All the issues raised by the reviewers except for the seasonal variability were included in the revised manuscript.

The most significant change was a revision aimed at reducing excessive description and redundancy, which resulted in a manuscript shortened by approximately four pages.

The abstract was also revised to follow the order of the manuscript.

Figure 1 was replaced by a figure with two panels: map distribution of the bathymetry (a) and EKE (b).

Response to Reviewer 1

05 January 2025

egusphere-2025-5507

The vertical structure of mesoscale eddies in the Azores Current corridor: a combined altimetry-Argo analysis

Silva-Fernandes and Peliz

Summary: In this manuscript, authors present results of an extensive analysis and census of mesoscale eddies in the Azores Current corridor. Using both satellite measurements of absolute dynamic topography and Argo float measurements of temperature and salinity, authors characterize mean eddy structure in three regions. Altimeter derived eddy tracks are used to find Argo profiles completed within eddies and to construct composite eddy structures. Results reveal east-to-west differences in mean eddy vertical structure linked to distinct locations and water masses of formation. A temperature and salinity heave and spice decomposition reveal much of the eddy signal to be associated with heave. Overall, the manuscript presents a comprehensive and careful analysis. Additional detail and clarification should be added to address how any potential biases could be linked to data sparsity (in space or time). The manuscript is a bit long, and readers may get lost in the details (many sentences quoting temperature/salinity differences from one region to the next). I would recommend focusing on the key results as they relate to larger scale circulation or how this region is unique with respect to mixing of unique water masses in the presence of a mid-ocean ridge.

We greatly appreciate your comments and suggestions, as we believe they have helped improve the quality of the manuscript. We hope that we have addressed all comments as thoroughly as possible.

We also recognise that the level of detail in some sections made the manuscript dense. This issue has been addressed in the revised version, which has been shortened by approximately four pages.

Main Comments:

1. Would recommend revision of "more barotropic/baroclinic" language. As Argo measurements extend only to ~2000 dbar, statements about depth independent structure over the sampled depth range would be more appropriate. Barotropic typically refers to depth independent over the entire water column.

We understand your comment. We agree that the term barotropic is conventionally used to describe a flow that is depth-independent over the entire water column.

In the revised manuscript, we have replaced the terms "more barotropic/baroclinic": "more uniform" instead of "more barotropic", and "with a well-defined subsurface maximum".

2. What additional information or key results are revealed through separate heave and spice calculations of SA and CT? Would it not be simpler to calculate heave and spice change with respect to neutral density surfaces alone?

We understand your question, and indeed, it would be simpler to compute heave and spice solely with respect to neutral density surfaces. However, in our study region the presence of Mediterranean Water (MW) is particularly important east of the MAR. Because MW has a strong and distinct salinity signature, analysing variability only in density space would mask the signal linked to it: inversion of signal around 750-1000 dbar seen only the salinity (Figure 8g of the manuscript) and not in the temperature.

Important differences do appear (Figure 8), but they do not seem to be discussed in detail (e.g. why is the SA heave (Fig. 8g) less spread out in the vertical than CT heave (Fig. 8d)?).

As the revision of the text was made, we also discussed Figure 8 in more detail.

Answering to your direct question: The presence of MW in regions R1 and R2 produces a strong salinity signal, including an inversion in the vertical gradient of its climatological profile. Because heave is calculated as the product of the isopycnal vertical displacement (IVD) and the gradient of the climatology, this inversion generates a visible inversion of the signal around 750–1000 dbar (Figure 8g). As a result, the CT heave appears more vertically spread than the SA heave.

I would also recommend adding more detail to the definition and calculation of ISOD (Eq. 1).

The text was altered to: “In this work, we use the ISOD to characterise the mesoscale structures and infer which process dominates. Following (Bindoff and Mcdougall (1994) and later Han and Yan (2018), the ISOD equation can be written as:

$$\Delta X|_p \cong X_{SPI} + (-X_{HEV}) + residue \cong \Delta X|_n + (-\Delta p|_n \nabla X) + residual \qquad (1)$$

Where $\Delta X|_p$ represent changes at a pressure level, $\Delta X|_n$ the changes along a given isopycnic surface, $\Delta p|_n$ the difference in pressure for each chosen isopycnal surface reflects the isopycnal vertical displacement ($-\Delta p|_n$- IVD), and ∇X is the climatology vertical gradient. A residual (RES) term is added associated with mixing and/or diffusion, which, for a well-stratified water column, should be near zero.

The ISOD of CT and SA was computed using the same methodology for both the Argo and climatological profiles, following these steps: 1) Neutral isopycnal surfaces (NIS) were computed using the software available at http://www.teos-10.org/preteos10_software/neutral_density.html (Jackett and McDougall, 1997) and subsequently interpolated onto a fixed grid. 2) CT, SA, RHO, and pressure were then computed along each NIS. 3) SPI and isopycnal vertical displacement (IVD) were computed as the difference between the Argo and climatological profiles along each NIS. 4) SPI and IVD were interpolated back onto pressure coordinates using the climatological density profiles. 5) HEV was computed as the product of the interpolated IVD and the vertical gradient of the climatological profile. 6) CT and SA anomalies were computed in pressure coordinates. 7) The residual term (RES) was defined as the difference between the total anomaly and the sum of HEV and SPI for each variable. This term can be associated with double diffusion and/or internal mixing in the eddy’s boundaries or its interior, or even other processes (like eddy stirring - e.g. McGillicuddy, 2016) that are not explained by the change of the property along the isopycnics (SPI) or due to their deflection (HEV); however, their origin is not the scope of this study and will not be referred to.

In summary, each Argo profile was converted into profiles of CT and SA anomalies, as well as IVD, HEV, and SPI (for both CT and SA). These metrics were then used to construct the eddy composites, which are analysed to assess how mesoscale structures affect the water column in our study region."

Where the detail of the ISOD calculation is underlined.

3. The three regions considered have significantly different surface areas. How does this, and subsequently the number of contributing profiles to composites, impact results.

The regions chosen for this study reflect different dynamics along the AzC before reported in our 2020 study (Silva-Fernandes and Peliz, 2020) apart from the region west of the ridge. The size of region 3 (west of the ridge) was reduced due to its proximity to the northwest corner of our domain, which is already under the influence of the Gulf Stream.

Despite the differences between the regions area, we do not believe that it impacts the composite results for the reasons below:

1) The number of sampled eddies is relatively high in both regions 1 and 2, being only smaller in region 3 due to its reduced size. In all regions this number is above 100 profiles (table 2) which from a statistical perspective this sample cannot be considered biased.
2) The composites are constructed in eddy-centred, normalised coordinates rather than in geographic space. Therefore, differences in regional surface area do not directly influence the composite structure, but only the number of available samples contributing to the statistics. Furthermore, the normalised distance of each profile from the eddy centre is radially well distributed (Figure 2b), which minimises potential bias when computing the radial composites.

Roughly how many unique eddies are being sampled/averaged in each composite?

In the table 2 the number of trajectories sampled refers to the trajectories of unique eddies. The number of eddies is the number of eddies being sampled along track belonging to those trajectories.

For example, in R1, 87 unique anticyclones (corresponding to 87 different tracks) were sampled 244 times in total along their trajectories, with a mean of 2.8 times in each track.

This is partly addressed in Table 2, but I'm left wondering as to the ratio of altimeter tracked eddies vs. Argo profiled eddies.

