Geoscientific
Model Development
Discussions

Open Access

[GMDD]

Interactive
comment

Interactive comment on "Evaluating the physical and biogeochemical state of the global ocean component of UKESM1 in CMIP6 Historical simulations" *by* Andrew Yool et al.

Anonymous Referee #1

Received and published: 25 December 2020

General Comments:

The authors are the developers of the Earth system model UKESM1, which is participating in CMIP6. In this study, they focused on the ocean physics and biogeochemical fields of the historical experiments using UKESM1, and analyzed the results by comparing them with various observations and other CMIP6 ESMs. They have done a comprehensive and good analysis of the UKESM1 performance, which I think provides useful information for those who are planning to do multi-model analysis using CMIP6 ESMs and for other ESM developers. I have the following questions and comments, which I hope will help improve the manuscript.

Discussion paper

Specific Comments:

Line 140 "Evaluation uses the period 2000-2009 of the CMIP6 Historical simulation and compares to corresponding periods of observational data." The analysis mainly uses the results of simulations and observations for the period 2000-2009. This period is known for its negative IPO index, so the observations include that signal. On the other hand, since the model takes 9 ensemble members, the effect of internal variability is expected to be negligible. This may contribute to the equatorial Pacific warm bias of UKESM1 (see Section 3.1), although it may be small. If possible, it would be better to extend the time period used in the analysis to 20 or 30 years. Even if this is difficult, it would be good to take a longer-term look at SST to confirm that the model bias of UKESM1 does not depend on how the average period was taken.

Line 189 "In the Arctic, sea-ice is typically multi-year, and this positive bias in modelled area is accompanied by excessively thick sea-ice." I think that this sentence is confusing and needs to be rewritten.

Line 230 "This is more pronounced in the Atlantic basin, in particular at tropical latitudes, where midwater (100-1000 m) biases up to 4 C are found in the model" I think that this is influenced by the high temperature bias in the formation region of the NADW. If this is the case, why don't we use Figure 1 to discuss the temperature bias in the deep layers in relation to the formation process of the NADW?

Line 233 "These show the model ocean, particularly the Pacific basin, to be more stratified vertically compared to observations, with generally lower density surface waters (< 1000 m) overlying more dense deep waters." This may be due to inadequate and overall small parameterization of vertical mixing, the mechanism that transfers heat from the surface to the deeper layers. In fact, the bottom layer circulation is weakened accordingly (Figure 8). It would not be a bad idea to point out that the parameterization of vertical mixing is insufficient.

Line 249 "Strong sinking around Antarctica, combined with a slightly weaker NADW, is

consistent with the colder and fresher conditions shown for the deep ocean (particularly the Atlantic) in Figures 6 and 7," It is difficult to understand why "consistent" is used, so please rewrite it in more detail.

Line 409 "CFC-11" It is difficult to follow the discussion because of the sudden appearance of CFC-11 here; the description of CFC-11 in Figure 18 appears later in Line 421, so please reconsider the structure of this section.

Line 584 "the weaker deep overturning cell north of the ACC combined with a NADW cell which is slightly too weak (Figure 8) leads to a colder and fresher deep ocean" I would like to see a more detailed description of the mechanism of why the weaker deep overturning cell north of the ACC and the slightly too weak NADW cell lead to a colder and fresher deep ocean.

Section 4.2 I would like to see a detailed description of the improvements in the model from the predecessor HadGEM2-ES, and what could be fixed to make it better. The distribution of silicic acid concentration seems to have improved significantly. (Figure S22) And, before the detailed description of the figure (Figure 23) in the main text, there is a detailed description of the supplement figures (Figures S21-S23), which seems odd to me, so please reconsider the structure of this section.

Technical Corrections:

Line 6 "a new Earth system (ESM)" should be "a new Earth system model (ESM)".

Line 175 "% citepmarzocchi2015" typo.

Line 178 Typo. The umlaut is attached to the m.

Line 196 "Much as with sea-ice extent itself, UKESM1 performs best in the Arctic," I don't think "best" is the right word.

Line 295 "Table 2" I think this should be "Table 3". If we do that, then Table 2 will not be mentioned in the main text.

Line 382 "the SO" The abbreviation "SO" is not used elsewhere except Line 499, so it should not be used here as well.

Line 499 "SO" See the above comments on Line 382.

Line 727 "the other three cycles" C, Fe, and O2? It's difficult to tell what cycles you are referring to, so please specify C, Fe, and O2.

Line 759 "MOCSY-2.0 Orr and Epitalon (2015)" This should be "MOCSY-2.0 (Orr and Epitalon, 2015)"

Figures Please add labels to each panel in each figure.

Figure 1 It is easier to understand if observed, simulated, and differences are arranged in a single column or row.

Figure 2 A color palette should be created that is white at 0.15 or less.

Figure 4 It is easier to understand if observed, simulated, and differences are arranged in a single column or row. There is no explanation of the differences figures in the caption.

Figure 8 Contour interval should be noted in the caption.

Figure 12 m-2 should be m^{-2} (superscript).

Figures 13 and 14 These include Hovmoeller diagrams, but aren't they unnecessary? There is no detailed description of the monthly variation in the main text.

Figure 19 The first time it is mentioned in the main text is probably in Line 464. This is later than Figures 20, 21, and 22. The numbering of the figures should be in the order in which they are mentioned.

Tables Various values are listed in the tables, but in the main text, only AMOC in Table 1 (Line 268) and silicic acid in Table 2 (3?) (Line 295) seem to be mentioned. It is good to include various values in the tables, but the text should be revised so that it is not

assumed that only a small part of the tables is covered in the main text.

Supplement Figures The numbering of the supplement figures should be in the order in which they are mentioned in the main text. Please check.

Figure S3 There is no explanation of the differences figure in the caption.

Figure S4 It is easier to understand if observed, simulated, and differences are arranged in a single column or row. This figure is not mentioned in the main text? If not, please remove it.

Figure S6 "Potential density anomaly in kg m−3 (minus 1000 kg m−3)." This description is confusing and needs to be rewritten.

Figures S18 It would be good to add observed limiting nutrients (e.g., Moor et al., 2013, Table S2, DOI:10.1038/NGEO1765) for comparison.

——————————————————

Interactive comment on Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2020-333, 2020.