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Interactive comment on "Hosed vs. unhosed: global response to interruptions of the Atlantic Meridional Overturning, with and without freshwater forcing" *by* N. Brown and E. D. Galbraith

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This manuscript presents results of millennial abrupt climate changes simulated by a global coupled model in hosed and unhosed situations. The idea is to compare the climatic impact of a collapsed AMOC in forced (hosing expt) and unforced (where intrinsic variability emerges) simulations. The paper is relevant, and certainly deserves publication in CP, because internal variability of the coupled ocean-atmosphere system on millennial timescales is often overlooked when interpreting the paleo record. However the description of the unhosed variability (evolution of ocean/climate variables during

an oscillation cycle and primary mechanism of the variability) is not convincing, and this would deserve further analysis.

Introduction (p4671). "most importantly through the existence of multiple stable states". I would add "and to the existence of *unstable* states". Mechanisms like stochastic resonance, noise-induced transitions do require multiple stable states (e.g. Timmermann and Lohman, 2000) but other mechanisms of abrupt climate changes are jumps between *unstable* states of the circulation. The example of deep-decoupling oscillations (Winton, 1993) is just like that (see Colin de Verdière, 2007).

Experimental design (p4674). The boundary forcings used by the authors seem to have been chosen to obtain intrinsic millennial variability in the model. Why have the authors applied a preindustrial ice-sheet topography in the unhosed experiment combined with a glacial value for the CO2 concentration ? Does the intrinsic variability emerge when all the boundary forcings are imposed to glacial values ? This should be discussed here or elsewhere in the paper. It would be useful that the authors provide the values of the main parameters used in their study (horizontal/vertical turbulent diffusivities at least) so that other groups of scientists can replicate or at least compare their results to the present ones.

Simulated changes in the North Atlantic (p4676). The authors present a description of the unhosed variability that is not supported by any analysis in the paper. There is no heat or salt budgets below the thermocline or in polar regions that are presented that would support the chain of events proposed by the authors. One figure presenting such budgets appear necessary at this point.

Simulated changes in the North Atlantic (p4677). Here the authors suggest that the mechanism is similar to that proposed by Kaspi (2004). This is very surprising since the mechanism proposed by Kaspi (2004) relies on an interactive ice-sheet component, but ice-sheet topography is prescribed in the model used by the authors... So how could the present mechanism be the same as that proposed by Kaspi (2004) ?

Similarly to my previous comment, the authors here do not bring any material to the reader to support their claim (differentiate one mechanism rather than another). Determining the origin of the existence of variability in a coupled model is not an easy task. Sensitivity experiments such as the ones performed by Arzel et al. (2010) and Arzel et al. (2012) are necessary to extract this kind of information. In these studies the origin of intrinsic millennial oscillations (similar to deep-decoupling oscillations) was ascribed to the reduced oceanic poleward heat transport in the North Atlantic (which weakens the negative temperature-advection feedback and thus decrease the stability of the circulation).

Conclusions (p4683). Existence and properties of intrinsic millennial oscillations are sensitive to vertical mixing (Peltier 2014) but also to the latitudinal profile of freshwater forcing (Colin de Verdière, A., 2007), CO2 levels and ice sheet topography (Arzel, O. et al. 2012). In summary such oscillations are sensitive to the background climate state (see also Wunsch, 2006 who proposed an alternative view). Some references should be added here.

Arzel, O. et al. (2010): The role of oceanic heat transport and wind-stress forcing in abrupt millennial-scale climate transitions, Journal of Climate, 23, 2233-2256

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Timmermann, A. and G. Lohmann (2000) Noise-Induced Transitions in a Simplified Model of the Thermohaline Circulation, J. Phys. Oceanogr., 30, 1891-1900.

Wunsch, C. (2006) Abrupt climate change: an alternative view, Quaternary Res., 65, 191-203

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