Response to reviewer RC2

We are thankful to the reviewer for their comments and we respond point by point in the following in blue.

The authors present a very interesting study with iLOVECLIM model about the last deglaciation period. The transient simulations and the sensitivity experiments unravel the relative importance of different components of interaction between cryosphere and climate. The draft is very well written and very legible and systematic, and thus recommends publication. Below are some questions, comments and some minor modifications which authors might like to consider answering and clarifying in the draft.

1) Line 115: "The updates are done abruptly, i.e. without temporal interpolation, every 500 years for the ICE-6G_C reconstruction and every 100 years for the GLAC-1D reconstruction".

Might be interesting to clarify here why such a choice has been made for the interacting time scales. Is this to match to temporal resolution of ice sheet reconstructions?

Yes, the ice sheet reconstructions are available every 500 years for ICE-6G_C (https://pmip4.lsce.ipsl.fr/doku.php/data:ice_ice6g_c) and every 100 years for GLAC-D (https://pmip4.lsce.ipsl.fr/doku.php/data:ice_glac_1d).

We have added this information:

"The difference in frequency update is due to the difference in the frequency of available ice sheet reconstructions (500 years for ICE-6G_C and every 100 years for GLAC-1D)."

2) Line 170: Can also clarify if the meltwaterflux is added uniformly across global ocean or in specific regions?

The meltwater flux is routed following the topography to the closes ocean. We have added this in the paragraph:

"With the new routing scheme, the fresh water flux from ice sheet melt is thus not added homogeneously in the ocean but routed towards the closest ocean grid cell following the topography."

3) Line 203:- Does the difference in time interval for updating ice sheet topography and albedo information in model, i.e 500 years in ICE-6G vs 100 years in GLAC-1D, can have an impact on why ICE-6G has not simulated the temperature decrease between in 14-12 kyr?

It is likely that the frequency of update has some impact, although changing from every 500 years to every 100 years with the same bathymetry reconstruction has probably less impact than using different reconstructions. To test this, we have run an additional simulation using the GLAC-1D reconstruction, and updating the bathymetry and land-sea mask every 500 years instead of 100 years. As shown on the figure below, the update frequency does have an impact, but the difference in temperature evolution compared to the simulation with the 100 year frequency is less than the one with the simulation with the other reconstruction (ICE-6G_C).

We have added this in the text (along with the new figure):

“To test the effect of the frequency update of bathymetry and land-sea mask, we have also run a simulation with GLAC-1D, updating the files every 500 years instead of 100 years.”

“The update frequency for bathymetry and land-sea mask is different for the two reconstructions: 500 years for ICE-6G_C and 100 years for GLAC-1D. To test the impact of different update frequency, we have run an additional simulation with the GLAC-1D reconstruction, with an update frequency of 500 years, similar to ICE-6G_C. As shown on Figure 13, the frequency update modifies the global temperature evolution. It often results in a delayed response compared to the simulation with 100 year frequency, as the bathymetry and land-sea mask change happens later, for example at ~19 ka, ~16.5 ka, ~11 ka or ~10 ka. Yet the effect is limited, and the difference between the two simulations with the same reconstruction but different update frequency is smaller than the difference between the simulations with the two reconstructions and the same update frequency.”