The total number of tracked eddies (individual trajectories) and the Argo profiled eddies, for the AzC System (the complete study region) and the individual regions is presented in the table 1.

Table 1 - Number of tracked eddies (TE) and Argo profiled eddies (APE)

		TE	APE	APE/TE (%)
AzC System	Anticyclones	5909	450	7.6
	Cyclones	5230	439	8.4
R1	Anticyclones	884	87	9.8
	Cyclones	807	85	10.5
R2	Anticyclones	1405	91	6.5
	Cyclones	1226	89	7.3
R3	Anticyclones	574	55	9.6
	Cyclones	537	40	7.4

Although the percentage of tracked eddies relative to the total number of trajectories is relatively low, the ratio of Argo floats emerging inside eddies (both anticyclones and cyclones) compared to those emerging outside eddies is consistent with values reported in previous studies.

In our study, a total of 2,393 Argo profiles (31%) emerged inside eddies and 7,641 outside eddies within the AzC system. For the AzCCo region specifically, 33% of the profiles emerged inside eddies. For comparison, Keppler et al. (2018) reported that 34% of profiles emerged inside eddies, whereas Lin et al. (2019) found a lower percentage of 16%.

4. A bit more should be said about the horizontal and temporal resolution of the altimeter product used, especially with respect to the first baroclinic deformation radius in this region.

While horizontal resolution of the available product is relatively high, much interpolation is carried out behind the scenes.

We have expanded Section 2.3 to clarify the horizontal and temporal resolution of the altimeter product and its relation to the first baroclinic deformation radius in the region. The CMEMS ADT product has a spatial resolution of ¼° and a daily temporal resolution. Although the grid spacing is relatively fine, the mapped fields are derived from interpolated along-track measurements, with an effective spatial resolution of approximately 200 km at mid-latitudes. In the study region, the first baroclinic deformation radius ranges between ~30 and 50 km, which lies near the lower end of the mesoscale spectrum. Consequently, features at this scale are only partially resolved, whereas larger mesoscale eddies are well captured.

The paragraph in section 2.3 reads as: "Absolute dynamic topography (ADT) maps between 2000 and 2020 from the Copernicus Marine Service (CMEMS; https://data.marine.copernicus.eu/) were used. The gridded product is based on merged observations from multiple satellite missions with ¼° spatial resolution and daily temporal resolution. Although the grid spacing is relatively high, the mapped fields are generated through interpolation of along-track measurements, with an effective spatial resolution of ~200 km at mid-latitudes (Ballarotta et al., 2019; Taburet et al., 2019), being structures with ~50 km radius resolved (Chelton et al., 2011, 2019). In our region, the first baroclinic deformation radius is approximately between the values of 30 and 50 km (Chelton et al., 1998), lying near the lower end of the mesoscale spectrum; features at this scale are therefore only partially resolved by the altimetric product, whereas eddies significantly larger are well captured. ADT fields were high-pass filtered using a first-order Bessel filter with a 700 km wavelength cutoff (Mason et al., 2014) to remove large-scale variability and then interpolated in space and time to the locations of the ARGO profiles. These maps were used to superimpose the atlas eddy trajectories."

Line-by-line:

L6: a bit misleading if you subsequently discard half of these profiles?

We understand your comment. It was corrected to more than 10000.

L26: consider conclusions of Abernathey and Haller 2018 (10.1175/JPO-D-17-0102.1)

The reference was removed.

L31: provide some longitudinal reference as well

The Azores current is located at 34ºN east of MAR.

The text was altered to:

L35: define a "free" eddy

As a "free eddy" we meant a coherent eddy.

The new sentence reads as: "The latitudinal band surrounding the jet, which we will loosely refer to as the Azores Current Corridor (AzCCo) is characterised by coherent eddies, meanders, and filaments, mostly evolving from baroclinic instability of the jet (Klein and Siedler, 1989; Alves and De Verdière, 1999), as well as several other types of structures propagating into the corridor."

L52: "presents more detected cyclones" this is confusing and/or is an incomplete sentence?

We meant more detected cyclones comparatively to anticyclones. The sentence was corrected in the text.

L54: consider adding corridor references to Figure 1 … as at least two corridor regions are separately identified?

Figure 1 was separated into two figures (see figure R1):

- Figure 1a - bathymetry of the study region and reference to the main topographic features in the region as well as the main corridors of eddies known.
- Figure 1b - mean EKE.

We also added in both figures an approximate representation of the Azores Current main axis following Silva-Fernandes and Peliz, 2020.

L60-61: maybe remove parentheses around citation?

Corrected.

L64: here and elsewhere, reference to regions or features (i.e. Azores plateau) need a visual reference. It is unclear what region is being referred to, especially if plotting of bathymetric contours only to 2500m. I don't see a plateau in Figure 1.

By "plateau," we refer to the region of relatively shallower bathymetry compared to its surroundings, corresponding to the portion of the Mid-Atlantic Ridge where the Azores islands are located. Its location is indicated in Figure R1 (Figure 1a in the revised manuscript).

L71: Figure 1 - consider using a log color scale for the EKE plot, the saturated high EKE region in the NW corner is a bit distracting. Would recommend expanding the lat/lon range of the plot or including an insert to provide greater geographical reference. Would also recommend using a fill color for land regions.

The EKE map was modified to represent a larger region (see Figure R1 bottom). Instead of a log scale, we expanded the top part of the colormap and changed the limit of the maximum EKE to the 1600 $cm^2 s^{-2}$ level. We also added white contours every 50 $cm^2 s^{-2}$ until the 400 $cm^2 s^{-2}$ level and then every 200 $cm^2 s^{-2}$. The colour white was chosen to represent land.

L75: I don't believe Argo needs to be in all capital letters (as it is not an acronym or initialism). Would say "Argo float profiles" and "altimetric measurements of absolute dynamic topography".

Corrected.

L89-105: citations for Argo and WOA should be included, not just links to datasets

These were added.

L98: what MLD definition is used?

We used the MLD definition from the GSW toolbox, following de Boyer Montégut et al., 2004. The mixed layer pressure is computed as 0.03 g/kg greater than the surface density.

L99: a bit more should be said about WOA and contributing observations. What is the spatiotemporal coverage in this region? Does the climatology primarily rely on the same Argo measurements used here?

We used the 2005–2017 monthly 0.25° WOA temperature and salinity fields as the reference climatology. This period corresponds to the Argo era, during which the upper 2000 m of the ocean is primarily sampled by Argo floats. Because our goal was to compute mesoscale anomalies from Argo profiles, using this climatology provides a consistent background state and minimizes biases associated with earlier, unevenly sampled periods.

L111: I believe it is possible for spice anomalies to arise without "eddy trapping". Trapping refers to a specific case of isolated cores of coherent vortices?

