Supporting Information for "Seasonal tracer subduction in the Subpolar North Atlantic driven by submesoscale fronts"

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S1. Description of the bias linked to the methodology

Figure S1 is a simplified scheme of a front cross-section illustrating our methodology and the associated bias. In this study, we associate surface points with the vertical velocity w below (orange crosses). When located in an anticyclonic front (1A area), we observe a change of w sign at a certain depth, usually close to the MLD : w goes from upward to downward velocity (see the article section 3.2). The scheme explains this phenomenon. The vertical velocity below the surface anticyclonic front is not always associated with an upwelling after a certain depth due to the slope of the front. Instead, we are associating the surface point in (1A) area with downward fluxes induced by the cyclonic part of the front. This may leads to a bias in our results around and below the MLD in the (1A) area.

S2. Horizontal resolution sensibility

To evaluate the grid resolution effect on the results, we compare two JPDFs using a snapshot of February 8th 2008 with (i) the numerical simulation presented in the paper ($\Delta x = 0.8km$) and (ii) with the parent numerical simulation in the region: GIGATL3 ($\Delta x = 3km$) (Figure S2). We computed the fraction of the cyclonic front surface area for both JPDFs and found that the front fraction with the 3 km resolution simulation is only 0.2%. With the 0.8 km, this increases to 3.8%, showing a significant sensitivity to the horizontal resolution.

S3. The seasonal evolution of the submesoscale instabilities scale

The scale of submesoscale mixed-layer instability (MLI) $lsml$ is estimated following the approach of Dong et al. (2020) :

$$lsml = 6\frac{N_{ML}H_{ML}}{f} \tag{1}$$

where N_{ML} is the averaged buoyancy frequency in the ML, H_{ML} is the ML thickness and f in the Coriolis parameter. By applying this method in our numerical simulation, we compute the *lsml* evolution during the whole year 2008 (Figure S3). We observe that the average scale of MLI is between 10 and 20 km in winter, while it decreases to 2-5 km in summer. These results are in agreement with the order of magnitude present in the region in Dong et al. (2020). With a resolution of 0.8 km, our effective resolution of $4\delta x = 3.2$ km should be sufficient to resolve MLI in winter. However, in summer, it is possible that MLI is not fully resolved.

S4. Temporal resolution sensibility

We compare the (1C) total surface fraction represented in the JPDFs and computed during the first 5 days of March with different output frequencies, which are daily, 3-hour, and 1-hour averaged. We also compute the JPDF with hourly snapshots. The figure S4 shows a significant difference between daily-averaged (1.6% of cyclonic front density) and hourly averaged or snapshot outputs ($>5\%$ of cyclonic front density).

References

Dong, J., Fox-Kemper, B., Zhang, H., & Dong, C. (2020). The scale of submesoscale baroclinic instability globally. *Journal of Physical Oceanography*, *50*(9), 2649–2667. doi: 10.1175/JPO-D-20-0043.1

