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**Version:** Revision

**Title:** Persistent Climate Model Biases in the Atlantic Ocean's Freshwater Transport

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## Point-by-point reply to reviewer

October 25, 2023

We thank the reviewer for their careful reading and for the useful comments on the manuscript.

*In this paper the authors study biases in the AMOC stability metric  $Fov$ , by analyzing two CESM simulations with different resolutions, as well as a large number of CMIP6 simulations. The authors conclude that the biases that existed in CMIP3 and CMIP5 persist in CMIP6. Furthermore, they point to several biases in the freshwater budget as likely culprits for these biases in  $Fov$ .*

*This is a very thorough analysis, and I commend the authors for the work they have done. That said, the depth of the analysis has gone at the expense of the readability of the manuscript; I have to admit –with some embarrassment– that I have not been able to get past the first pages of the Results section, despite several attempts. In my mind, the information density is far too high to make this a comfortable read. To illustrate this point, page 4 alone refers to Fig. 1 (4 panels plus 7 insets), Fig. 2 (8 panels, each with two insets), and 5 figures in Supplemental. The total number of panels + insets covered on page 4 is 70. That is a lot of information to get one's head around in the space of 30 lines.*

*I hope that the authors will reconsider simplifying the paper and improve its readability. The paper can be slowed down significantly, simply by taking more time to develop the material. Not by adding more information, but by more carefully walking the reader through the argumentation following the key results. I understand that it is a challenging task, but the authors should make an effort to boil down the figures to those that are most critical to the storyline. Relegating more figures to Supplemental would be an option, but*

*it only works if they are indeed treated as being of secondary importance, with limited referencing in the main text to avoid distracting from the main storyline. Although the insets might be useful in some cases (after careful study, Fig. 2 started to make sense), in others they are definitely a distraction (Figs. 1, 3). The insets that are critical to the narrative deserve their own figure and should be described and referenced in the proper order.*

**Author's reply:**

Indeed, the information density is quite high, in particular on page 4, but there certainly is room to slow down the pace of the text and to simplify the figures.

**Changes in manuscript:**

We will rewrite and reduce the pace of the manuscript, in particular the result section. We will also strongly reduce the number of insets in the figures and only present the most relevant quantities in each panel. More specifically, we suggest the following changes to the figures in the manuscript:

- Figure 1 – Remove the P-E trends (insets panels a & b) and salinity trends (insets panels c & d). The P-E trend can be explained in the text and the freshening of the Indian Ocean is clearly depicted by the time series.
- Figure 2 – Remove all insets and only mention the relevant results in the text.
- Figure 3 – Remove the P-E trends (insets panels a & b) and replace the salinity trends (insets panels c & d) by only indicating the three different regions (Labrador, Irminger and Iceland basin).
- Figure A1 – Remove from manuscript and explain in text, the results will still be available through Zenodo.
- Figure A2 – Remove from manuscript and explain in text, the results will still be available through Zenodo.
- Figure A3 – Remove from manuscript and explain in text, the results will still be available through Zenodo.

- Figure A4 – Remove from manuscript and explain in text, the results will still be available through Zenodo.
- Figure A5 – Remove from manuscript and explain in text, the results will still be available through Zenodo.

The presented material is then less dense and is expected to improve readability as suggested by the reviewer.

*It is possible that there is simply too much ground to cover for one paper, in which case the authors might consider splitting it up in two companion papers.*

**Author's reply:**

We believe that splitting the story into two parts is not beneficial for our study. To understand the onset of the CESM biases we need to analyse the pre-industrial simulations and to realistically compare the biases against reanalysis we need to analyse the historical simulations as well. Our claim of persistent model biases can not be made by only analysing the CESM and a full CMIP6 comparison is essential. These analyses alone cover 8 out of the 9 main figures, the far majority of the manuscript. Apart from the present-day comparison, the projected freshwater transport trends under climate change (Figures 7 and 8) are also relevant to the manuscript given the importance of  $F_{ovS}$  as discussed in the manuscript. Substantially revising the text and figures, as suggested by the reviewer, is then sufficient to present the results in one manuscript.

**Changes in manuscript:**

We do not follow the suggestion to split the manuscript into two parts, we follow the aforementioned suggestions by reducing the information density of the manuscript.

**Editor comment (not posted online, 17 July 2023):**

*This manuscript is within Ocean Science aims and scope and thus the review and discussion process can begin. I note that it is common to use the following acronyms for the following Southern Ocean water masses: Antarctic Intermediate water (AAIW) and Antarctic Bottom Water (AABW).*

**Author's reply:**

Yes, we agree with the editor and will change this to AAIW and AABW.

**Changes in manuscript:**

The acronyms will be changed accordingly in the text, figures and analysis software.