HAL
open science

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

Özge Yelekçi, Guillaume Charria, Xavier Capet, Gilles Reverdin, Sébastien Theetten, Frédéric Vandermeirsch, Joël Sudre, Hussein Yahia

To cite this version:

Özge Yelekçi, Guillaume Charria, Xavier Capet, Gilles Reverdin, Sébastien Theetten, et al.. Spatial and Seasonal Distributions of Frontal Activity over the Continental Shelf in the Bay of Biscay Focus on Density Fronts in Winter. 2016 AGU Ocean Science Meeting, Feb 2016, New Orleans, United States. , 2016. hal-01275158

HAL Id: hal-01275158

https://inria.hal.science/hal-01275158

Submitted on 16 Feb 2016

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Spatial and Seasonal Distributions of Frontal Activity over the Continental Shelf in the Bay of Biscay

Focus on Density Fronts in Winter

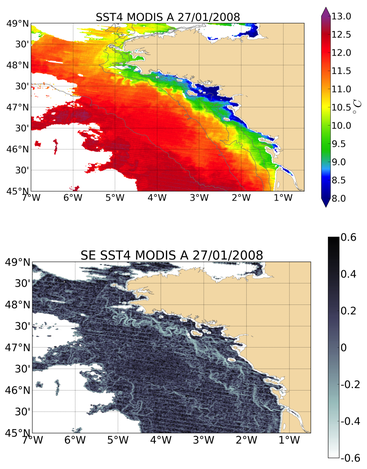
Özge Yelekçi[1] (ozge.yelekci@ifremer.fr), Guillaume Charria[1], Xavier Capet[2], Gilles Reverdin[2], Sébastien Theetten[1], Frédéric Vandermeirsch[1], Joël Sudre[3], Hussein Yahia[4]

[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:

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

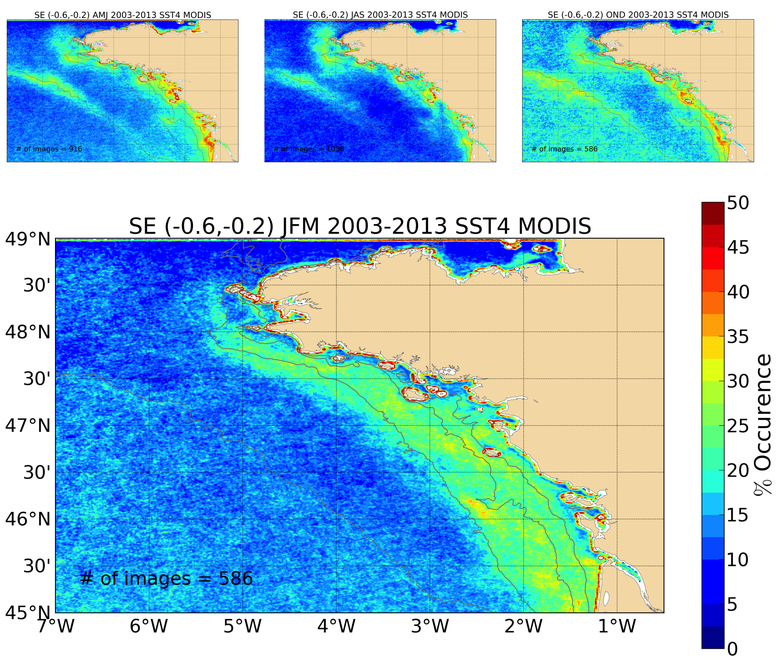


Figure 2 : Front occurrence frequency in spring, summer, autumn, and **winter**.

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.