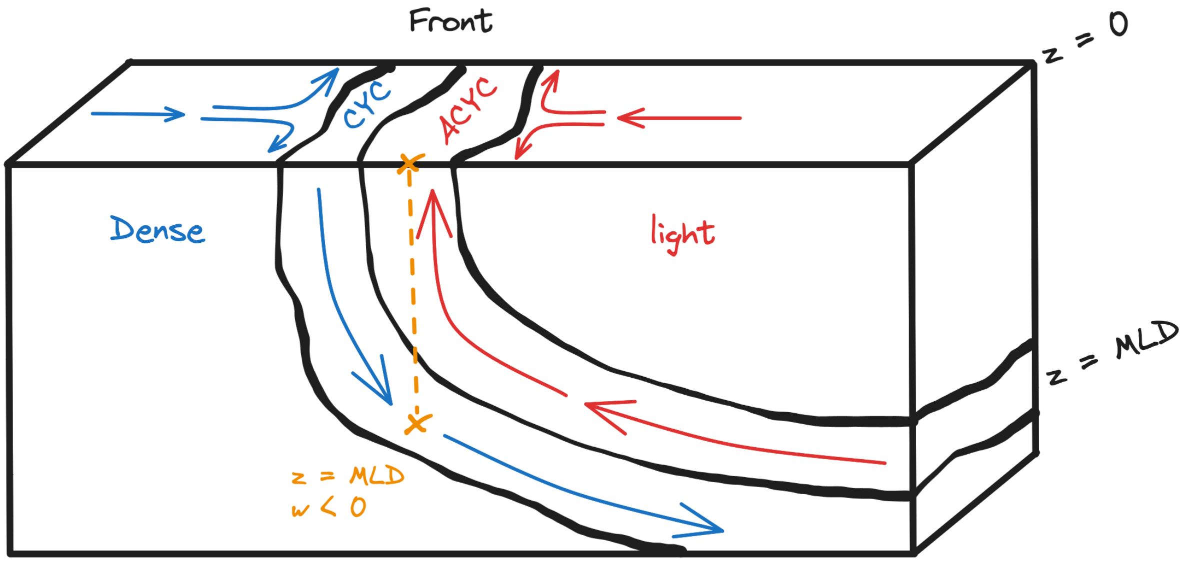

Figure S1. Scheme of a front cross-section. The front is composed of a dense cyclonic part (blue) and a light anti-cyclonic part (red). The orange cross represents a point at the surface that belong to anti-cyclonic front area (1A).

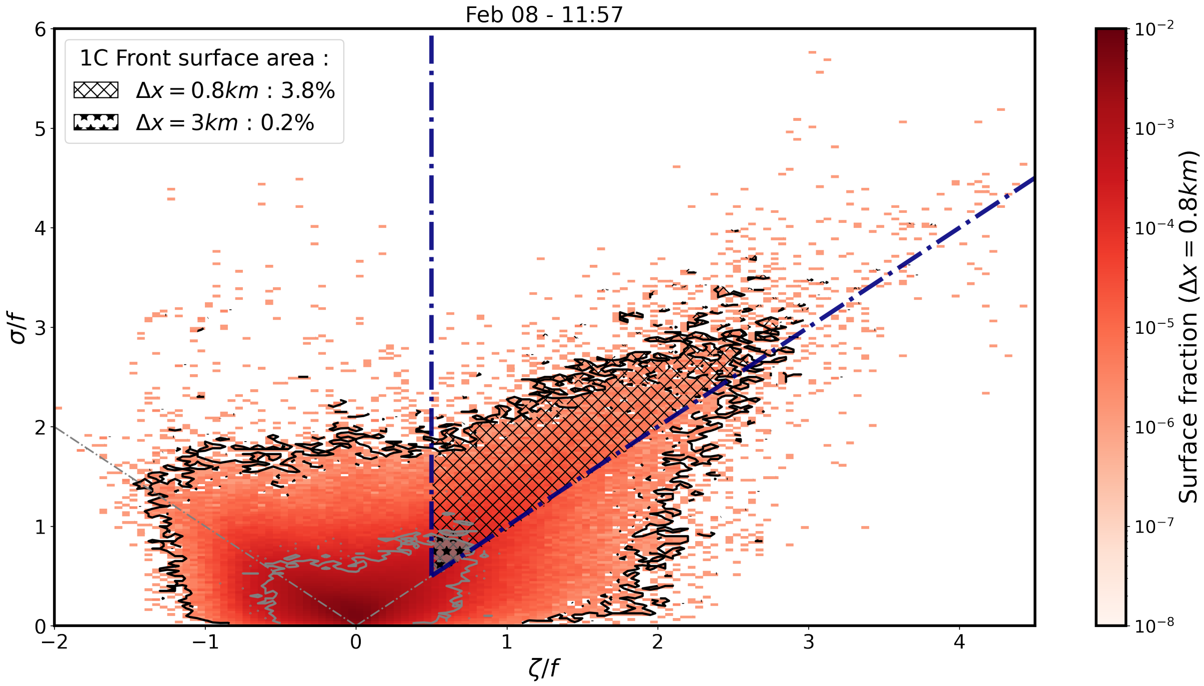

Figure S2. Surface strain - vorticity JPDF for a snapshot in February 8th 2008 March. The contours is the integrated domain containing 99.99% of the points. The black contour represents the domain for the 0.8 km simulation and the grey contour for the 3 km simulation. The total surface fraction in (1C) is represented by the hatched zone (0.8 km) and stars (3 km).

