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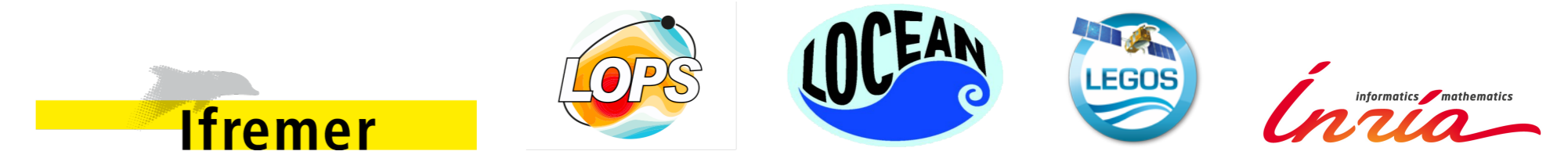
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Spatial and Seasonal Distributions of Frontal Activity over the Continental Shelf in the Bay of Biscay

Focus on Density Fronts in Winter

Özge Yeleği¹ (ozge.yeleki@ifremer.fr), Guillaume Charria¹, Xavier Capet², Gilles Reverdin², Sébastien Theetten¹, Frédéric Vandermeersch¹, Joël Sudre³, Hussein Yahia⁴

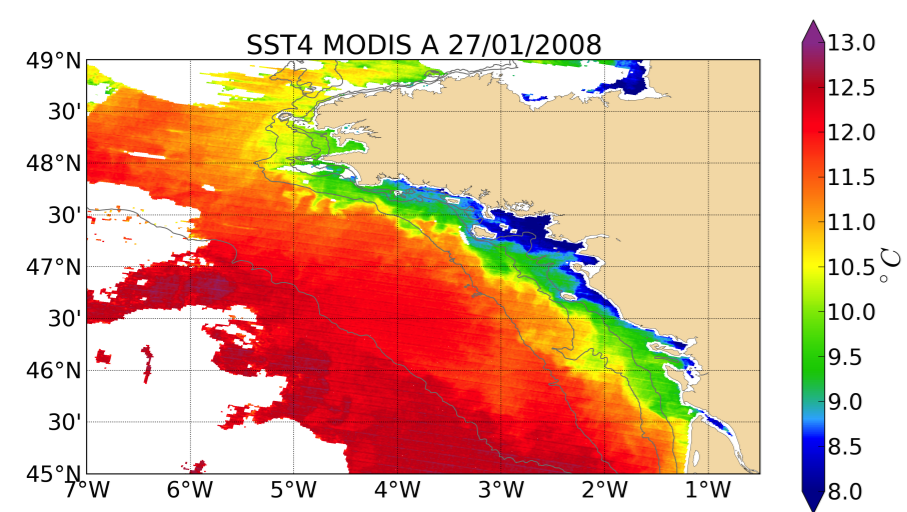
¹IFREMER/LOPS, France, ²LOCEAN/IPSL, CNRS/UPMC/IRD/MNHN, France, ³LEGOS, Université de Toulouse, CNES, CNRS, IRD, UPS, France, ⁴GeoStat team, INRIA Bordeaux Sud-Ouest, France



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 occurrence frequency:

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

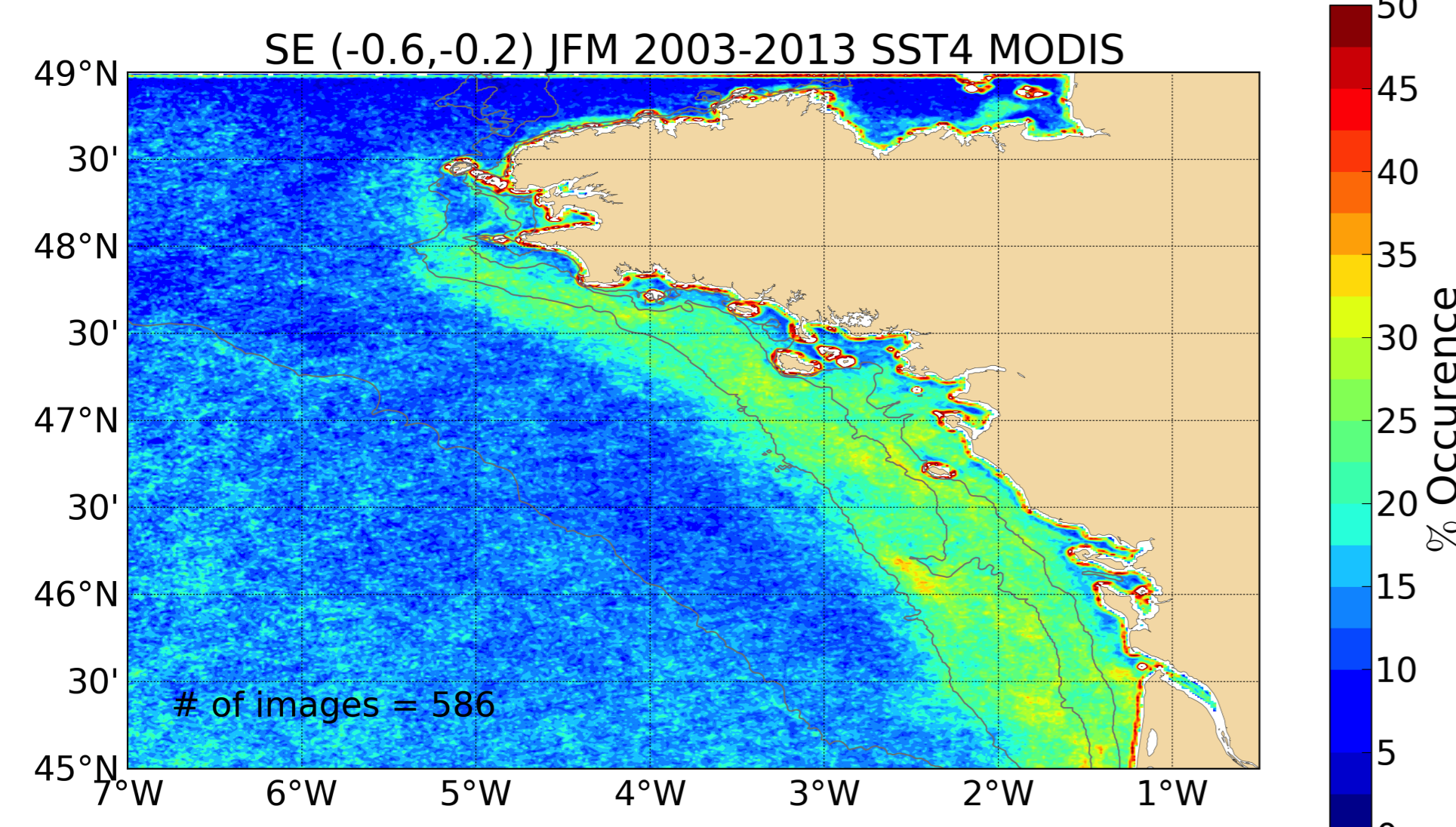
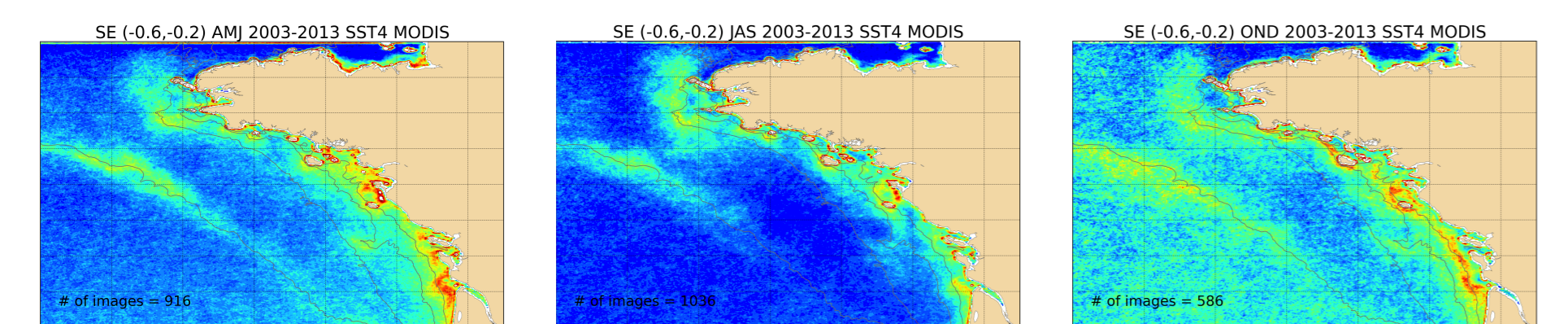


