Clim. Past Discuss., 5, C273–C277, 2009
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Climate of the Past Discussions

Interactive comment on "Investigating the impact of Lake Agassiz drainage routes on the 8.2 ka cold event with climate modeling" *by* Y.-X. Li et al.

Anonymous Referee #2

Received and published: 28 May 2009

GENERAL COMMENTS

The study by Li et al. describes the response of the ECBILT-CLIO-VECODE model to freshwater perturbations applied to different locations along the east coast of North America. The model shows a stronger response when the freshwater is applied to the Labrador Sea region as compared to more southerly locations such as Cape Hatteras.

The findings are discussed in the context of the 8.2Ka event, which is seen as an abrupt cooling in the Greenland ice cores and is thought to be caused by a drainage of proglacial lakes created by the retreat of the Laurentide ice sheet.

The manuscript is well organized and clearly written. However, the analysis of the model results is mainly descriptive and does not include sufficient discussion of the

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mechanisms responsible for the changes observed and how the results compare to the proxy record.

To simplify the manuscript and focus more on the mechanisms and understanding of the results in light of available proxy data, it would be an advantage to only discuss one of the southerly routing experiments. All three experiments R2-4 show similar results and it is therefore not necessary to discuss all of these in the manuscript, and at the same time it would make the figures even more clear.

It is necessary to add plots showing the state of the model in the control simulation, in particular for convection and meridional overturning strength (Atlantic meridional stream function). Adding a plot of the AMOC for R1 will make it possible to evaluate the response of the model to freshwater and facilitate comparison to previous studies as well as proxy data. Similarly the manuscript should include maps of SAT (with the points used in fig. 6 indicated) and sea ice extent for at least the control and R1 experiments.

SPECIFIC COMMENTS

A few specific suggestion for improvements are as follows:

Section 2.2:

Wiersma et al. (2006) is cited extensively, however it is not clear what the difference between the two studies is. E.g did Wiersma use a fixed routing for the freshwater? This should be made clear at the start of this section. Also did this previous study include a background freshwater flux to the Labrador Sea. If not, it should be discussed how this changes the results.

Is the model at equilibrium with 8.5Ka boundary conditions and added background flux of freshwater to the Labrador Sea? The drift in temperature of the deepest layer is stated, but it would be more appropriate to state the drift in salinity of the deep ocean. Also, is the background flux of 0.172 Sv of freshwater balanced?

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The locations of the freshwater routing is shown in figure 1, however the areal extent of the perturbation is not clear and needs to be described (e.g. over how many grid points of the model is the anomaly applied). Also, the amount of freshwater should be given in Sverdrups, making it easier to compare with previous studies. Are these freshwater amounts exactly the same as in Wiersma et al. (2006), if yes state this, if not state why they are different.

Section 3.1:

It is stated that the freshwater anomaly for R1 is more confined than in the other experiments. As shown in figure 2, it is the salinity anomaly in R1 which is the least confined of the 4 experiments.

The definition of the MOC in the North Atlantic and GIN Seas, as well as the heat transport plotted in figure 3 need to be given. Also, the Atlantic meridional stream function for the control simulation (at least) needs to be included in a plot to be able to validate the model results and compare with previous studies.

When discussing changes in the MOC, be clear on which (Atlantic or GIN).

It is stated that convection in the Labrador seas and GIN seas decreases in experiment R1. This should be discussed, in particular the observation that the convection in the GIN seas decreases more in the R1 scenario then in the other experiments. It is not clear why (or if) the R1 freshwater perturbation is more easily transported upstream to the GIN seas.

It should be discussed why there is a more immediate response of the sea ice in experiment R1 versus R2-4.

Section 3.2:

The temperature response to the freshwater perturbations at two locations are described, however the duration of the response is not discussed. This is crucial when comparing the model results to the proxy record and assessing wether the imposed

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freshwater flux could indeed help explain the 8.2Ka event.

Similarly the initial warming seen in the southerly routing experiments is not explained. What causes this response of the model and does it correspond the what is observed in the proxy records?

Section 4:

The difference between the routings chosen in this study and the study of Wiersma et al. (2006) has not be discussed in the paper, although it is stated that the locations of R1-4 were chosen to complement the results of this previous study. Is there a difference in the response using R1 versus the routing of Wiersma et al. (2006)?

Section 4.3:

It is stated that a southerly route is feasible to explain the d18O data in the Labrador Sea, but would require a relatively large freshwater perturbation to explain the 8.2Ka event. The temperature history of these experiments should be compared with the available proxy data (including Greenland ice cores) as the model suggests an initial warming only in the case of a southerly routing.

TECHNICAL COMMENTS

Title: ...cold event with a climate model.

1164.8: Mention briefly what low d18O values mean in terms of salinity.

1164.14: Very long sentence. Also, do not introduce abbreviations (e.g. R1, R2, etc) in abstract, this should rather come in the main text describing the model experiments.

1164.16: Too much detail on hosing experiments in abstract, e.g. the different amounts used are not essential in the summary.

1165.8: Cooling (if caused by AMOC change) is not necessarily abrupt. If so, this should be documented and the rate of AMOC changes and observed cooling should

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be compared.

1166.3: Give reference for studies focusing LAO drainage in Labrador Sea.

11.67. 6: What was changed in version 3 which made it possible to form deep water in the Labrador Sea? Add reference.

1167.8: "...the western boundary current..." is misleading and should be rewritten to make it more clear that this is the hypothesized drainage route from LAO.

11.69.11: "...the magnitude of decrease....". Rewrite this sentence.

1170.11: replace convection with convective.

1171.13: replace "both" by "all"

Fig.3: Black = R1.

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