Spatial and Seasonal Distributions of Frontal Activity over the Continental Shelf in the Bay of Biscay Focus on Density Fronts in Winter

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Focus on Density Fronts in Winter

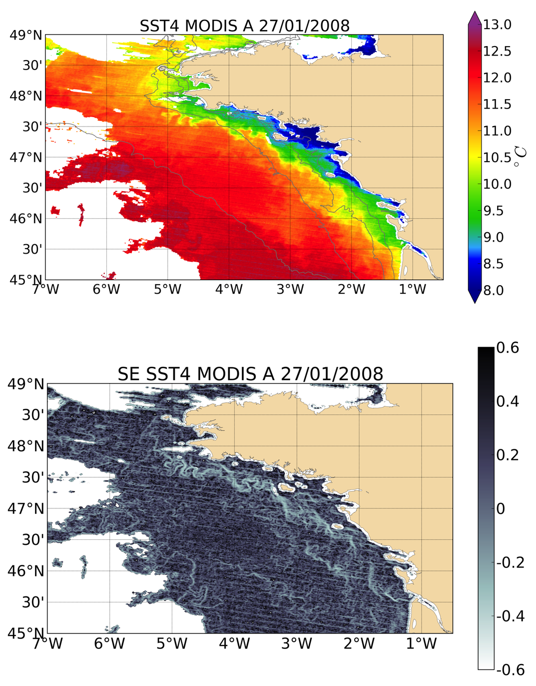
Özge Yelekçi[1] (ozge.yelekci@ifremer.fr), Guillaume Charria[1], Xavier Capet[2], Gilles Reverdin[2], Sébastien Theetten[1], Frédéric Vandermeirsch[1], Joël Sudre[3], Hussein Yahia[4]

[1]IFREMER/LOPS, France, [2]LOCEAN/IPSL, CNRS/UPMC/IRD/MNHN, France, [3]LEGOS, Université de Toulouse, CNES, CNRS, IRD, UPS, France, [4]GeoStat team, INRIA Bordeaux Sud-Ouest, France

AIMS

- Describing spatial and seasonal distributions of frontal activity over the continental shelf in the Bay of Biscay,
- Investigating the wintertime mid-shelf fronts in vicinity of the river plumes,
- Exploring the physical dynamics and the existence of baroclinic instabilities in such fronts from a scale decomposition of the vertical buoyancy flux.

FRONTAL ACTIVITY - OBSERVED VIA SATELLITE



Product: MODIS Aqua & Terra, Level-2, nighttime sea surface temperature (SST)
Resolution: ~1 km, daily
Period: 2003 - 2013

Singularity Exponent (SE)
A diagnostic for front detection:
A measure of the degree of regularity or irregularity of a function [1].
−SE → stronger frontal activity
+SE → weak frontal activity
Frontal pixel: $-0.2 \geq SE \geq -0.6$

Figure 1 : MODIS SST and SE field on 27/01/2008.

Front occurence frequency:

$$\frac{\#\text{ of times frontal pixel}}{\#\text{ of times cloud free}} \times 100$$