Figure 2: Front occurrence frequency in spring, summer, autumn, and winter.

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.

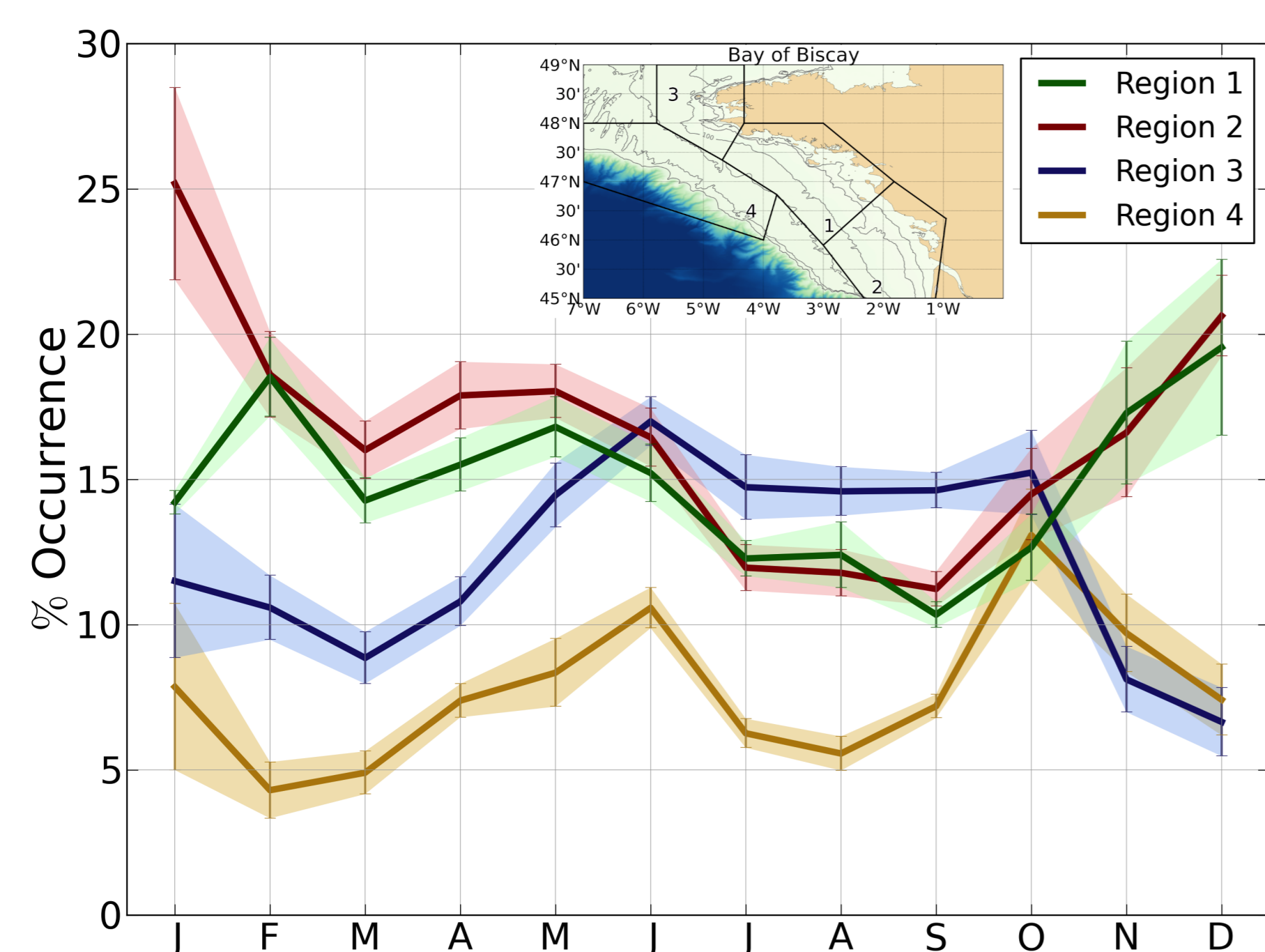


Figure 3: Monthly averaged front occurrence frequency in each of the regions defined. Error bars