Dear Authors.

I now have referees' comments on your revised manuscript. One is content, the other asks for minor revision; their comments are copied below with some <> of mine. Please respond to all these and upload a re-revised manuscript.

Yours sincerely

John Huthnance (editor).

Response: We sincerely thank you for your continued and careful handling of our manuscript, as well as for your constructive suggestions throughout the review process. In this round, we have carefully addressed all comments from the referee and revised the manuscript accordingly. A re-revised version, together with a detailed point-by-point response to the reviewer's comments and your notes in angle brackets, has been uploaded for your consideration.

Referee comments with some <>

I thank the authors for their thorough work addressing my comments on the manuscript's previous version. I believe the revised version has certainly improved, but I still have some points to raise.

Response: We sincerely thank the reviewer for the careful re-evaluation of our manuscript and for the constructive comments. We appreciate your recognition of the improvements in the revised version and have carefully considered all remaining concerns. Corresponding revisions have been made in the manuscript, as detailed in our point-by-point responses below.

Authors' response to point m2: "The local first deformation radius inshore of the 100 m isobath (apart from the coastal area) ranges from a few to ~10 km, which is sufficiently larger than the model resolution yet at least an order of magnitude smaller than the shelf width, so the nonlinear terms likely play only a minor role in the depth-averaged vorticity balance. In the revised manuscript, we included at end of section 3.2: It is also noteworthy from this figure that landward of the 100-m isobath (excluding the immediate nearshore), the first baroclinic Rossby radius exceeds the model grid spacing yet remains an order of magnitude smaller than the shelf width, supporting the validity of the climatic scales adopted in this study."

In Fig. 6b,c, it is shown that the Relative Vorticity Advection (RVA) nonlinear term dominates the bottom along-isobath pressure gradient force's (PGF_{y*}^b) structure. Comparing Fig. 6b and Fig. 6c shows that the PGF_{y*}^b and the RVA actually have similar magnitudes and spatial patterns just inshore of the 100 m isobath, as stated by the authors in lines 325-329 of the revised manuscript. This seems to contradict the authors' response to this point, as the nonlinear term does play a major role in the depth-averaged vorticity balance in those areas.

Response: We apologize for the confusion caused by our earlier wording.

Our statement that the nonlinear terms "likely play only a minor role" was intended to refer to a scale analysis of the depth-averaged momentum equations, in which the Rossby number over the NSCS shelf is small and the intensity of advective nonlinearity is weaker than intensity of the Coriolis and pressure-gradient terms, particularly in the cross-shelf momentum balance. In this sense, the large-scale shelf circulation remains close to geostrophic, and the nonlinear terms are secondary in setting the overall momentum balance.

By contrast, Fig. 6b–c shows the decomposition of the bottom along-isobath pressure-gradient term in the depth-averaged vorticity equation. In this vorticity budget, the Relative Vorticity Advection (RVA) term (in the right-hand-side of the PGF^b_{y*} equation) is indeed comparable to, and locally dominates, the structure of PGF^b_{y*} just inshore of the 100 m isobath, which explains the similar magnitudes and spatial patterns of RVA and PGF^b_{y*} in that region. This analysis is used to diagnose how nonlinear advection helps maintain the along-isobath pressure-gradient structure, rather than to suggest that nonlinear terms dominate the total pressure-gradient forcing or overturn the near-geostrophic large-scale balance.

To avoid ambiguity, we have revised the relevant sentence in Sections 3.2 and 4 to clarify that nonlinear terms are dynamically secondary in the large-scale momentum balance, but can still be the leading contributor to the PGF^b_{y*} and thus to the detailed structure of cross-isobath velocity anomalies. We believe this clarification reconciles our previous statement with the patterns shown in Fig. 6.

Line 300-303: "At the climatic scales in this study, the Rossby number is small, so nonlinear advection remains dynamically secondary in the depth-averaged momentum balance, and the large-scale shelf circulation is close to geostrophic, particularly in the cross-shelf direction."

Line 338-340: "Thus, while nonlinear advection is secondary in the large-scale depth-averaged momentum balance, it can still emerge as the leading contributor to the PGF^b_{y*} and thereby shape the detailed structure of cross-isobath velocity anomalies over the coastal band."

A shelf deformation radius of a few kilometers up to ~10 km sounds like the scale one would expect, but the authors need to specify where this estimate is derived from and how it was calculated (e.g., by solving an eigenvalue problem based on model vertical density profiles). <>

Response: We thank the reviewer for raising this important point and for prompting us to clarify the derivation of the first baroclinic deformation radius. In this study, we estimated the baroclinic Rossby radius using the standard two-layer approximation: $R_0 = \frac{\sqrt{g'H}}{f}$. Here, H is the water depth, f represents the Coriolis parameter, and the reduced gravity $g' = \frac{\Delta\rho}{\rho}$ ($\Delta\rho$ could be approximated as the density difference between the upper and lower layers, and ρ denotes the domain-averaged density as reference density). Using this formulation, the deformation radius over most of the shelf indeed falls within a few kilometers to ~10 km.

