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Title: Physics of AMOC Multistable Regime Shifts due to Freshwater Biases in an EMIC

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Point-by-point reply to reviewer #1

May 7, 2025

We thank Susanne Ditlevsen for their careful reading and their generous review.

General comments:

It is of great importance to understand the risks of tipping of the Atlantic Meridional Overturning Circulation (AMOC). This is often done using climate models, however, these are known to have biases, in particular, freshwater biases in the Indian and the Atlantic Ocean, which might affect the model evaluations of AMOC stability. It is therefore of great interest to quantify how such biases might affect model outputs. This is the goal of the paper. The paper conducts larger simulation studies of CLIMBER-X, an Earth System Model of intermediate complexity to study the effect of biases in surface freshwater flux on AMOC tipping behavior. Several scenarios of biases are introduced in the Indian and Atlantic Ocean, as well as the reference level with no bias. Then they perform hysteresis experiments on all scenarios, where the surface freshwater forcing is slowly ramped up in the North Atlantic until the AMOC collapses; subsequently, the forcing is reversed until the AMOC recovers again.

The paper shows that the AMOC stability is hugely affected by freshwater biases. This is an important result, and underpins the importance of being careful when drawing quantitative conclusions from climate models regarding tipping elements, in particular the AMOC.

The paper is very well written, the methods well chosen and executed and statements, conclusions, methods and goals clearly detailed. Figures are of

high quality.

Congratulations with a really nice work.
Technical corrections:

It is confusing with the notation REF for the reference model. It looks like there is an error with a reference. This is not important, just a suggestion to change the notation.

Author's reply:
We agree that the current notation can lead to confusion.

Changes in manuscript:
We will rename the reference case to baseline case and use the abbreviation BASE instead of REF.