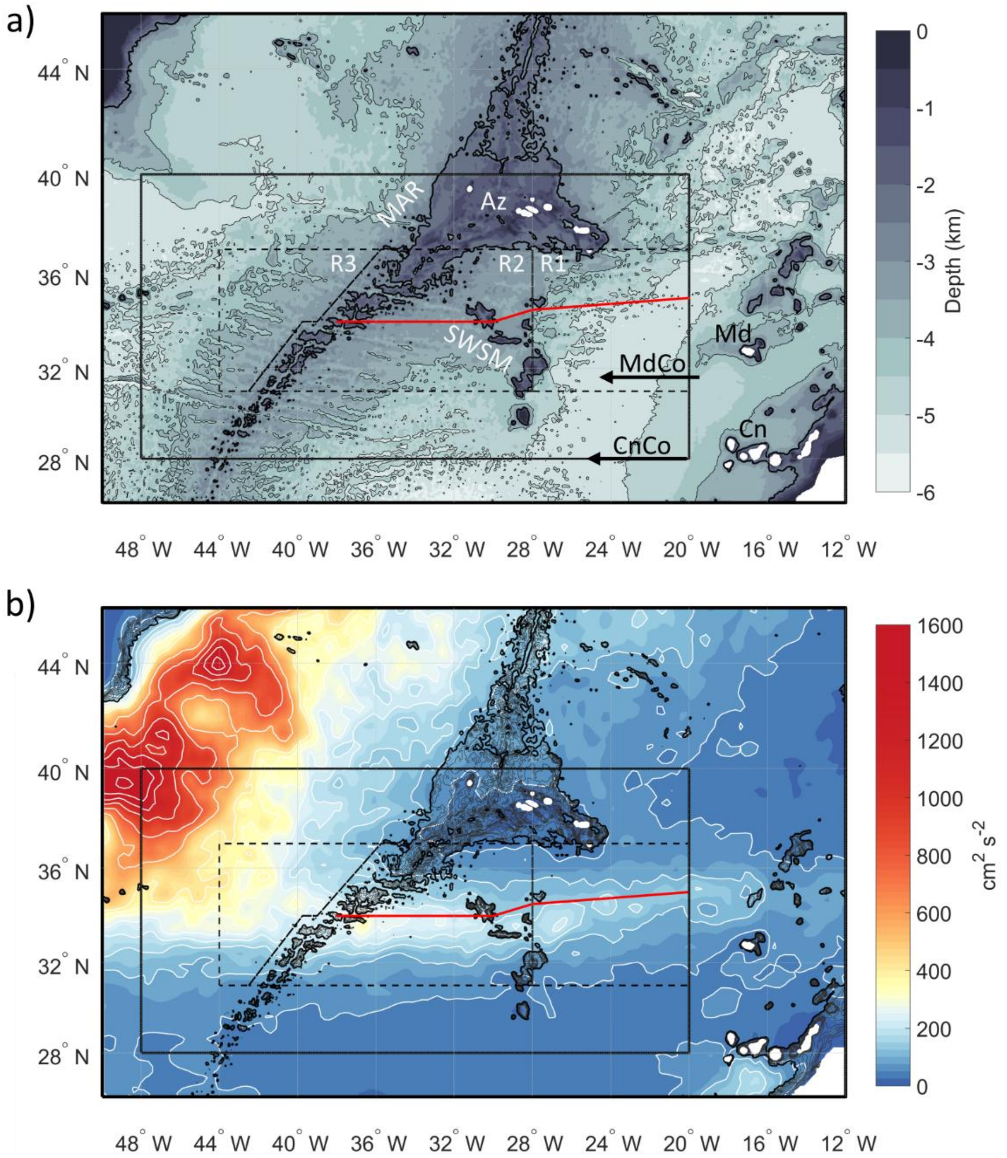

Figure R1 - (Figure 1 in the revised manuscript) (top – Figure 1a in the revised manuscript) Bathymetric map. The thick black contour represents the 2.5 km bathymetric and the black thin ones the 4 and 5 km bathymetric (bottom – Figure 1b in the revised manuscript) Mean EKE for the period 2005-2017. The contours are highlighted in white every 50 cm2/s2 until the 400 cm2/s2 level and then every 200 cm2/s2. The thick black contour represents the 2.5 km bathymetric. On both figures the black box represents the study region and the black dashed boxes the 3 regions of the AzCCo; the dotted line represents approximately the current axis between 20 ºw and 40 ºW following Silva-Fernandes and Peliz, 2020. Land areas are represented in white.

We understand and agree with your comment, as spice anomalies can arise from processes such as lateral advection of different water masses or mixing, without requiring eddy trapping.

In the context of our study, however, “eddy trapping” refers specifically to coherent eddies. The ability of an eddy to trap water is related to the ratio U/c, where $U$is the swirl velocity and $c$the propagation speed. When $U/c \gg 1$, the eddy is nonlinear and capable of retaining water during its formation, releasing it later as the eddy weakens (Chelton et al., 2011; McGillicuddy et al., 2016). The eddies tracked in this work exhibit high U/c values (not shown), and are therefore considered nonlinear, with the capacity to trap water along their trajectories. Accordingly, in this work, eddy trapping was quantified using spice anomalies within the cores of these coherent eddies.

L116: "+ residual"? The | notation is a bit confusing. Should the values to the right of the | be subscripted? Meaning deltaX on a surface of constant pressure?

Residue was corrected to residual. p and n are meant to be subscripted, indicating changes along an isobaric surface - p - and along an isopycnic surface - n. This was also corrected in the equation 1.

L137: this is a bit confusing. the following paragraph clears this up, but at this point it is unclear if smoothed ADT fields were interpolated to Argo profiles or ADT eddy tracks were interpolated.

We interpolated the ADT filtered field to the location/time of the Argo floats, not the centroid of the detected eddy.

L173: "all Argo"?

By all Argo we mean the Argo profiles that sampled anticyclones and cyclones inside the AzCCo.

The text was altered to: "Its x (east–west) and y (north–south) components were also computed, and the locations of the Argo profiles sampling the eddies in the regions along the AzCCo are shown in Figure 2b."

L175: missing period, "symmetry"?

We meant symmetry. Corrected.

L187: "Argo profiles"

Corrected

L193: Figure 3 - what distinction is to be made in panels b,d,f of All vs. AzCCo statistics?

All refer to all eddies sampled in our study region and AzCCo to those sampled inside the AzC corridor. This description was added to the caption of the Figure 3.

L241: missing region name for panel b?

Corrected.

L257: Figure 6 - do these plots derive from WOA or the contributing Argo profiles?

They derived from the WOA climatology.

L258: Figure number missing?

We meant from Figure 6. It was corrected in the text.

L275: consider making all panels the same size and including subplot labels for each of the four panels. It is a bit confusing as is.

Corrected.

L320: Very nice figure

We appreciated your comment, thank you.

L447-448: this sentence doesn't really provide new information?

The sentence was removed.

L463-470: This discussion (along with the conclusion section) seems a central result of this analysis.

Extensive characterization of eddy structure differences across the three regions considered makes the manuscript a bit cumbersome. Greater synthesis and focus on key takeaways would make it all more digestible.

We appreciate this comment. In response, we revised the Results, Discussion, and Conclusions sections to reduce redundant descriptions and improve synthesis, with greater emphasis on the key findings. These revisions aim to make the manuscript more concise and easier to follow.

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<u>Response to Reviewer 2</u>

Review of "The vertical structure of mesoscale eddies in the Azores Current corridor: a combined altimetry–ARGO analysis" by Silva-Fernandes and Peliz

This manuscript investigates the characteristics and vertical structure of mesoscale eddies in the Azores Current corridor of the North Atlantic Ocean using satellite altimetry and Argo observations.

It describes regional differences in eddy propagation and in the composite temperature and salinity anomaly structures within the AzCC. The study further suggests that most eddy-induced anomalies arise from eddy pumping, manifested as vertical deflections of isopycnal surfaces. While the manuscript presents potentially important results on mesoscale eddies along the AzCC, substantial revision is required before it can be considered for publication.

