Response to Reviewer 2

We appreciate the constructive and insightful comments from the reviewer. A number of changes have been made to the text at the reviewer's request and we feel that the revised paper is now substantially clearer and stronger as a result. Detailed replies to each of the reviewer's points (in blue italics) are provided below, and changes to the text have been highlighted in red in the revised paper.

"The DOE E3SM Version 2.1: Overview and Assessment of the Impacts of Parameterized Ocean Submesoscales" has two aspects: it is the report detailing the new version of this model (highly appropriate for GMD) and it is a scientific report on the consequences of including the 2011 version of the MLE parameterization into this model. The latter is not novel in application, but instead compares the sensitivity of the E3SM vs. that of other models incorporating this scheme. The basic result is that upper ocean biases and RMSEs are improved, which then improves many climate metrics. I have only minor suggestions for the authors to consider.

Minor Comments:

Comment 1: *Using a constant L_f is not a common choice, although it is not unprecedented. The authors should review the results of extensive testing of different choices of L_f as constants and as variations with mixed layer deformation radius in Calvert et al. (2020).*

We thank the reviewer for bringing our attention to this typo. L_f does indeed vary in our implementation with mixed layer deformation radius, as is suggested in Eq. 13 of Fox-Kemper et al. (2011) and is used in Calvert et al. (2020), and rather $L_{f,min}$ is what is set as a constant. This has now been clarified in the following way in the revised manuscript on lines 65-67:

...Eq. 3 as an estimate of the typical local width of mixed layer fronts, set here in this model configuration as the mixed layer deformation radius. While recent work has been done to improve the representation of L_f (Bodner et al., 2023), we use the original formulation from Fox-Kemper et al. (2011) here in this study...

Comment 2: *In Fig. 4, which MLD observations are used? Are they consistent with the definition of MLD used? The new SEANOE MLD product is very nice in its incorporation of much more Argo data than previous versions.*

We thank the reviewer for pointing out this discrepancy. Our MLD observations are from ARGO floats from 2000-2017 using the Holte and Talley (2009) method, while our model MLDs are calculated using the 0.03 kg m^{-3} density threshold method. We have now swapped out the original MLD observations for the SEANOE MLD observations the reviewer has suggested, which uses the same density threshold method and incorporates more Argo data. Our conclusions in the manuscript based upon this change in observational product do not significantly change, but we have made the following changes in the revised manuscript on lines 100-102 to note the use of this new observational data set:

...from ARGO floats100 and the NCEI-NOASS World Ocean Database (WOD; Boyer et al. (2018)) through the SEANOE data product from 1970-2021 for the mixed layer depth (MLD) (de Boyer Montégut et al., 2004)...

Comment 3: *I recognize that there are many centuries of simulation data reported here, but I wonder the extent to which the MLE parameterization is responsible for these changes as opposed to the many other changes made. Are there any runs available for comparison with the v2.1 that differ only in turning off the MLE parameterization?*

We appreciate the reviewer's question as it brings to our attention that this was not initially clear in the manuscript. The only climate changing code change from the v2 to v2.1 configuration is the addition of the MLE parameterization. Most of the code changes listed in Appendix B are stealth features that are not active in these v2.1 simulations, and the remainder are bug fixes that exhibited no significant climate changing impacts. Thus the authors are assuming that the changes seen in this manuscript are due solely to the addition of the MLE parameterization and any feedbacks the addition of the parameterization induced. We have now added the following text on lines 49-52 of the revised manuscript to help clarify this:

...All other features listed in Appendix B are not active in the v2.1 configuration simulations used in this study, and any bug fixes were shown to have no significant climate changing effects in testing, thus we will assume any changes from v2 to v2.1 are due to the addition of the FK11 MLE parameterization and any feedbacks it may induce in the model...

Sincerely, the authors.