

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

Observed from Satellite Sea Surface Temperature

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The logo for Ifremer, consisting of a yellow horizontal bar with the word "Ifremer" in black text centered on it.

Bay of Biscay Continental Shelf

Data & Methods

Variability of Frontal Activity

Conclusions

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Physical processes at mesoscales (10-100 km, \sim weeks) and sub-mesoscales (1-10 km, \sim days) widely studied in the **oceanic domain**, not well known **over the continental shelves**.

Objectives:

- ▶ Identification of the frontal activity over the continental shelf from a satellite SST archive,
- ▶ Investigating the physical driving mechanisms of these structures.



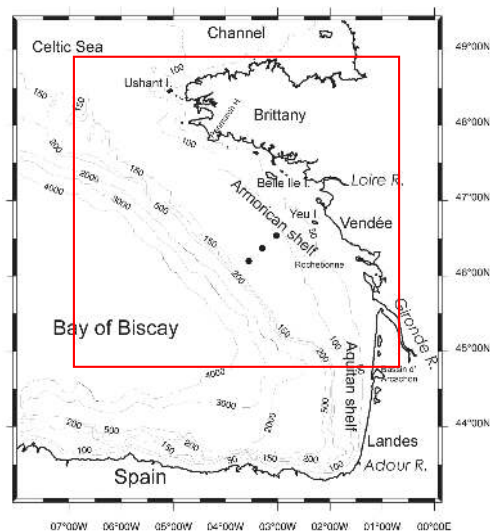
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Objectives:

- ✓ Understanding the impact on biogeochemistry at these scales; using coupled models.



Bay of Biscay Continental Shelf



From Lazare et al., 2008

Geography:

- ▶ **Wide shelf:** Armorican shelf, 150 - 180 km; Aquitaine shelf, 50 - 150 km
- ▶ **Major rivers:** Loire and Gironde, $\sim 900 \text{ m}^3 \text{ s}^{-1}$; Adour, $\sim 150 \text{ m}^3 \text{ s}^{-1}$; Vilaine, $\sim 100 \text{ m}^3 \text{ s}^{-1}$
- ▶ **Seasonal winds:** October - March, SW; April - September, NW



Main drivers of general circulation:

- ▶ **Winds:** SW in autumn-winter; NW in spring-summer ($\sim 10 \text{ cm s}^{-1}$)
- ▶ **Density gradients:** in vicinity of Loire and Gironde plumes ($\sim 10 \text{ cm s}^{-1}$)
- ▶ **Tides:** semidiurnal (M2) tide dominant, weak residual current over the shelf ($\sim 3 \text{ cm s}^{-1}$)

Bay of Biscay Continental Shelf

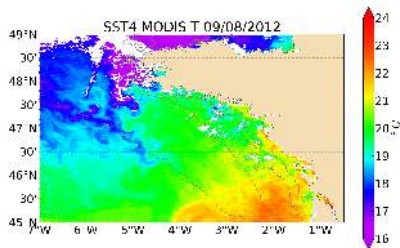
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SST: MODIS onboard Aqua & Terra

- ▶ 11 years from 2003 to 2013
- ▶ $\sim 1\text{km}$ spatial resolution, daily
- ▶ L2 products
- ▶ $\leq 90\%$ cloud covered

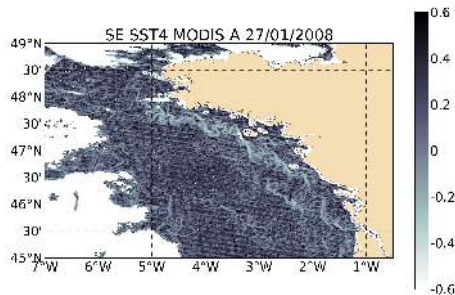


PREVIMER: Coastal observations & Forecast models

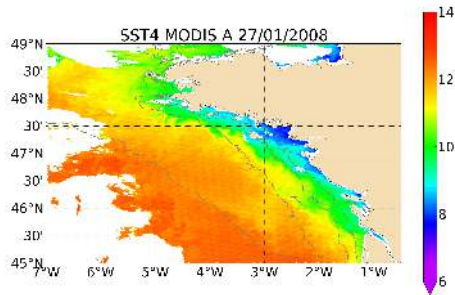
- ▶ MARS3D over the Bay of Biscay and English Channel
- ▶ $\Delta x = 2.5\text{km}$, 40 σ -layers
- ▶ Tidally filtered daily products

The process of calculating the degree of regularity or irregularity of a function at each point in a domain (Turiel et al., 2008).

