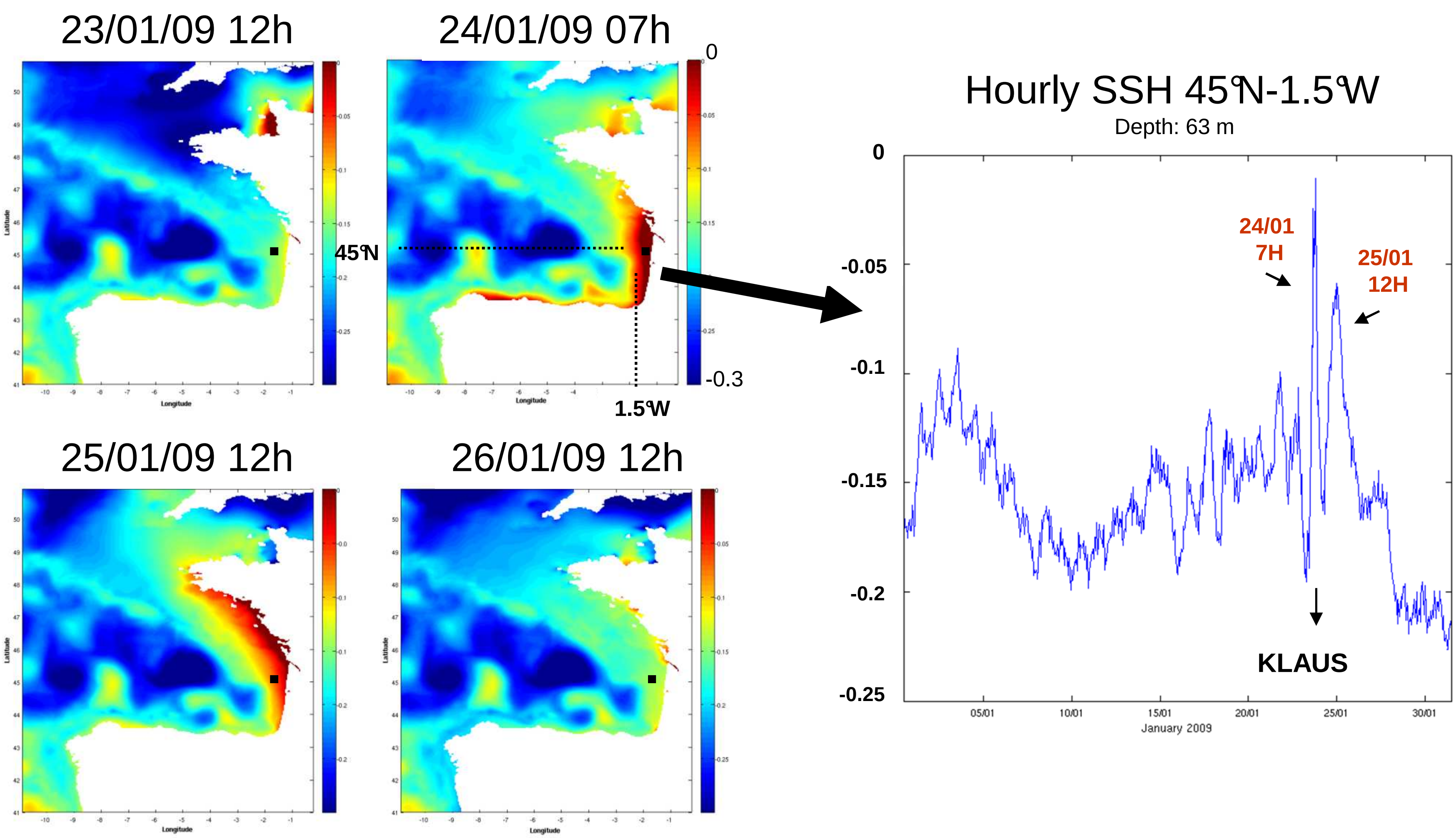


12h-average zonal current at 4 buoys along Northern Spanish coast



KLAUS

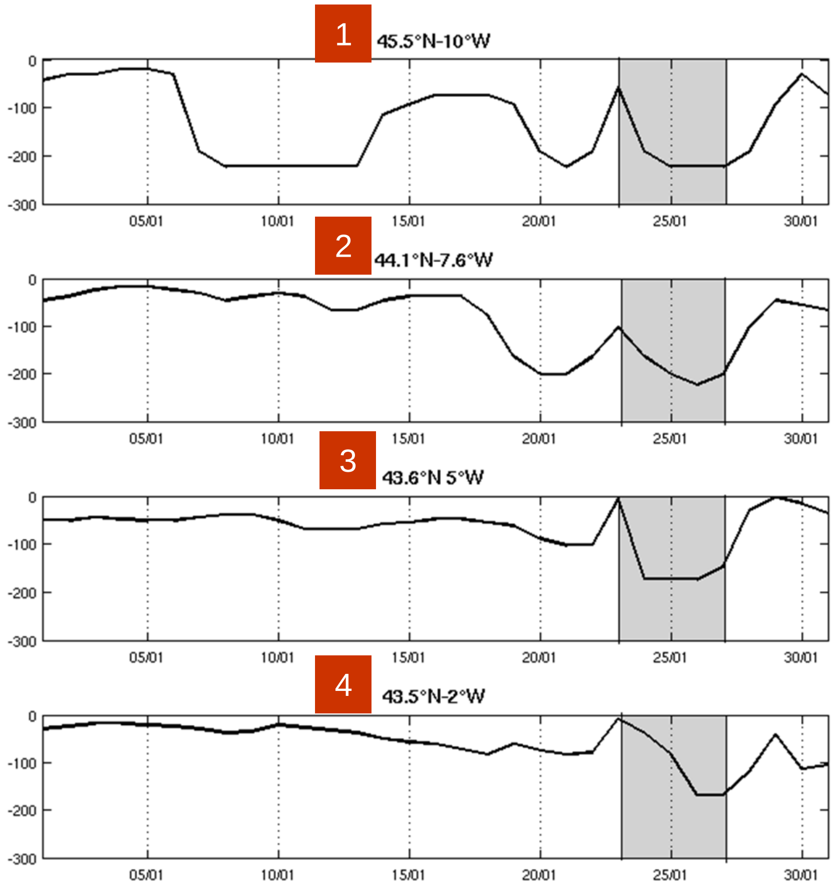
Sea surface elevation at the coasts