My major concerns and suggestions are outlined below.

We greatly appreciate all the comments and suggestions, as we believe they have helped improve the quality of the manuscript. We hope we have addressed all of them as thoroughly as possible.

Main Comments

1. How does the strength of eddies vary spatially across the study area?
   Do mesoscale eddies exhibit similar magnitudes in regions R1–R3? Including a discussion supported by spatial maps of eddy amplitude would strengthen the manuscript.

In our previous study of this region (Silva-Fernandes and Peliz, 2020), the surface eddy field was analysed using a different eddy-tracking product, and the kinematic properties of eddies were examined spatially. Although the product used in that study differs from the one used here, the overall results are consistent.

Figure R1a) to c) corresponds to part of Figure 7 from Silva-Fernandes and Peliz (2020). It shows that west of the ridge (i.e., west of 40° W), eddies exhibit not only higher amplitudes but also larger radii and stronger swirl velocities. Furthermore, these properties decrease progressively eastward. In Figure R1 d), we present the same spatial distribution for eddy amplitude, computed using the properties of the sampled eddies in the present study. The results confirm that eddies in region R3 are indeed more intense than those located further east.

As the surface eddy field in this region has already been thoroughly characterised in our previous study, we chose to include a concise paragraph in the Introduction summarising

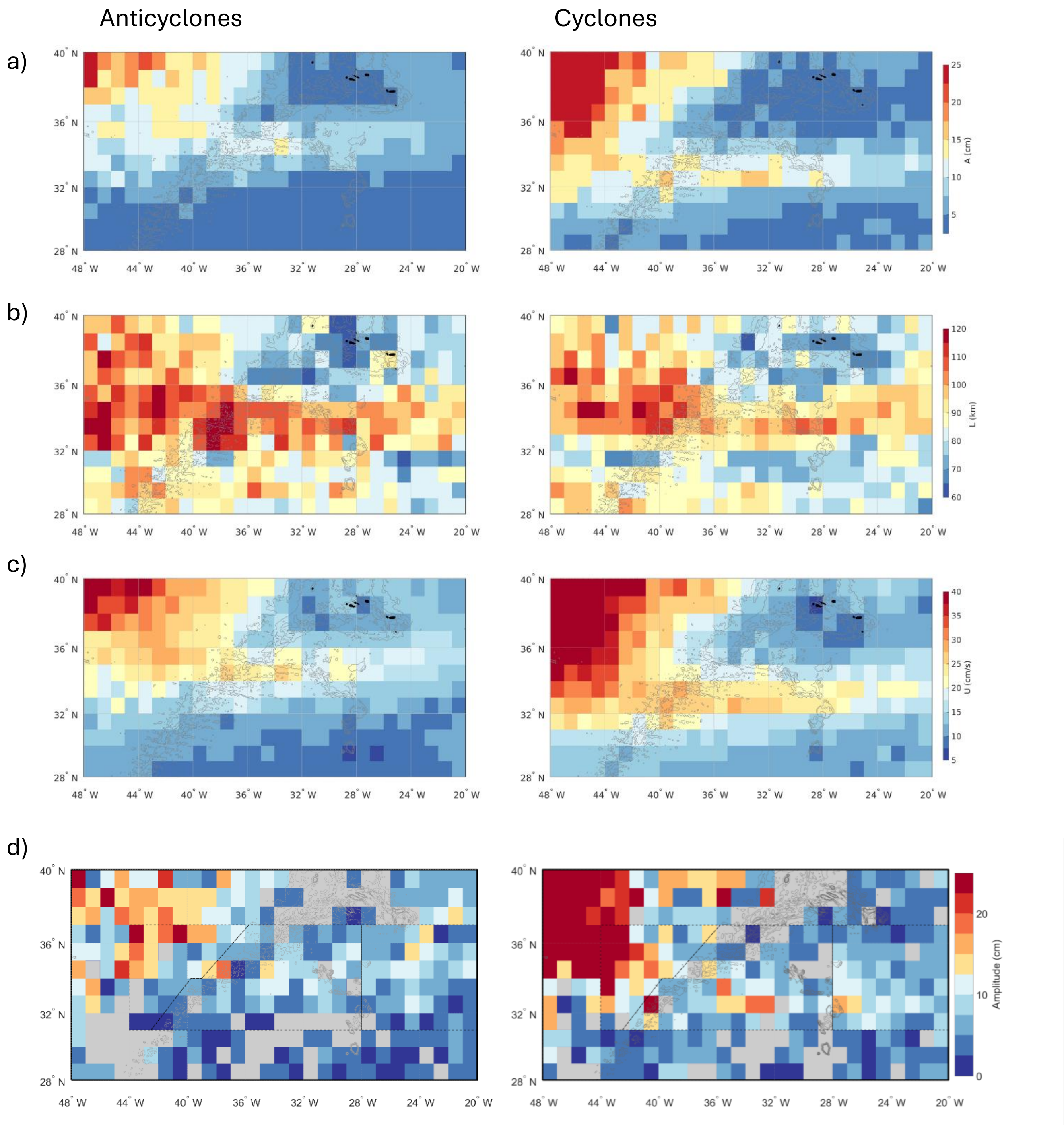

Figure R1 – Spatial distribution of the Eddy Kinematic Properties: (a) amplitude A (cm), (b) radius L (km) and (c) swirl velocity U (cm/s), adapted from Silva Fernandes and Peliz, 2020. d) Spatial distribution of amplitude (cm) of eddies sampled by Argo in this work.

the spatial differences in kinematic properties across the AzCCo, rather than repeating the same analysis.

The second paragraph of the manuscript was altered to: "The Azores current (AzC) is a highly turbulent zonal jet located around 34° N, east of the Mid-Atlantic ridge (MAR), with mean eddy kinetic energy (EKE) values above 200 cm^2 s^{-2} (Figure 1), the highest of the eastern subtropical North Atlantic. The current system and its associated frontal zone have been revisited several times over the last decades (e.g., Gould, 1985; Juliano and Alves, 2007; Frazão et al., 2022). The latitudinal band surrounding the jet, which we will loosely refer to as the Azores Current Corridor (AzCCo) is characterised by coherent eddies, meanders, and filaments, mostly evolving from baroclinic instability of the jet (Klein and Siedler, 1989; Alves and De Verdière, 1999), as well as several other types of structures propagating into the corridor. Different zonal sectors with distinct characteristics have been identified within the AzCCo, characterised by a decrease in EKE values from west to east. These sectors approximately coincide with the locations of two main topographic features in the region. Furthermore, as the Mid-Atlantic Ridge (MAR) acts as a partial barrier between the basins west and east of the ridge, eddies west of the MAR are not only more energetic but also exhibit larger amplitudes, greater radii, and stronger swirl velocities (see Silva-Fernandes and Peliz, 2020, their Figure 7b), c) and d)). East of the MAR, Barbosa Aguiar et al. (2011) identify three main sectors: (i) the western sector between the MAR and the Seewarte Seamount Chain (SWSM) (~28° W); (ii) the central sector between 28° W and 20° W; and (iii) the eastern sector extending toward the Gulf of Cádiz."

The text regarding the spatial magnitude variation of the eddies kinematic properties is underlined.

2. The composite structure indicates an elongated vertical structure for anticyclones in region R2. While I acknowledge that the number of Argo profiles within eddies in R2 is small and that many profiles are concentrated near the southwestern corner, close to the boundary with R3 (L312), it is unclear whether this alone justifies the interpretation. Such a conclusion should be supported by additional analysis.

