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Responses to Anonymous Reviewer #1

Reviewer's comments in **black**
Authors' comments in red

Comments:

The description of experiments is not sufficiently complete and precise. For example, it is not clear whether the same Greenland ice sheet (altitude,extent,…) is used for PI, Modern, MIS1, MIS5e,MIS11c,MIS31. In the case of MIS5e, the description of this interglacial states that Greenland ice core records suggest a modern reduction in the size of the GIS. In the discussion, the authors wrote 'our simulations of MIS-5e with a near-modern GIS'. However, it is not clearly mentioned whether a reduction of the size (or any other change) of the GIS compared to present-day (pre-industrial or modern) is applied for the simulation. Is the same GIS used for PI and Modern simultations? How realistic is it? As far as the orbital forcing is concerned, the authors stated that Earth's orbital configuration has changed little in 120 years (from PI to Modern, I guess). Has this modern change been taken into account? The authors should also check the orbital parameters for MIS31.

Description of the experiments have been fixed and made clearer for the audience. Thank you for your suggestions throughout the comments. The same Greenland Ice Sheet (modern; same elevations and extent) is used for our modern, pre-industrial, MIS-1, MIS-5e and MIS11GIS simulations. No GIS is used in our MIS11NG and MIS-31 simulations. In regards to Earth's orbital configuration since pre-industrial, this is a great question. Precession has changed within the time from of ~120 years (from PI to modern) which accounts for ~ 1% change in the orbital configuration. However, Berger's astronomical solutions are calculated for every 1000 years. To keep within his solutions, we used his values. This is a great question - the orbital parameters for MIS-31 are correct. The values of precession in the table are our GCM precessional values. They are slightly different than Berger's astronomical solutions. The GCM reads precession as the prograde angle from perihelion to the vernal equinox. To avoid future confusion for the reader, we have changed the precession value in our table to omega defined by Berger.

There are major defects all throhgout the text. Very regularly, the authors forgot to mention their reference, which is either PI or Modern. I agree that the problem would not exist if there were only one reference! Very regularly, the authors forgot to mention the time in the year (Summer, July, Annual, …) that applied on the provided values. Very regularly, the authors forgot to mention the region (Lake E, Beringia, Arctic) that applied to the provided values. This issue must be solved.

Thank you for your very detailed comments. We have fixed most of these issues and have done a very thorough editing of our manuscript.

Several authors, including Yin and Berger (2011) that the authors quoted, selected peak interglacial for their study. However, they do not agree on the date corresponding to this peak interglacial. For example, for MIS1, Yin and Berger (2011) selected 12ka, Lisiecki and Raymo (2005) pointed towards 6ka and Melles et al (2012) choose 9ka. Could the authors elaborate on the reason for the difference (as well as for the other interglacials) and explain how they make their choice? By the way, peak of summer warmth may be different from peak of boreal summer insolation.

This is a great question. Unfortunately, an in-depth discussion regarding the definition of the defined timing of the interglacials is beyond the scope of this study. We agree there is some community disagreement regarding what defines early Holocene warmth however, for simplicity, we follow the same protocols of Melles et al., 2012 (9ka is the time of peak boreal warmth and insolation at the lake).

The authors do not seem to be aware of other modeling studies performed from the Eemian, such as…

Thank you very much for a listing of these references. We will take a look and add them appropriately.

Detailed comments

Page (P.)3128 line(l.)18 - 'A prescribed enhancement of oceanic heat transport into the Arctic ocean has some effect on Beringian climate, suggesting intrahemispheric coupling seen in comparisons between Lake El'gygytgyn and Antarctic sediment records might be related to linkages between Antarctic ice volume and ocean circulation.' I do not understand this sentence.

Thank you very much. This has been fixed and the sentence is clearer.

P.3129 l.13 - I suggest using Lake E everywhere throughout the main text (from section 1 to section 4-included).

Thank you. We agree and this has been changed.

P.3131 l.19 – The authors should define **summer** insolation. The value they are giving for summer insolation seems rather large. However, it may be correct depending on their definition of summer insolation. A reference for the insolation should be provided in the text (and not only in the table).