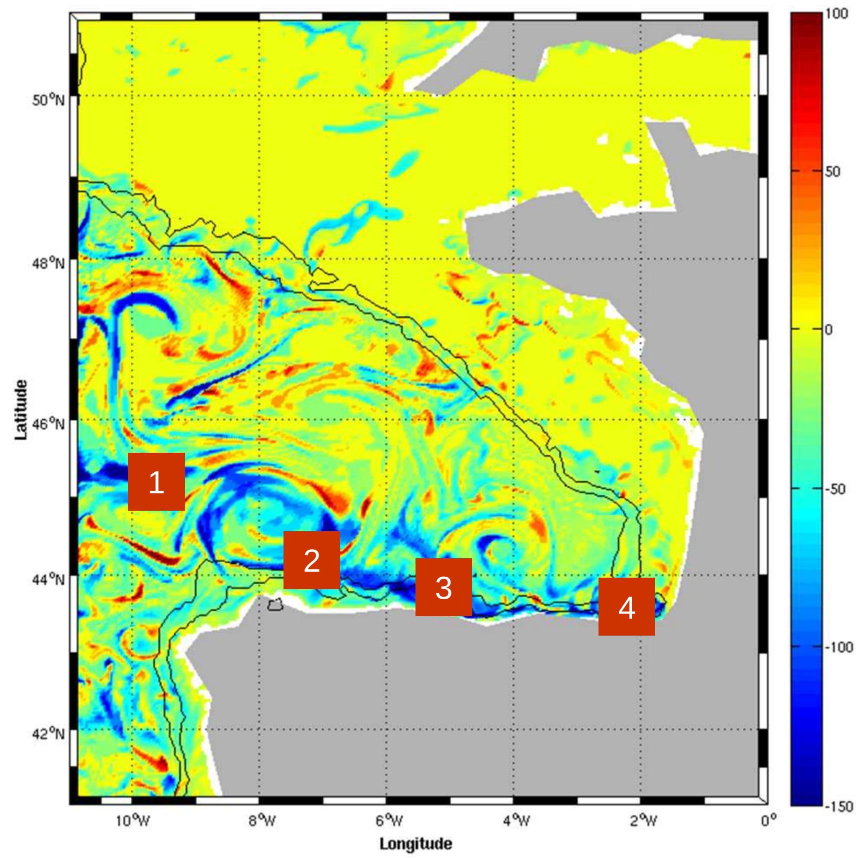
Comparison with tide gauges data (in progress)

Deepening of the mixed layer from SYMPHONIE

MLD (m) at 4 locations on the Klaus storm's pathway



MLD (25/01/09) – MLD (23/01/09)



