Reply referee 1

We would like to thank the reviewer for his/her review and constructive feedback. We appreciate the effort and time the reviewer has invested in evaluating our work. Please find our point-to-point response below in blue.

General Comments

This paper investigated the dynamics North Brazil Current (NBC) rings and computed volume and heat transports of the surface and subsurface NBC rings. Their computations relied on the recent in situ observations from the EUREC4A-OA field experiment and satellite altimetry. Compared to previous studies, their computations utilized the vertical structure of the eddies provided by the unparalleled vertical and spatial resolution of the EUREC4A-OA field experiment. Previous studies emphasized surface rings as the dominant force of water transport in this region. They estimated that the subsurface brazil current rings transport water mass between 0.4 Sv and 9.7 Sv, and the surface rings transport about 1.5 Sv. Their estimates cast doubt on previous estimates, but their estimates of subsurface ring transport still has large uncertainty. The drift velocity and transported volume can depend on factors like surrounding flow, topography etc, which I think the paper should remind the reader of those factors.

We thank the reviewer for his/her constructive comment. Indeed, both the drift velocity and the transported volumes may be influenced by factors such as the surrounding flow and underlying topography. We have highlighted these aspects in the discussion section of the revised manuscript..

Heat transport of the surface and subsurface rings were estimated to be lower than previous estimates. I find Methods and assumptions are clearly explained, and their computations support their conclusions.

Specific Comments

1. The paragraph starting from line 344 does not have enough data to support the statements. Is it appropriate to include the paragraph?

We thank the reviewer for bringing this to our attention. The paragraph starting from line 344 deals with the evolution of the second vertical superimposition of two NBC rings. We agree that we do not have enough data to discuss the formation of this vertical superimposition of two NBC rings, nor its evolution after February 7. However, the evolution from January 25 and February 7 is supported by Figure 4 and 6, which shows the surface signature of this structure as well as cross-sections carried out in the structure. This paragraph, Figure 4 and 6 show that (1) a surface NBC ring, that is detected by the TOEddies algorithm can remain trapped in the retroflection, (2) a subsurface NBC ring can have a surface signature (this is also supported by Figure 4. c.), (3) a subsurface NBC ring is not necessarily trapped within the retroflection region and can drift away independently of its surface counterpart. Although more precise temporal data are not available, we are confident in these observations, which are supported by both in situ measurements and altimetry data. We therefore consider it important to retain this paragraph, as it offers valuable insight into the surface and subsurface dynamics of the region.

2. The section on Cyclonic eddy seems to be isolated in the paper. I don't see the connection of this section with the rest of the paper.

We thank the reviewer for his/her constructive comment. One of the objectives of this study was to construct an eddy census based on in situ data. We agree that cyclonic eddies are not central to our analysis and are generally less significant in the transport of water masses in this region. However, previous studies have shown that some cyclonic eddies can be intense and capable of transporting water masses toward the French West Indies (Fratantoni et al. 2006). As NBC rings are, by definition, anticyclonic eddies, cyclonic eddies in the region are often under-documented. Here, we contribute a description of the vertical structure of a cyclonic eddy, an aspect that remains relatively rare in the literature.

3. In section 4.2, eddy boundaries are determined using $|\Delta EPV_z|/|EPV_x|$. However, section 3.2 line 215 says eddy boundaries are identified using a chosen isoline of ζ. I get confused which method is used for the calculations in section 4.2 and what are the purposes of the two methods of identifying eddy boundaries.

We thank the reviewer for his/her constructive comment. We agree that this choice may appear confusing at first glance, but several factors motivated it. First, in Section 3.2, our aim was to compare eddies contours identified by the TOEddies algorithm with in situ data (Figure 2.b. and Figure 4.b). To do so, we selected a criterion based solely on the velocity field. Second, the resolution of the hydrographic data did not allow for the computation of $|\Delta EPV_z|/|EPV_x|$ across all cross-sections. In some cases, the spacing between uCTD or CTD profiles was too large to reliably estimate the required gradients. To ensure consistency throughout Section 3.2., we therefore used relative vorticity ζ in Figures 2 and 4. Moreover, using ζ provides insight into the dynamical interactions between the surface and the subsurface NBC rings, which have been shown to be significant in previous studies (e.g., Napolitano et al. 2024).

4. On line 397, eddy boundaries are determined using $|\Delta EPV_z|/|EPV_x| = 30$. How sensitive is the volume estimate to this criteria?

We thank the reviewer for his/her important comment. We acknowledge that this is not a commonly used criterion. It was first proposed by Barabinot et al. (2024) to estimate the volume of mesoscale eddies while accounting for their turbulent boundaries. The method was further developed in Barabinot et al. (2025), where the authors discuss the appropriate threshold values to be used.We kindly refer the reviewer to these studies for a detailed justification of the approach. Below, we provide a summary of the main idea, illustrated with an example.

Figure 1 displays the quantity $|\Delta EPV_z|/|EPV_x|$ for the subsurface NBC ring sampled along cross-section 32 of the RV Atalante. In the figure, the core of the eddy is saturated in dark red, indicating values of $|\Delta EPV_z|/|EPV_x|$ > 50. A sharp gradient can be observed at the eddy boundary, for example, at z=-300 m, the ratio increases from 1 to 50 over a horizontal distance of 2.8 km.

Using a threshold of $|\Delta EPV_z|/|EPV_x|$ = 50 instead of 30 reduces the estimated eddy volume by only 2.3%. The rationale is that $|EPV_x|$ should be negligible compared to $|\Delta EPV_z|$, ensuring that the effect of submesoscale instabilities near the eddy edge can be safely neglected.