Singularity Exponent:

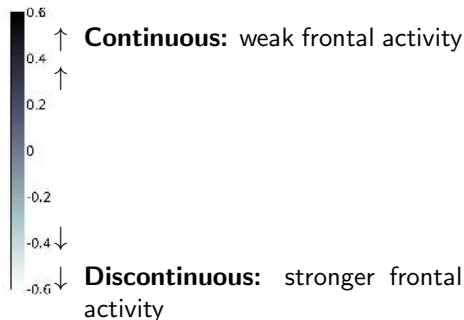
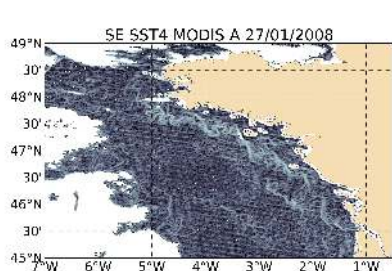


SST domain:

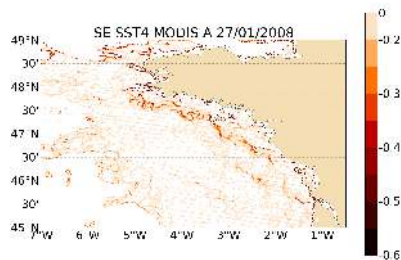
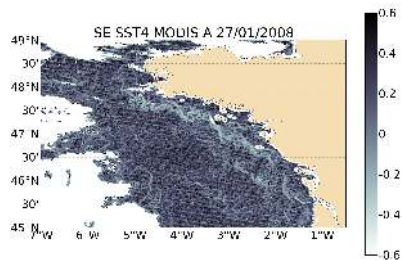


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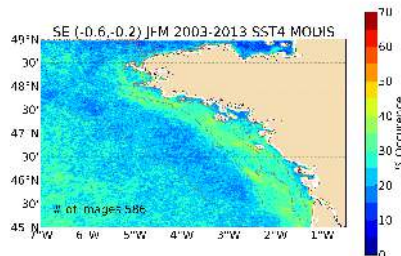


A frontal pixel, if $-0.2 \geq SE \geq -0.6$



Front occurrence frequency

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



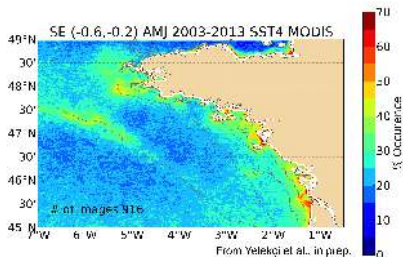
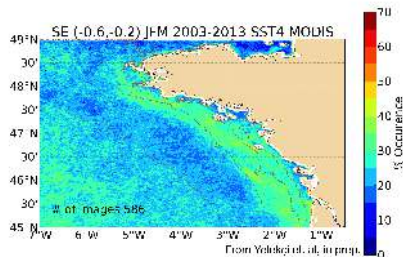
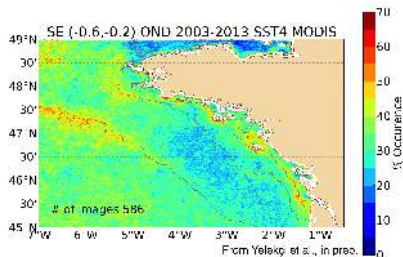
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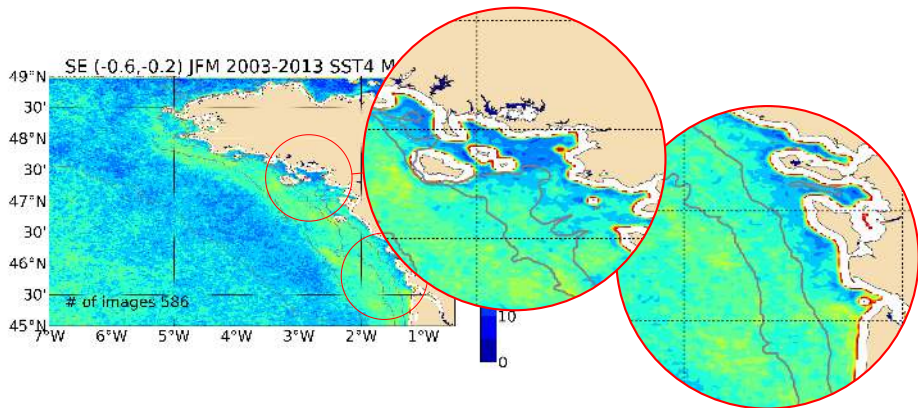
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Density Fronts

