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Climate of the Past Discussions

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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Thank you for reviewing our paper and providing us with useful comments. We address each of your comments below in a point-by-point format.

"Comments in order of appearance:
P4675 line 8: The un-hosed oscillations are different from those of Peltier and Vettoretti (2015) in that theirs were more symmetric (roughly similar duration for strong and weak mode) whereas these are biased towards the cold mode. Please comment?"

We were also intrigued by the contrast between models. The unhosed simulation has been run for twice as long now, and the oscillations have become much more symmetric. Thus, the initial asymmetry may have largely to do with the adjustment to initial conditions. However, our oscillations appear to remain less regular than those of Peltier and Vettoretti, which may reflect the different boundary conditions, or model-dependent characteristics (coarser resolution? Differences in subgridscale parameterization?). We will use these new results in the revised paper.

"P4675 line 9: The authors use a highly unrealistic model setup for their un-hosed experiment and I presume that they do not find the same transitions when using more realistic conditions like Peltier and Vettoretti (2015)? The authors should comment more on this and add a line about the 'observed' occurrence of D-O variability being limited to conditions of intermediate ice volume. This is one of the weaker parts of the paper and should be treated with more detail to avoid dismissal by a section of the readership."

As discussed in the response to Dr. Arzel, the unhosed experiment was part of a large matrix of simulations spanning glacial-interglacial CO2 and orbital configurations. Adding full glacial ice-sheets stabilized AMOC in a stronger state. We will clarify this issue in the revision, with additional text and a new figure.

"P4675 line 11: Why not use the same flux of FW as the other hosing experiments?"

Indeed, we agree this was not an ideal choice. Therefore, we have already rerun the same simulation with a FW flux of 0.2 Sv instead of 0.05. The results are similar and we will use this new simulation for the revision.

"P4675 line 20: Can the authors comment on the apparent lack of sensitivity to orbital configuration for the pre-industrial experiments?"

It is true that the Atlantic's response has less sensitivity to orbital configuration under preindustrial boundary conditions when compared to glacial conditions. We believe this is because obliquity has a much larger control on initial N.Atl. sea-ice extent under glacial conditions. As shown in Figure 1, the initial low-obliquity sea-ice extent is more than double that of the high-obliquity under glacial conditions, but is basically the same under preindustrial conditions. Since sea-ice extent can have a large impact on other climatic variables (Li2010), we think it is this discrepancy in initial sea-ice states that is mostly responsible for the greater sensitivity under glacial conditions.
However, the Pacific's sensitivity to orbital configuration is dominated by the development of a strong PMOC under preindustrial hosing (not the case in glacial). The small variations in how the PMOC develops have impacts all over the Pacific, which show up mostly in intermediate-depth O2, ideal age and export.

We will add a sentence regarding this sensitivity to the revision.

"P4679 description of Fig. 5: Why do we see such pronounced changes in intermediate depth [O2] in the un-hosed experiments, particularly the Equatorial Atlantic?"

Keeping in mind that these values are normalized to AMOC changes, the absolute changes are not as pronounced as they seem in figure 5. Yet, it is true that the unhosed experiment has a slightly more pronounced absolute change in the Equatorial Atlantic. Export is similar in this region for both hosed and unhosed experiments, while intermediate-depth age is relatively lower in unhosed, suggesting that freshwater-driven stratification of thermocline ventilation within the Atlantic is behind the difference. In the revised paper, the use of the new, longer unhosed simulation allows us to plot the figures without normalizing. This helps to provide a more balanced view of the differences between the simulations.

"P4680 Section 3.4: For the un-hosed experiment the final 300 years or so seem to

enter a 'third state', with a strong AMOC and high salinity North Atlantic but intermediate values for Greenland temperature and N. Atlantic ice free area. Can the authors comment?"

Indeed, the reviewer raises a very interesting observation. It appears that that the modeled ocean-ice-atmosphere system can become locked for several hundred years in an interstadial state of strong AMOC and high salinity, but intermediate sea-ice and Greenland temperature. After 5000 years of model integration, these '3rd state interstadials' become the norm rather than the exception. The apparent contradiction of a stronger AMOC with intermediate Greenland temperature and sea-ice can be resolved by a southward shift of NADW formation, which allows more sea-ice to form thereby cooling Greenland. We have attached a hovmoller plot of the N.Atl. mixed layer depth (calculated from KPP) that shows the southward shift in NADW during the longer '3rd state interstadials'.