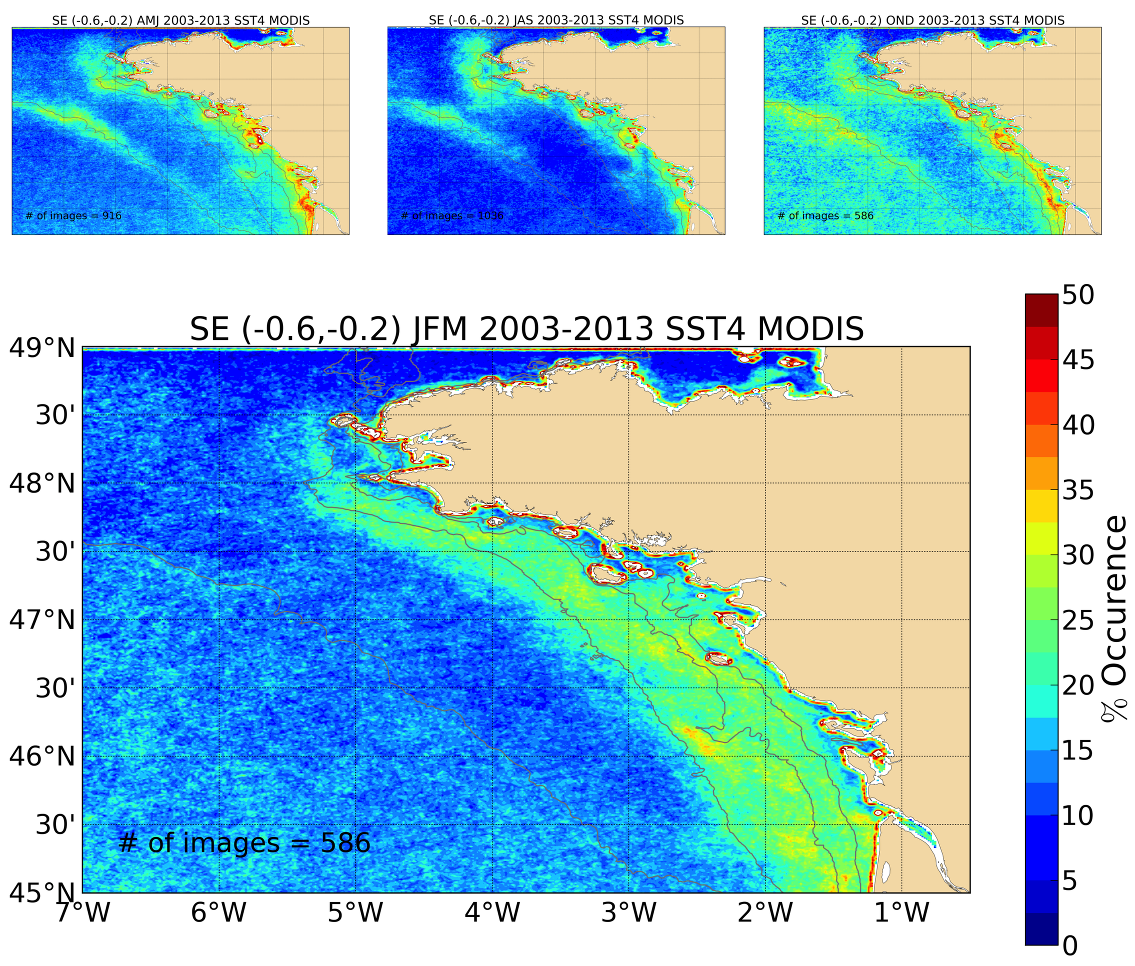


Figure 2 : Front occurrence frequency in spring, summer, autumn, and **winter**.

Seasonal & spatial variabilities of frontal activity

- Previously well-known tidal fronts and internal tidal wave induced shelf break front during thermally stratified months.

Winter maximum over the shelf:

- From mid-autumn to mid-spring, along a band between 30 - 100 m isobaths,
- Density fronts at northward propagating river plumes confined along the coast,
- Sustained by the downwelling-favorable winds and surface cooling,
- Average cross-front gradient of 2 °C km^{-1},
- Locally increased at the offshore edges of islands.