represent $\sigma/n^{1/2}$ centered around the average, σ = standard deviation, and n = number of independent images.

FRONTAL ACTIVITY - NUMERICAL MODELLING

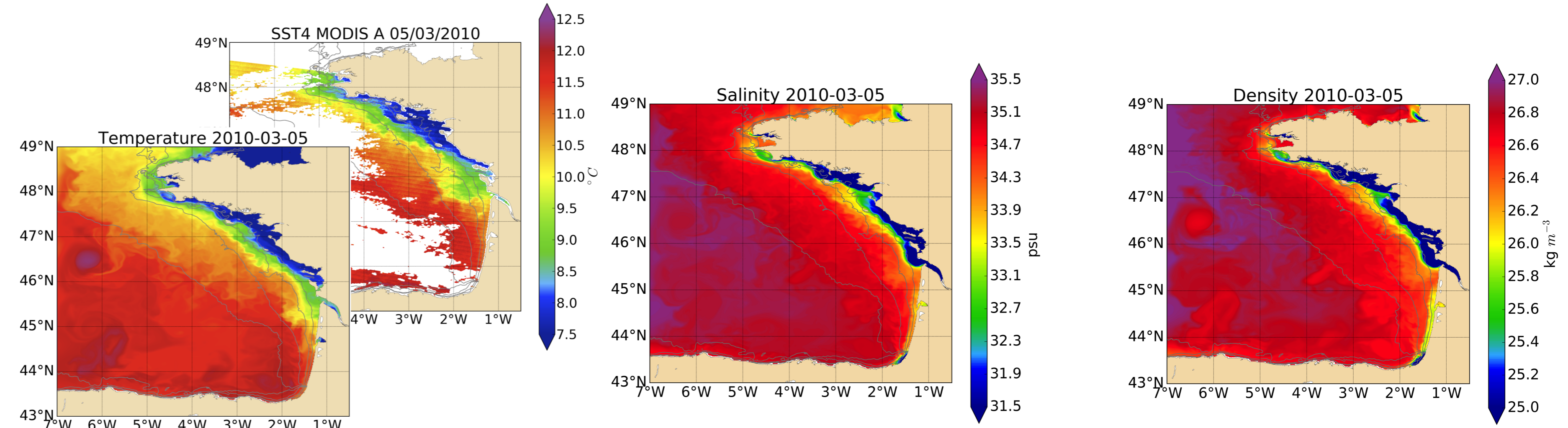


Figure 5: Modelled sea surface salinity and density on 05/03/2010.