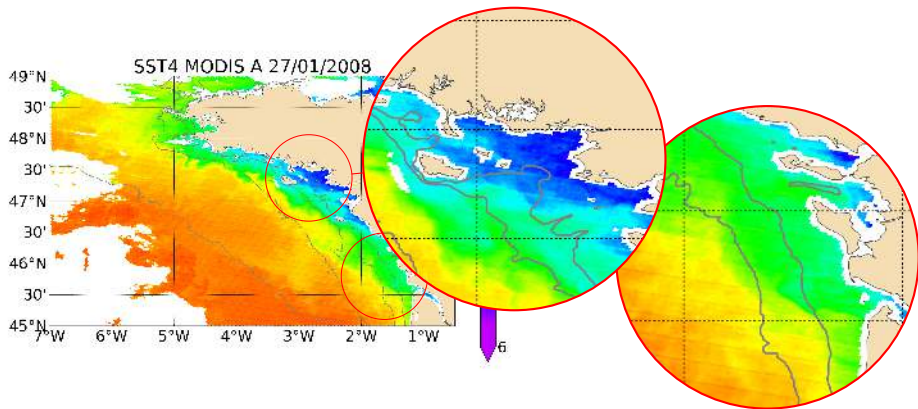


- ▶ Fronts induced by fresh water input in vicinity of plumes
- ▶ Driven by surface cooling and haline stratification

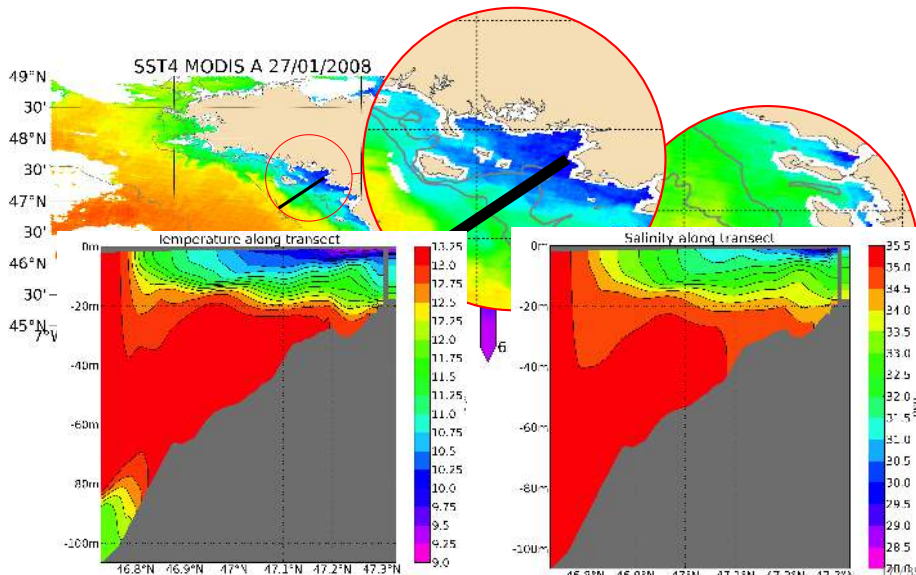
Density fronts along the coast: Fresh water inshore the 50m - 100m & Surface cooling.



