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Climate of the Past Discussions

Interactive comment on "Low-frequency oscillations of the Atlantic Ocean meridional overturning circulation in a coupled climate model" *by* M. Schulz et al.

Anonymous Referee #1

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Review of " Low-frequency oscillations of the Atlantic Ocean meridional overturning circulation in a coupled climate model" by M. Schulz, M. Prange, and A. Klocker.

General comments

This paper analyses a mode of internal variability that is associated with long term changes in the overturning circulation in a model of intermediate complexity. The processes in the model are analysed in detail and the mechanism is precisely described. The relevance of this mechanism for the real climate system is difficult to asses because of the lack of data and of our lack of knowledge of the causes of climate variability in the north Atlantic during the Holocene. It is thus not possible to be sure that this mechanism is playing a role in observed changes during the Holocene but this can neither be ruled out. Furthermore, the authors propose a method to test the validity of their hypothesis. This study is thus an interesting contribution to our knowledge of the natural variability of the climate system during the recent past. I would only suggest a few minor modifications as described below.

1. The author should describe clearly what they mean by present-day boundary condition. I suppose that this term is used to make a clear difference with glacial conditions, for instance. However, because of the experimental design, they could not claim that they are using present-day boundary condition (as mentioned for instance in the abstract) because they add a freshwater perturbation in the Labrador Sea. This perturbation is small compared to the one used in water hosing experiments but is nevertheless big enough to consider that the authors are not analysing present day conditions but perform a sensitivity study compared to present-day conditions. This point should be made clearer in the manuscript.

2. The authors argue that the mechanism of variability is different than the one found in 2-D models. I agree on that point but I would be pleased to see some comparison with the low frequency variability found in some 3-D models (e.g. Hall A. and Stouffer R.J., 2001, An abrupt climate event in a coupled ocean-atmosphere simulation without external forcing. Nature 409, 171-174; Goosse H., H. Renssen, F.M. Selten, R. J. Haarsma and J.D. Opsteegh, 2002. Potential causes of abrupt climate events: a numerical study with a three-dimensional climate model. Geophysical Research Letters 29(18), 1860, doi:10.1029/2002GL014993) as well as with the decadal variability found in some other models (e.g., Delworth T., S. Manabe and R.J. Stouffer (1993). Interdecadal variations of the thermohaline circulation in a coupled ocean-atmosphere model. J. Clim. 6 1993-2011; Timmermann A., M. Latif, R. Voss and A. Grotzner, 1998, Northern hemispheric interdecadal variability: a coupled air-sea mode. J. Clim. 11, 1906-1931; Knight JR, Allan RJ, Folland CK, Vellinga M, Mann ME, 2005, A signature of persistent natural thermohaline circulation cycles in observed climate. Geophysical Research Letters 32

(20): Art. No. L20708). For the latter type of variability, the time scales are different but some parts of the mechanism could be similar.

3. The authors use a coupled atmosphere-ocean model but do not give a lot of details about the change in atmospheric circulation while they mention that some changes are noticed in their experiment. I would be pleased for instance to see the change in atmospheric circulation between the "strong" and "weak" states

Specific comments

1. Fig. 3, why is there a cooling over Siberia?

2. Page 809, line 11. The authors mention there that "independently of the state of the AMOC, the upstream deepwater formation area in the Nordic Seas tends to destabilize the down-stream water column in the Labrador Sea". Such a sentence, and very similar ones that are used later, are confusing to my point of view. At first sight, it seems that the upstream flow destabilizes the water column inducing deeper convection and then a stronger overturning for both strong and weak state of the overturning. But, if I understand well, it is not the meaning of that sentence. It rather means that the upstream flow always tend to induce a change in the modes from strong to weak state or from weak to strong state (a kind a negative feedback in an oscillation). The authors should thus be clear when they are talking of the destabilization of the water column (and of deep mixing) or of the stability of the mode of operation.

3. Fig 5. The correlation is rather low. Does it increase when low frequency changes are analysed?

4. Page 810, line 15. I do not understand the sentence" the built-in random generator, that can be used to parameterize weather in ECBILT-CLIO, was switched off in all experiments". Does the standard version of ECBILT-CLIO include a 'random generator'? What is then the source of the high frequency noise seen for instance in figure 1?

5. Section 4.3. I was wondering if it was not possible to find a similar behaviour in

the conceptual model for both cases in fig. 8 (i.e. with and without a Greenland Sea inflow) when using a larger amplitude for the noise. In other words, is it possible to obtain transitions from strong to week state without Greenland inflow using a larger noise level? What is the justification then of using a value of 0.2 Sv?

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