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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.

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We thank the reviewer for providing the detailed and constructive comments. Following the reviewer's suggestion, we have focused our discussion about the model responses of a southerly route on R3 only and Fig. 3 has been revised accordingly. In addition, we have presented plots of convection depth, maximum of the meridional overturning streamfunction (Fig. 4A, D) and a map of the surface air temperature distribution (Fig 6A) of the control simulation. Changes in sea-ice extent in response to the freshwater perturbations are shown in Fig 5.

In the revised version, we provide interpretations for the modeled initial warming in the Greenland temperature time series of R3, immediate sea-ice expansion for R1, and stronger impact of R1 on the MOC of GIN sea than that of R2-R4. We also compare



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modeled temperature anomalies at Greenland Summit and Ammersee with proxy data from these two sites to suggest that southerly route drainage is plausible. Brief reply to some of these comments is provided below in the "specific comments" section.

Specific comments

Section 2.2

More details of Wiersma et al. (2006) have been provided in the introduction section. Wiersma et al. (2006) included a baseline flow and introduced freshwater to the Labrador Sea from a fixed location.

The model with the 8.5 ka boundary conditions and a baseline flow of 0.172 Sv was run for 900 years to reach a quasi-equilibrium state prior to introducing a freshwater perturbation. Since the baseline flow is included, salinity is not balanced and the ocean becomes fresher as time goes on. Such an experimental design emulates the boundary conditions in the early Holocene when the Laurentide Ice Sheet was rapidly melting and sea level was rising.

Freshwater was introduced to one grid cell for each routing experiment. We introduced 0.45 m sea-level equivalent (SLE), or 1.60 x 10ˆ14 mˆ3, 0.90 m SLE, and 1.35 m SLE freshwater in our study. Wiersma et al. (2006) introduced 1.63 x 10ˆ14 mˆ3, 3.26 x 10ˆ14 mˆ3, and 4.89 x 10ˆ14 mˆ3 freshwater. So the amounts of freshwater are almost the same as those of Wiersma et al. (2006).

Section 3.1

The center of freshwater anomaly for R1 is more expanded than those of other three southerly routes (Fig. 2).

Fig. 3 shows time series of maximum overturning stream function (Sv) in the North Atlantic (A) and the GIN Sea (B), and meridional heat transport in the Ocean at 30° S (C).

Atlantic MOC or GIN MOC has been clarified in the revised version.

Why freshwater is more easily transported upstream to the GIN seas?

Fig 2 shows that the majority of the freshwater anomaly of R1 appears to be transported by the northern part of the North Atlantic drift to the GIN sea while portions of freshwater anomalies of R2-R4 were dissipated southward (south of 40 N) by gyres. As a result, R1 caused stronger impact on GIN MOC strength than do R2-R4.

Why there is an immediate response of sea-ice in R1 than R2-4?

The freshwater release site of R1 is closer to the deepwater formation site in the Labrador Sea than other southerly routes (R2-R4). R1 route caused shutdown of convection in the Labrador Sea, leading to immediate expansion of sea ice.

Section 3.2

The duration of temperature anomaly are discussed in section 4.3 of the revised version. The initial warming is discussed in section 4.1 of the revised version. The brief warming in a southerly route is probably due to local intensification of convective activity near Iceland that compensates local weakened deep convection near Svalbard. The warming is brief because of the continuing freshening of the surface ocean. This brief warming does not occur in R1 probably because R1 scenario has the most effective freshwater forcing, which may prevent this from happening.

Section 4

Is there difference in response between this study and Wiersma et al. (2006) in terms of routing?

Our model responses show similar variation patterns to those of Wiersma et al (2006). A new figure (Fig. 7) has been provided in the revised version.

Section 4.3

Modeled temperature anomalies at Greenland Summit and Ammersee are compared with proxy data from these two sites suggest that a southerly route can better reproduce temperature anomalies, implying that a southerly drainage route is plausible.

What was changed in version 3 of the model to make it possible for deepwater formation in the Labrador Sea?

Details of version 3 of the model are provided at http://www.knmi.nl/onderzk/CKO/ecbilt.html Wiersma et al. (2006) run the model under modern climate conditions and show that the new version can reproduce deepwater formation in the Labrador Sea.

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