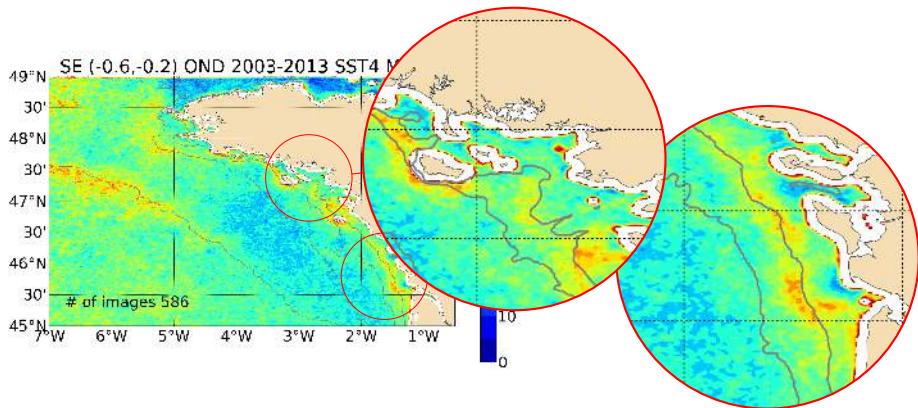
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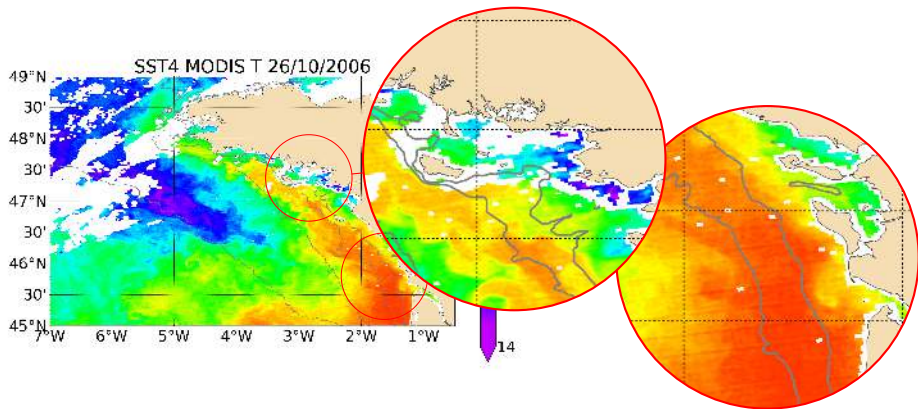
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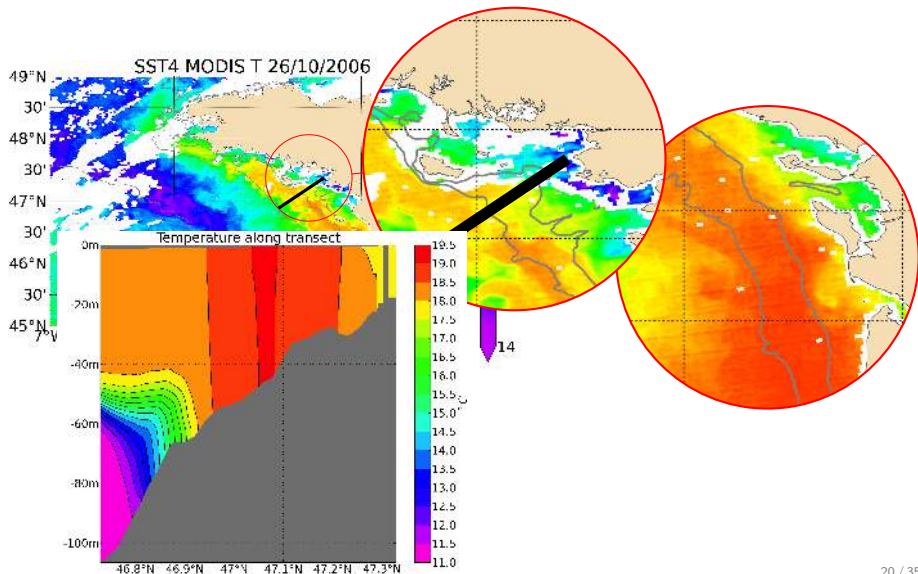
Onset of density fronts in autumn: Fresh water inshore the $\sim 30\text{m}$ & Surface cooling & Warm current.



