Author response to comments on “On Mode Water formation and erosion in the Arabian Sea: Forcing mechanisms, regionality, and seasonality" by Font et al., (Preprint egusphere-2025-468)

We thank the referee for critically reading this manuscript and providing helpful feedback, which has added a great deal to improve the manuscript and clarify certain sections.

We respond to all issues addressed in their comments below, as well as we add the revised changes in the manuscript. The Reviewer comments are included here in black, and the answers below the respective comments in blue. The text that has been modified in the manuscript according to the reviews is presented in *italic*. The line numbers in the answers refer to the new manuscript version after the suggested changes.

Referee #2

This paper uses Argo observations alongside one- and three-dimensional models to examine the formation mechanisms of Arabian Sea High Salinity Water, one of the key water masses in the upper Indian Ocean. ASHSW formation is found to be atmospherically driven in the main, although there are regions where ocean processes exert an appreciable influence.

The formation of ASHSW received a fair bit of attention a few decades ago: it is nice to see the topic revisited with new observations and tools, and a fresh approach. I have a few comments and questions below, but this is a well-written paper with nice figures, and I suspect that the revisions I’ve suggested are fairly minor.

Line 27. “… Over the Argo era…” – give the year, just for clarity?

Thank you. We added to the period. Text changed to: Line 27 ”*... over the Argo era (2005–2020, Z. Li et al., 2023).”*

Line 39. The paper has a lot of acronyms in it: I might not use one for Arabian Sea.

We agree with the referee on reducing the number of acronyms. The Arabian Sea is not an acronym anymore.

Line 42. Comma after mass?

Thank you, added.

Line 62. Acronym already defined, so should be OMZ.

Thank you, changed.

Line 68. My feeling is that this sentence should be the start of a new paragraph – perhaps joined with the one after?

Thank you for the suggestion. We moved it to the start of the following paragraph to improve the flow of the text (see line 72).

Line 85. The number of profiles for half-degree bin: is this over the whole time period?

Yes, it is over the whole period. We have clarified it in the text (line 85: "*over the studied period*" and in the caption of Figure 1: "*The total*")

Line 145. Is mode water thickness defined on depth or density? The upper and lower boundaries are defined in density – but is this then converted into a depth? Either is fine, but would be good to state clearly.

The MWT is defined in depth space. We have clarified (Line 149. "*on either side of the core of the MWL in depth space"*

Line 147. Have the authors done any sensitivity analysis on these definitions? For instance, does choosing 30 days give very different results to choosing 20? Or 40?

Thank you for your comment regarding the sensitivity of our definitions. The choice of 10 m for MWT is constrained by the vertical resolution of our data gridding, which is 4 m. To ensure robustness in our analysis, we require at least three data points within the MWL. Defining MWT with a thinner threshold (e.g., 8 m) could lead to increased uncertainty, while a thicker threshold (e.g., 12 m) would not substantially alter our conclusions. The 30-day duration was selected as an optimal balance to minimize the influence of data gaps, given that our dataset has a 10-day temporal resolution. A shorter threshold (e.g., 20 days) might be more sensitive to transient variations, while a longer threshold (e.g., 40 days) could smooth out meaningful variability. The stratification threshold of $5x10^{-5}s^{-2}$ was chosen to represent a physically meaningful transition, as it approximates the background stratification typically observed in the region outside of the MWL. This ensures that the erosion definition captures the point at which the MWL is no longer distinguishable from the surrounding water column. To clarify these choices, we have now explicitly stated this rationale in the revised manuscript as follows:

Line 158-162: "*The erosion time of the MWL is defined as when the stratification at the core of the MWL exceeds* $5x10^{-5}\ s^{-2}$ *(*$N^2_{MWL} > 5x10^{-5}\ s^{-2}$*) or when its thickness falls below 10 m (MWT < 10 m), sustained for at least 30 days. The* N^2_{MWL} *threshold represents the approximate background stratification in the region, ensuring that MWL erosion is defined relative to physically meaningful conditions. The 10 m threshold ensures sufficient vertical data coverage given the 4 m depth resolution, while the 30-day duration is chosen to account for the 10-day temporal resolution and minimize the impact of data gaps*."

We hope this addresses your concern.

Line 172. I think the paper would be clearer if the authors referred to the monsoons either as summer and winter, or north-east and south-west.

We now refer solely to summer and winter monsoons and have removed all the NE-SW monsoon references.

Line 182. "Equatorial"?

Thank you, changed.

Line 185. “It’s”?

Thank you, changed.

Line 191. “Monsoons”?

Thank you, changed.

Line 192. I’m not quite sure what this sentence is trying to say – and especially because “the importance of the North” has not yet been demonstrated.

Apologies for the confusion. We have removed the sentence as it was unclear, and we believe did not bring any information that is included later in the paragraph.