Barabinot et al. (2024, 2025) concluded that the eddy volume derived from this isoline-based method is not very sensitive to the specific threshold value chosen.

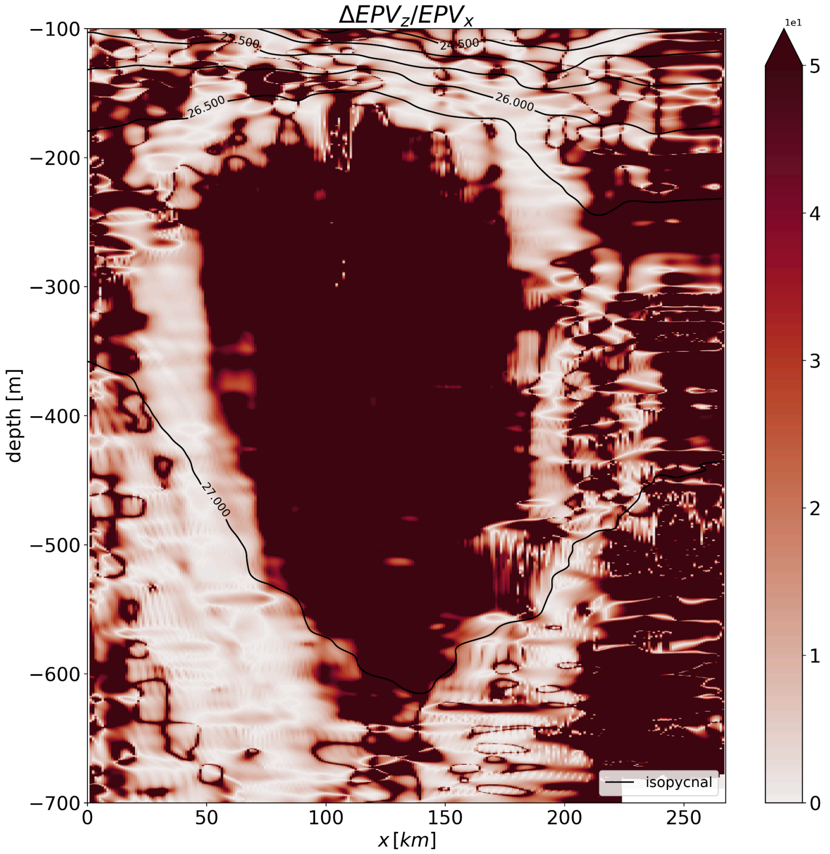

Figure 1. $|\Delta EPV_z|/|EPV_x|$ for the subsurface NBC ring sampled by the cross-section 32 of the Atalante.

5. The drifting velocity of $NBC_{sub}2$ is used to estimate transported volume. What about also using the drift velocity of $NBC_{surf}1$ to make a lower estimate of transported volume of surface rings? It seems that the transported volume of both surface and subsurface rings can have large variability due to factors like background flow, topography, seasonality etc.

We thank the reviewer for his/her helpful comment. The drift velocity of $NBC_{surf}1$ was used to estimate the transported volume of surface rings as described between lines 407 and 414. In contrast $NBC_{surf}2$ exhibits no drift as it remains trapped within the retroflection region.

We agree that the transported volume of both surface and subsurface rings can vary significantly due to factors such as background flow, topography, seasonality etc. Our estimates are specific for the conditions observed in January and February. We have added a sentence in the discussion section to clarify this point.

Technical Corrections

1. In Figure 12 panels (c) and (d), the x-axis extents are different from panel (a) and (b). I think it will be better to have the same x-axis limits if you have the data.

We thank the reviewer for bringing this to our attention. The axes are indeed the same; however, the x-axes of panels (b) and (c) are shlightly compressed due to the presence of the colorbars. In the revised version of the manuscript, we adjusted the figure accordingly.

2. In figure 9, it seems that WNACW and ENACW are shaded, but not mentioned in the caption.

We thank the reviewer for bringing this to our attention. We agree, and the abbreviations WNACW and ENACW have been added to the figure caption in the revised manuscript.

3. Line 303 and 332 mention "Section 1", but it's not clear which section they are referring. Similarly, "Section 4" on line 341 is also confusing.

We thank the reviewer for bringing this to our attention. We have modified the numbers in the revised version of the manuscript.

4. Line 225 should delete word "used".

We thank the reviewer for bringing this to our attention. The typographical error has been corrected in the revised manuscript..

5. In equation (7), Δz is the layer depth. I find it confusing it to express it as $z_{sup} - z_{inf}$, which is the depth of the whole eddy.

We thank the reviewer for bringing this to our attention. The typographical error has been corrected in the revised manuscript.

6. Add space on line 421 between "km" and "captures".

We thank the reviewer for bringing this to our attention. The typographical error has been corrected in the revised manuscript.

7. Add space on line 440 between "section" and "3.3".

We thank the reviewer for bringing this to our attention. The typographical error has been corrected in the revised manuscript.

References:

- Fratantoni, D. M., & Richardson, P. L. (2006). The evolution and demise of North Brazil Current rings. Journal of Physical Oceanography, 36(7), 1241-1264.
- Napolitano, D. C., Carton, X., & Gula, J. (2024). Vertical interaction between NBC rings and its implications for South Atlantic Water export. Journal of Geophysical Research: Oceans, 129(4), e2023JC020741.
- Barabinot, Y., Speich, S., & Carton, X. (2024). Defining mesoscale eddies boundaries from in‐situ data and a theoretical framework. Journal of Geophysical Research: Oceans, 129(2), e2023JC020422.
- Barabinot, Y., Speich, S., & Carton, X. (2025). Assessing the thermohaline coherence of mesoscale eddies as described from in situ data. Ocean Science, 21(1), 151-179.