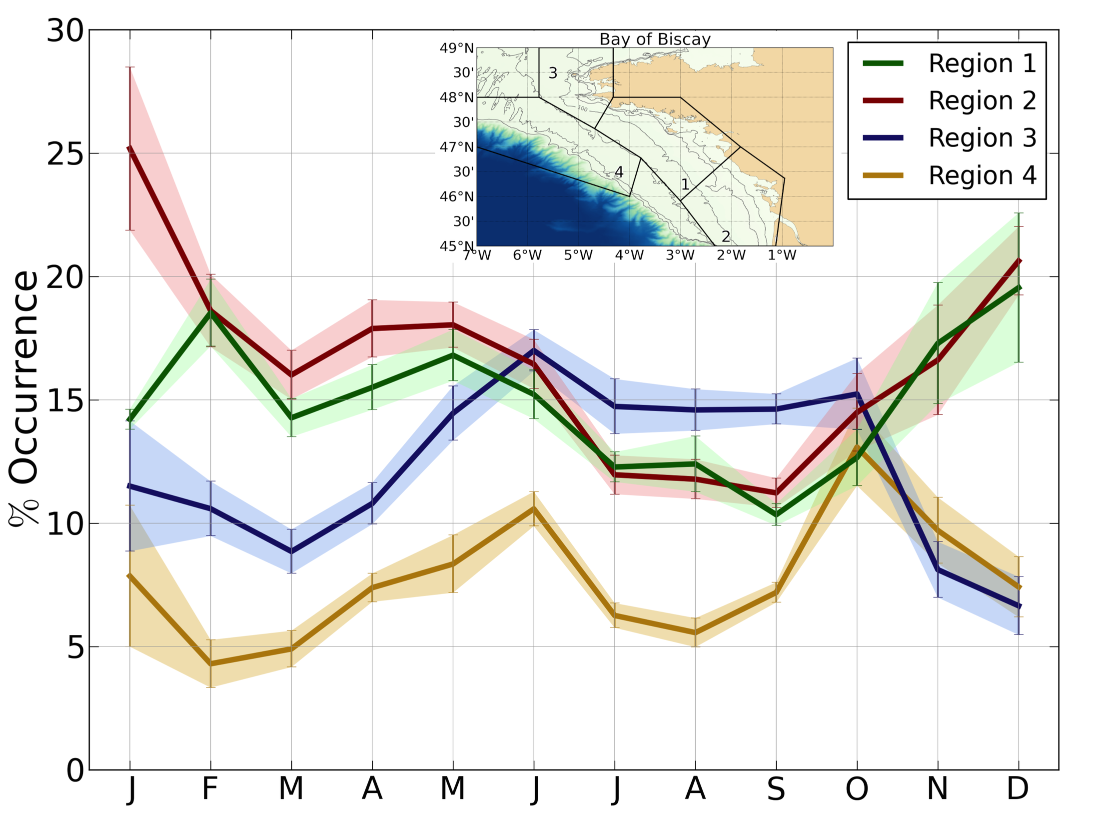


Figure 3 : Monthly averaged front occurrence frequency in each of the regions defined. Error bars represent $\sigma/n^{1/2}$ centered around the average, σ = standard deviation, and n = number of independent images.