This citation has been added in the text and table. Citation is as follows:

Laskar, J., Robutel, P., Joutel, F., Gastineau, M., Correia, A. C. M., & Levrard, B. (2004). A long-term numerical solution for the insolation quantities of the Earth. *Astronomy and Astrophysics*, *428*(1), 261–285.

Summer insolation is defined at latitude 67.5°N using the astronomical, long-term solution of (see reference above).

P.3132 l.6 – '(Dahl-Jensen et al., 2013) suggest warm conditions throughout the Arctic'. I think that Dahl-Jensen et al. (2013) suggest warm conditions recorded at NEEM site. How is it extrapolated for the whole Arctic?

You are correct in questioning whether the NEEM record can be extrapolated for the entire Arctic. I do agree the sentence is improperly worded and it is indeed hard to assume this one record can be a circum-Arctic imprint of temperature. We have fixed this sentence so it is clearer.

P.3132 l.16 – 'insolation plays a dominant role on the on precipitation'. Something is going wrong in this sentence.

Fixed.

P.3132 l.21 – 'The simulation of LIG shown here is used to compare with the paleoenvironmental conditions in the Arctic during this period of and investigate temperature, vegetation and precipitation and correlate the data to pollen proxy analysis.' Something is going wrong in this sentence.

This now reads: 'The simulation of LIG shown here is used to compare paleoenvironmental conditions in the Arctic, such as, temperature, vegetation and precipitation, to Lake-E pollen proxy analysis. Orbital and GHG values are estimated for 127 ka; peak warmth during MIS 5e.'

P.3133 l.1 – I am not sure that the paper (Miller et al., 2010) is dealing with MIS11.

You are absolutely correct. This was the wrong citation. It has now been fixed. See below:

See the section on MIS 11 -

Miller, G. H., Brigham-Grette, J., Alley, R. B., Anderson, L., Bauch, H. A., Douglas, M. S. V., … Wolff, E. W. (2010). Temperature and precipitation history of the Arctic. *Special Theme: Arctic Palaeoclimate Synthesis (PP. 1674-1790)*, *29*(15–16), 1679–1715. doi:10.1016/j.quascirev.2010.03.001

P.3133 l.1 – 'insolation forcing ... was remarkably long'. I do not understand what this mean. Does it mean that the insolation (which one?) remains high over a long time interval?

I have changed the wording of the sentence to be clearer. This now reads:

Unlike the other interglacials, MIS-11c was remarkably long, with two insolation maxima anomalies at ~ 409 ka and 423 ka, apparently creating extensive warmth throughout the Arctic (Melles et al., 2012).

P.3133 l.28 – 'distributions of are used' a word is missing preventing the understanding of the sentence.

Fixed

'Furthermore, simulations using prescribed distributions of biome flora are used to quantify the local effect of changing vegetation cover around the region.'

P.3134 l.13 – What is 'MIS model'?

Removed "MIS"

P.3135 l.23 – 'the GCM is only +0.5 °C warmer than the modern reanalysis data' When? In Summer? In July? In annual mean?

Fixed – this is a mean July temperature difference.

"The difference indicates that mean July GCM temperatures are only + 0.5 °C warmer than the modern mean July reanalysis data in the Lake-E region, signifying relatively reliable temperature results."

P.3136 l.10 – 'precipitation is rather dry'. I am sorry! This does not make sense to me. Please clarify what you mean.

Thank you for catching this. This part of the sentence is not clear. However, it is supposed to mean "precipitation is rather low…" I have changed the word "dry" to "low"

P.3136 l.27 – Please avoid to write that temperatures are cooler/colder/warmer. Indeed a region can be cooler/colder/warmer than another but temperatures can only be larger/smaller/lower ...

Thank you. Noted.

P.3137 l.20 – Is this for Lake E or for Beringia or for the Arctic?

This is for Lake-E. I added the location within that sentence.

P.3137 l.7 – When? In summer or in July or in annual mean?

Summer = mean JJA precipitation. This has been fixed and made clearer.

P.3138 l.12 – ppmv instead of ppm_V.

Thank you. Noted.