Line 195. Is there a typo in this equation? ImpactFactorregion appears on both sides and so, as written, should cancel… Also, what does region mean? I assume northern and southern Arabian Sea but, as written, it’s not crystal clear. Also, if ImpactFactor is volume over area, could it be described as a scale depth of the mode water later, perhaps?

Thank you. There was a typo in the equation, and the right-hand side Impact Factor had to be MW volume. We have fixed the typo and restructured the paragraph and definition of this metric to be clearer and precise.

Line 210-215: “*Thus, we build an impact factor scaling the volume of MW by the contribution of the northern and southern Arabian Sea to the total Arabian Sea area (Figure 3p). The impact factor of MW is computed as Impact Factor_region= MW volume_region·(Area_Arabian Sea／ Area_region); where the MW volume for each grid cell is computed as the MWT multiplied by the cell area; the Arabian Sea area is defined by the ocean area shown in Figure 3a and the region areas are the northern or the southern Arabian Sea delimited by the 20ºN parallel. The northern Arabian Sea is 10% and the southern Arabian Sea the 90% of the total area.*” and Caption in Figure 2 “*...as MW volume scaled by the region’s area contribution to the total Arabian Sea area*”.

Moreover, there was also a typo in the units as the Impact Factor is a volume. Thus, we updated the units in Figure 3p.

Line 199. This sentence makes no sense.

Apologies for lack of clarity. We have paraphrased it to Line 215-216: “*The impact of the northern Arabian Sea on the total volume of MW is larger than the south in the first half of the year, despite its area being 10% of the total Arabian Sea (Figure 3o).* “

Figure 3. Panels (o) and (p) – say north and south, to match the names for the regions used in the text (if I’ve understood the text correctly), rather than re-stating the definition. And plotting things against day/week or year is one of my personal bug-bears – plotting against month is much more straightforward. (See also Figures 4, 8 and 9.)

We changed the labels in panels o and p to north and south to match the text and modified the Figure caption accordingly. Also, we agree that changing the x-axis to month instead of

day/week improves readability of the figures. Figures 3,4,8,9 have now per month on the x axis.

Line 226. Again, this sentence makes no sense. I have turned the phrase “latitudinal regionality” over and over, but I cannot understand it.

Apologies, we agree it lacks clarity. We have paraphrased to Lines 244-246: “*The annual cycle of MW presence, represented as the percentage of float profiles containing MW per latitudinal bands, shows the formation once a year in the northern Arabian Sea and the biannual presence in the southern Arabian Sea (Figure 4a)*.”

Line 228. “collocated”: co-located? Does this involve interpolation, or do the authors just pick the closest ERA5 grid point?

Thank you for this comment. We agree that it is important to clarify how the ERA5 is collocated. We have chosen the closest ERA5 grid point, and now it is specified changing collocated to Line 247: “*...from ERA5 closest to the float profiles..* “.

Line 270. Seasons haven’t been defined? Does this mean “per three month period”?

Thank you, we acknowledge the importance of defining the seasons, We have specified in the methods section Line 162-163: “*Throughout this study, we use the definition of seasons based on three-month periods: winter monsoon (December–February, DJF), spring (March–May, MAM), summer monsoon (June–August, JJA), and fall (September–November, SON)*.”.

Line 298. “… simplifying dynamics to their maximum”. This is a pretty vague phrase – might be good to be a little more specific?

Thank you, we have changed this sentence to be clearer and specific to Lines 317-318: “*we can represent this layer by isolating vertical processes (1-D) from the three-dimensional (3-D) dynamics.*”

Line 306. I’m not sure that I understand the logic here: surely the existence of a regionally invariant bias would suggest limitations in the ability of a one-dimensional model to replicate mixed-layer processes?

We appreciate the reviewer’s comment and the opportunity to clarify our statement. Our original intent was to convey that the regional variability in the 1D model MLD bias suggests that the model’s ability to represent mixed-layer processes is influenced by local dynamics, which are not uniformly captured by a purely 1D approach. To improve clarity, we have reworded the sentence as follows: Lines 327-328 "*The 1D model MLD bias displays regional variability, which could indicate that the 1D approach cannot fully represent surface mixed layer processes.*" This revision aims to better reflect our reasoning while addressing the reviewer’s concern. We hope this modification resolves the ambiguity.

Line 362. Modulate ASHSW how?

Thank you. We have clarified and specified how it could change ASHSW by altering the upper ocean stratification and the winter convective mixing.

Line 452. I’m not sure reminiscence is what you mean here?

Thank you. We changed it to “*The remnant MWL*”

Line 529. More important than what?

Thank you. We have clarified the comparison. Line 562 “*...as a more important oxygen reservoir in the northern Arabian Sea than in the south,*”

Line 544. ESM – acronym not defined? Also I’m pretty sure “impotence” is a typo…?!

Thank you. Removed the acronym to the earth system model and substituted to climate models. We appreciate the referee’s thoroughness and apologize for the typo. We have changed to the correct word: importance. See line 577: “*...MWs in climate models is crucial due to their importance….*”