I therefore suggest recalculating the vertical structure after excluding profiles located near the regional boundary to substantiate this argument.

To test the hypothesis that eddies near the R2–R3 boundary influence the vertical structure of anticyclones, we shifted the R2–R3 boundary eastward, approximately following the ridge axis (red box R2_a in Figure R2, top panel). In this configuration, eddies located along the western flank of the ridge are excluded.

Although Figure R2 presents CT anomaly composites for both cyclones and anticyclones, our analysis focuses exclusively on the vertical structure of the anticyclones.

Inspection of Figure R2a and R2b (left panel) shows that excluding the western flank of the ridge results in a vertical structure with a shallower core and an elongated vertical extent reaching approximately 1500 dbar. This supports our hypothesis that eddies located near the R2–R3 boundary influence the vertical structure of anticyclones in R2.

When initially defining the boxes representing the different dynamical regions of the Azores Corridor, we considered a region (R4 in Figure R2, bottom panel) encompassing the longitudinal extent of the ridge. In this configuration, R2 was subdivided into two regions: R4 and R2_wr, the latter representing only the area east of the ridge. The objective

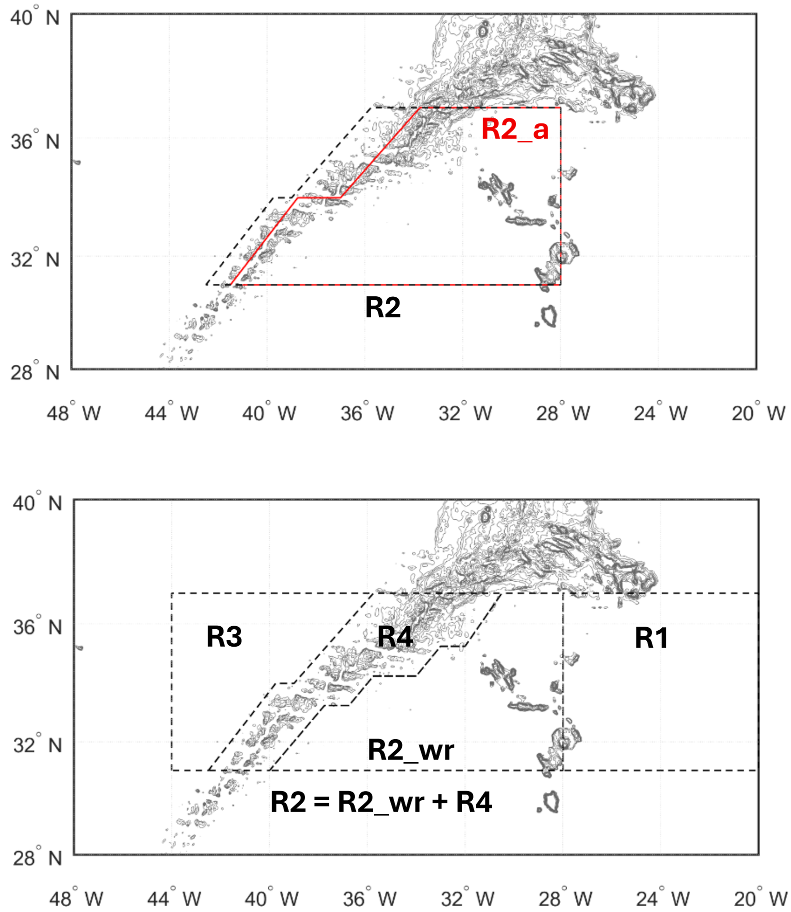

Figure R2 – Boxes used to compute the composites along the Azores corridor. top - excluding the western flank of the ridge. bottom - excluding the ridge itself.

was to assess differences in the mesoscale vertical structure east and west of the ridge, as well as directly above it.

Composites for R4 and R2_wr were computed and analysed. However, because the number of Argo profiles in R4 was limited and their spatial distribution within the box was sparse and radially asymmetric after normalization, we decided to merge R2_wr and R4 into a single region (R2) as described in the manuscript.

Nevertheless, inspection of Figure R3b (centre and right panels) shows that R4 exhibits a deeper core, whereas R2_wr presents core depths similar to those of region R2_a. These results suggest that the vertical structure in R4 may be biased by eddies sampled along the western flank of the ridge, where deeper cores are observed, while the cores in R2_wr and R2_a remain comparatively shallower.

In conclusion, the elongated CT vertical structure of anticyclonic eddies in R2 appears to be influenced by eddies sampled near the boundary between R2 and R3.

3. Large IVD coincides with the temperature/salinity anomaly core in regions R1 and R2; however, in region R3, it extends down to 1500 dbar with little variation, whereas the CT/SA anomaly core remains confined to around 500 dbar.

What physical processes could explain this discrepancy?

We understand your comment.

In regions R1 and R2, the largest IVD values do not exactly coincide with the temperature and salinity anomaly cores but are instead located slightly deeper in the water column. Regarding R3, we do not agree that the CT and SA anomaly cores are confined to approximately 500 dbar. Instead, the anomalies extend to greater depths: in the cyclonic case, CT (SA) anomalies reach approximately 1000 dbar (750 dbar), and in the anticyclonic case, CT anomalies extend down to about 1500 dbar. Since IVD represents the vertical displacement of isopycnal surfaces, it reflects the combined influence of CT and SA variability. In R3, the IVD maximum occurs at approximately 1000 dbar, below the depth of the strongest CT anomalies. A similar vertical offset between the thermohaline anomaly cores and the IVD maximum is also observed in R1 and R2 for cyclonic structures. Furthermore, in the anticyclonic case in R3, the maximum IVD contour is closed near 1500 dbar at the centre of the composite, indicating that the largest vertical displacements occur deeper in the water column and that the eddy structure exhibits a pronounced vertical extent.

Because eddies in R3 are generally larger and more energetic, with higher amplitudes, they are expected to induce stronger and deeper isopycnal displacements. In our view, the observed differences in vertical structure are therefore primarily related to differences in eddy characteristics and origin between the regions (manly between the east and the west of the ridge), rather than to an additional distinct mechanism.

Providing estimates of the mean water depth in each region would help place the vertical structure in context.

A new figure showing the bathymetry of the study region has been added to the manuscript (Figure R5a; Figure 1a in the revised version). From this figure, it can be observed that R2 and R3 present maximum depths of approximately 4000 m, whereas R1 includes deeper areas exceeding 5000 m.

