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Earth System Dynamics
Discussions

Interactive comment on "Mechanism for potential strengthening of Atlantic overturning prior to collapse" *by* D. Ehlert and A. Levermann

A. Cimatoribus (Referee)

andrea.cimatoribus@nioz.nl

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The article presents results from a simple analytical model of the AMOC, building on the classical Gnanadesikan pycnocline model, and discussing in particular a mechanism for the strengthening of the overturning rate before a collapse of the AMOC. Overall, I think that the paper is clear, concise and presents interesting results. However, before publication, I think that a few points should be considered in more detail. My main comments are in fact linked to our recent papers "Meridional overturning circulation: stability and ocean feedbacks in a box model" on Climate Dynamics (2014) and "Reconciling the north-south density difference scaling for the Meridional Overturning Circulation strength with geostrophy", under review in Ocean Science Discussions. It should be clear, however, that this does not imply that the authors should follow our

approach.

- The authors follow Marotzke (1997) considering the pole-tropics density difference as the one controlling the overturning rate. In the papers mentioned above, we suggest that the definition of the density difference may be essential for reproducing some results of numerical models. How essential is the definition of $\Delta\rho$ for obtaining the results shown in the present paper?
- From lines 7-10 on pag. 38 I understand that m_N can have negative values, a result which is not discussed in much detail. This amounts to an enhanced upwelling in the high latitudes of the north Atlantic. Is this the case and, if so, how can this be physically justified?
- pag. 38, line 18: pycnocline depth increases with increasing freshwater forcing in fig. 4a. Furthermore, do the negative values of F_N in the figure mean that freshwater is transported from the high to the low latitudes? Surface fluxes tend to transport freshwater from the low to the high latitudes in the real world, so how should be F_N interpreted?
- pag. 41, Freshwater-induced MOC strengthening: a strengthening of the AMOC under increasing freshwater forcing is shown in Fig. 5 of Cimatoribus et al. 2014, but the definition of the forcing freshwater is different therein. Is there a link between these two results, in particular concerning the mechanism causing it?
- pag. 43, lines 1-4: Could this mechanism be interpreted as a change in the baroclinic modal structure (i.e. in the depth of the first baroclinic mode)? In the real ocean, gradients tend to decrease with depth; could this change the results?

Minor comments:

- pag. 33, lines 15-17: "The four meridional tracer transport processes..." could this sentence be rephrased more clearly?
- pag. 35, lines 16-...: Since the use of this parameterisation for the eddy flow is one of the main new elements in the model, I would suggest that a more detailed motivation for the parametrisation is given, even if it has already been discussed in Levermann and Fürst 2010.
- pag. 36, eq. 6a: it seems to me that the equation should read $\ldots - S_U(m_N + m_E)\ldots$ instead of $\ldots - S_U(m_N + m_W)\ldots$. Even if at the steady state they are equal, I think that the equation would be more easily understandable this way.
- pag. 37, lines 8-11: as far as I understand all the results presented refer to steady states of the system. I think that the last sentence of this paragraph could be misunderstood as saying that time-dependent states are considered.
- pag. 37, line 21: "provide" instead of "provided"
- pag. 41 line 7: Can this result be obtained more rigorously by taking the limit $m_E \to 0$?
- pag. 41, lines 21-22: please rewrite the sentence.
- pag. 42, line 21: “strong” should read “strongly”
- pag. 42, line 25: missing “depth” at the end of the line.
- pag. 44, line 23: the two papers cited mostly deal with numerical models. Comparisons with observations are found, to my knowledge, in the works of Talley and Bryden.
- Fig. 2: I could not find where Figure 2 is discussed in the text.

Interactive comment on Earth Syst. Dynam. Discuss., 5, 29, 2014.