Clim. Past Discuss., 9, C1789–C1799, 2013
www.clim-past-discuss.net/9/C1789/2013/

Climate of the Past Discussions

Interactive comment on "Simulating last interglacial climate with NorESM: role of insolation and greenhouse gases in the timing of peak warmth" *by* P. M. Langebroek and K. H. Nisancioglu

Anonymous Referee #1

Received and published: 22 August 2013

Langeboek and Nisancioglu present an analysis of 6 LIG climate simulations together with a model-data comparison focussing on the role of changes in insolation and greenhouse gas concentrations respectively, on the role of seasonality and on the timing when maximum LIG warmth occurred. Especially the seasonality aspect and the focus in the model-data comparison on the North Atlantic region is an important addition to previous work and makes the manuscript worth publishing in my opinion. Furthermore they present a number of interesting findings. For instance the simulated changes in the subpolar gyre and its impact on the local sea surface temperature

evolution; that greenhouse gas concentrations alone might explain the reconstructed early LIG colder climate; and the simulated early LIG peak summer warmth in the high southern latitudes in contrast to the local summer insolation peak.

However, I do have a number of concerns that I would like to see addressed before publication.

Main concerns:
Section 3.1 Since a number of studies (like Lunt et al., 2013) have presented LIG snapshot simulations previously I think a more thorough comparison and discussion should be included.

Section 3.2 A comparison is made in figure 4 between reconstructed SSTs at different North Atlantic sites and simulated monthly temperatures. The fact that monthly values are used rather than summer mean values like JJA makes that this manuscript goes more into depth than previous studies. However, in section 3.2 only JAS values are discussed. Please describe the important differences between the different months; specify and discuss which ones fit to the reconstructions and which don't.

4457.17 According to Figure 4 the impact of including early LIG GHG values in the simulations is rather limited (1 degree at most). Is that sufficient to explain the lower early LIG temperatures as described for instance by Govin et al. (2012)? Furthermore, the word 'significant' will make the reader wonder how you calculated this significance, at what confidence level etc.

4458.19 The model-data fit of the peak LIG warmth as shown in Figure 4 is quite

fascinating in the sense that at site CH69-K09 the simulated August and September temperature maximum is indeed later in comparison to the other sites, in good agreement with the temperature reconstructions. However, according to figure 5 this might well be strongly linked to the fact that this core site is located in the 'feature' described by the authors on lines 4458.16-21. In my opinion it is because of this importance for the model-data comparison that this feature should be explained and discussed more thoroughly because it raises many questions like: How do the authors know that it is a expansion of the subpolar gyre that causes the temperature change? What causes this expansion of the subpolar gyre? If the separation of cold and warm water is shifted southeast, wouldn't you expect both a cooling and warming signal instead of only a clear regional cooling? Is the change in gyre configuration connected to changes in the AMOC? How model dependent is the simulated change in the subpolar gyre and therewith the good model-data fit? Is there other proxy-based evidence for such subpolar gyre changes? How do the changes relate to the inflow of warm water into the Nordic Seas?

4459.14-28 The authors describe peak summer and winter warmth over the Southern Ocean and over Antarctica. The simulated early LIG summer peak is intriguing since it appears to be in good agreement with proxy-records but it is different from the results of the model inter-comparison published by Bakker et al. (2013). Assessing in what way and why the simulated temperatures by NorESM are different from previous studies would in my view be a great addition to the manuscript (different model set-up? Forcings? Feedbacks? Analyzing method?).

4459.23-28 I find this section (and therewith also lines 4461.4-6) somewhat confusing. Please clarify how a negative early LIG summer (DJF) insolation anomaly at high southern latitudes (Figure 1) can result in winter warming and how that in turn can explain the early LIG peak summer temperatures. Doesn't it appear from figure 1 that

the positive early LIG spring (SON) anomaly should play a role in explaining the early LIG summer peak warmth at high southern latitudes? Finally, please be more specific on how the processes in the Southern Ocean region feedback on the adjacent land (Antarctica). Related to this, could the authors explain the large high southern latitude temperature difference between ocean and land at 115ka (Figure 6).

