Author response for egusphere-2025-2326

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Letter to reviewer RC1

Dear Reviewer,

We are extremely grateful to your suggestions at our manuscript upon submission to Geophysical Research Letters and now, to Ocean Science. Your in-depth comments have been invaluable in guiding us as to how to provide a more coherent description of the processes driving AMOC weakening under abrupt climate change and the importance of addressing it under density space. We hope that our response to this comment truly addresses all concerns raised and produces a substantially improved manuscript that advances our knowledge on this important subject.

Sincerely,
Authors

Response to RC1's comments

1. The one suggestion of mine that the authors have not responded to is the one concerning the representation of convection in FESOM2.5. Section 2.1 needs to include a statement of how FESOM addresses density inversions: does it massively enhance vertical mixing, as, is done for instance, in NEMO? Or is there an explicit advective exchange of water parcels? I have been unable to find an explicit answer to this question in previous FESOM papers (e.g. Timmermann 2009, Sidorenko et al. 2014). In the context of the present paper, which distinguishes in detail between downwelling in depth space and density transformations in density space, I think such an explanation is essential.

#Response#: In FESOM2.5, the K-profile parameterization (KPP; Large et al., 1994) scheme was employed for vertical mixing. Consequently, convection is parameterized through enhanced vertical mixing rather than explicit advection of water parcels. In practice, when convective conditions arise, the model artificially increases the vertical diffusivity (on the order of $0.01\,\mathrm{m^2\,s^{-1}}$) to homogenize the water column. This approach is common in hydrostatic ocean models, which cannot explicitly resolve convective plumes or advective exchange across isopycnals due to the hydrostatic approximation. Fully resolving convective

overturning would require a non-hydrostatic model with horizontal grid spacing comparable to the vertical scale ($\sim$1 m), an unattainable resolution for global simulations on current supercomputers.

We added the following text into Section 2.1:

"In FESOM, the K-Profile Parameterization (KPP; Large et al., 1994) scheme is employed for vertical mixing. Consequently, convection arising from local static instability is parameterized through locally enhanced vertical diffusivity, set to $0.01\,\mathrm{m^2\,s^{-1}}$*."*

2. Technical corrections

L304. "Here, we examined..." is awkward. I suggest replacing with "We have examined...".

L309. "Yet..." would read better if it were replaced by "Nevertheless...".

L342. "and rampant" is unnecessary – I would suggest deleting it.

#Response#: We appreciate the corrections and have replaced the terms accordingly.

References

Large, W. G., McWilliams, J. C., and Doney, S. C.: Oceanic vertical mixing: A review and a model with a nonlocal boundary layer parameterization, Reviews of Geophysics, 32, 363–403, https://doi.org/https://doi.org/10.1029/94RG01872, 1994.