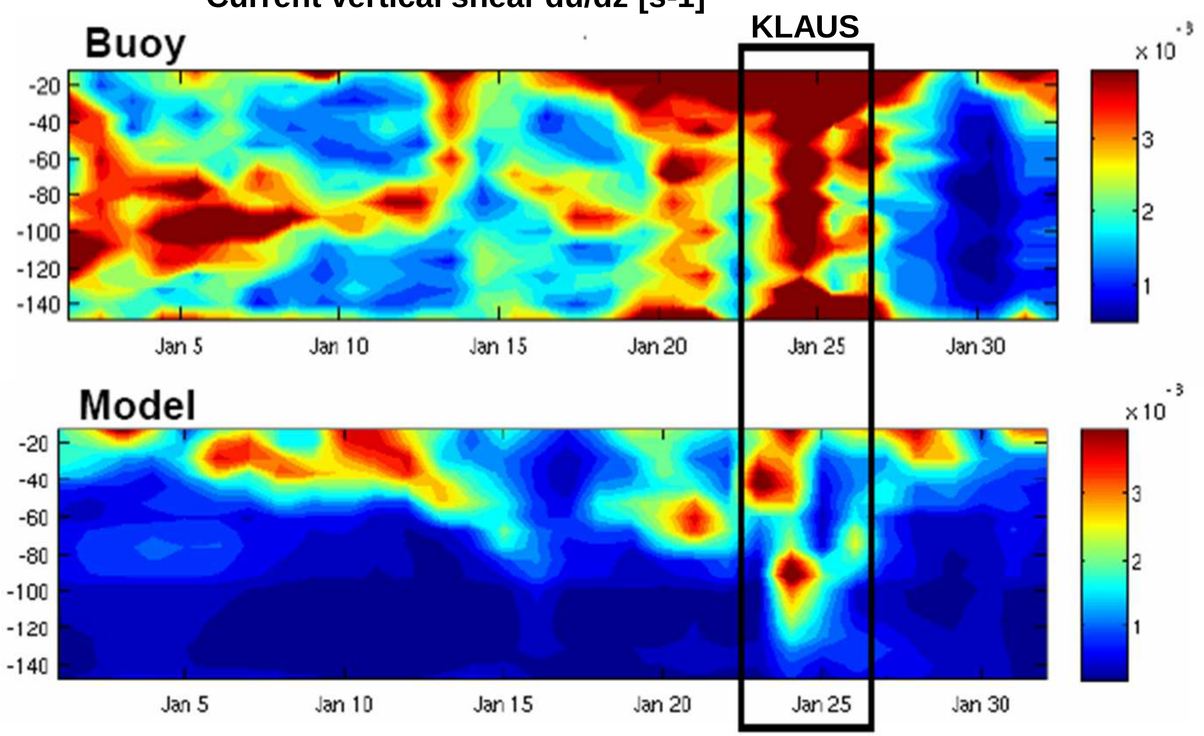
Vertical shear of the horizontal current

→ From the in situ data, Rubio et al (2011) suggest that the current shear in the inertial frequency band is partly responsible for the vertical mixing in winter

<u>OBJECTIVE</u>: What is the contribution of the inertial currents vertical shear to vertical mixing in the model ? Is it consistent with the observations ?

- **Donostia**

Current vertical shear du/dz [s-1]

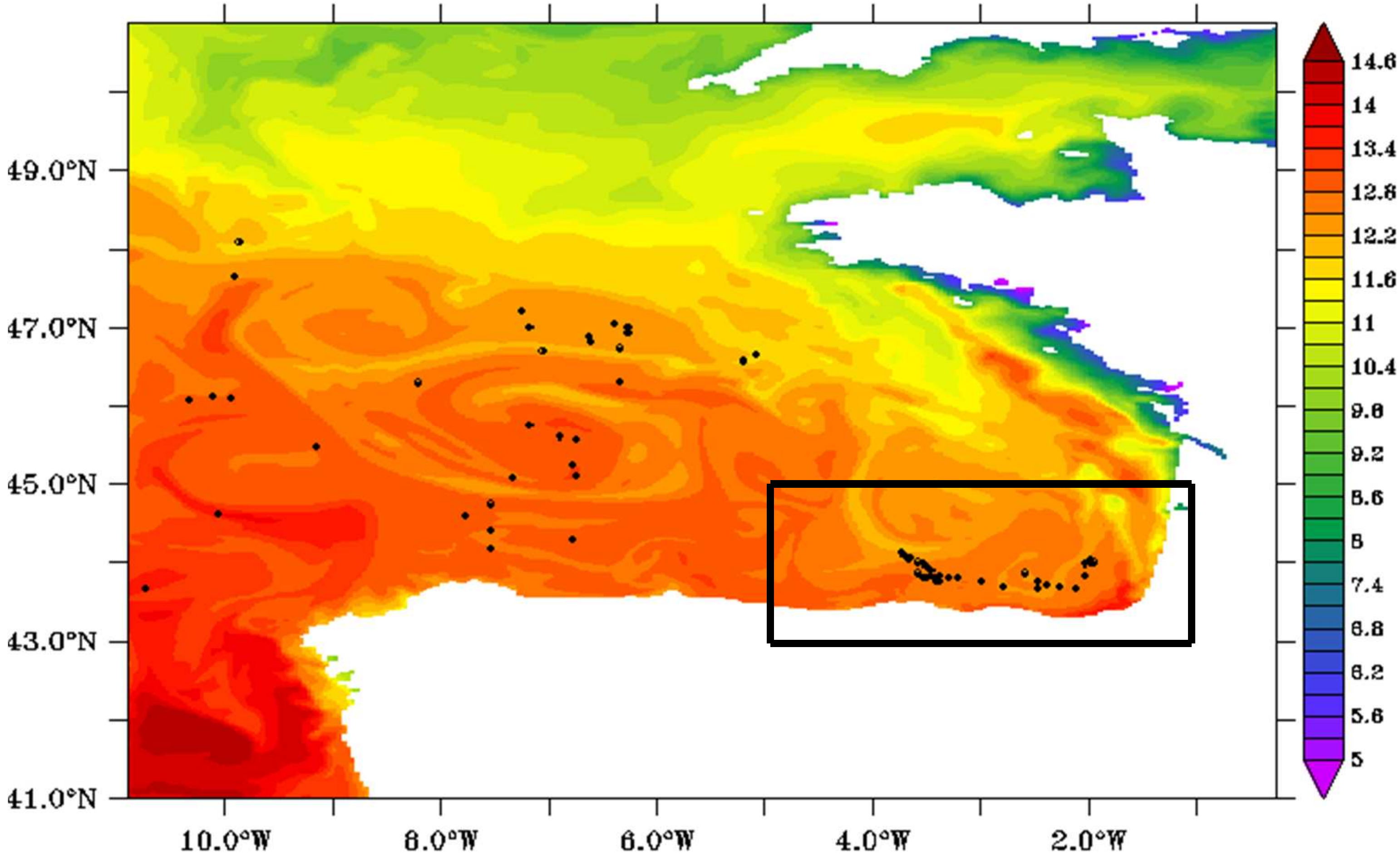


-Increase of the current vertical shear during the storm in both the model and data
- Underestimation of the current shear by the model at this location