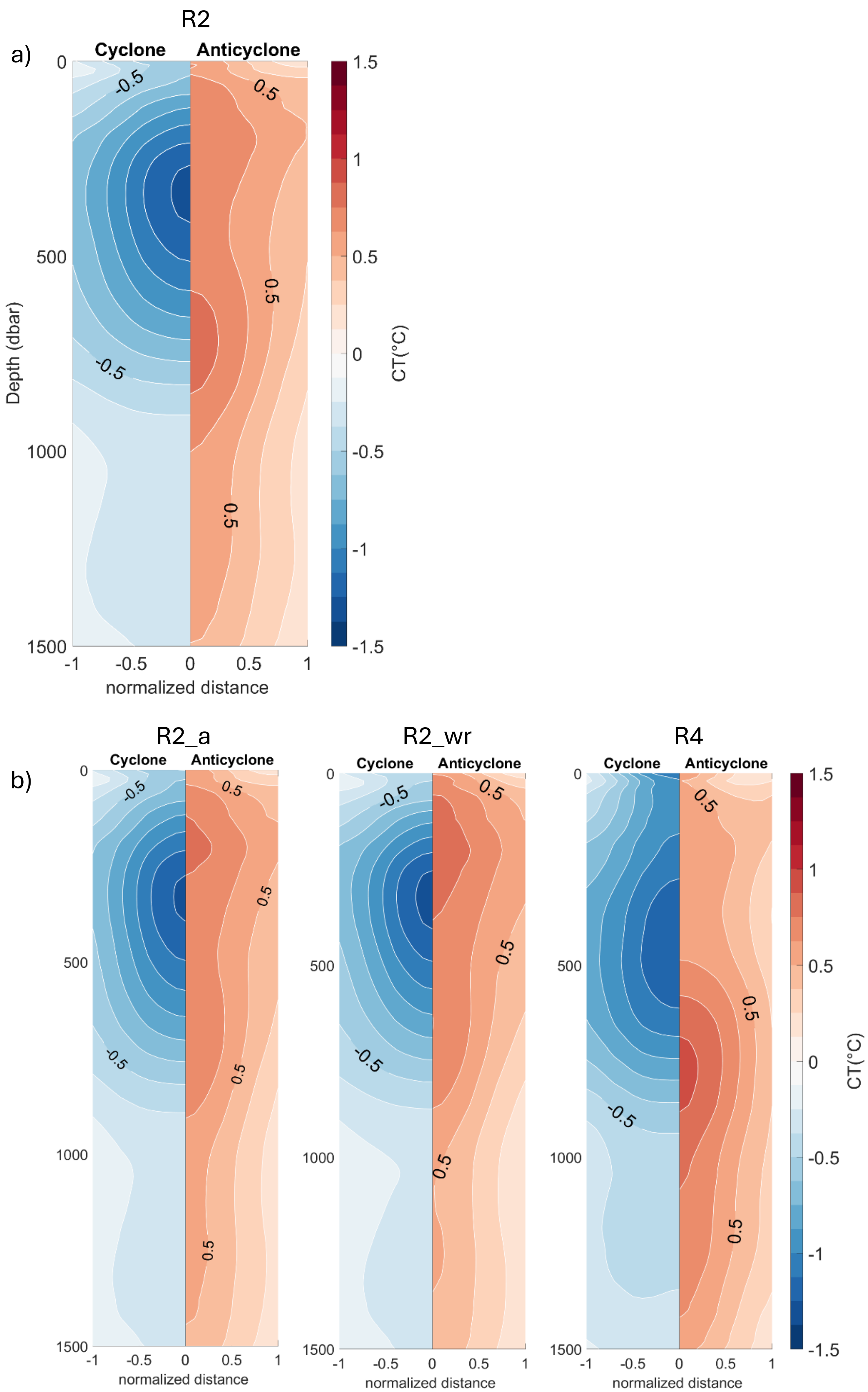

Figure R3 – CT anomaly composite in a) original R2, b-left) R2_a, b-centre) R2_wr and b-right) R4.

Since the overall depths in R2 and R3 are comparable, we do not consider differences in

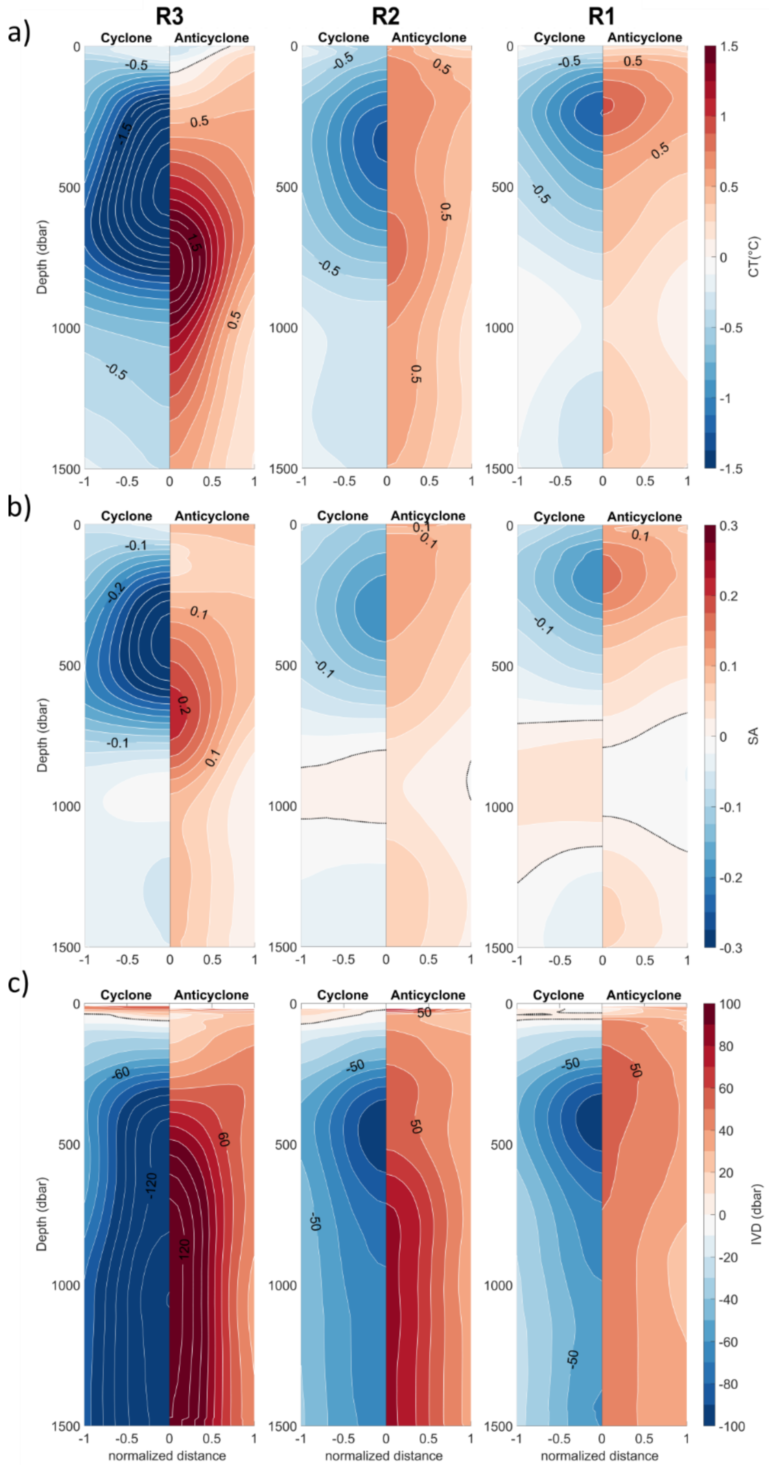

Figure R4 - (Figure 8 of the manuscript): ISOD decomposition: radial vertical structure composite for sampled eddies inside R1, R2 and R3 for both anticyclonic and cyclonic structures. (a) CT anomaly, (b) SA anomaly, (c) Isopycnal Vertical Displacement (IVD). The dotted black line contour represents zero for that variable.

bottom depth to be the primary factor controlling the contrasting vertical structures observed east and west of the ridge. Instead, as discussed previously, we interpret these differences as being mainly associated with the distinct characteristics and origins of the eddies in each region.

