Reviewer 1

Dear **RC1**:'Comment on egusphere-2025-3823' , Anonymous Referee #1, 28 Nov 2025,

On behalf of the co-authors, we thank you for your thoughtful comments on our manuscript. We believe it brought a good perception of what can be improved. You can read below our reply to your comments in blue, and you'll see the modifications marked in the text.

Specific comments on figures:

- Figure 1. I suggest changing the blue color, as it makes the label "Amazon" difficult to read. Additionally, increasing the latitude and longitude numbers, as well as the colorbar numbers and title, would improve overall readability.

Thanks for the suggestions. We have implemented the color and letter size modifications you suggested, and we hope they improve readability now.

- Figure 8. The years on the x-axis are hard to read. Rotating them 45º would enhance clarity. Consider including the BMC and trend within the corresponding subplot for easier interpretation.

Thanks for the observations. We evaluated, and the rotation indeed looks better, but the legend is still at the end of the figure, as we think it is easier for the reader to find there.

Minor comments and typos:

- Line 19. The acronym Brazil-Malvinas Confluence (BMC) is defined twice. I recommend removing the second occurrence in the abstract.

That is fixed now. Sorry for missing this.

- Line 21. I suggest changing "mixing layer depth" to Mixed Layer Depth (MLD) to maintain consistency with the rest of the manuscript.

We agree that would be a better definition. Thanks for the comment.

- The term Kelvin wave(s) appears with both uppercase and lowercase "w" throughout the text. I recommend choosing one for consistency.

We agree with the comment and made the fix.

- Line 119. The acronym GLORYS is not defined. Moreover, the reanalysis is referred to inconsistently as Glorys, GLORYS12s, GLORYS12, GLORYS 12v1, GLORYS12 v1. I recommend standardizing the notation for consistency, while keeping distinctions when referring to different resolutions of the product.

That is a good point, thanks for the comment, we fixed the reference to GLORYS12v1 and took it as the standard.

- Line 198. The sentence currently repeats “during winter”. I suggest rewriting it to avoid this redundancy.

Thanks for the attention here. We removed the additional sentence

- In section 3.1.2. Are the authors referring to temperature? Or is it potential temperature?

It is the potential temperature. We have specified in the first sentence to make it clear.

- Line 276. A hyphen is missing. It should be: meso- and large-scale circulation.

Indeed, thanks for the comment.

- Line 303. The acronym SSH should be defined.

We are adding this at line 307.

- Line 340. The statement “Different Authors indicated that both currents can widely vary their transport from 5 to 88 Sv”. Should be reconsidered. According to Goni et al. (2011), “Most recently, it has been reported that the transport of this current varies widely between 10 and 88 Sv [*Garzoli*, 1993;*Peterson*, 1992].” Please verify and update citation.

During the research, various mean transport values for the currents were identified, but according to Goni et al. (2011), the variability ranges from 10 to 88 Sv. We made the amendment in the text according to Goni et al., (2011).

- Line 404. There is a missing space in 22Sv.

Fixed.

- Lines 407 and 436. The authors refer to Figures 8a and 8b, but the subplots in Figure 8 are not labeled. I recommend either adding the letters to the subplots or removing the references to “a” and “b” in the text.

We believe it’s better to add the letter to the subplots, as they refer to different accountable values that need distinction. Figure 8 is updated with this adjustment.

- Line 409. The sentence “With maximum latitude at 5ºN”. I suggest adding “With a” to improve readability.

Yes, we believe that sounds better. We made the adjustment in the sentence that is on line 416 in the new version of the paper.

- Lines 413-417. These sentences could benefit from improved clarity and consistency in terminology. Currently, wind speed and wind intensity are used interchangeably, which may confuse readers. Additionally, the discussion of reduced wind speed as a limiting factor is somewhat repetitive. I recommend combining the explanation of the cause (low wind speed) with its consequences (reduced wind stress, weaker eddy formation, and decreased NBC retroflection transport) into one sentence.

Response: We had the chance to rephrase this paragraph to ease the understanding. This is lines 417-425 in the updated manuscript.

- Line 436. The acronym North Brazil Current (NBC) does not need to be defined here, as it has already been introduced earlier.

Agreed, that was removed at this line.

Major comments:

- Lines 215-217. The authors state that the unbalanced freshwater influence is primarily local and does not lead to a general bias. However, I observe differences in the mixed layer depth, particularly in the Brazil-Malvinas Confluence. I suggest including a plot of the MLD bias in Figure 2 to provide additional support for this claim. Furthermore, in the following section, the authors note critical differences in MLD compared to observational data.

