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Geoscientific Model Development Discussions

Interactive comment on "An improved parameterization of tidal mixing for ocean models" *by* A. Schmittner and G. D. Egbert

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Thank you for your constructive comments. We will revise the manuscript according to your suggestions as outlined in detail below.

Comments and suggestions: - p.4477, l.9: Indicate why 178m-depth is chosen for demarcation.

Climate model depth levels are chosen. We will note this now in the caption to Table 1.

- p.4477, l.11: .... has little effect ....

Will be corrected in revised manuscript.

- p.4478, l.7-9: Explain why larger scale fluxes are well constrained.

There is no simple answer to this question. We will reword the sentence in the revised manuscript to specify the scales and direct the interested reader to Egbert and Ray (2001) who provide a detailed discussion of the robustness of the estimate at large scales. Zaron and Egbert (2006) illustrate that the distribution of E at small scales is not well constrained.

- p.4478, l.21: Indicate which is longitude and latitude.

Indicated in revised manuscript.

- p.4480, l.5 and l.7: Use the degree symbol for the first fractions as well.

Done

- p.4480, l.18-19: JS01 value from Table 1 is 1.99 and it is 16% more.

Corrected in revised manuscript.

- p.4480, l.21: 1.23 TW should be 1.50 TW.

Corrected in revised manuscript.

- p.4481, l.1: Indicate that the energy available depends on model grid or resolution used.

We will reformulate this paragraph to

"Averaging on the climate model grid and masking out grid points that are designated land in the climate model leads to a reduction of the global energy flux. Note that this depends on the climate model grid and resolution used. In our version of the the UVic model this reduction is larger for . . ."

- p.4481, Eq.4: It will be useful to include the explicit form for F(z,z') here.

We note in the revised manuscript that F is identical to eq. (3).

- p.4482, l.3: (e.g., ...) ?

Wunsch 1975 reference added.

- p.4482, l.24 and l.26: Use the degree symbol for the first numbers as well.

Done

- p.4482, l.24: Add reference for etopo20.

Done

- p.4482, l.27: I do not follow "where only one vertical level has a value different from zero."

We will change the text here to better explain our scheme:

“We thus average E onto the horizontal grid of a high-resolution (0.3âŮę $\times$0.3âŮę) bathymetric dataset (etopo20; Edwards 1986). Next we assign E (on the high-resolution grid) to a vertical climate model level that corresponds to the actual (high-resolution) sea floor (Fig. 3c). (We use velocity grid levels since the UVic model uses a staggered grid and diffusivities and tracer fluxes are calculated on the velocity grid, which corresponds to the grid box boundaries of the tracer grid.) High-resolution bathymetry below the deepest model grid box are assigned to the deepest model grid box. This leads to a three-dimensional (3-D) map at high horizontal (0.3âŮę $\times$ 0.3âŮę) and coarse vertical (the 19 climate model levels) resolution, where only one vertical level has a value different from zero. Subsequently this field is averaged horizontally onto the coarse resolution model grid and negative values are set to zero. This results in a three-dimensional field ETS(x,y,z) on the climate model grid, which is used in Eq. (4) to compute ε. “

- p.4483, l.7: Both here and elsewhere throughout the manuscript, replace "models" with "simulations" or "experiments" because the same model is being used in the manuscript.

Done.

- p.4483, section 2.4: Explain how the second term on the right-hand-side of Eq.(1) is regularized as NËĘ2 approaches zero. In other words, is there a maximum cap on the resulting k_v? Is the available energy fully used?

This is explained in the model description section (2.1). Nˆ2 and k_v are both limited.

- p.4484, l.2: Reword the title for section 3.1.

Done.

- p.4484, l.6: 75% should be 82% and 4% should be less than 1%.

Corrected.

- p.4484, 7-8: Both here and elsewhere (e.g., Table 3), replace sum-of-squared-errors with root-mean-square (rms) error as it is more conventional. rms has the same units as the variable being considered.

Done.

- p.4484, section 3.2: Figure 4 is not discussed at all. It is a very useful figure and I suggest that it is kept.

We keep Fig. 4. It illustrates the upward shift of mixing in the 3D experiments as well as differences between ER01 and JS01. We added one sentence introducing Fig. 4 at the beginning of this subsection.

- p.4484, last paragraph: I do not understand this paragraph. More dissipation at shallower depths explains the differences between the 2D and 3D cases, not the differences between ER03 and SJ01 cases. Indeed, as also stated here, ER03 and SJ01 cases have similar diffusivities at shallower depths. With relatively similar 2D energy (2.77 TW in JS01 and 2.92 TW in ER03), why are the resulting diffusivities differ so much at depth between 2DE and 2DJ cases as shown in Figs. 4 and 5?