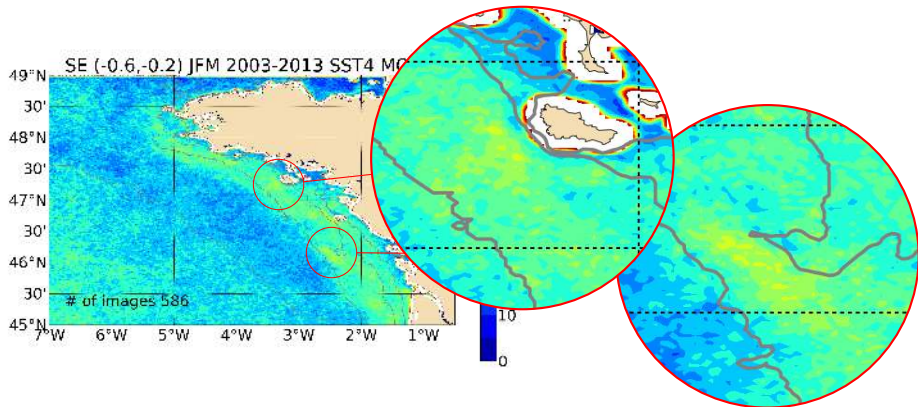
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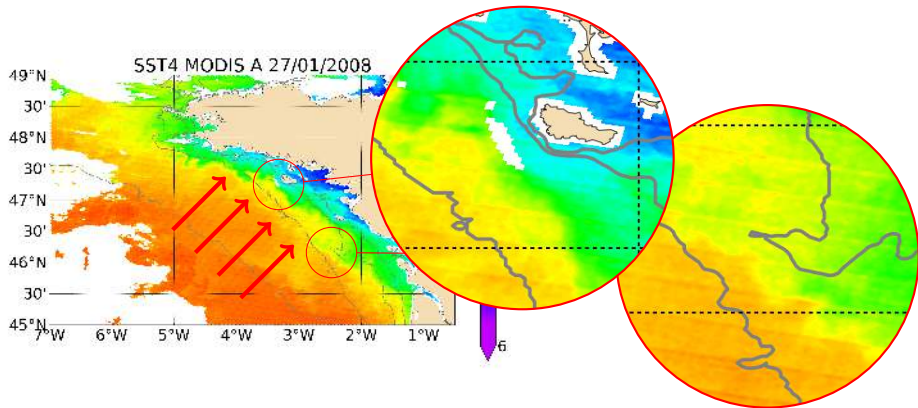
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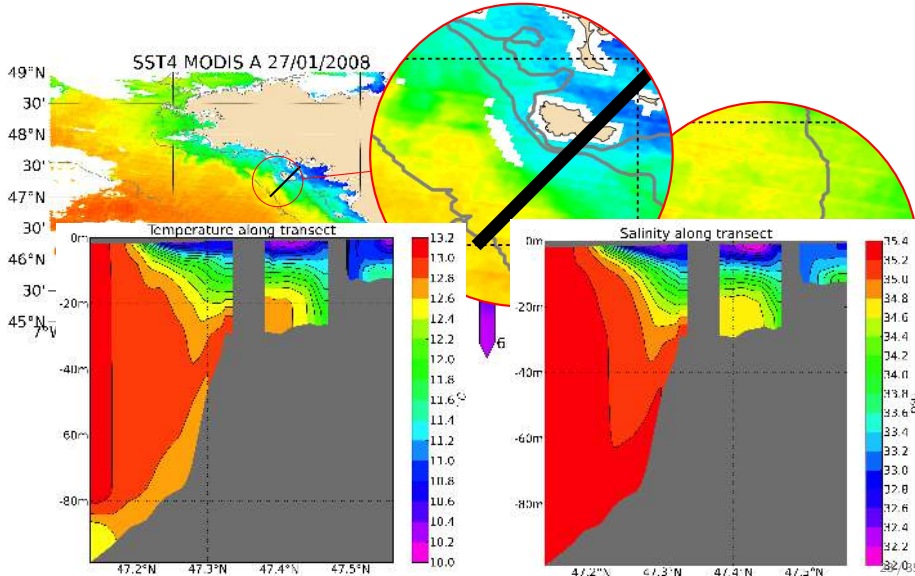
Locally increased frequency at bathymetric features: Northward propagation of the plumes & SW (downwelling favorable) winds.