P.3138 l.15 - Is this for Lake E or for Beringia or for the Arctic? As long as there is a 2°C difference between PI and Modern simulation, it is difficult to understand that the comparisons to PI and to Modern are similar. Please explain.

Added that the location of this comparison is Lake-E.

P.3138 l.20 - Is this for Lake E or for Beringia or for the Arctic?

This is for Lake-E as well. This has been cleared up.

P.3138 l.26 – The reference to Fig4c is not correct.

Fixed. This should have read Fig 3c.

P.3139 l.14 – What does 'mean annual summer temperature' refer to?

This represents JJA averaged temperatures. This has been fixed.

P.3140 l.9 – Is modern value 478mm yr^{-1}?

Modern values are 475 mm yr^{-1}. Thank you. This has been corrected.

P.3140 l.11 – The reference to Fig4d is not correct.

This has been corrected to Fig 3D.

P.3141 l.2 - Is this for Lake E or for Beringia or for the Arctic?

This is for Lake-E. Thank you. This has also been fixed.

P.3141 l.7 – Is it really for the Arctic? I thought that it was for Lake E.

This is for Lake-E. This has been fixed.

P.3141 l.21 – 'more than' instead of 'more then'. What is the reference here? 150mm yr^{-1} decrease compare to what?

This was not made clear but has been fixed. The comparison was with respect to the integration without large NH ice sheets.

P.3142 l.13, l.16 – This seems to contradict numbers previously given. I am sure that this will be immediately clarified with the revised tables. There are three MIS-11c simulations. Which one is referred to here?

Revised tables will clear this up. This sentence refers to the MIS 11c runs w/o a Greenland Ice Sheet (MIS11NG).

P.3142 l.21-22 – What do the authors mean with 'thermal maximum are variable'? Does

it mean that thermal maximum has a large variability measured with a large standard deviation? In that case, why could the authors conclude that it is large? What is their reference for such a conclusion? 'smaller anomalies reconstructed ...' Which anomalies are the authors discussing? What is the reference, i.e smaller than what? Why is it so?

Great questions. We have revised this sentence to make it clearer. Thank you.

P.3143 l.3 – 'a reduction in the Greenland Ice Sheet adding 1.6 to 2.2 m of equivalent sea level rise'. Adding water to what? To which reference sea level?

Colville et al., 2011 states that analysis of sediment sources during the LIG relative to the early Holocene denote greater southern GIS retreat during the LIG. This is consistent with a suite of GIS models and a GIS contribution of 1.6 to 2.2 meters to the >= 4-meter LIG sea level global highstand.

P.3143 l.6 – 'the thickness decreased by '. Once more, what is the reference? A decrease from what?

NEEM concluded the decrease of 400 ± 250 meters reached surface elevations of 130 ± 300 meters lower than present ~ 122 ka years ago. Therefore, surface elevations 122,000 years ago were anywhere from +170 m higher than modern to 430 meters lower than modern surface GIS elevations. This was fixed and made clearer in the manuscript.

P.3144 l.5 – In this simulation, the authors increased the heat flux convergence under sea ice in the Arctic Ocean. I assume that the reduction in sea ice fraction and the summer warming are not prescribed but rather a consequence of the increased heat flux. This should be made clear. The reference to Fig3a is not correct.

Excellent suggestion. This has been fixed.

P.3144 l.21 – Is this statement valid for MIS11 (i.e. deduced from the comparison between MIS11GIS and MIS11NG) or is it more general (deduced maybe from additional simulations not shown)?

These statements are valid for MIS11 numerical model simulations

P.3145 l.13 – 'atmospheric CO_2 was higher'. Higher than what? I suggest that the authors explain in more details what they have in mind with this sentence.

The sentence is comparing the MIS 31 with the late Pleistocene interglacials, which start at the Eemian. The sentence should say:

"Elevated GHG concentrations and a very warm orbit with a large precession can explain much of the warmth during MIS-31, assuming atmospheric CO_2 was higher than MIS-11 and the late Pleistocene interglacials (Hönisch et al., 2009)."

P.3145 l.23 – It was stated that PANN for the Modern simulation was 475mm yr^{-1}. This

is NOT 350mm yr^{-1}less than 600mm yr^{-1}. This should be clarified.