It is now included in line 296-299: ($\sqrt{g'H}/f$, where H is the water depth, f represents the Coriolis parameter, and reduced gravity: $g' = \Delta\rho/\rho$. $\Delta\rho$ is the density difference between the upper and lower uniform layers, and ρ denotes the domain-averaged density as reference density) ranging from a few to ~10 km,

Point m6 (statistical significance of the regression maps): Considering that most of the manuscript's results (Figs. 4-9) are based on regression maps of various flow diagnostics, I still think it is important to accurately determine the areas where the regression maps are significant (i.e., the gray area indicated in Fig. 4c,d [and Fig. 6c,d?]) by accounting for temporal correlation.

Response: We thank the reviewer for highlighting the importance of properly assessing statistical significance in the regression maps. In our analysis, each data point corresponds to a summer-mean (June–August) value, so the regression is performed on interannual seasonal means rather than on monthly or daily time series. Our primary working assumption is therefore that successive summers can be treated as approximately independent realizations for the purpose of a first-order linear regression and *t-test*.

Following this assumption, we used a standard two-tailed *t-test* with N-2 degrees of freedom, which is explicitly stated in the caption of Fig. 4. At the same time, we fully recognize that temporal correlation at interannual scales may reduce the effective number of independent samples. To reflect this, the manuscript notes that: “For the simple linear regression, the degrees of freedom are N − 2 (N is the number of observations), assuming independent observations. As temporal autocorrelation may reduce the effective number of independent samples, the reported regions with 90% confidence level may include uncertainties.” (Figure Captions of Fig. 4 and 6-9).

We have chosen a relatively modest confidence level (90%) and use the significance mask primarily to de-emphasize noisy areas (e.g., parts of the continental slope), rather than to draw strong conclusions from marginal features. The large-scale patterns emphasized in the text (such as the meandering shelf current and the JEBAR-dominated offshore response) are robust to reasonable changes in the significance threshold and to the precise treatment of temporal autocorrelation.

Finally, our approach is consistent with previous shelf-circulation studies that applied linear regression to interannual or seasonal-mean quantities without explicitly correcting for temporal autocorrelation in the *t-test* (e.g., Rosentraub & Brenner, 2007; Lentz, 2022). We have clarified this rationale and our assumptions in the revised manuscript to make the limitations and interpretation of the significance maps transparent to readers.

References:

Rosentraub Z, Brenner S. Circulation over the southeastern continental shelf and slope of the Mediterranean Sea: direct current measurements, winds, and numerical model simulations. Journal of Geophysical Research: Oceans. 2007 Nov;112(C11).

Lentz SJ. Interannual and seasonal along-shelf current variability and dynamics: seventeen years of observations from the southern New England inner shelf. Journal of Physical Oceanography. 2022 Dec;52(12):2923-33.

There is also no mention of statistical significance in Figs. 5, 7, 8, and 9. Including that would yield more confidence in the results not just for the NSCS as a whole, but would reveal in what areas of the shelf and for each of the diagnostics the regression analysis is most reliable.

Response: We thank the reviewer for this constructive suggestion. We agree that clearly indicating the statistically robust parts of the regression patterns helps to build confidence in our results.

For the **horizontal** regression maps, we now explicitly show statistical significance where it is most critical for interpretation. In Fig. 8, each panel presents a regression-based diagnostic under different runoff and ENSO conditions. Although the exact regions that pass the 90% confidence test differ somewhat among panels, our analysis and discussion focus on the band near the 100 m isobath, where the signal is consistently robust. To avoid overloading the figure with multiple overlapping masks, we have revised Fig. 8a and 8d to include shading that marks areas below the 90% confidence level, while leaving the key region around the 100 m isobath visually clear. The same 90% threshold and testing procedure are applied consistently to other plan-view regression maps (Figs. 4 and 6).

For the **vertical** transects (Figs. 5, 7, and 9), the situation differs from the horizontal fields. Here, grid points that do not reach the 90% confidence level are almost exclusively associated with very small absolute anomalies, i.e., weak signals that are not emphasized in our physical interpretation. As illustrated by an example provided in our response as Fig. R1, such regions naturally coincide with low regression coefficients. We therefore chose not to overlay significance shading on the anomaly profiles in order to preserve visual clarity and avoid obscuring the main structures of interest (e.g., the cores of temperature, salinity, density, and stratification anomalies). In the text, we only draw conclusions from the prominent, high-amplitude features, which we have verified to exceed the 90% confidence level.

To make our treatment of significance explicit for readers, we have updated the manuscript as follows:

Lines 269–270 (Fig. 4 caption): "Shaded areas (mainly over the continental slope) in (c) and (d) denote regions where the 90% confidence level is not met; this convention is followed in subsequent regression maps."