In addition, why do eddies appear to penetrate deeper layers in R1 compared to the other regions?

We understand from our results that eddies penetrate deeper layers in R3 rather than in R1. If the reviewer was referring to R3, this deeper penetration is discussed above and is consistent with the stronger and more vertically developed structure of eddies in that region. If a different interpretation was intended, we would appreciate clarification so that we may address it appropriately.

4. Many of the references to regional bathymetric features (e.g., plateaus, ridges, and islands) are confusing and are not clearly represented in the figures.

I suggest revising Figure 1 to include a broader map of the Atlantic Ocean showing bathymetry, the location of the Azores Current, the Mid-Atlantic Ridge (MAR), and the names of the major islands and island chains.

Regions R1, R2, R3, and the Seewarte Seamount Chain should also be clearly marked in Figure 1.

A new Figure 1 was made (Figure R5). The boundaries were extended, and the figure was divided into: Figure 1a: which highlights the main geographic and bathymetric features present in the study region; Figure 1b: which shows the mean EKE distribution. In both panels, is represented not only the study region and the AzCCo, but also the mean axis of the current between 20° W and 40° W, following Silva-Fernandes and Peliz, 2020.

In addition, the bathymetric contours are difficult to discern in the current figures. Plotting the contours in a contrasting colour (e.g., black) would help highlight the bathymetric features in all spatial maps.

The colour of the bathymetry was changed to a darker one in all figures where bathymetric lines were present.

5. The manuscript does not adequately address the seasonal variability of the background circulation and its potential influence on eddy trajectories and vertical structure.

We understand and agree with your comment. The seasonal variability of the background circulation is indeed important, and further investigation is needed in this region given the current scarcity of studies.

Even though we did not make a thoroughly characterisation of the variability in this region, a superficial analysis of the inter-annual and seasonal eddy kinetic energy (EKE) and the geostrophic kinetic energy (GKE) variability was made.

The differences presented were not very significative in terms of seasonal variability. A first analysis indicated that the inter-annual variability could play a more important role

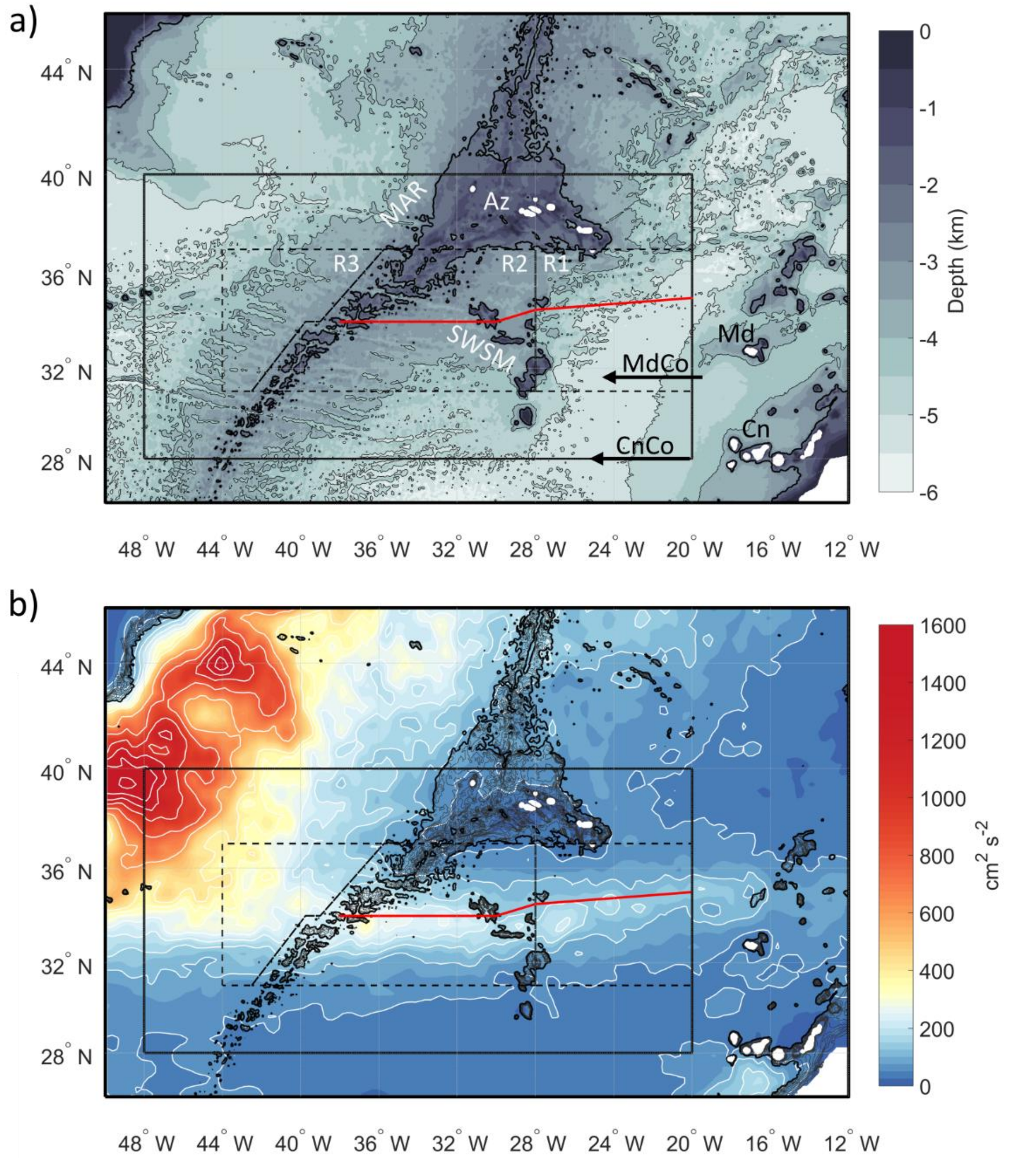

Figure R5 - (Figure 1 in the revised manuscript) (top – Figure 1a in the revised manuscript) Bathymetric map. The thick black contour represents the 2.5 km bathymetric and the black thin ones the 4 and 5 km bathymetric (bottom – Figure 1b in the revised manuscript) Mean EKE for the period 2005-2017. The contours are highlighted in white every 50 cm2/s2 until the 400 cm2/s2 level and then every 200 cm2/s2. The thick black contour represents the 2.5 km bathymetric. On both figures the black box represents the study region and the black dashed boxes the 3 regions of the AzCCo; the dotted line represents approximately the current axis between 20 ^{o}w and 40 ^{o}W following Silva-Fernandes and Peliz, 2020. Land areas are represented in white.

in this region, since years with lower values of EKE or even in the GKE will reflect less instability of the AzC and consequent generation of eddies.

We understand and agree that seasonal variability of the background circulation could influence eddy trajectories and vertical structure. In the present study, we did not analyse eddy trajectories seasonally or inter-annually, so we cannot quantitatively assess these effects. However, our results focus on eddy composites constructed from a multi-year dataset, which integrates a range of conditions. Therefore, the composite structures are expected to reflect the general characteristics of anticyclones and cyclones in the region.

Furthermore, since the number of Argo floats emerging inside eddies in each season is relatively low (see Table R1), seasonal composites would be based on very few profiles and would therefore not provide a statistically robust representation of the eddy structure. As a result, good seasonal composites cannot be reliably produced from the available dataset.