Fixed. This has been clarified.

P.3146 l.6 – Starting from here, the discussion focuses on the 116K simulations. This should appear more clearly in the text.

We will use a heading to differentiate the discussion topics.

P.3146 l.19 – The authors seems to explain the aridity during the 116K simulations with more frequent storms. Actually, I would guess that more frequent storms would drive more precipitation. Can this be clarified?

Storm track during this period has been shifted south along the southern coast of west and east Beringia. The storms, due to synoptic changes attributed to the ice sheets, never make it more northward than the southern coast of Beringia essentially drying out the Lake-E region and the Arctic interior.

P.3146 l.26 - The reference to Fig6a and b is not correct, at least if the discussion is still about July. If not, this must be clearly stated.

This section has been removed from our paper. We had difficulty making this section fluid with the rest of the paper.

P.3147 l.8 - Is this for Lake E or for Beringia or for the Arctic?

Clarified this point. It was in relation to Lake-E.

P.3148 l.1-4 – I assume that this comes from data (observation) or did one/several of the simulation account for changes in the GIS?

This is demonstrated in our model simulations where when the GIS is removed, Greenland surface temperatures increase but Lake-E regional temperatures are not affected.

P.3153 - I already made suggestions and comments about table1. Here are a few additional ones. It is written that 'precession is Ω'. Ω must be defined and the units must be provided. It is written that 'temperatures are mean July temperatures'. I assume that they are for Lake E. There is no explanation about Prec in the caption. The reader can but assume that it is annual mean precipitation simulated at Lake E. Is this correct? The obliquity at MIS1 may be 24.229 instead of 24.29. This should be checked.

Precession is now defined in the table (degrees). Precession is also no defined for the reader. Obliquity of MIS-1 is 24.229 – this has been corrected. Thank you.

P.3155 - Which calendar is used for this plot? Orbital calendar? Present-day calendar (360 or 365 days)? The resolution of the plot seems to be better than 'monthly' or is it the interpolation from the graphic tool?

The calendar used in this plot is a normal present-day calendar with monthly data averaged over latitude. Contour intervals are in 10's therefore contour distribution looks rather dense.

P.3156 – Are these plots for annual, summer or July temperature? 'Area of no shading (white)'. I am sorry, I do not understand what this mean. Actually the white shading, according to the color bar, corresponds to zero warming. It is therefore difficult to imagine how it also represents statistically significant anomalies. At last it is surprising to label these figures as **warming** relative to PI while there is also cooling.

The difference with respect to Pre-Industrial is mostly red indicating temperatures that are warmer than Pre-Industrial simulations. There is some blue shading along the eastern Beringia coast, but it is on the order of >1 °C. These cooling areas could be noise in the model data making them insignificant. Most of the circum-Arctic is warmer by a few degrees.

P.3157 – Figure A is most probably pre-industrial vegetation rather than modern vegetation. It should be mentioned if figure D is MIS11GIS or MIS11NG.

Thank you for your suggestion; this has been fixed.

P.3159 – What is Polar MM5 regional climate model? It is not discussed in the main text.

*****This section has been removed from our paper*****

The polar MM5 is a regional atmospheric model, with high spatial resolution and multiple options for physical parameterizations. Polar MM5 is the Pennsylvania State University-National Center for Atmospheric Research (PSU-NCAR) Mesoscale Model (MM5; Dudhia 1993; Grell et al., 1994) adapted for simulations over Polar Regions (Bromwhich et al., 2001; Cassano et al., 2001). We did not go into depth about the Polar MM5 model because it was not fundamental to our simulations.

P.3161 – The caption indicates that figures show anomalies with respect to the simulations without NH ice sheet. Actually, anomalies can be computed with respect to one simulation (at least one at a time). Which simulation (name) is used here? Strictly speaking 'MTCM temperature' is a bit awkward, indeed when the acronym is expanded it reads Mean Temperature of the Coldest Month temperature.

*****This section has been removed from our paper*****

Thank you. This caption has been fixed. Simulations with northern hemisphere ice sheets and without northern hemisphere ice sheets are now correctly named with their experimental name.

"MTCM temperatures" has been changed. We removed the word "temperatures".