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Geoscientific Model Development Discussions

Interactive comment on "Comparison of ocean vertical mixing schemes in the Max Plank Institute Earth System Model (MPI-ESM1.2)" *by* Oliver Gutjahr et al.

Anonymous Referee #1

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The paper compares the effects of four different ocean vertical mixing schemes provided by the Community Vertical Mixing (CVMIX) library on the mean state simulated by the coupled model MPI-ESM1.2. Used are the Pacanowski and Philander (PP), K-profile (KPP), turbulent kinetic energy (TKE) vertical mixing schemes as well as a prognostic schemes for internal wave energy and its dissipation (IDEMIX) which is combined with TKE. The author addresses temperature, salinity, and vertical mixing differences of the different vertical mixing schemes on a global scale but also regionally for crucial areas of the ocean, e.g. Fram Strait, Arctic Ocean, subpolar North Atlantic, Southern Ocean and Weddel Sea. As a summary, none of the presented vertical mixing schemes can be claimed superior on a global scale since they all produce

quite similar patterns. Only on a very regional scale some vertical mixing schemes can be favored of the other. Here, the more realistic and energetically consistent TKE+IDEMIX, with a more heterogeneous vertical mixing pattern, improves the circulation in the Nordic Seas and Fram-Strait reducing the bias of the Atlantic water layer in the Arctic Ocean. To my knowledge, the here presented work is novel to the MPI-ESM an general modeling community. The author presents quite well the biases shown by the different mixing schemes and attributes their causes especially on the regional scale. I would therefor recommend that the paper is accepted after some minor revision.

Comments: Abstract, line 3: The abbreviations for PP, KPP and TKE should be already made clear here.

1. Introduction: The author mentions the CVMIX library in the connection with TKE and IDEMIX it maybe should be made clearer that to this point neither TKE or IDEMIX are yet part of the CVMIX library, they just use its infrastructure routines and might join the project officially at some point.

1. Introduction: If I understood well, for PP vertical mixing, the MPI-ESM original PP implementation (which I guess is quite tuned) is used, not the CVMIX PP vertical mixing, right ? Reading the introduction from line 25 onward one might get a little bit miss leaded. It could be of benefit to clarify a bit more what at the end has been used from CVMIX. Furthermore, for my own interest, was the CVMIX PP parameterisation implemented into MPI-ESM and has there been also a comparison between the original PP and CMVIX PP implementation.

1. Introduction: Although PP and KPP are very common vertical mixing schemes, often described and widely used in the ocean modeling community, TKE is a bit more exotic but also not completely novel. It would be nice to have some more information about what has been done with TKE by others, for example in the NEMO community (e.g. Breivik, Ø. et. al 2015, Surface wave effects in the NEMO ocean

model: Forced and coupled experiments, J. Geophys. Res. Oceans, 120, 2973–2992, doi:10.1002/2014JC010565.)

1. Introduction, line 66: Despite the latter but because of ... Please reformulate this sentence.

1. Introduction, line 69: In section 2 we briefly... Please reformulate this sentence.

2. Model description:, line 89: ...Community Vertical Mixing (CVMIX) . . . replace with CVMIX. . . (Abbreviation already defined in introduction)

2. Model description:, line 92: . . . (TKE: Gaspar et al., 1990. . .replace with ...TKE (Gaspar et al., 1990. . .

2. Model description:, line 94: . . . because both schemes rely on . . . replace with ... because TKE and IDEMIX rely both on. . .

2.1 Experiments: Does MPI-ESM show any differences in the spin-up behavior (model drift, convergence,...) when using different vertical mixing scheme. Are there any differences in temporal evolution of quantities (e.g. AMOC, overflow, . . .).

3.1 Spatial distribution of the vertical diffusivity: line 124: ... where N is large and a large K in the high-latitude ocean where N is small . . . replace with . . . where N is positive and a large K in the high-latitude ocean where N is negative...

3.2 Sea surface temperature and salinity bias: line 138: . . . generate biases, the causes of which are often complex. . . . replace with . . . generate biases, whose causes are often complex. ...

3.2 Sea surface temperature and salinity bias: line 138: . . . the resolution, discretisation, and parameterisation of . . . replace with . . . the resolution, the vertical discretisation, and the parameterisation of . . .

3.2 Sea surface temperature and salinity bias: line 140: . . . with vertical mixing being just on complex process . . . replace with . . . with vertical mixing being just on of the

complex processes . . .

3.2 Sea surface temperature and salinity bias: line 147: The North Atlantic SST is sensitive. . . Please reformulate this sentence.

3.2 Sea surface temperature and salinity bias: line 153: . . . probably due to increased inflow from the Mc Kenzie River. Is this an educated guess or are their any proves for it in the model?

3.3.1 Horizontal maps of hydrographic biases: line 156: Why using the 740m depth layer?

3.3.1 Horizontal maps of hydrographic biases: line 173: Probably, using IDEMIX reduces the vertical mixing in the Mediterranean Sea and especially near the overflow sill ... Is this statement no rather counter-intuitive? Would one not expect the under IDEMIX, there should be more vertical mixing along the continental slopes of the Mediterranean and the outflow area?

4.1.1 Fram Strait: line 215: Wekerle, C., Wang, Q., von Appen, W.-J., Danilov, S., Schourup-Kristensen, V., & Jung, T. (2017). Eddy-resolving simulation of the Atlantic Water circulation in the Fram Strait with focus on the seasonal cycle. Journal of Geophysical Research: Oceans, 122, 8385–8405. https://doi.org/10.1002/2017JC012974 should be cited here as well.

4.1.1 Fram Strait: line 215: . . . recent studies indicate a third pathway of the WSC ... From the context before must it not be ...a fourth pathway...

4.1.2 Arctic Ocean: line 262: . . .Turbulence in the quiescent interior Arctic ocean . . . replace with . . . Turbulence in the interior Arctic ocean...

4.2.1 Convection and mixed layer depths: line 304: Maybe I oversaw it but is somewhere said which MLD definition is used? Also regarding Fig. 10 and Fig. 14, the colorbar seems to be cut of at a 1000m. It would be nice if at least the text could mention the actual simulated maximum value of MLD also as general information for the

broader modeling community.

4.2.2 Overflows from the Nordic Seas: line 357: . . . the FSC overflows are of about similar magnitude . . . replace with . . . the FSC overflows are of similar magnitude ...

Please also note the supplement to this comment:
https://gmd.copernicus.org/preprints/gmd-2020-202/gmd-2020-202-RC1-supplement.pdf

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