Because JS01 puts almost no energy in the deepest ocean, the abyssal plains (see

Figs. 1 & 4). The largest differences in dissipation between 2DE and 2DJ are in the deep ocean (Fig. 2). We've expanded the explanation here to make this more clear to

"This follows from Eq. (1), according to which an upward shift in dissipation leads to a decrease in global mean kv since N2 is larger at shallower depth and kv is proportional to dissipation ε weighted by the inverse of N2."

and

"Whereas ER03 and JS01 result in similar globally averaged diffusivities in the upper ocean, ER03 produces substantially larger values in the deep ocean (Fig. 5) consistent with more dissipation there (Figs. 1, 2)."

- p.4485, l.8 and l.20: Replace "faster" with "stronger" or "larger".

Done

- p.4486, section 3.3.1: Lumpkin and Speer (2007, LS07) do not represent observations. They use an inverse model with many caveats. Please do not refer to LS07 as observations or observational indices. This needs to be addressed throughout the manuscript. I suggest using the RAPID data set for the Atlantic Ocean at 26.5ËĘoN. "mid global" values can be either kept or deleted.

The analysis was repeated with the RAPID data instead of the LS07 "mid global" and the table will be changed accordingly in the revised manuscript. The conclusions are unchanged. We also rephrased the reference to LS07.

- p.4486, l.8: Given the general results of this paper, I do not think that use of "inferior" is justified.

This will be rephrased to "The root-mean-squared-error (RMSE) indicates that experiments using ER03 are slightly better compared with JS01 based on the six indices considered. "

- p.4486, l.13 and l.16: Lumpkin

Corrected

- p.4487, l.11: .... the largest ....

Corrected

- p.4487, l.24: Diffusive vertical .... Also, define T.

Corrected

- p.4488, l.1: Insert a reference to Fig. 8 right after "600 m".

Done

- p.4488, l.4: Define t.

Done

- p.4488, second paragraph: References are needed here for the observations.

Done

- p.4488, l.19-20: Rephrase saying that models are consistent with observations.

We left this sentence as it was because it already stated that models are consistent with observations. The order of the words does not change the meaning of the sentence.

- p.4488, section 3.3.3: Given the observational spread in the upper 500 m and the lack of observations below this depth, it is not clear to me if judgmental statements can be made. For example, all cases appear to be within the observational range below about 100 m depth.

We have rephrased these statements to make clear that the judgements depend on the assumption that the time averaged observations fall are $\sim$10^-2 m^2/s (Nakamura et al. 2006).

- p.4489, l.10: Fig.11 should be Fig.12.

Done

- p.4489, l.22-23: Replace "slow" with "low".

Done

- p.4489, l.24-25 and p.4490, l.1-3: I believe "larger" should be "smaller". ... or, this sentence needs some rewording to avoid confusion.

Changed to “less”.

- p.4490, last paragraph: I recommend deleting the geothermal heating experiment because a different model version is used and it is not a clean comparison. In addition, other parameterization choices can of course impact the results.

Done

- p.4494, l.18: Not sure if this reference is cited in the text.

It is cited in the model description section.

- p.4495, Table 1 label: Replace 1/3ËĘdegree with 1/6ËĘdegree.

Done

- Fig.1: The red labels over Asia are difficult to read.

We’ve replaced the labels with thicker font.

- Fig.3 caption: As indicated above, I do not follow "On this grid there is only one level of non-zero data. Ditto for "which leads to some latitudes having more than one non-zero values in the figure."

The description in the main text was changed to clarify the scheme as indicated above.

- Fig.4 caption: Fig.2 should be Fig.3.

Corrected.

- Fig.5 and Fig.11: Use a different (more distinguishable) color for 3DE q_d=0.3 case.

We replot with blue instead of purple.

- Fig.5 caption: Jayne should be replaced with JS01.

Done

- Fig.6 caption: Replace "2000" with "4000", "World Ocean" with "global", and the last "left" with "right".

Done

- Fig.7 caption: Include a reference for WOA05.

Done

- Fig.8 caption: as Fig.7 .... Also, what is K/a?

Corrected. Units are Kelvin per year now explained in caption.

- Fig.9 caption: Indicate these are horizontally-averaged and both 10-day and equilibrium distributions are shown. Also, I do not follow the choice of 2.7ËĘdegrees.

Done. The choice of 2.7 is explained. It corresponds to the average latitudinal width of the model data used.

- Fig.11 caption: Indicate that both 10-day and equilibrium distributions are shown.

Done

- Fig.12 caption: The latter observations need references.

References were added.

Interactive comment on Geosci. Model Dev. Discuss., 6, 4475, 2013.