We agree that the writing needs revision as it has created confusion. The sentence offers a very broad understanding of the outcome. The model provides a biased version when compared to observations. This is especially the case in Figure 2 near the coastline, as the observations provide a low-resolution MLD field with less information in this region. We believe it will increase the sensitivity of the result if we reformulate the sentence from:

The results indicate that the amount of freshwater on the surface and the lower density contribute to less mixing in shallower depths. *The similarity of the results far from the coast, especially MLD and density patterns, indicates that this unbalanced freshwater influence is primarily local at the delta of the Amazon and La Plata Rivers and does not lead to a general bias.*

to:

The results indicate that the amount of freshwater on the surface and the lower density contribute to less mixing in shallower depths. *At higher depths, the similarity of the results, especially in MLD and density patterns, indicates that the unbalanced freshwater influences the appearance of local biases more strongly at the deltas of the Amazon and La Plata Rivers. However, there are still biases near the BMC and in tropical regions that may be due to other factors.*

- Line 414. It would be interesting if the authors could demonstrate this: “This represents the lack of mixing, which can be either due to the influence of the wind speed (Figure 5c) or the use of a z-coordinate vertical structure.” It would improve clarity and support the conclusions (line 533) if the authors explicitly quantify or visually demonstrate the relative contributions of each factor.

This is indeed an interesting investigation. To pursue this, we made a simulation with a similar configuration using a different coordinate system called hybrid coordinates. We present the outcome in the new version of Figure 5. Due to time constraints, the hybrid simulation is smaller than the one with the initial z-coordinate, so the analysis period in this figure was reduced to 5 years (compared with 20 years initially considered). However, we could demonstrate with clarity that the range of bias in the vertical structure is highly dependent on the vertical discretization. We thank you for your suggestion. Adding this really improved the results to have this verification. We also added the previous figure as a

supplementary figure, to serve as a comparison of the 5-year period mean and the 20-year period.

Reviewer 2

Dear **RC2**: 'Comment on egusphere-2025-3823', Anonymous Referee #2, 09 Jan 2026,

Thanks for your time and patience in reviewing our manuscript. We believe your comments were very important to enhance the value of this study and make the scientific content more instructive to readers! Writing below, we are making our comments in blue under yours and hoping we satisfy your concerns and show a better, improved manuscript after reformulation.

Text:

Lines 29 to 34: is not clear how the authors are presenting the work, I suggest reformulate these first sentences.

Response: The sentence was reformulated, we hope that the explanation is plain on how this work intends to contribute to science.

Line 46: I will suggest another term to replace “intercepted”, maybe just mention that the BC and the MC confluence at… and include some more citations of works that have study the confluence zone.

Response: Thanks for the suggestion, we rephrase the sentence now to: *The BC and the Malvinas Current (MC) confluence at a southward region (Garzoli and Bianchi, 1987; Goni et al. 2011; Combes and Matano, 2014b; Barré et al. 2006; Ferrari et al. 2017; Artana and Provost 2023), forming the Brazil-Malvinas Confluence (BMC).*

Line 47: include citations from Barré et al. 2006; Ferrari et al. 2017; Artana and Provost 2023, they have studied this region in terms of ocean dynamics and **will give the authors some more ideas to explain clearer the confluence zone.**

Response: Thank you for indicating the references. We amended the text and are also considering the citations.

Line 50 and 51: Search for citations to support the sentence.

Response: Thanks for pointing this out. We believe that the best citation for this sentence is Combes and Matano 2014b (https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2014GL062523) which shows some relation between the ACC and MC.

Line 193: did authors thought of performing and EOF analysis to find if there is a dipole?

Response: No, we actually performed EOFs for the entire basins, but for other purposes, rather than to distinguish the density cores found in the bias plot in Figure 3. We appreciate your interference here. The sentence was reviewed for clarity.

Line 283 and lines 293 to 297: I will include more citations from recent works that also describe the MC and BC and their confluence using GLORYS12 and satellite data.

Response: We believe the most recent findings from GLORYSS12 are consistent with the 38S location for the BMC. We added this information in line 383, the location in the text that we choose to precisely discuss the BMC. They are the following:

Artana, C., Provost, C., Poli, L., Ferrari, R., Lellouche, J.-M.. Revisiting the Malvinas Current upper circulation and water masses using a highresolution ocean reanalysis. Journal of Geophysical Research. Oceans, 126 (6), doi.org/10.1029/2021JC017271, 2021

Artana, C., Provost, C., Lellouche, J.-M., Rio, M.-H., Ferrari, R., & Sennéchael, N. The Malvinas Current at the Confluence with the Brazil Current: Inferences from 25 years of Mercator Ocean reanalysis. *Journal of Geophysical Research: Oceans*, 124, 7178–7200. **https://doi.org/10.1029/2019JC015289, 2019**

Lines 304 to 305: so then is the NBC the most prominent current? (lines 287). Explain clearer related to the preview statement in line 287.