"P4681 Line 10: I note that the authors do not normalise for the difference between hosed and un-hosed scenarios (okay) but then they compare the difference to 'absolute' values shown in Figs. 3-7. But this is not a real comparison because those values have been normalised."

We agree with the reviewer that this was confusing. In the revision, we will show all Figs. 3-7 as un-normalized values.

"Figs 3 and 4: I can't make out the contoured values. Perhaps add 2 additional plots in each Fig to show std dev separately?"

We will try different colors and line thicknesses. If that doesn't work, we will add 2 additional plots per figure as suggested.

"Minor comments:

P4670 line 1: Better to stick with data-based studies for this set of citations, rather than model studies using freshwater."

Good point, we will address this in the revision.

"P4670 line 2: by 'early on' you mean in early studies (or early in the D-O cycle?)"

Here, we are referring to 'early studies', not 'early in the D-O cycle'. We will rephrase this sentence for the revision.

"P4670 line 2: layers can't be dramatic – you mean that the layers imply that a dramatic event must have occurred."

We will rephrase this sentence for the revision.

"P4670 line 11: Meaning of 'plumbed' here?"

In this context, 'plumbed' was used as a synonym of 'tested' or 'measured'. We will rephrase this sentence with a less colourful verb in the revision.

"P4672 line 24: IRD is associated with most if not all stadials (e.g. Bond and Lotti, 1995)."

We can rephrase the sentence accordingly for the revision.

"P4680 line 3: Add refs – e.g. Hendy and Kennett (1999, Geology)"

We will add more references to back that statement in the revision.

References:

Camille Li, David S. Battisti, and Cecilia M. Bitz, 2010: Can North Atlantic Sea Ice Anomalies Account for Dansgaard–Oeschger Climate Signals?*. J. Climate, 23, 5457–5475.

Interactive comment on Clim. Past Discuss., 11, 4669, 2015.

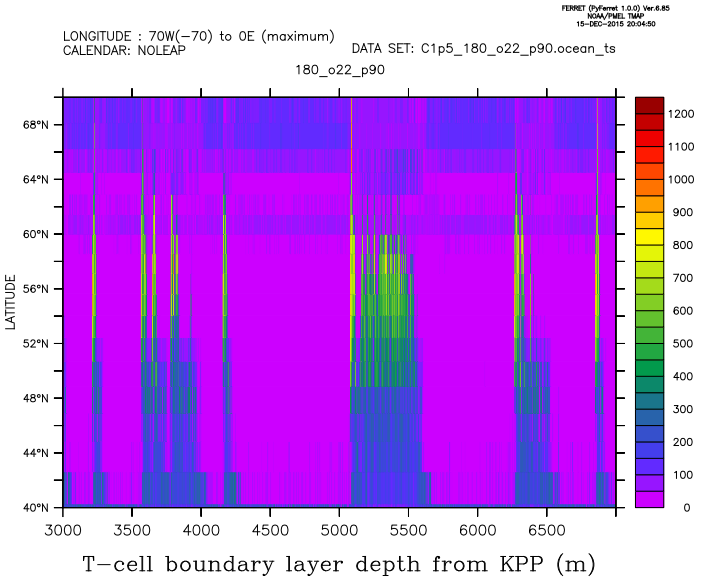
FERRET (PyFerret 1.0.0) Ver.6.85
NOAA/PMEL TMAP
15-DEC-2015 20:04:50
LONGITUDE : 70W(−70) to 0E (maximum)
CALENDAR: NOLEAP
DATA SET: C1p5_180_o22_p90.ocean_ts
180_o22_p90
LATITUDE
68°N
64°N
60°N
56°N
52°N
48°N
44°N
40°N
3000
3500
4000
4500
5000
5500
6000
6500
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
T−cell boundary layer depth from KPP (m)

Fig. 1.