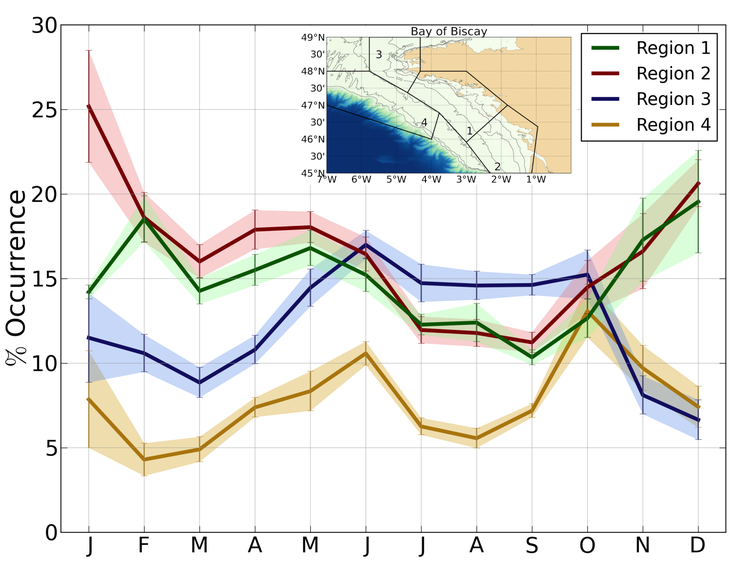


Figure 3 : Monthly averaged front occurrence frequency in each of the regions defined. Error bars represent $\sigma/n^{1/2}$ centered around the average, σ = standard deviation, and n = number of independent images.

FRONTAL ACTIVITY - NUMERICAL MODELLING

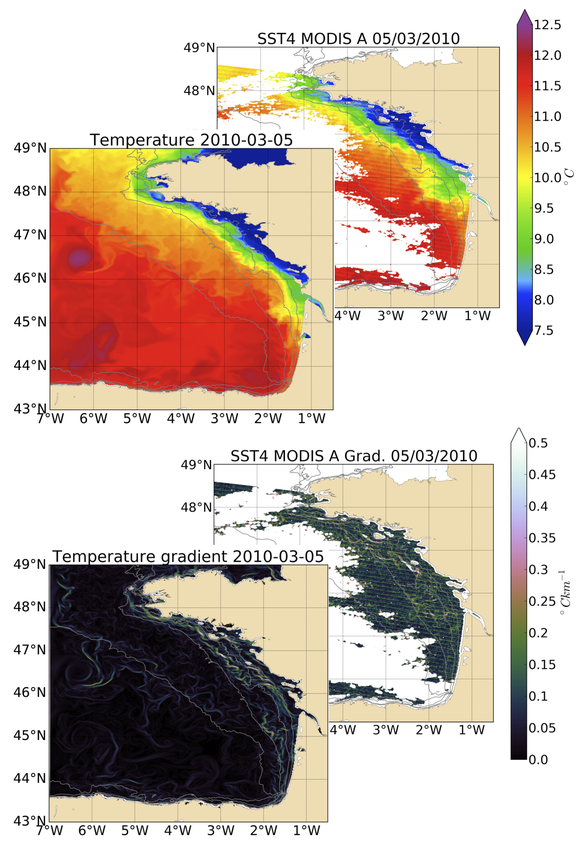


Figure 4 : Modelled & observed SST and SST gradient on 05/03/2010.

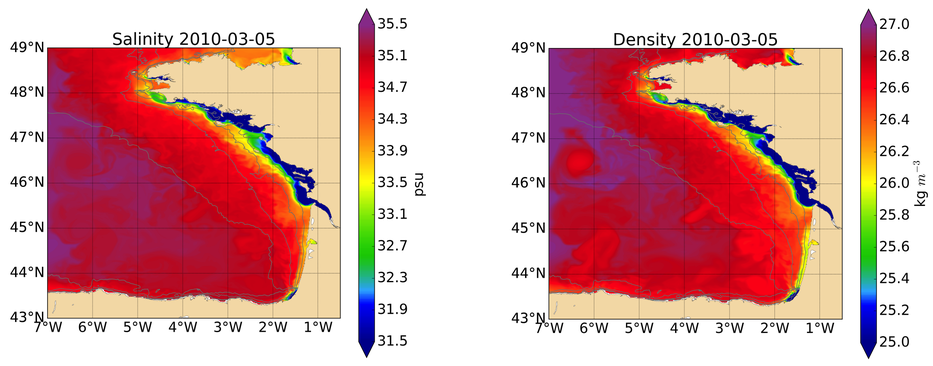


Figure 5 : Modelled sea surface salinity and density on 05/03/2010.