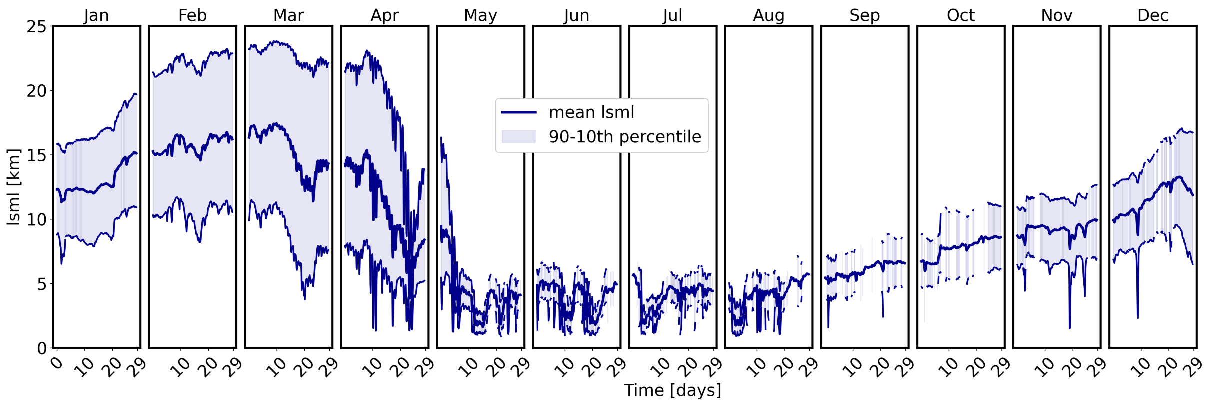

Figure S3. *lsml* evolution for each month of 2008. Blue solid line represents the mean lsml. The blue zone is the 10th and 90th percentile area.

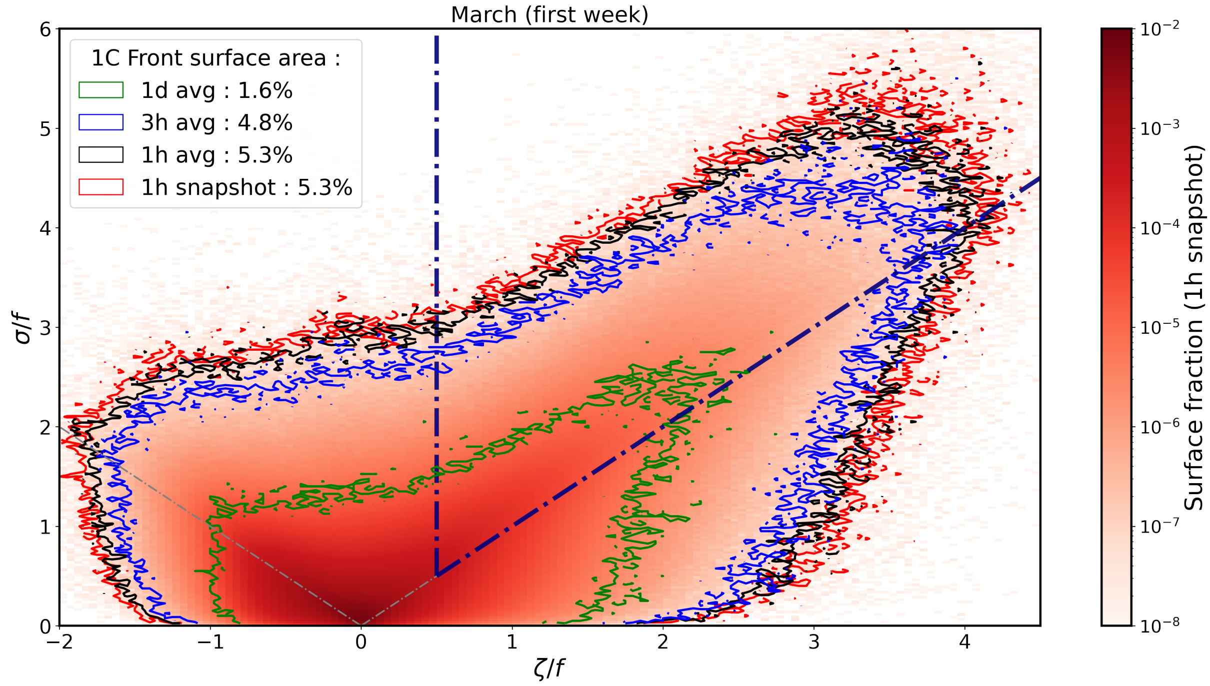

Figure S4. Surface strain-vorticity JPDF for 4 different output types which are daily averaged (green), 3-hour averaged (blue), 1-hour averaged (black) and hourly snapshot (red). The black contour is the integrated domain containing 99.99% of the points. The fraction of points within (1C) (front fraction) is computed for each JPDF and presented in the top left-hand panel.