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Interactive comment on "Verification of the mixed layer depth in the OceanMAPS operational forecast model" *by* Daniel Boettger et al.

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1 General comments

A1 .On the temporal extent of the dataset. While the relatively short duration of the dataset had been mentioned in the manuscript, we have expanded upon the implications of this for our results and modified the title to include the season.

A2. On the impact of model changes on MLD estimation. The reviewer questioned whether the impact on MLD performance of other changes between model versions can be assumed to have a minor impact. We agree that it is not possible to completely isolate these other impacts, but our analysis was designed to minimise the impact of changes other than the vertical mixing scheme. We also note that the configuration of the version 3.0 system was developed over a series of disparate hindcast experiments, over different time periods and geographical regions. Because of this it is not possible to quantify the impact of each change systematically, but we argue in section 2.1 that these changes will be of second-order effect in comparison to the vertical mixing scheme. For example, while the data assimilation software was upgraded, both versions utilise an identical ensemble optimal interpolation method (The software allows for EnKF, but this is to be implemented in a later version). Changes to the bathymetry are mostly limited to the continental shelf (discussed below), while our Argo dataset is concentrated over the deep ocean. The main change, apart from the vertical mixing scheme, is the reduced spin-up period in version 3.0. We minimise the impact that this will have on our results by performing the analysis over the forecast period, which is three to five days beyond the spin-up period. In any case, we acknowledge that our analysis does not constitute a controlled experiment and this poses limits to the attribution and interpretation of results. Where relevant, we have noted these limitations and modified our assertions as appropriate in the revised manuscript.

2 Scientific comments

B1. On the discussion of vertical mixing. Our argument regarding the impact of a telescopic grid has been restructured to make it clearer. We have also revised figures 4 and 5 to show normalised MAE as suggested by the reviewer.

B2. On the model description. Additional details regarding the model vertical coordinate have been included.

B3. On the reason for a change in vertical mixing scheme. When version 2.0 of OceanMAPS was implemented, the Chen et al. (1994) mixed layer scheme was acknowledged by its developers as out of date. However, testing with a KPP scheme did not show a significant reduction in errors and Chen et al (1994) was retained. The MOM4 model provided the GOTM package as an option which prompted the application of a K-epsilon scheme. This was first undertaken in regional studies with positive results

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before being applied to the operational global model.

B4. On the implementation of the GOTM scheme. The implementation of GOTM in OceanMAPS version 3.0 includes the breaking wave TKE model of Craig and Banner (1994), as modified by Umlauf et al. (2003). This is an improvement on the Chen et al (1994) scheme, which did not explicitly account for breaking waves. However, while breaking waves have certainly been shown to increase mixing in the ocean boundary layer, the depth over which this occurs is of the order of the significant wave height (see e.g. Terray et al., 1999, D'Asaro, 2014, Umlauf et al., 2003). In the region of the ACC, where the MLD is O(100m) during the study period, it is unlikely that breaking waves would play a significant role in mixed layer deepening. We assess that the inclusion of a breaking wave parameterisation would have a small, but largely insignificant, impact on the version 3.0 MLD results in this study period. The stability functions of Schumann and Gerz (1995) was used in the GOTM implementation in OceanMAPS version 3.0. While use of a more complex function (e.g. as discussed in Burchard and Bolding, 2001) may improve MLD results, the primary aim of our study is to compare the performance of the two model versions and a discussion of the GOTM settings to this detail falls outside of this scope. A follow-on study conducted as a controlled experiment would be ideal to quantify the impact of these settings.

B5. On the impact of sea ice. The lack of a sea-ice parameterisation within OceanMAPS certainly affects its performance at high latitudes. However, as both versions of OceanMAPS compared in this study do not include sea-ice, the impact on the relative performance of each model is negligible.

B6. On the impact of the upgraded bathymetry. A change in bathymetry dataset for version 3.0 has mainly resulted in better resolution over the continental shelf with negligible change over the deep ocean (figure R1, below). The coverage of the CLASS4 dataset is negligible over the continental shelf (figure 1). As tidal forcing is not included in OceanMAPS, the impact of bathymetry on internal tide mixing also does not affect a comparison between model versions.

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B7. On skill scores. References to typical skill scores have been included in the manuscript.

3 Technical comments

C1. The reviewer identified an error in the document cross-referencing. This has been corrected

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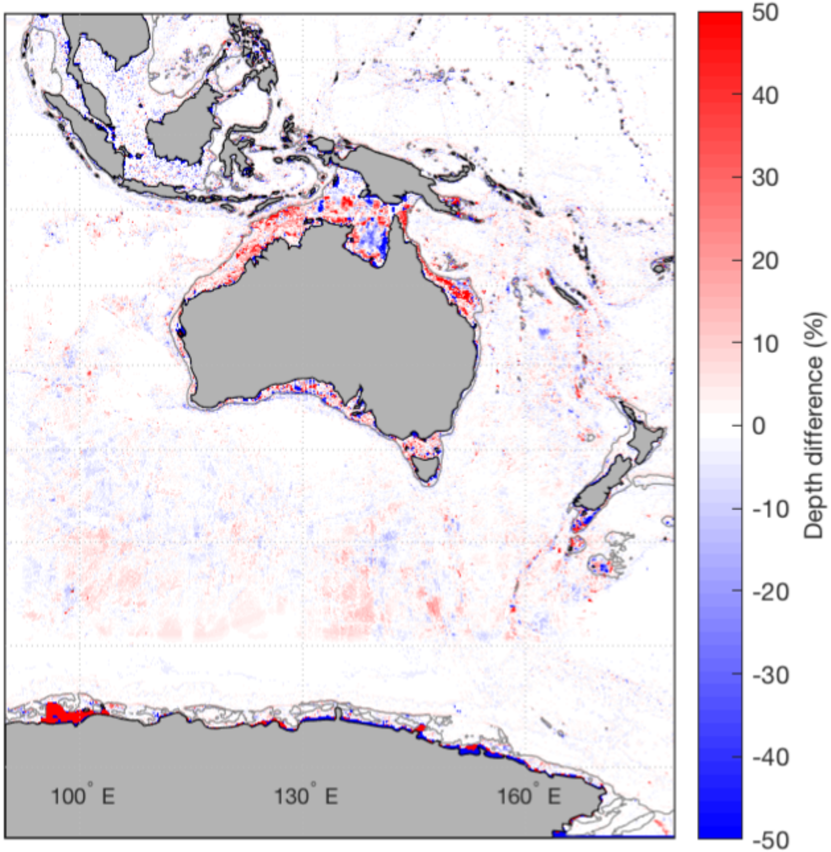

Fig. 1. Relative bathymetry change from OceanMAPS version 2.2.1 to version 3.0

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