General questions:

4456.17 Does this mean that the positive feedback from melting sea ice in summer is stronger than the negative feedback related to winter sea ice growth?

4457.25 A reduced inflow of relatively warm Atlantic water into the Nordic Seas is mentioned. But is this found in the simulations? Or in proxy-based reconstructions? Related to the previous question. Bakker et al. (2013) describe large differences in the evolution of the AMOC among different climate models. What are the characteristics of the AMOC in the NorESM simulations and do they change between the different snapshots? How does this in turn relate to the changes in Atlantic water inflow and subpolar gyre mentioned in the manuscript?

On page 4457 Langebroek and Nisancioglu describe a good fit between simulated and reconstructed temperatures. How does this relate to earlier findings by for instance Lunt et al. (2013) who describe an overall poor model-data comparison? Is this difference related to the specific regions chosen in this study? To the types of temperature proxy used in the different studies?

4460.1-4 Does this finding implicate that including 'more realistic' GHG concentrations in LIG simulations results in a larger disagreement with proxy-reconstructions that

show an early LIG temperature peak over Antarctica?

Minor comments: (page.line)

Abstract: Please make more clear in the abstract what the goal of this research is. 4450.7 and 4457.11: On several occasions the authors mention that during the early LIG GHG concentrations were low. This is indeed true for 130ka and, to a lesser extent, 125ka but around 128ka a maximum in CO2 is found (Luthi et al., 2008). Please be more specific.

4450.20 'the fit', please be more specific.

4450.22 Clarify why these two are exceptions.

4450.25 Please specify how relatively warm winters relate to the Southern Ocean austral summer peak temperatures.

4451.6 Clarify for the reader what difference it would make if a warming is forced by changes in insolation or GHG concentrations.

4451.26 The model inter-comparison study by Lunt et al. (2013) includes simulations performed with the NorESM model. Please mention this and clarify if these are the same or that there are differences in the model, in the experimental set-up and or the model results.

4453.3 and 4453.17 Please look carefully if such details are relevant for this manuscript.

Section 3.1: Please quantify the described changes in insolation and temperature.

4455.20-4455.22 I do not see the described evolution of SH insolation in Figure 1. Please clarify.

4456.2 Global temperatures are mentioned but are these also shown?

4456.12 this 23 ppm only relates to CO2 and not to GHG in general, please be more specific.

4456.22 Discuss the strong SST decrease in most of the cores after 116ka.

4457.19 It is important to note that this temperature reduction by lower GHG values is valid for 130ka and 125ka but not for 129-128ka, a period with higher GHG concentrations.

4457.27 Please give references for the claim that SSTs can be too high.

4458.1 For some of the core locations, the model-data comparison reveals a clear bias (as described on 4457.22) but is this bias likely to be explained by the calibration error?

4458.5 I would be careful with a reasoning like this because indeed taking into account

the uncertainties in simulated and reconstructed temperatures make for a reasonable model-data fit, but wouldn't that also imply that then most any simulated temperature evolution will likely fit to the data?

4458.9 Could you provide a reference to this habitat depth issue? Maybe also refer to the recent findings by Lohmann et al. (2013).

4459.14 Please clarify 'large-scale phenomenon'.

4459.5 Can the authors explain a bit more what they used as reference values and how the mean variations have been calculated?

4459.12 This 'slightly earlier maximum (120ka)' is not easy to see in Figure 6.

4459.13 In this section the peak summer warmth is described for different regions but I think the authors should make it more clear that there are actually large differences between the different summer months as is illustrated by Figure 4 (see also the main concern about section 3.2).

4459.14 Such a late winter peak is not found over the high northern latitude oceans according to Figure 6.

4460.21 Maybe specify which month instead of 'summer' since the difference between the different summer months appear large.

Figure 2:

Why have absolute temperatures been used in figures 2 and 4 and temperature anomalies in figures 3 and 5?

Figure 4:
I find the lines representing the simulated temperatures somewhat misleading since they represent only 4 'dots' based on the snapshot simulations. Maybe show both the actual dots and the lines? Maybe for both the data and the simulations present-day or pre-industrial reference values can be depicted to clarify for the reader if temperatures were above or below present-day.