FRONTAL ACTIVITY - NUMERICAL MODELLING

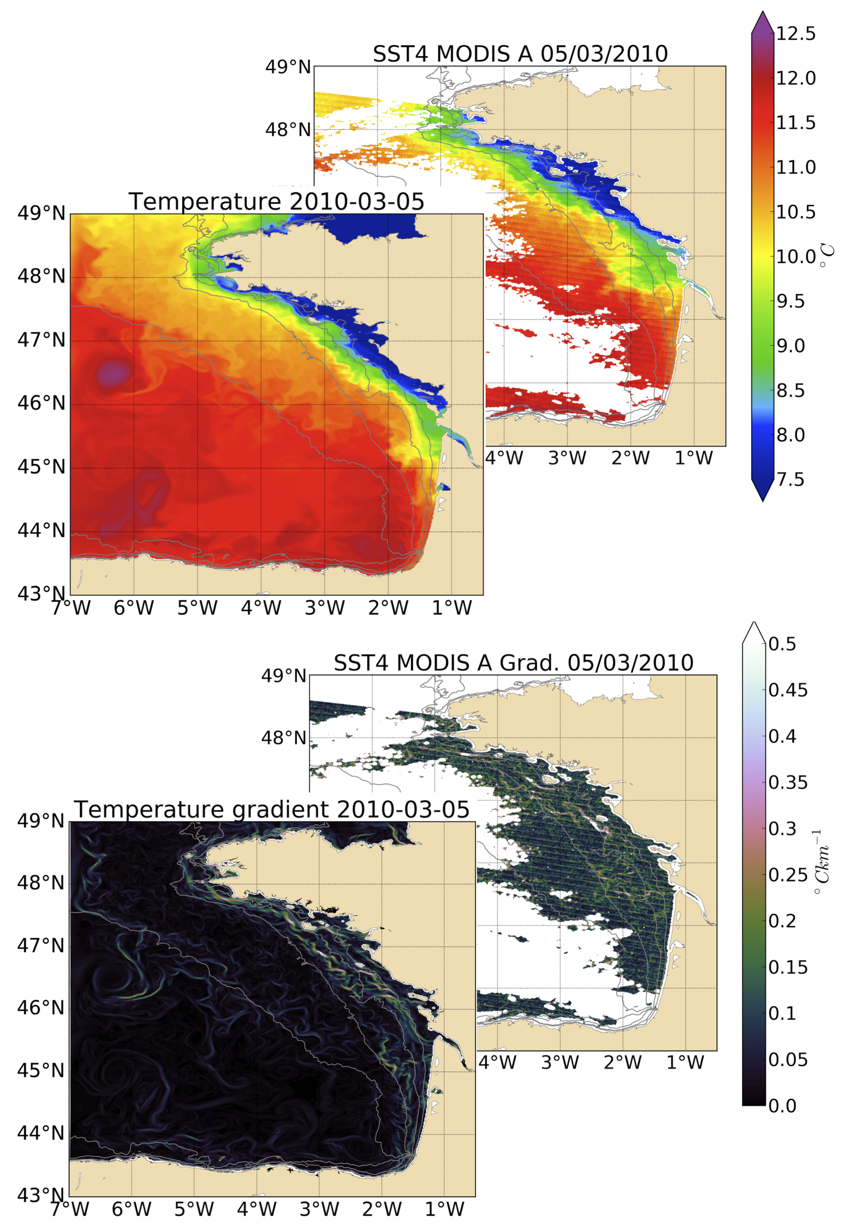


Figure 4 : Modelled & observed SST and SST gradient on 05/03/2010.