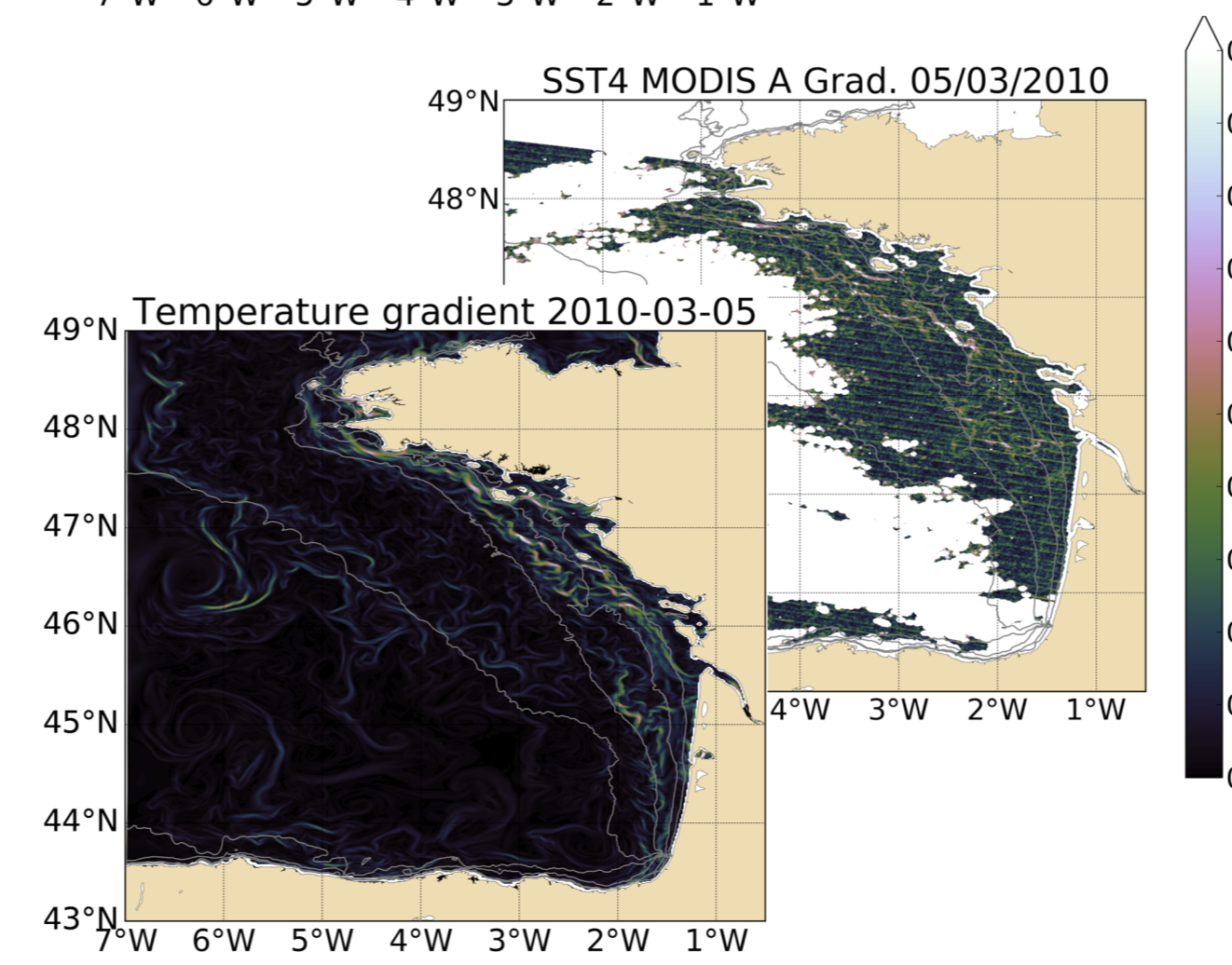
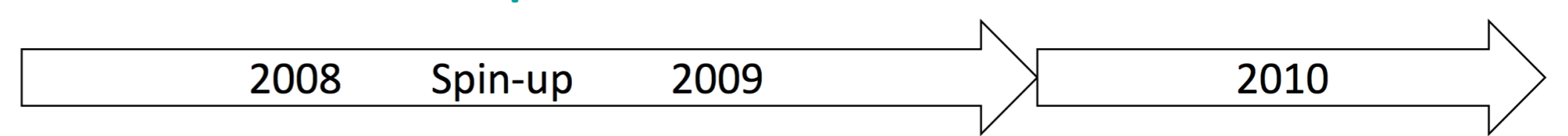


Figure 4: Modelled & observed SST and SST gradient on 05/03/2010.

MARS3D Model Set-up



- Configuration adapted for the Bay of Biscay and the English Channel (BACH) [2],
- $\Delta x = \Delta y = 1 \text{ km}$, 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, $1/12^\circ$ [4],
- Runs on Bull super-computer OCCIGEN in CINES (<https://www.cines.fr>).