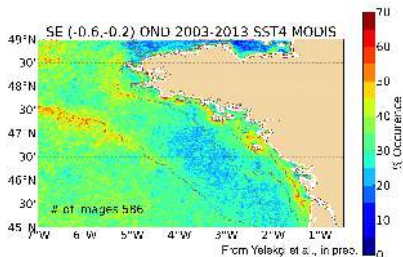
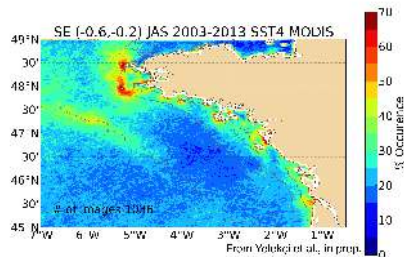
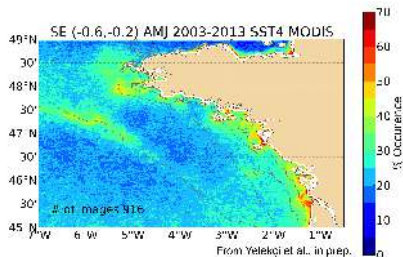
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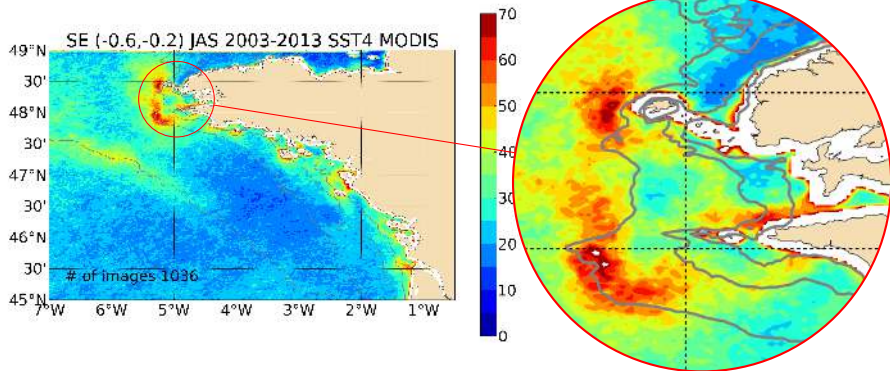


Tidal & Shelf Break Fronts

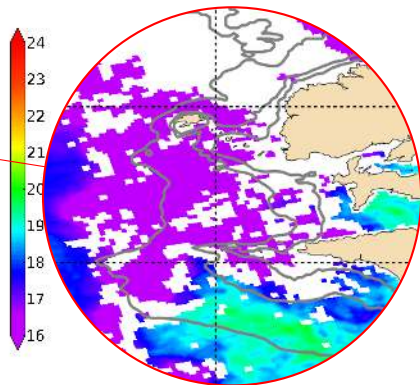
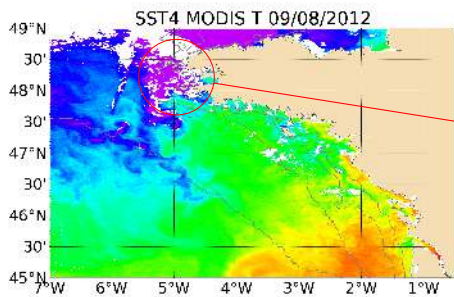


- Fronts induced by tidal mixing and internal wave activity in thermally stratified months

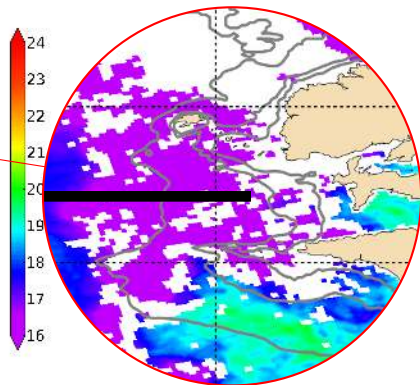
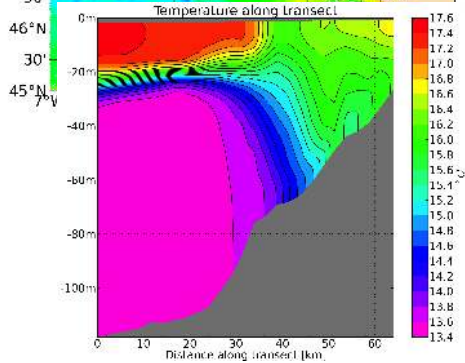
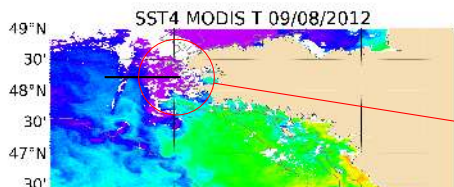
Ushant front: $\sim 70\%$ of the time, permanent in Summer.