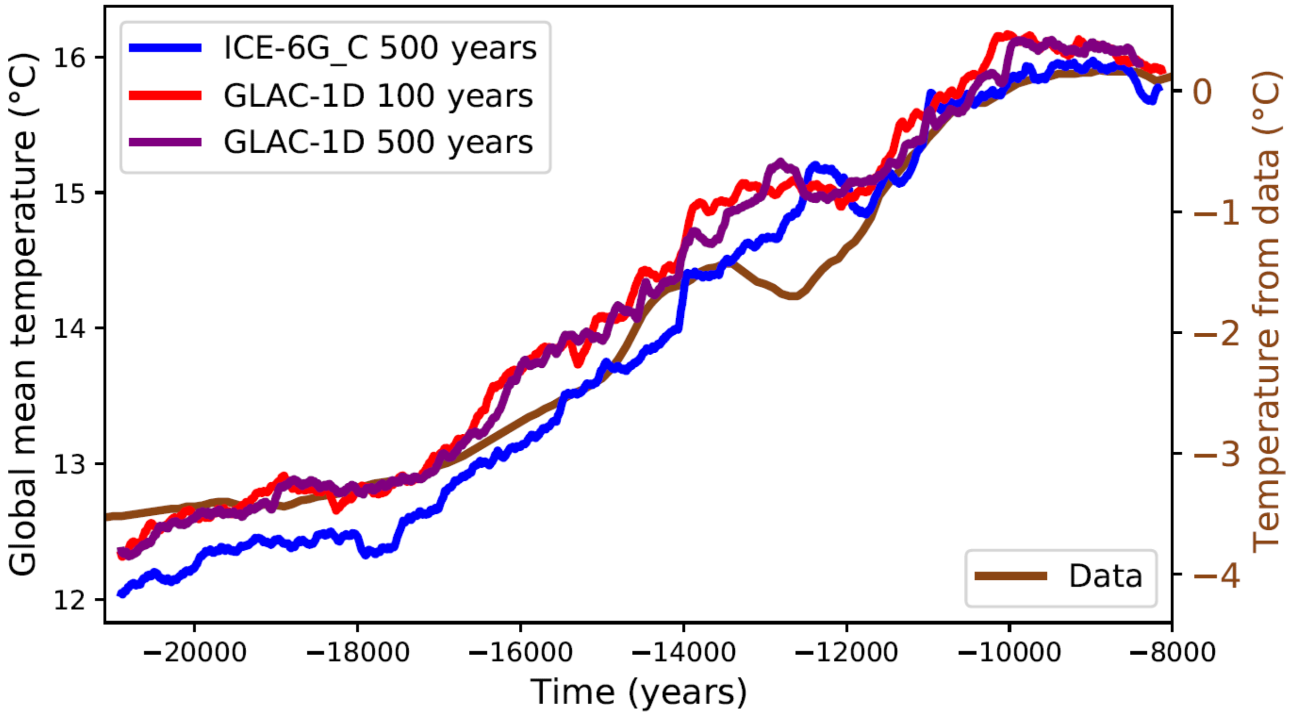

Figure 13. Evolution of global mean temperature (°C) for the simulations with evolving bathymetry with the ICE-6G_C or GLAC-1D reconstruction. For GLAC-1D, two update frequencies (100 and 500 years) have been tested. The simulated results are shown as running mean over 100 years. Data are from Shakun et al., 2012. Note that the vertical scales for the model simulations (left) and for the measured data (right) are different.

“In addition, we have chosen to keep the frequency of bathymetry update from the original frequency of the ice sheet reconstructions. This results in two different frequencies for the two reconstructions (500 and 100 years). Testing the impact of different update frequencies for the same reconstructions show some limited impact: a less frequent update leads to delays in the climate response as the changes take place later. Yet this effect is small compared to the change in climate from the two different reconstructions with the same update frequency.”

4) Lines 234-235: "The salinity change at the LGM that is computed directly from the volume change (1.4 psu for ICE-6G_C and 1.3 psu for GLAC-1D)) is larger than the one prescribed in the standard protocol without bathymetry change (1psu)"

Does this means there must be a 0.3 Psu difference between dashed and solid lines in Figure 6 ?

No, the standard protocol refers to the PMIP4 protocol when no bathymetry change is accounted for, i.e. when the bathymetry is set to the pre-industrial (it is one option in the protocol). Here the bathymetry is set to the LGM and the salinity change computed accordingly. We have modified the sentence to make it clearer:

"The salinity change at the LGM that is computed directly from the volume change (1.4 psu for ICE-6G_C and 1.3 psu for GLAC-1D)) is larger than the one prescribed in the PMIP4 standard protocol without bathymetry change where the bathymetry is fixed to the pre-industrial one (1 psu)."

5) Line 270:- "Due to the sea level increase, the ocean surface in the high latitudes of the Northern Hemisphere increases with time"

Since this experiment does not include melt water flux input, is there significant sea level increase in this experiment due to thermal expansion of water?

The experiment does not include melt water flux directly, meaning there is no addition of fresh water in some ocean regions, but the bathymetry and land-sea masks are modified according to the ice sheet change (mostly ice retreat) so that the water coming from the melting is added to the ocean through the change of bathymetry and land-sea mask. The increase of ocean surface is due to this change of land-sea mask.

We have added more details: "Due to the sea level increase from ice sheet melt, the land-sea mask is modified, and the ocean surface in the high latitudes of the North Hemisphere increases with time"

6) It is interesting to see a consistent dip and then retrieval in albedo and seaice in southern hemisphere between 14-12k in ICE-6G_C evolving bathymetry experiments. Corresponding temperature rise is seen in time series of model temperature in EDC location as well. Did authors further investigated about processes in southern ocean resulting in such changes? It would be informative to add some inferences about this in the draft.

See Response to reviewer RC1 question number 21.

7) Line 261 "At high latitudes where it is cold enough to have sea ice, the continental surface is replaced by surfaces with sea ice, which has a higher albedo, in particular in summer, leading to the colder temperatures"

Can authors explain bit further on the difference in albedo caused by sea ice formation. Is the sea ice is replacing icesheet surfaces in higher latitudes? Is the difference because icesheet surfaces have lower albedo than sea ice? Doesn't sea ice albedo depends on how thick is the ice and how much snow is on the top etc, which all tends to reduce surface albedo compared to ice sheets?

See response to reviewer RC1 question number 18.

The albedo of ice sheet is typically 0.85. If there is no ice sheet, the continent can be covered by snow, especially in winter, whose albedo is also high, around 0.8. If the snow melts, the albedo decreases, and when no snow remains the albedo varies between 0.1 and 0.3 depending on the vegetation. Hence if the continent is not completely recovered by snow, especially in summer, its albedo will be less than sea ice.

8) How is AMOC strength in Figure 11 is computed?

It is the maximum of the overturning circulation in the North Atlantic.

9) Why there is such large differences between sea ice formation and AMOC strength for two icesheet reconstructions with evolving bathymetry. Again, does the time interval for ice sheet and bathymetry updates to the model could produce any of the differences?

The update frequency has a limited impact, see response to question number 3.

Minor comments/corrections:

10) Line 199: When temperatures from both simulations have similar values,:- when temperatures from both simulations reach similar values seems more appropriate ?

done

11) line 204-205 The sentence can be rewritten as lots of comma separated statements make it difficult to understand.

As suggested we have rewritten this part:

“This can be linked to the Northern hemisphere ice sheet reconstructions. In GLAC-1D the ice volume decreases strongly until 14ka, then stays constant from 14 ka to 12 ka. With ICE-6G_C it continues to decrease, although at a lower rate.”

12) Line 275:- this effect is counteracted by the increase of ocean surface at high latitudes so that the sea ice area shows a more limited evolution.

“reduction” might be more suitable than “evolution” in this sentence?

Yes, done

13) In both Figure 11,14 captions :AMOC is expanded as Atlantic Meridional Oceanic Circulation instead if Atlantic Meridioanal Overturning circulation.

This has been corrected.