Comparison with in situ T/S profiles

(EN3 dataset - Met Office Hadley Centre)

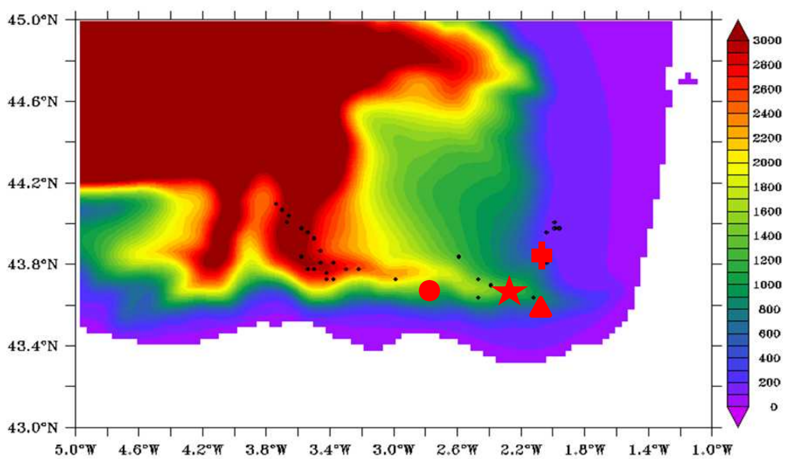
Available profiles for January 2009 (about 60 profiles)



Comparison with in situ T/S profiles
(EN3 dataset - Met Office Hadley Centre)

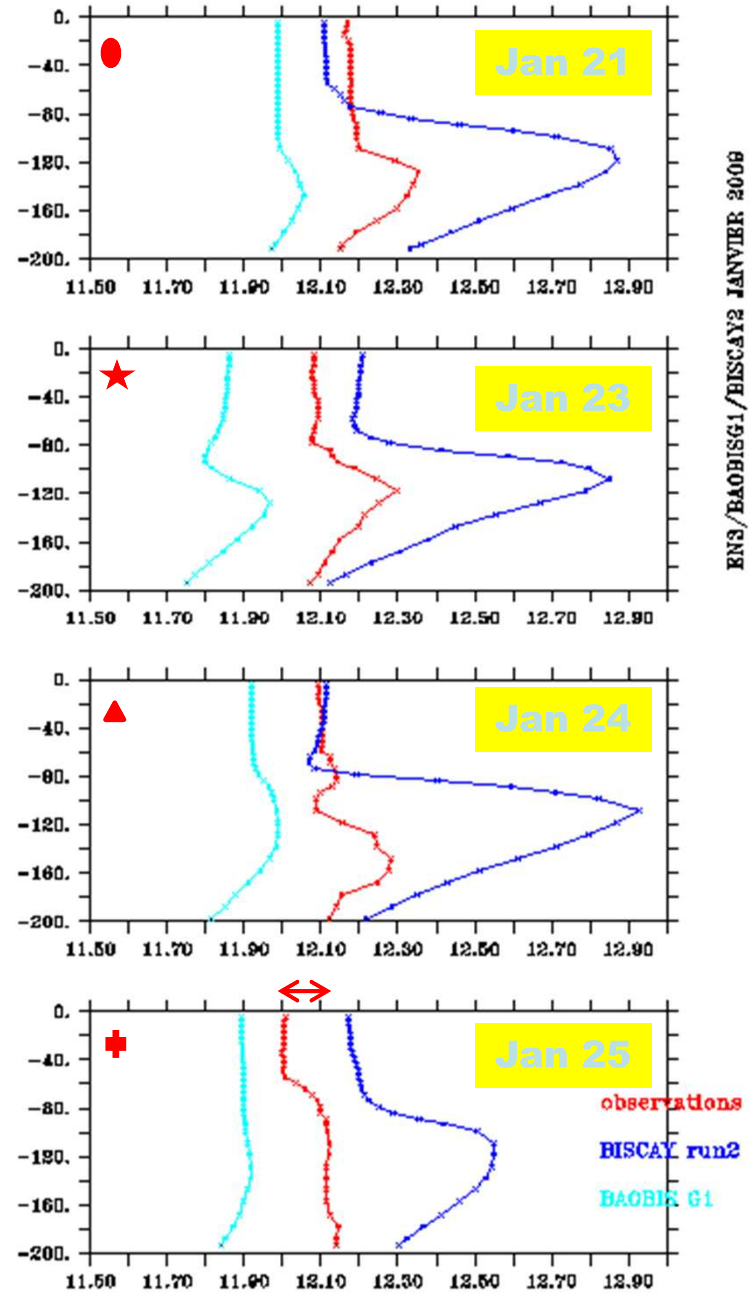
Temperature profiles:

- observations (red)
- simulation 1 (long run) (blue)
- simulation 2 (short run, enhanced mixing) (cyan)



Very slight cooling during the storm : 0.1°C in surface (above the error bar?)