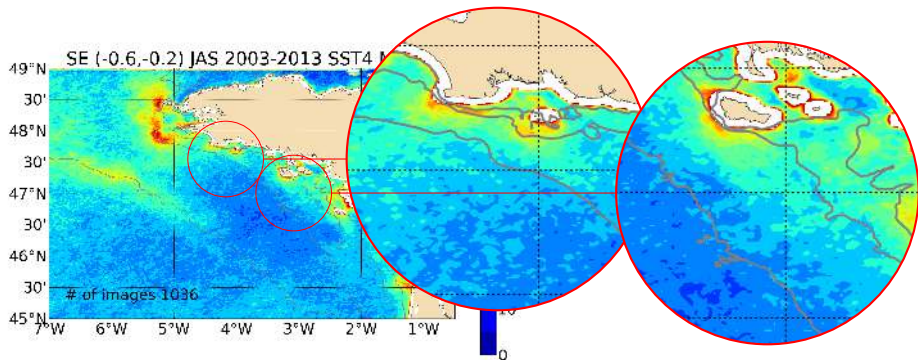
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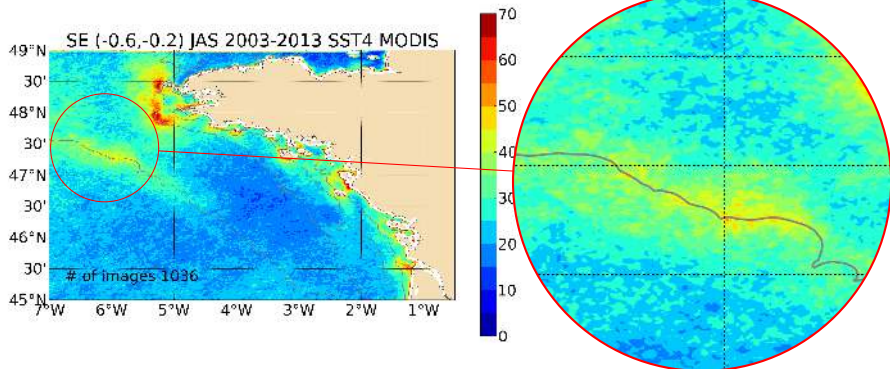
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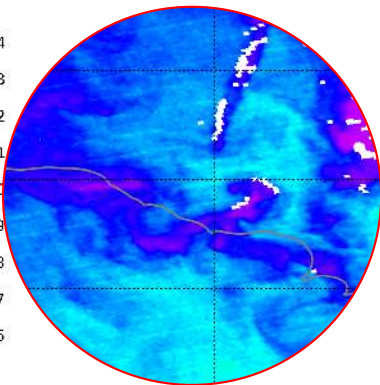
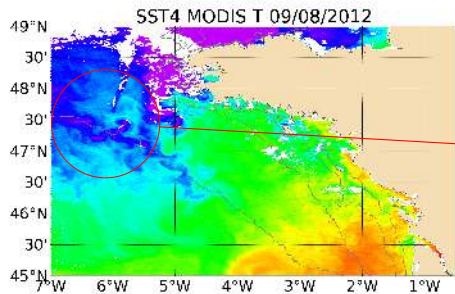
Tidal fronts along the coast & around islands: Stratification & tidal mixing.