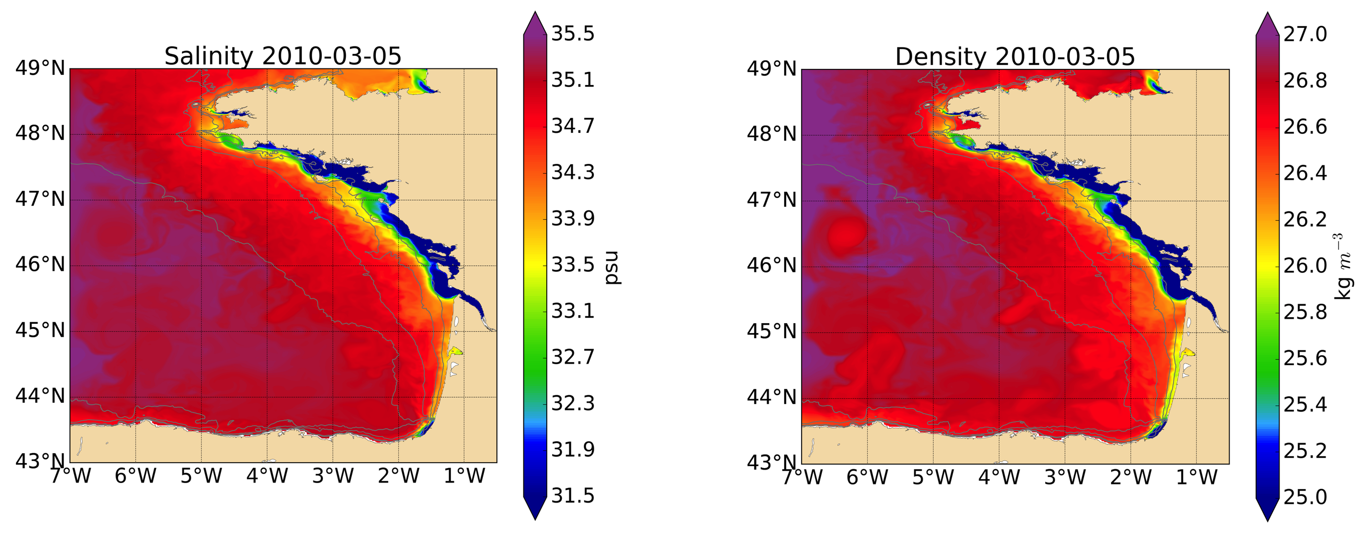


Figure 5 : Modelled sea surface salinity and density on 05/03/2010.