Large sensitivity of the model to the mixing parameters and initial conditions



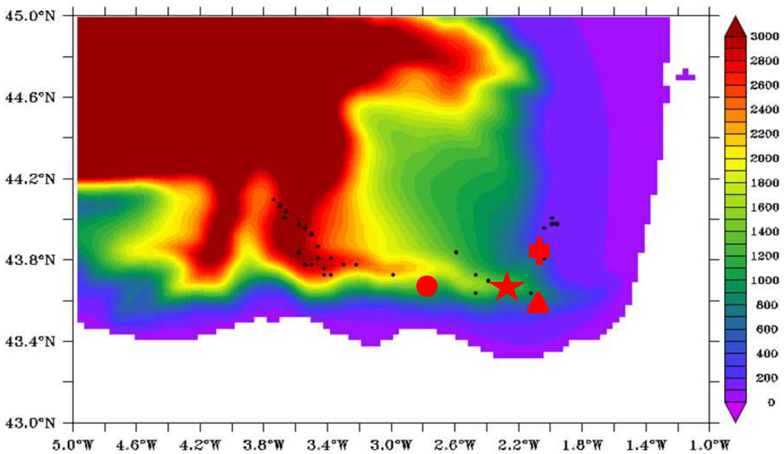
11.5°C 13°C

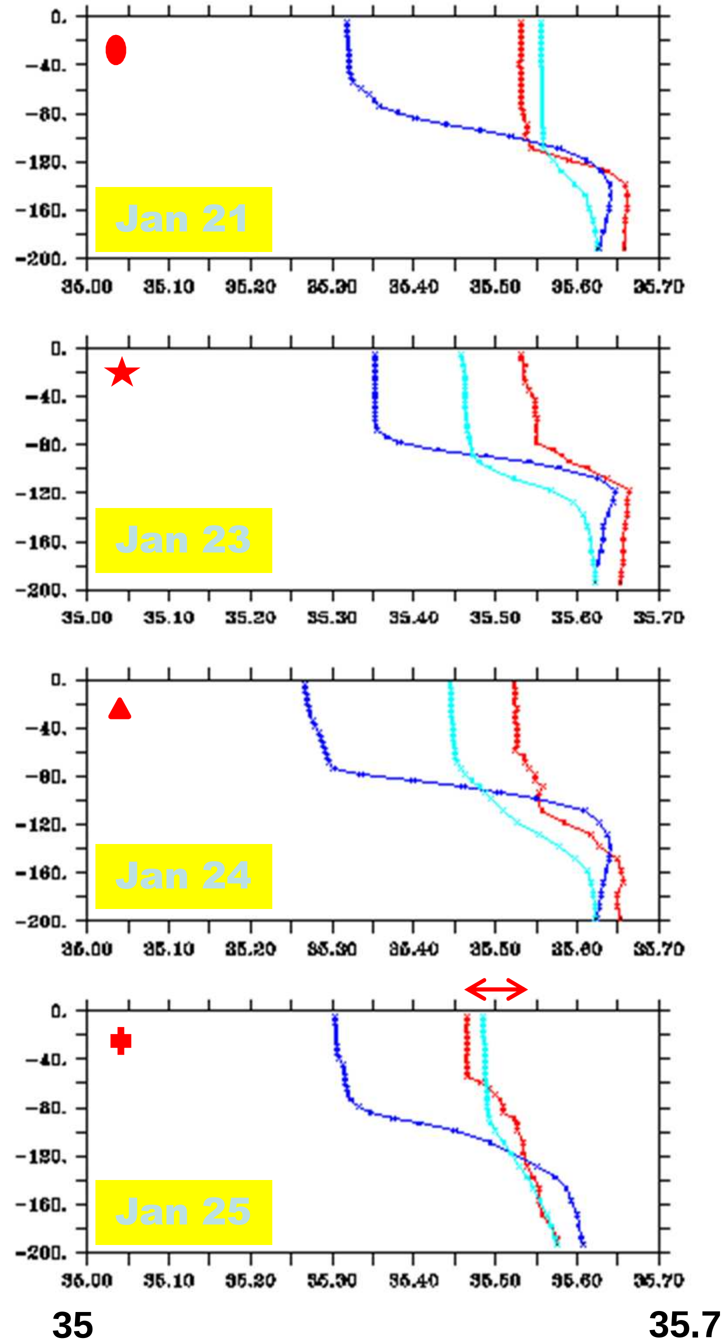
Comparison with in situ T/S profiles

(EN3 dataset - Met Office Hadley Centre)

Salinity profiles:

- observations (red line)
- simulation 1 (long run) (blue line)
- simulation 2 (short run, enhanced mixing) (cyan line)