Response: Thank you for this observation. It is true that, despite being the WBC with the highest current speed in the Southwestern Atlantic, the NBC SSH standard deviation patterns don’t stand out. This suggests that in this region, the energy cascade may not drive local eddy formation. This is explained at the end of this paragraph with some additional information on lines 318-320

Line 316: the variability depends on the dynamics the BMC is a confluence of 2 currents and the dynamic associated to this feature explains the high variability of the region. Search for more literature and explain better this concepts.

Response: Corrected text: **The high variability in the BMC occurs due to the physical processes related to the confluence of the BC and MC, which, near the Patagonian shelf, promote eddy formation due to the continental slope. As it shows fewer SSH deviations, the propagation of eddies in the NBC in this simulation is reduced. This suggests that the energy cascade primary process may not only drive eddy formation in this region but also other physical dissipative processes. The distinguished aspects found for the NBC and the BMC are covered in different sections in the following chapter, where this study evaluated the seasonal variability and trends.**

Line 346: support with citations related to bottom friction and bottom currents in the Argentine Basin, there are many works in the region.

Response: We think a rephrasing was needed here. We wanted to compare the regional model development with ROMS and MOM6. In the ROMS outputs, from Combes and Matano (2014a), the authors reveal that the ACC transport and the bottom friction interfere the MC variability. In our case, the ACC transport is given through the reanalysis, so the only interference to the MC variability is the bottom friction, which is obtained in the model with the bottom parametrization in the ocean model.

Line 363: replace Glorys with GLORYS12 reanalysis.

Response: Corrected. Thanks for pointing this out.

Line 416: support with citations

Response: We emphasize in lines 425 and 426 the influence of wind on the currents' eddy kinetic energy and vertical mixing with this reference: Song, H., Marshall, J., McGillicuddy, D. J., & Seo, H. (2020). Impact of current-wind interaction on vertical processes in the Southern Ocean. Journal of Geophysical Research: Oceans, 125, e2020JC016046. https://doi.org/10.1029/2020JC016046

Line 443 to 445: support with citations

Response: The additional supporting citations can be found in line 463 in the new version.

Line 477: support with citations

Response: You will find the citations and an improved description in lines 485-488.

Lines 482 and 483: This is an important result can you explain a bit more.

Response: Thanks for the comments. Considering this, we are presenting a better representation of the waves in the diagram with an auxiliary diagram in Figure 11. We think that would improve the understanding of the results.

For the summary and conclusions if the authors accept the suggestions of new literature to be cited then this will enhance also the discussion.

Line 499: The maximum negative SST bias of 1.0°C is sufficiently good performance for forecasting ocean conditions. Why?

Response: In South America, global models usually present seasonal biases, as noted in Adcroft et al., (2019). This interfere in the distribution in the energy and could imply in major problem with the interactions with the atmosphere.

Figures:

Fig. 1: I think the river is in blue is Parana River and Rio de La Plata is the estuary in the discharge of Parana and Uruguay rivers.

Response: Thanks for the observation, La Plata is indeed the estuary. In the plot, we show the Parana River and up north, the Paraguay River flowing in Bolivia. We renamed accordingly.

Fig. 2: I suggest to use a thinner grid line is a bit to strong and difficult to appreciate the data, also will be good for the reader to plot more isolines to compare better the results from the model with the observation data.

Response: Agreed, that was fixed in the new version. We hope the new design is more appealing

Fig. 3: same grid problem as 2 and also some thinner isolines will help as well.

Response: Agreed, that was fixed in the new version. We hope the new design is more appealing

Fig. 4: I will suggest to remove the grid is making complicated to understand the results.

Response: Agreed, we removed the horizontal grid

Fig. 6: maybe will be a good idea to show in the figures again the main currents and play a bit more with colors to enhance the MC and BC. Also grids thinner.

Response: We changed the colors displayed in Figures 6 and 7. We believe that already helped to observe the main features and currents in the domain.

Fig. 8: for the years I suggest to put one year yes one year not they are too tight like it is.

Response: Thanks for the suggestion. We plotted the years rotated, and hope it improves the readability.