MARS3D Model Set-up

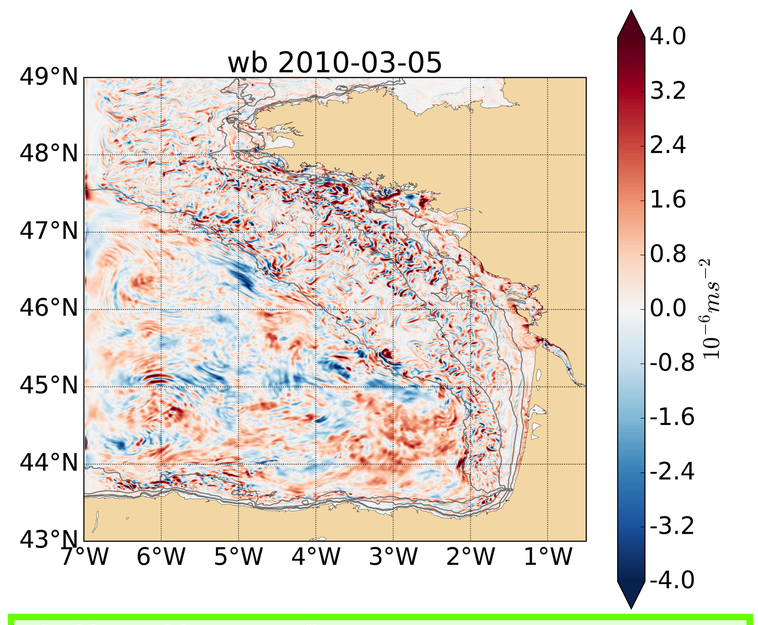
2008 Spin-up 2009 → 2010

- 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

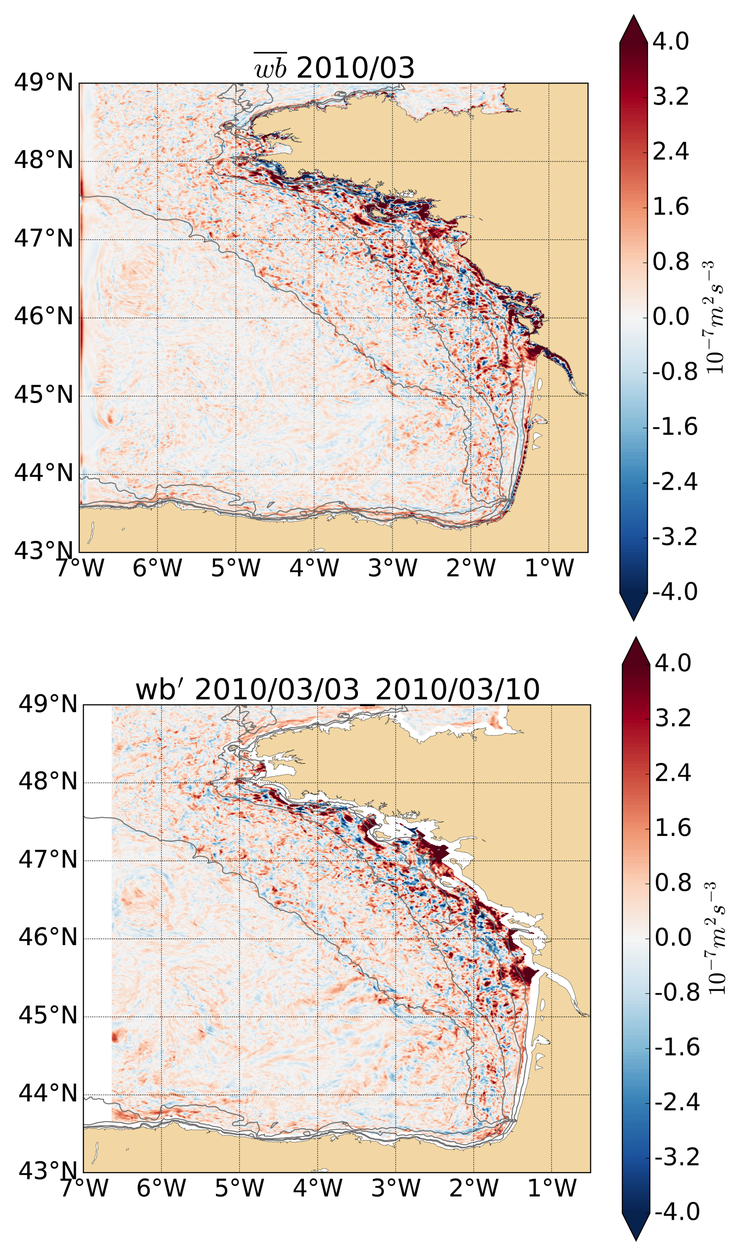
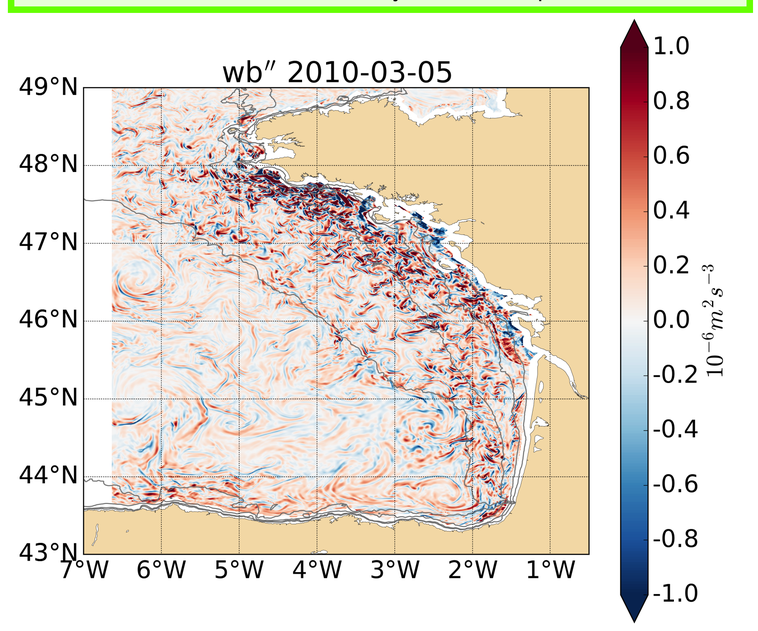


Figure 6 : Modelled vertical buoyancy flux, its mean, meso-, and (sub)mesoscale components on 05/03/2010.



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.

Acknowledgements: This study is part of the LEFE/GMMC project ENIGME. The funding is provided for the Ph.D. study of Ö. Yelekçi by Brittany region and IFREMER.

References:

[1] H. Yahia, J.Sudre, C.Pottier, and V.Garçon. Motion analysis in oceanographic satellite images using multiscale methods and the energy cascade. Pattern Recognition, 43(10):3591–3604, October 2010.

[2] F.Vandermeirsch, S.Theetten, G.Charria, O.Yelekci, and N.Audiffren. Interannual evolutions of (sub)mesoscale dynamics in the Bay of Biscay. In prep.

[3] M.Déqué, C.Dreveton, A.Braun, and D.Cariolle. The ARPEGE/IFS atmosphere model: a contribution to the French community climate modelling. Climate Dynamics, 10(4-5):249–266, 1994.

[4] J.M. Molines, B.Barnier, T.Penduff, A.M.Treguier, and J.LeSommer. ORCA12.L46 climatological and interannual simulations forced with DFS4.4: GJM02 and MJM88. The DRAKKAR Group, Experiment report LGGE-DRA, 2014.

[5] X.Capet, J.C.McWilliams, M.J.Molemaker, and A.F.Shchepetkin. Mesoscale to Submesoscale Transition in the California Current System. Part I: Flow Structure, Eddy Flux, and Observational Tests. Journal of Physical Oceanography, 38(1):29–43, January 2008.