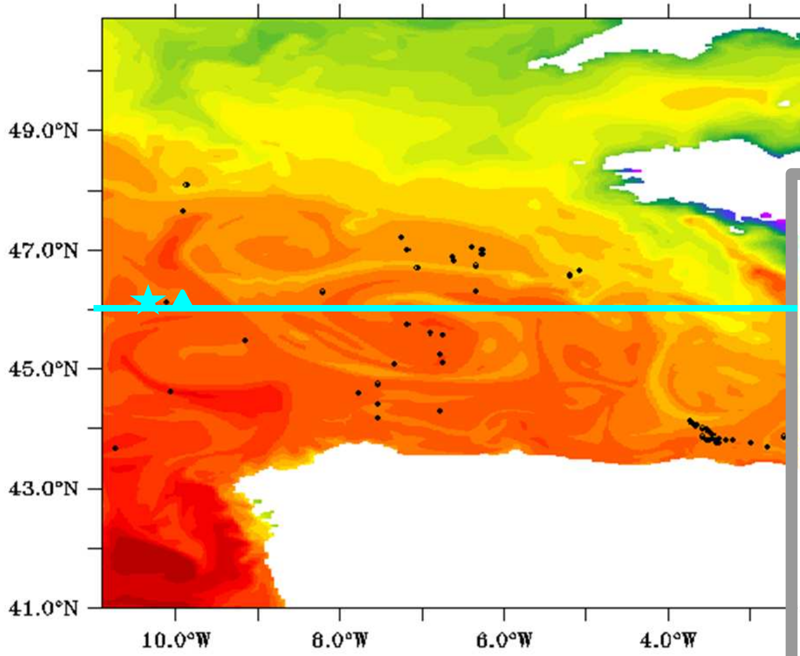


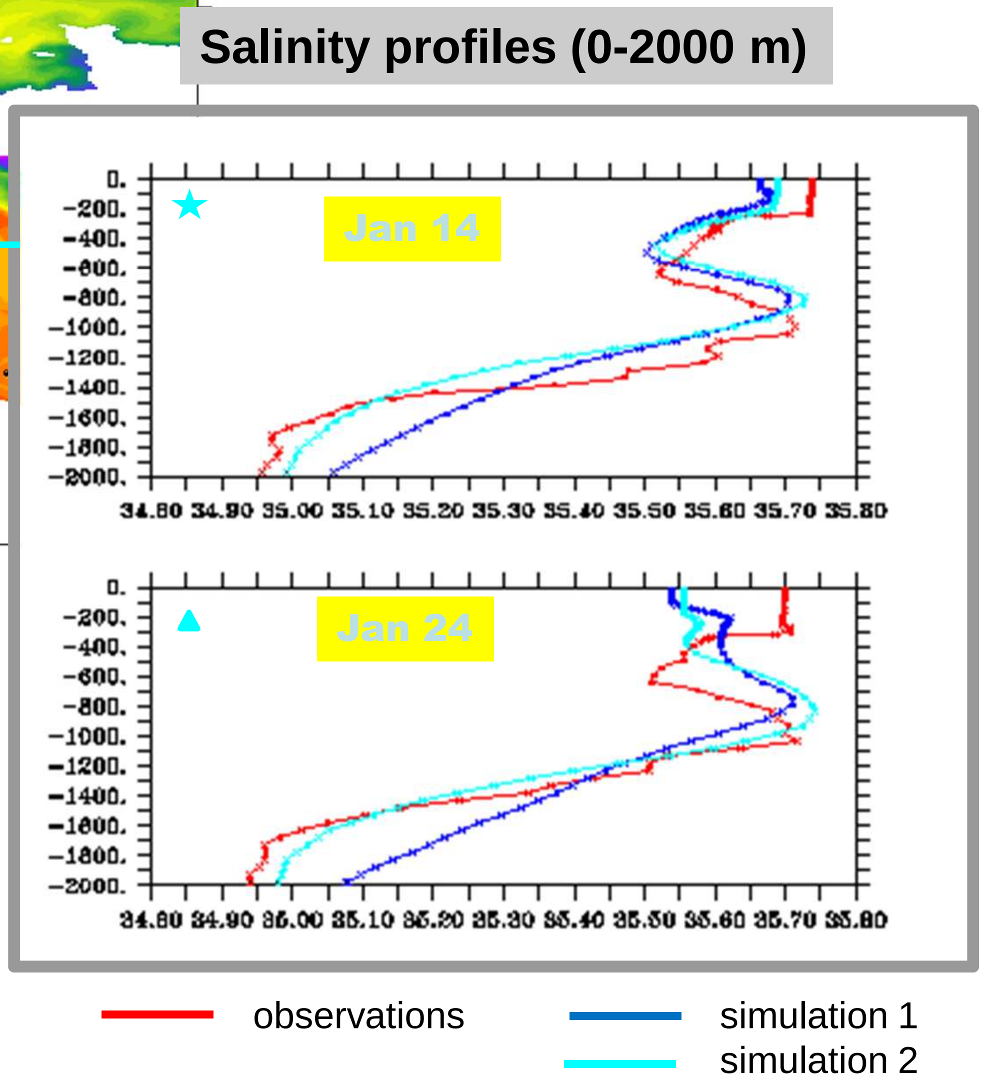
Very slight freshening during the storm :
0.05 in surface (above the error bar?)

Too weak SSS in simulation 1
→ impact on the temperature profile
→ due to a SSS bias in initial conditions (PSY2V3) and a too weak mixing?