In addition, the study does not discuss the monthly distribution of Argo profiles sampled within eddies in each region. Any potential bias arising from uneven sampling or oversampling during particular months should be evaluated and discussed.

Table R2- Number of Argo floats by season emerging inside eddies.
Wi – Winter, Au – Autumn, Sp – Spring and Sm- Summer

Anticyclones	**R1**	**R2**	**R3**
Wi	76 (31%)	60 (25%)	21 (16%)
Au	46 (19%)	59 (24%)	21 (16%)
Sp	81 (33%)	41 (17%)	39 (30%)
Sm	41 (17%)	82 (34%)	50 (38%)
Total	244	242	131

Cyclones	**R1**	**R2**	**R3**
Wi	57 (21%)	45 (22%)	39 (34%)
Au	74 (28%)	32 (15%)	27 (23%)
Sp	60 (22%)	72 (34%)	22 (19%)
Sm	77 (29%)	60 (29%)	28 (24%)
Total	268	209	116

In Figure R5a and R5b, the number of eddies per month is shown for both anticyclones and cyclones. Overall, there is no evident bias in the monthly sampling. Some exceptions exist, such as the low number of sampled anticyclones in September–October in R1 (Figure R5a) and of cyclones in November–December in R2 (Figure R5b), but in general, the number of sampled eddies is well distributed across all months in all regions for both anticyclones and cyclones.

The manuscript includes an excessive description of the figures that reiterates information already evident from the visuals. I recommend reducing these descriptive passages as well as repetition and instead focusing on the key results and their underlying physical interpretations.

We appreciate your comment. This issue has been addressed in the revised version, which has been shortened by approximately four pages.

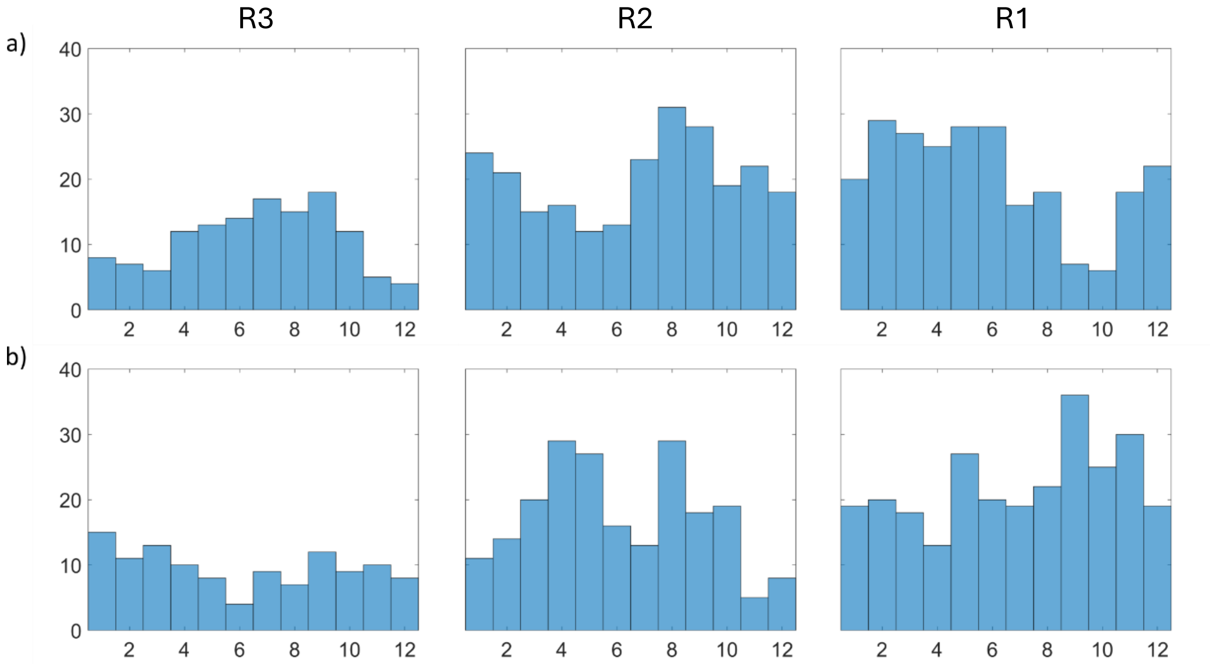

Figure R6 – Number of Argo per month inside eddies: a) anticyclones and b) cyclones.

Minor Comments

. L39: MAR is not defined in the manuscript except in the abstract.

MAR is now defined in the line 40 of the revised manuscript.

. L80: The order of the main research questions presented here does not match the current structure of the manuscript.

We appreciate or comment. The order of the questions in the introduction was changed to match the structure of the manuscript.

. L108: Extra parentheses.

Corrected.

. L134: Repeated sentence.

Corrected.

. L162: The method is not clear.

What we meant was: An eddy was considered to belong to a region if the Argo float sampling that eddy was located within that region, meaning that we used Argo locations rather than eddy centroid positions. This approach was adopted because, given an eddy's spatial extent, it can span multiple regions; even if its centroid falls within one region, the Argo sampling it could be located in another. Therefore, we assigned eddies to regions based on the location of the Argo float sampling them.

The text was changed to: “To avoid ambiguities when eddies extend across regional boundaries, regional attribution was based on the location of the Argo float sampling the eddy rather than on the eddy centroid position.”

. L214: Grammatical error. Provide the latitude of the current axis for clarity. The north-south difference in sampled eddy trajectories is not evident in Figure 4.

The error was corrected. The latitude of the current axis is provided in Line 32 of the revised manuscript, and a red line was added in Figure 1 to represent the current axis.

Regarding the north-south difference, that is more evident in region 2 We added this detail in the text: “Along the AzCCo, the highest trajectories numbers are located north (south) of the current axis (~34º N) for anticyclones (cyclones) in R2, whereas other areas show a more even distribution.”

. L226: Madeira Island is difficult to locate and is not denoted in the study area.

Its location was added in Figure R4a (Figure 1a of the revised manuscript).

. L241: Region 2(b) is missing in the figure caption.

Corrected.

. L256: Figure caption is unclear (“shown in Figure CT (left) and SA (right)”).

We were referring to Figure 6. The number of the figure was added to the text.

. L307: Figure 7a does not show the anomaly. Check the figure reference.

The figure is 8a not 7a. It was corrected in the text.

. L334: The nearly uniform magnitude of isopycnal vertical displacement does not constitute a barotropic eddy structure. Consider using alternative terminology to avoid confusion.

We understand your comment. In the revised manuscript, we have replaced the terms “more barotropic/baroclinic”: “more uniform” instead of “more barotropic”, and “with a well-defined subsurface maximum” instead of baroclinic.

. L410: Figure reference is not correct. Figure 10 is not referred to in the manuscript.

The Figure 9 in lines 410 to 411 is in fact Figure 10. It was corrected in the text.

. L380-382: These details are part of the figure caption. Why discuss it as a result?

We appreciate your comment. Those details were deleted.

Correct the reference Frenger et al. (2015).

Corrected.

Figures

Figure 3: Use the same sequential colour scale in panels (a) and (c) for easier comparison of the number of profiles inside cyclonic and anticyclonic eddies.

We chose to use the same colour as panel (e) - green

Add tick marks on the axes. The minimum and maximum of the whiskers are not clear.

We re-did the boxplots with thicker ticks and whiskers.

Figure 5: Eddy trajectories are not clearly visible.

The figure was re-done with a thicker line for the trajectories.

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