MARS3D Model Set-up

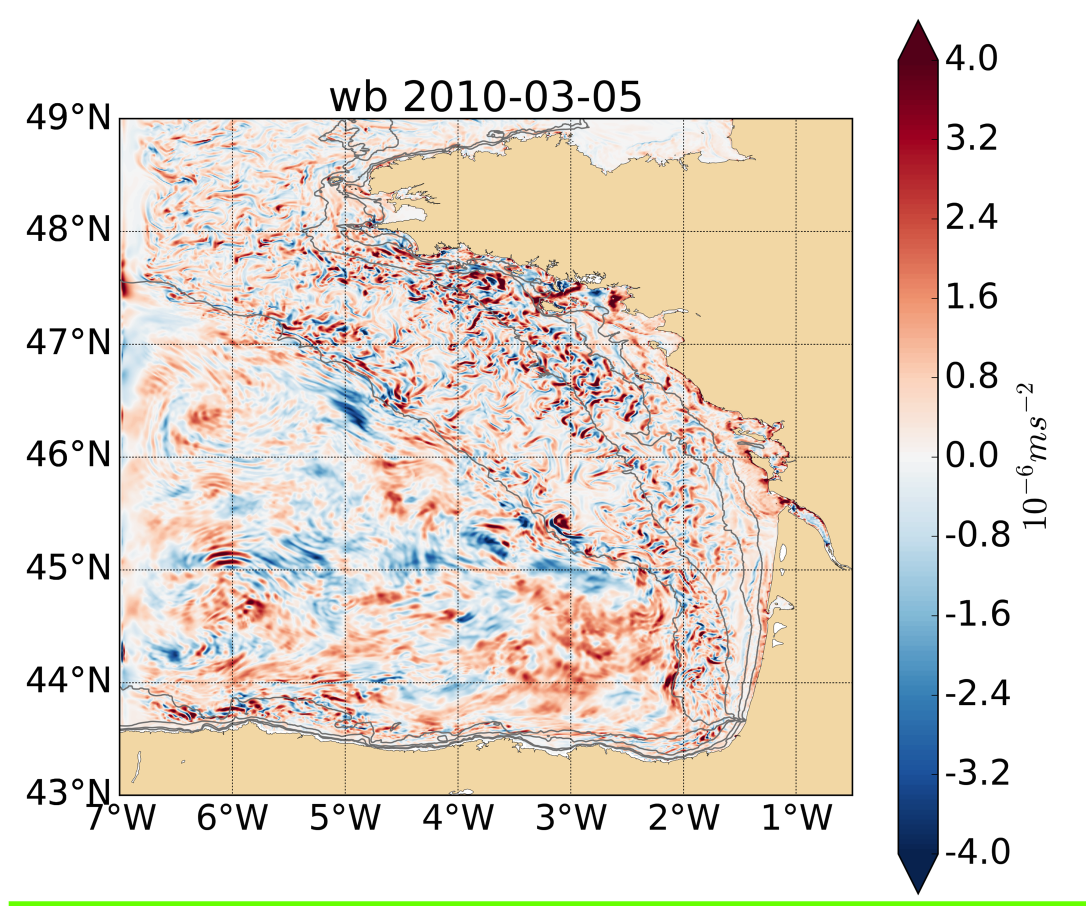
2008 Spin-up 2009 → 2010

- Configuration adapted for the Bay of biscAy and the English CHannel (BACH) [2],
- $\Delta x = \Delta y$ = 1 km, 40 σ-layers,
- **Atmospheric forcings:** ARPEGE HR Meteorological model output, 0.1° [3],
- **Rivers:** CDOCO (Data Center for French Coastal Operational Oceanography) dataset, daily,
- **Initial & open boundary cond.:** ORCA12-MJM88 global simulation, 1/12° [4],
- Runs on Bull super-computer OCCIGEN in CINES (https://www.cines.fr).

SCALE DECOMPOSITION

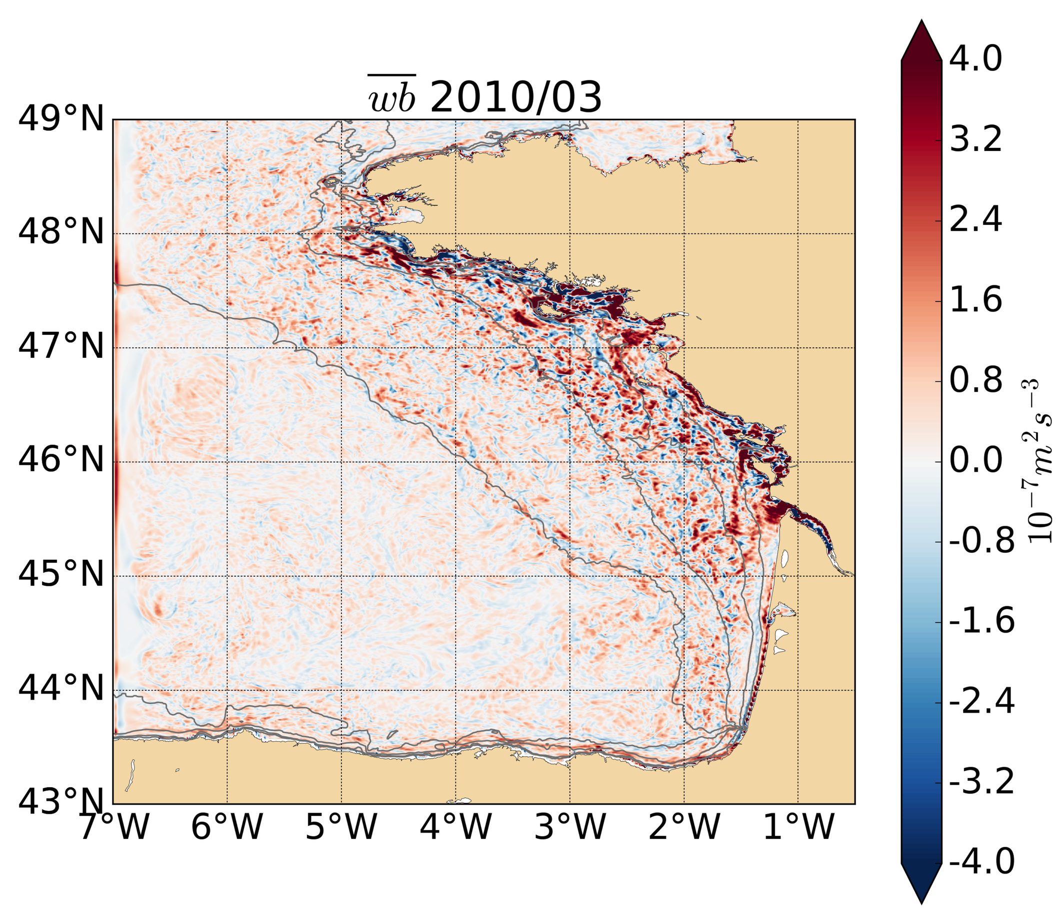
$$V = \bar{V} + \underbrace{(\tilde{V} - \bar{V})}_{V'} + \underbrace{(V - \tilde{V})}_{V''} \quad [5]$$