Lines 351–352 (Fig. 6 caption): "The shaded areas indicate regions that fail to attain the 90% confidence level."

Line 421 (Fig. 8 caption): "The shaded areas denote the approximate regions that do not pass the 90% confidence test."

Line 403 (main text related to Fig. 8): "The region adjacent to the 100 m isobath consistently satisfies the 90% confidence level."

These clarifications indicate where and how the significance tests are applied, while maintaining figure readability and focusing attention on the dynamically meaningful, robust features.

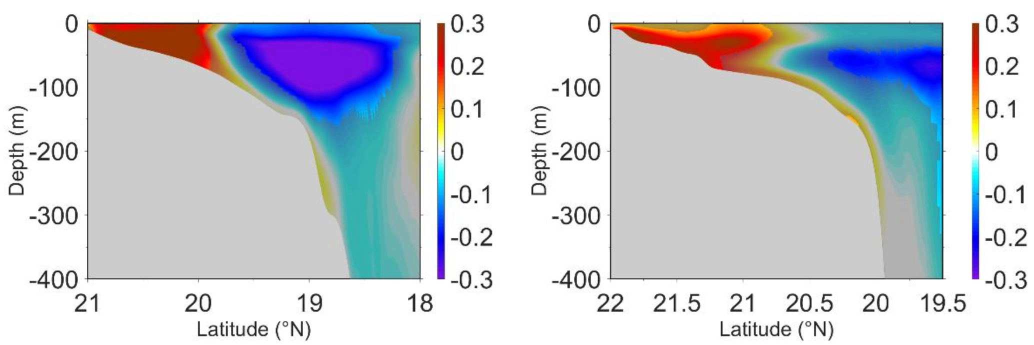

Figure R1. Regression maps of temperature anomaly profiles (°C) at Transects A and B (locations shown in Fig. 4b) during the summer of positive MVPC1 years (Table 1), with the shaded area indicating where they fail the 90% significance test.

Minor point (Fig. 6 caption): I assume the shaded areas in Fig. 6c,d are those not significant at the 90% confidence level, as in Fig. 4c,d, is that correct? Please indicate here if so, of clarify if not.

Response: We thank the reviewer for this careful clarification request. Yes, the shaded areas in Fig. 6c,d serve the same purpose as in Fig. 4c,d, i.e., they indicate regions that do not attain the 90% confidence level in the regression analysis. We have now made this explicit in the revised caption by adding the sentence: "The shaded areas indicate regions that fail to attain the 90% confidence level." (Line 351-352).

Related to this point, what is the temporal resolution of the fields used in the MVEOF analysis? Apologies if I missed this information, but could not find it in Section 2. Figures 2-3 seem to have yearly resolution, but I assume the temporal resolution of the fields used in the regression analysis is higher. <>

Response: We thank the reviewer for raising this point and for carefully checking Section 2. The temporal resolution of the fields used in both the MVEOF and regression analyses is indeed annual, consistent with Figs. 2 and 3. Specifically, for each year we compute summer-mean (June–August) fields of evaporation minus precipitation (E–P), air temperature, wind stress, SST, SLA, and SSS, and then form interannual anomaly time series from these JJA means. No higher-frequency (e.g., monthly or daily) fields are used in the regression or MVEOF analyses. To clarify this in the manuscript, we have revised the description in Section 3.1 to read (lines 155–156): "…including evaporation minus precipitation (E–P), air temperature, wind stress, SST, SLA, and SSS, all aggregated at annual (June – August) resolution."

m9 (JEBAR term units) Are the quantities plotted the gradients of the baroclinic terms, or the baroclinic terms themselves? If the quantities plotted are as stated in the caption and in Equation 6, it seems the units should be m3/s2, as the lateral derivatives are not present. <>

Response: We thank the reviewer for carefully checking the units in Fig. 8. The quantities plotted there are indeed the baroclinic terms themselves, consistent with Equation (6), rather than their horizontal derivatives. Accordingly, their units are m^3/s^2, not m^2/s^2 as previously indicated. This has been corrected in the revised manuscript; the caption for Fig. 8 now reads: "Regression maps of horizontal components (m^3s^{-2}) in the JEBAR term…"

Minor edit (line 372): Cartesian coordiante -> Cartesian coordinate system

Response: Corrected and many thanks!

< Figure 3d. I guess the curl is the background colour and wind speed is the arrows colour. Please clarify this in the caption.>>

Response: We thank the reviewer for pointing this out. Yes, in Fig. 3d the sea surface wind stress curl is shown as the background shading and the wind speed as vectors. We have clarified this in the revised caption, which now states (lines 168–169): "(d) sea surface wind stress curl (N m^{-3}; shown by the background color) and wind speed (m s^{-1}; denoted by the arrows);..."