Comparison with in situ T/S profiles

(EN3 dataset - Met Office Hadley Centre)



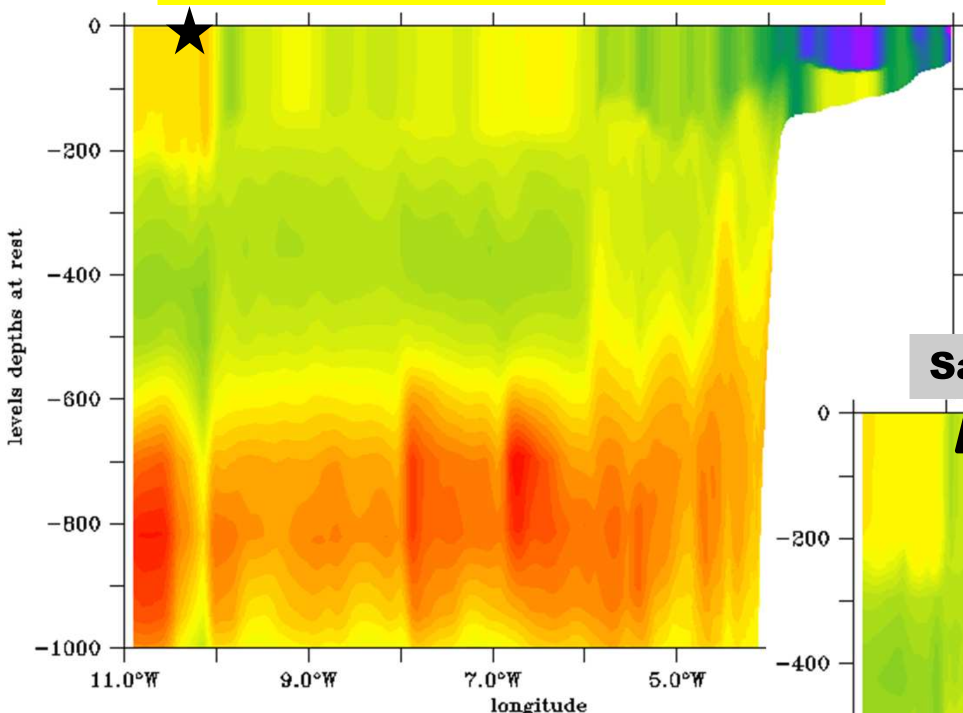


Very different profiles in the model down to ~600 m

- due to differences in date?
- due to differences in location?