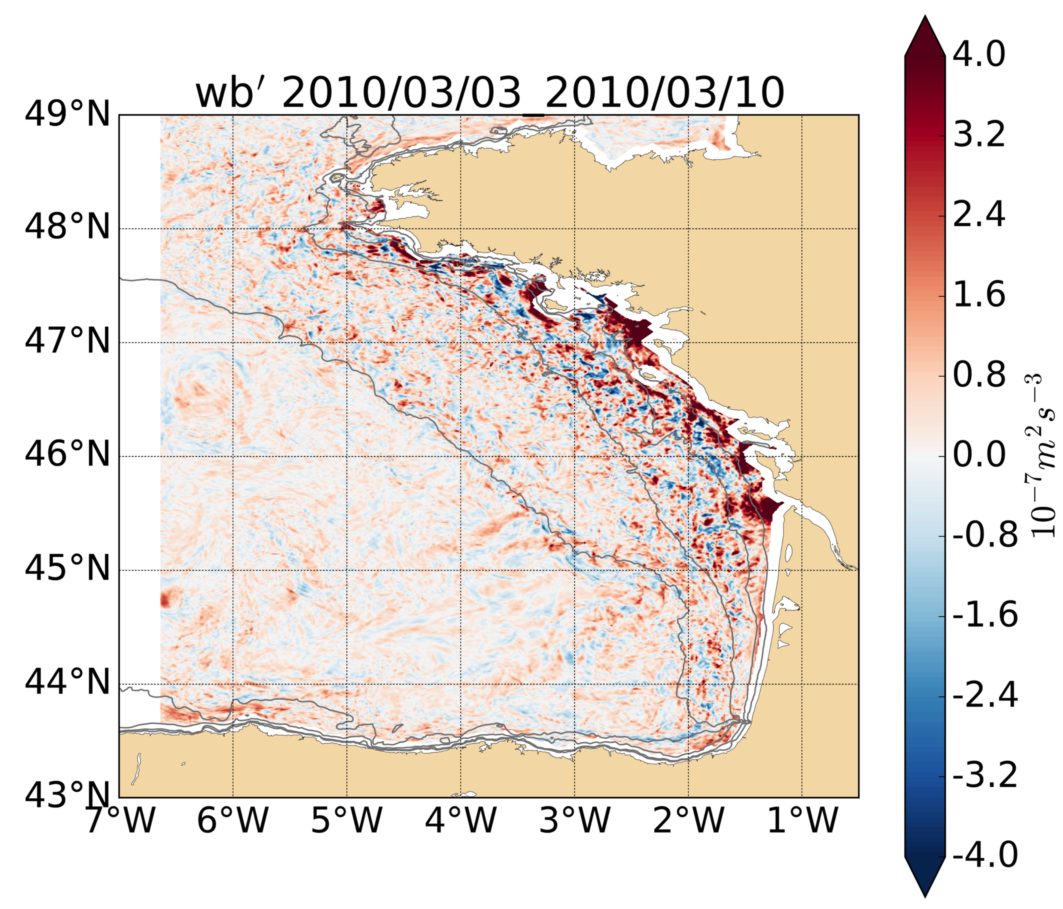
$\bar{V}$: very low-pass filtered, monthly average in time,
$\tilde{V}$: medium low-pass filtered, weekly average & 8 × 5-point smoothed in space (~ 10 km → shelf mesoscale),
V′: mesoscale component,
V″: (sub)mesoscale component.



