Review: "Origins of Mesoscale Mixed Layer Depth Variability in the Southern Ocean"

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Minor comments

•Description of model domain. Lines 91–92: "Mesoscale anomalies are clearly visible in all fields (Fig.1)." Because this paper is focused on the ocean mesoscale dynamics, it is worth to add a snapshot of Eddy Kinetic Energy (EKE). I suggest replacing the SSS pattern (Fig. 1b) with an EKE pattern.

- We replaced SSS with EKE field in fig.1. We have revised the description of Figure 1, as indicated in lines 90-94.

•MLD pattern in model domain. In the model domain, which is a region in the Western Indian sector of the Southern Ocean, the deep MLD forms in the southern and eastern part of the domain (Fig. 1c). In fact, this deep MLD distribution is quite different from that in most other regions of the Southern Ocean, where the deep MLD forms on the northern flank of the ACC jets. More discussion/clarification is needed here.

- Thank you for bringing the confusion to our attention. It is important to note that Figure 1 displays a snapshot of MLD and exhibits several transient features. On the other hand, Figure 6f of Perlin et al. (2020) illustrates the mean and standard deviation of MLD, revealing deeper MLD formation in the northern flank of the ACC jets in the Southern Indian sector. We have clarified this in lines 90-94 of the revised manuscript.

•Figure 6. Line 144: I am confused about the logic here. Should the authors show the correlation between SSTA and MLD, instead of SSTA and MLDA, in Fig. 6 In this way, the authors can contrast the contributions of SST with and without mesoscale anomalies to the MLD variability.

- We aim to investigate the processes responsible for the mesoscale MLD variability. From a large-scale perspective, there is a positive correlation between SST and MLD, indicating that cooler (warmer) SST leads to deeper (shallower) MLD. However, from a mesoscale perspective, there is low correlation between SST and MLD mesoscale anomalies, suggesting that their relationship becomes more complex for mesoscale anomalies.

- Figure 8. Can the authors comment on why the RMS MLD anomalies in the two sensitivity experiments show a similar response in time?

- -We extended the discussion of the similarity between two experiments on ll. 269-274 The reviewer may be wondering why mesoscale heat flux and momentum flux drive similar MLD responses over time. We believe that seasonal variations are a significant factor in the RMS MLD anomalies variability and its response to atmospheric forcing at mesoscale, regardless of whether this forcing is due to heat or momentum fluxes. Specifically, during the summer season, the MLD is shallower, and the atmospheric forcing is typically more influential. Conversely, during winter, the MLD is deeper and has higher inertia, and atmospheric forcing is generally less critical.

- Figure 9. The signals of two sensitivity experiments in the domain average are small and not very clear. I suggest to conduct the same calculation, but only averaged for the areas where the wintertime MLDs in the control experiment are deeper than a certain threshold, i.e. ≥400 m. I expect that the signals would become clearer.

- We followed the reviewer suggestion and repeated the calculations with set the threshold to be 200 m. Despite an increase in the strength of and the signals, the figure did not change qualitatively and are indeed stronger but not necessarily clearer. The time series still show the same conclusion (see attachment “fig09v2.png”). We decided to keep the original version of the figure.

- Figure 3. There are some ‘white spots’ close to the surface in Fig. 3e, f. This issue can be solved by modifying the colorbar.

-We modified the color bar and the white spots are gone.