Figure 6:
The colour coding and the applied normalization procedure nicely show high and low temperatures and insolation values. However, it appears that the normalization has also caused in a number of occasions the sign to change. For instance, DJF 130ka insolation at high southern latitudes appears positive in Figure 6 but negative in Figure 1. I do not think that a normalization procedure should make values change sign. Another somewhat strange feature is the monotonic southward increase in JJA insolation for 130ka depicted in Figure 6 which is rather different from Figure 1 showing an increase from 90N to the equator and then a decrease towards 90S.

Technical comments: (page.line)
Be consistent with using abbreviations throughout the text. If the LIG is introduced on 4450.2 and 4451.2 then use it in the remainder of the text. The same holds for instance for 'GHG'.

Often the word 'our' is used but perhaps it is better to use a more general formulation.

4450.10 ‘in two simulations additionally GHG forcing was’, please rephrase this sentence.

4450.14 ‘compare our modelled results’, please rephrase this sentence.

4450.16 ‘Our modelled’, please rephrase this sentence.

4450.17 ‘trend of the proxy summer temperatures’, maybe use ‘reconstructed’ summer temperatures.

4450.19 ‘computed by the simulations’, please rephrase.

4450.22 ‘follows’, maybe use ‘is in line with’.

4451.4 Not sure if the plural form should be used here. Maybe use ‘by a warm high latitude climate’.

4451.13 Please rephrase.

4453.25 LIG already mentioned.

4454.1 mentioning ‘atmospheric greenhouse gas concentrations’ and ‘CO2, CH4 and N2O’ seems a bit redundant.

4454.10 130 ka, respectively.

4454.15 ‘(from model year 495 to 1000)’ is maybe a bit too specific.

4454.15 ‘new’, maybe reword.

4454.23 Reverse order in 115-130.

4455.19 and 4455.24 and 4456.4. Perhaps it is confusing for the reader that the meaning of ‘late LIG’ is not consistent throughout the text.

Figure 4: Perhaps use Reconstructed and modelled instead of proxy and modelled in the figure caption.

References:

Bakker, P., Stone, E. J., Charbit, S., Gröger, M., Krebs-Kanzow, U., Ritz, S. P., Varma, V., Khon, S., Lunt, D. J., Mikolajewicz, U., Prange, M., Renssen, H., Schneider, B., Schulz, M., 2013. Last interglacial temperature evolution – a model inter-comparison. Clim Past 9, 605-619.

Govin, A., Braconnot, P., Capron, E., Cortijo, E., Duplessy, J. C., Jansen, E., and Labeyrie, L., Landais, A., Marti, O., Michel, E., Mosquet, E., Risebrobakken, B., Swingedouw, D., Waelbroeck, C., 2012. Persistent influence of ice sheet melting on high northern latitude climate during the early Last Interglacial. Clim Past 8, 483-507.

Lohmann, G., Pfeiffer, M., Laepple, T., Leduc, G., and Kim, J.-H.: A model–data comparison of the Holocene global sea surface temperature evolution, Clim. Past, 9, 1807-1839, doi:10.5194/cp-9-1807-2013, 2013.

Luëthi, D., Le Floch, M., Bereiter, B., Blunier, T., Barnola, J.-M., Siegenthaler, U., Raynaud, D., Jouzel, J., Fischer, H., Kawamura, K., and Stocker, T. F.: High-resolution carbon dioxide concentration record 650,000–800,000 years before present, Nature, 453, 379–382, 2008. 4451, 4454

Lunt, D. J., Abe-Ouchi, A., Bakker, P., Berger, A., Braconnot, P., Charbit, S., Fischer, N., Herold, N., Jungclaus, J. H., Khon, V. C., Krebs-Kanzow, U., Lohmann, G., Otto-Bliesner, B., Park, W., Pfeiffer, M., Prange, M., Rachmayani, R., Renssen, H., Rosenbloom, N., Schneider, B., Stone, E. J., Takahashi, K., Wei, W., and Yin, Q., 2013. A multi-model assessment of last interglacial temperatures. Clim Past 9, 699-717.

Interactive comment on Clim. Past Discuss., 9, 4449, 2013.