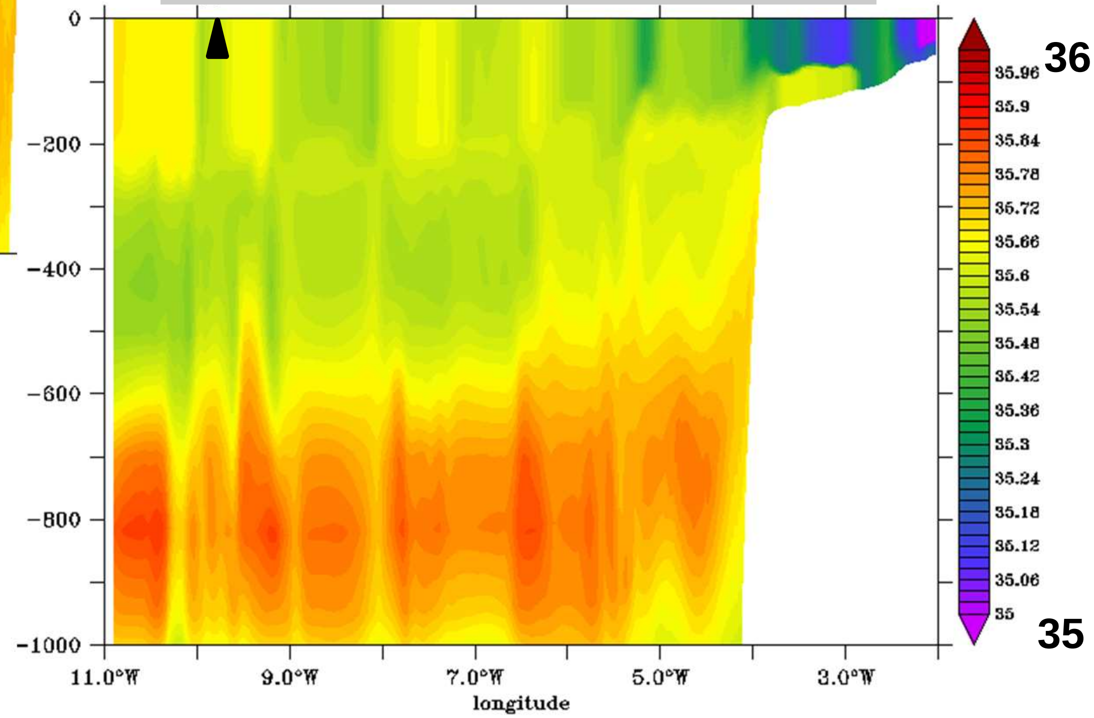
Comparison with in situ T/S profiles

Salinity profile at 46°N on Jan 14



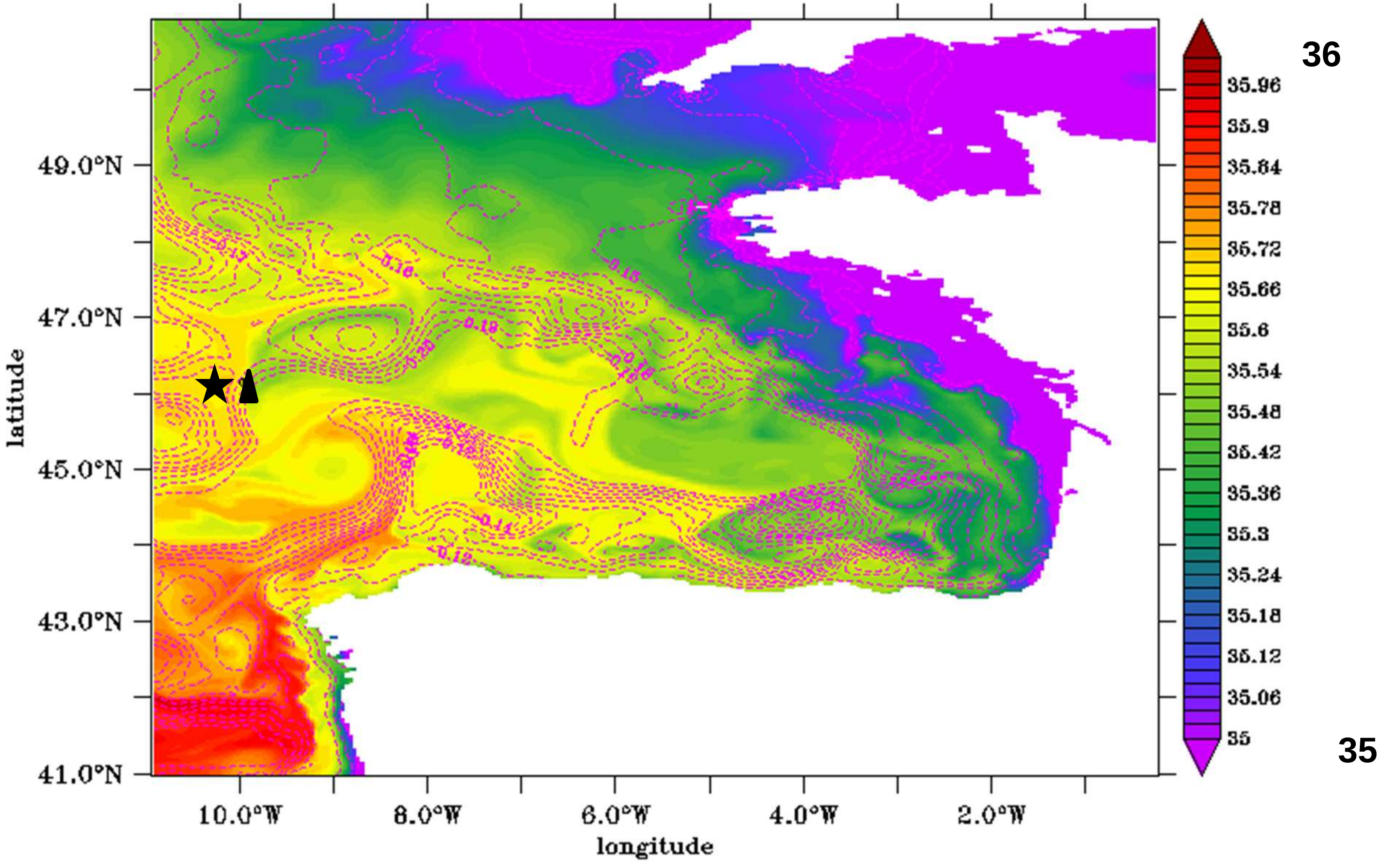
west of 9°W:
freshening and deepening of the mixed layer during the storm

Salinity profile at 46°N on Jan 24



The 2 profiles are sampled on both sides of a salinity front in the model probably associated with an eddy in the model

Model sea surface salinity on Jan 14 and SSH contours



CONCLUSION

Work in progress …

OCEAN RESPONSE FROM OBSERVATIONS AND MODEL

- **Weak temperature and salinity response** at Donostia and in the simulation: role of the previous wind gusts in mixing ?

- **Mixed layer depth deepens** by 150 meters locally.

- **10 cm surge** along the western and northern French coast: to be compared to tide gauges data (work in progress).

- **Generation of a strong eastward current** along northern Spanish coast

- **Increase of vertical current shear** at Donostia (weaker than in the observations though).

CONSISTENCY WITH OBSERVATIONS AND LIMITS OF THE MODEL

- **Good agreement with temperature and salinity** signature from mooring buoy data in surface and subsurface: main features of the observed temperature and salinity distribution and time variability well represented.

- **Bias in surface salinity** (rivers runoff and initial conditions)

PERSPECTIVES

- ❑ Investigate the processes involved in the surface layers mixing (vertical current shear, winds, role of inertial currents) and cooling (mixing, heat flux, river runoff…)

- ❑ Analyse the heat flux

- ❑ Explore the sensitivity of the model response to wind forcing