SCALE DECOMPOSITION

$$V = \bar{V} + \underbrace{(\tilde{V} - \bar{V})}_{V'} + \underbrace{(V - \tilde{V})}_{V''}$$

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

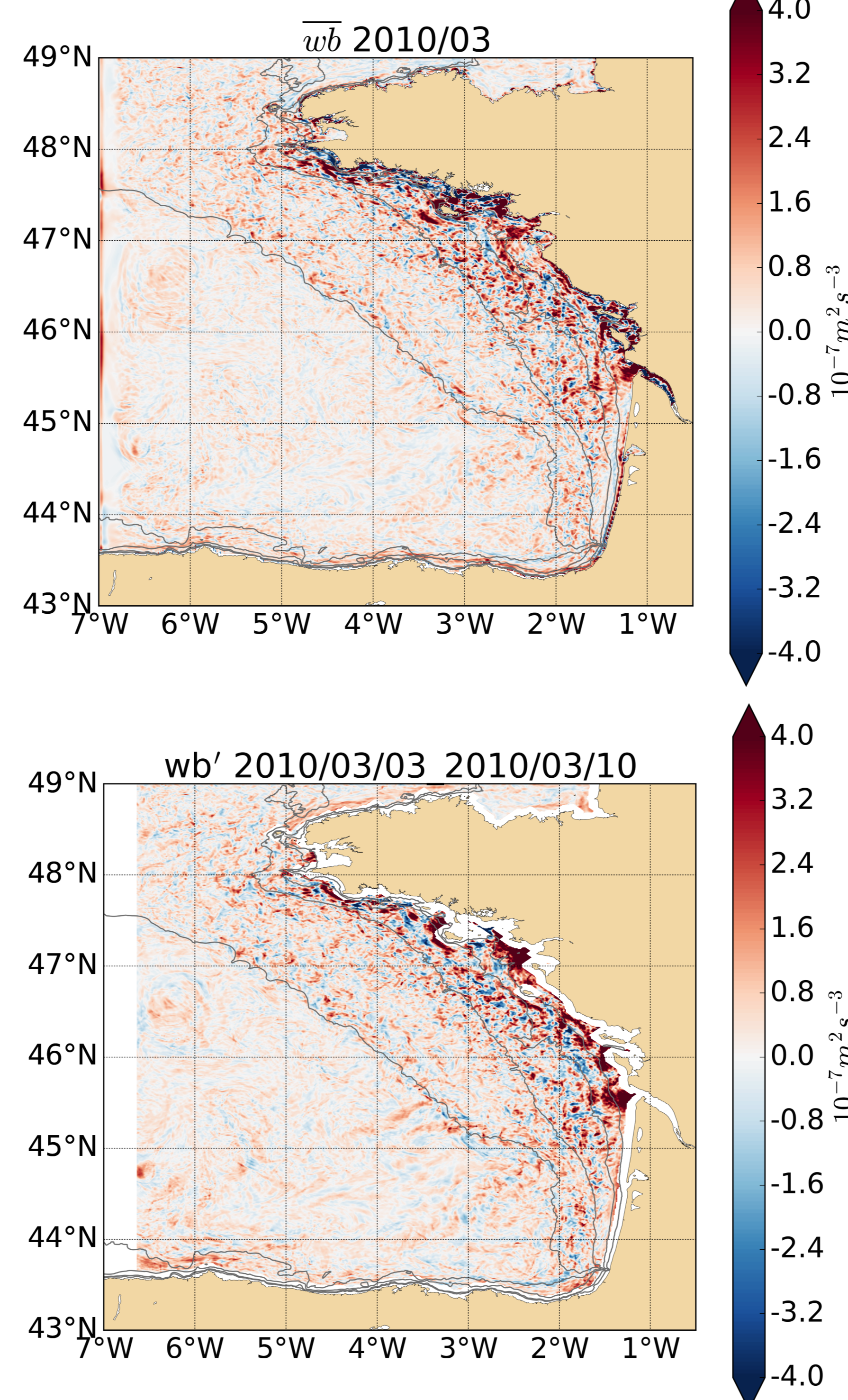