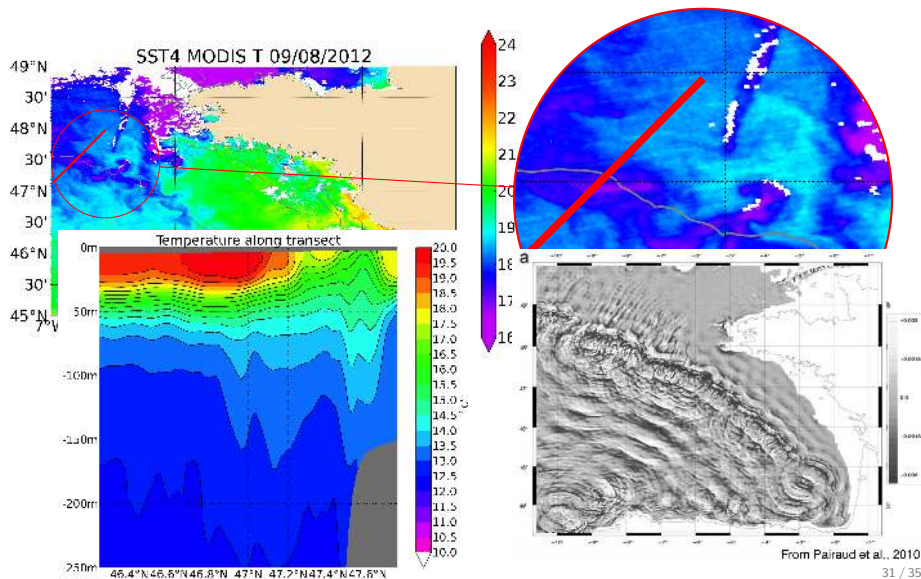
Shelf Break Front: Stratification & internal wave activity.



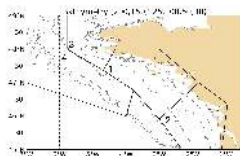
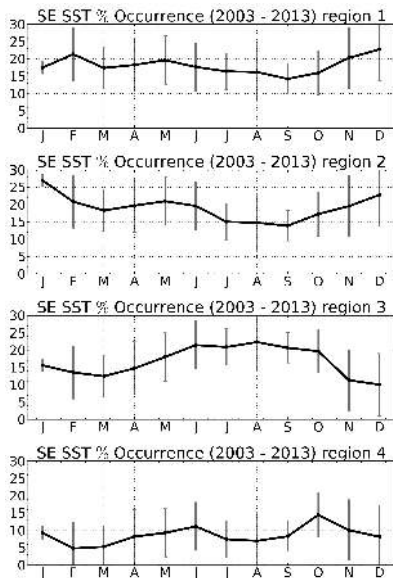
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Seasonality of Frontal Activity



Seasonality of front occurrence frequency:

- ▶ **In vicinity of river plumes:**
Starts in autumn, through winter, declines summer.
- ▶ **Iroise sea & Shelf Break:**
Prominent in stratified months, declines in autumn.

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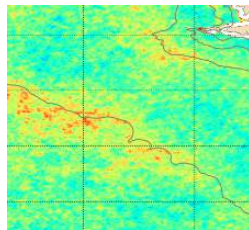
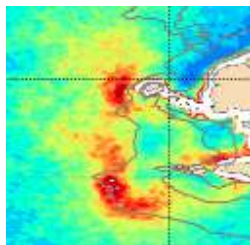
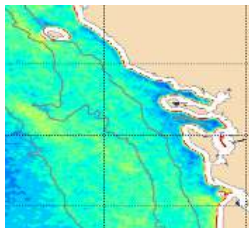
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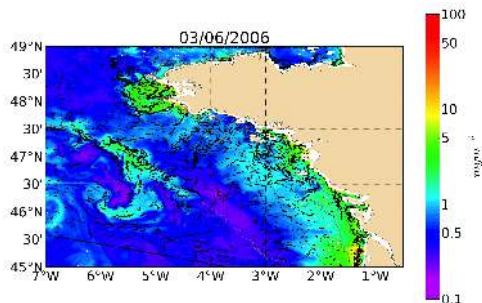
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Conclusions

Spatial and temporal variability of frontal activity investigated from a long term satellite archive;

- ▶ **Density fronts:** induced by river runoff & the role of wind and topography,
- ▶ **Tidal fronts:** induced by tidal mixing, Ushant tidal front,
- ▶ **Shelf break front:** induced by internal tides.





- ▶ Interactions between the frontal activity & biogeochemistry

Modeling approach for understanding frontal dynamics:

- ▶ Physical set-ups for each of the identified groups, and their specific environmental conditions,
- ▶ Suggested driving mechanisms of the observed frontal activity put to test by a series of model experiments.