wb: Vertical buoyancy flux

- Available potential to kinetic energy conversion at density fronts,
- Baroclinic instabilities in vicinity of the river plumes





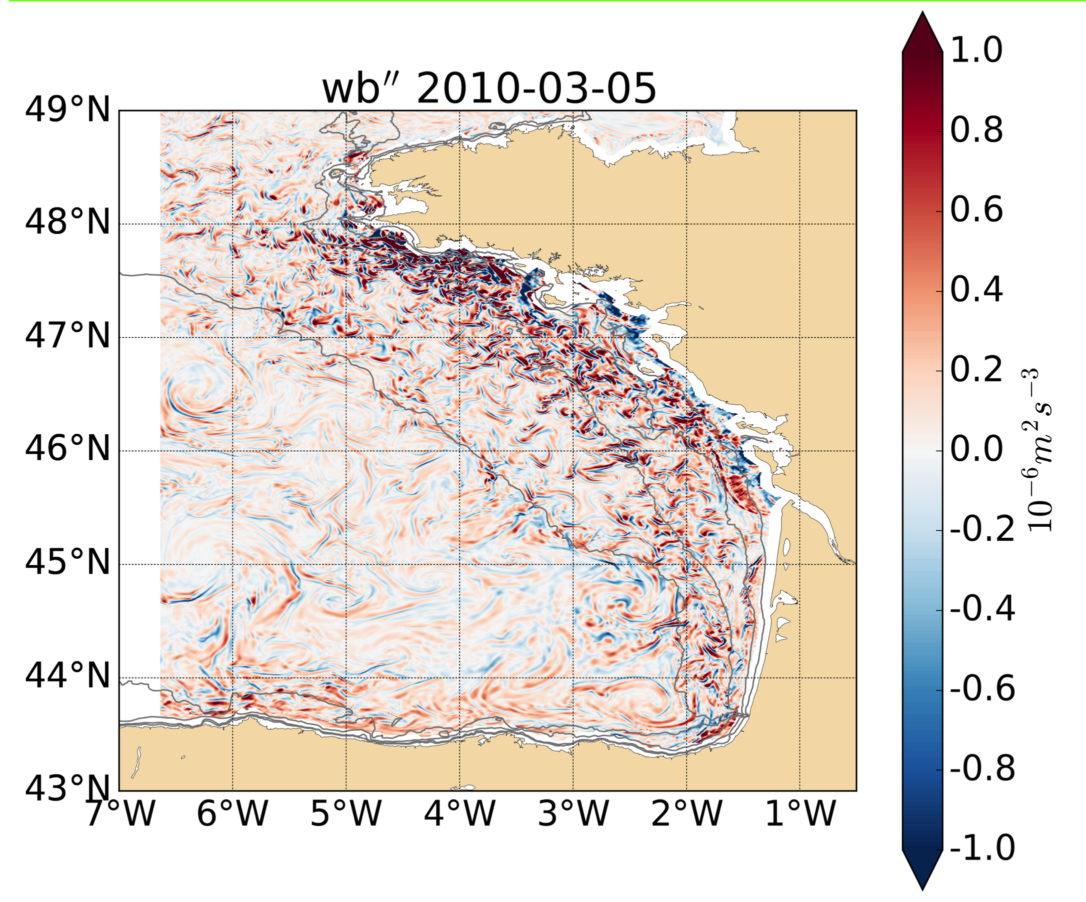


Figure 6 : Modelled vertical buoyancy flux, its mean, meso-, and (sub)mesoscale components on 05/03/2010.

CONCLUSIONS:

- Plume fronts, driven by the increased fresh water input, wind stress, and air-sea fluxes, dominate the frontal activity over the shelf in winter,
- (sub)mesoscale component, w″b″, prevails in vicinity of these fronts,
- Instabilities occur at the plume fronts and at a succession of weaker fronts inside the plumes,
- Spatial variability of w″b″ along the plumes: topography, tides, and atmospheric forcings are potential influences.

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