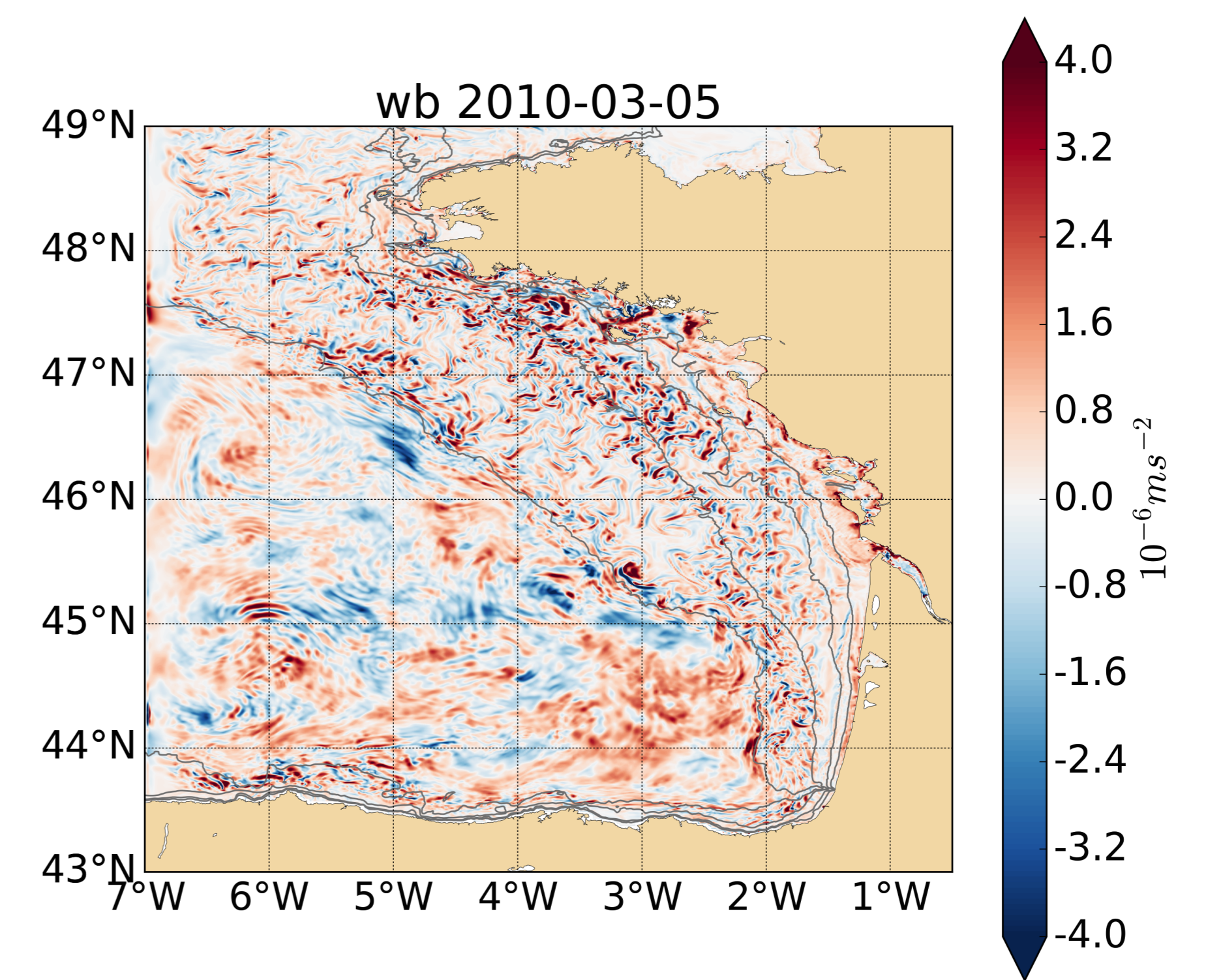
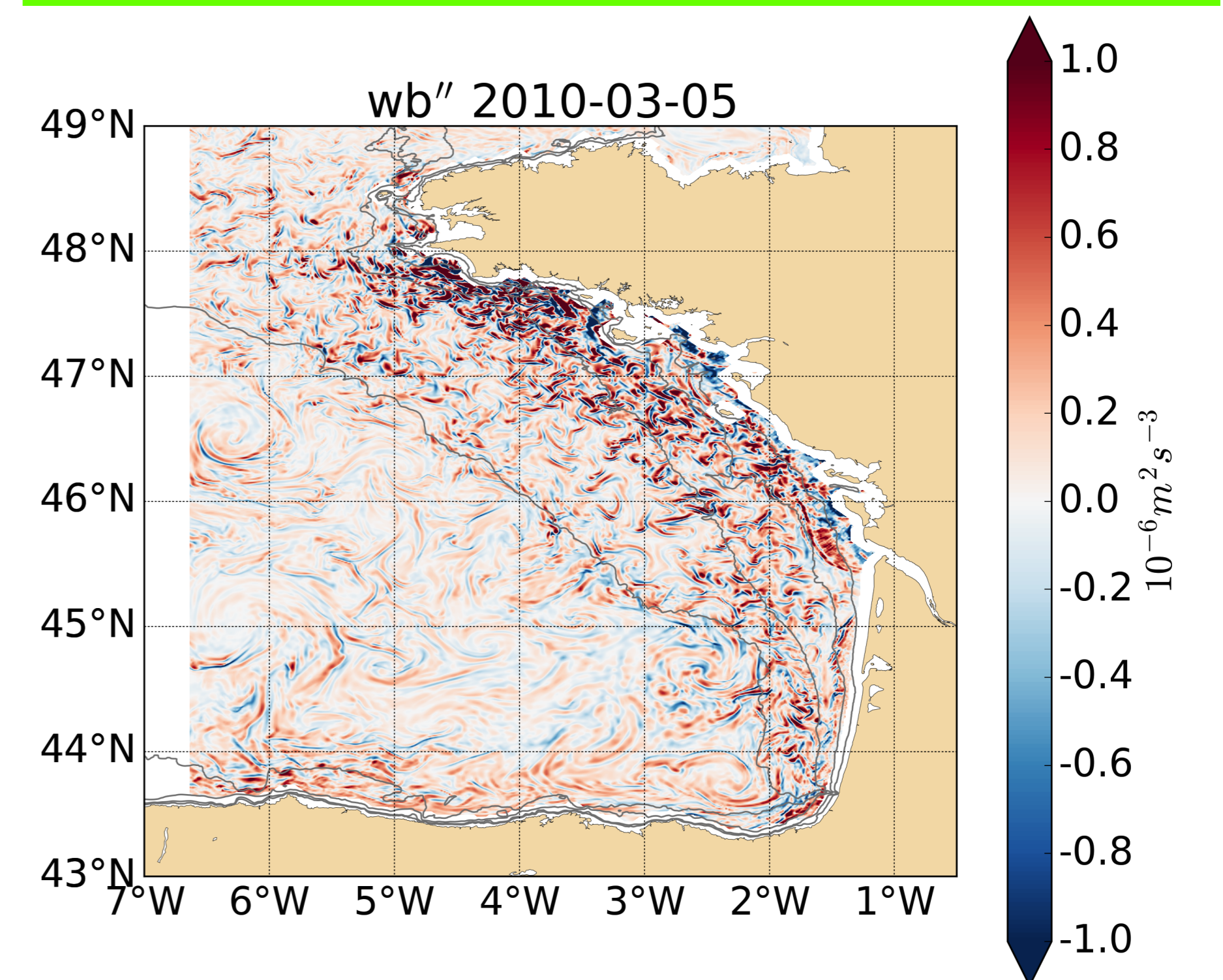


Figure 6: Modelled vertical buoyancy flux, its mean, meso-, and (sub)mesoscale components on 05/03/2010.



wb: Vertical buoyancy flux

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



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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