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Climate of the Past Discussions

Interactive comment on "Last interglacial temperature evolution – a model inter-comparison" *by* P. Bakker et al.

Anonymous Referee #2

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GENERAL COMMENTS

The study by Bakker et al. presents an assessment of the last interglacial temperature evolution as represented by a suite of climate models. The models considered include both Earth Models of Intermediate Complexity (EMICs) as well as low resolution General Circulation Models (GCMs). The models have been forced with orbital insolation, and in some cases changes in greenhouse gases, through the last interglacial period (∼130-115 ka BP). As summarized in the abstract, the model ensemble show a few common features such as a relatively warm period between 130 and 122 ka BP, with July temperatures above pre-industrial levels in the Northern Hemisphere (NH). However, in January the models only agree in the Southern Hemisphere (SH) and in the mid-latitudes of the NH.

As the consistency between the models is rather poor, the potential contribution of this study to advancing the field would be by providing a better understanding of the causes of the different transient temperature evolutions simulated. This should therefore be given due attention in a revised manuscript and form the basis of the main conclusions and summary of the paper. Similarly the seasonal, latitudinal and depth (not included) dependent response of simulated temperatures to the forcing is interesting and highly relevant for the interpretation of proxy based temperature reconstructions. Clear conclusions and a summary of this topic should be included, making its relevance clear to the proxy community.

SPECIFIC COMMENTS

1) Abstract: the abstract is quite extensive. However, details of the temperature maxima for the different periods is given too much focus and is not as valuable to the reader as the mechanisms behind the inter-model differences. These mechanisms are briefly listed (sea ice, Atlantic Meridional Overturning Circulation - AMOC, remnants of continental ice, change in monsoons), however, a clear description of their relevance is lacking. As an example, statements such as "for the Atlantic region, the Southern Ocean and the North Pacific, possible changes in the characteristics of the Atlantic meridional overturning circulation are critical" do not give much information.

2) Model simulations: the number of years used for the spin-up of the initial (equilibrium) state should be stated for all models. This is important the assess the possible influence of initial model drift.

3) Data processing: it is stated that the effect of the acceleration technique in CCSM3 and KCM on the ocean is of minor importance. However, when using this approach it is important to note that possible changes in deep ocean hydrography as well as overturning circulation will not be captured correctly. Therefore, one can only consider changes in the atmosphere and in the ocean mixed layer. Analyzing changes in AMOC, as done in this manuscript should be avoided, as it will not be consistent with the slow

orbital forcing. See also Lorenz & Lohmann (2004).

4) Evolution of the main climatic forcing..: in figures 2, 3 and 4 monthly anomalies of simulated last interglacial (LIG) temperatures relative to pre-industrial are analyzed. However, as shown by Joussaume & Braconnot (1997) the choice of calendar used by the model can significantly impact these results. In particular for the last interglacial where changes in the length of the seasons are large relative to today. Even with a fixed vernal equinox there will be biases when comparing monthly model output between a given period of the LIG and pre-industrial. The effect of this should be assessed and if large a different approach should be used in the analysis of the results (e.g. use astronomical positions). Also, make sure that all models use the same date for vernal equinox.

5) Results (page 4675): It is stated that simulated January temperatures are consistent with December insolation for the mid-latitudes, however there is no robust trend for winter temperatures at high latitudes between the models. To clarify this and to make the difference between models forced solely by insolation compared to insolation and greenhouse gases (GHG) it would be beneficial to make a separate section focusing on the impact of including transient GHG forcing (in the Discussion section). It is possible that the GHG forcing will help explain winter temperatures at high latitudes (where the insolation forcing is weak or absent). See also General Note on change in focus of the manuscript.

6) Sea-ice and LIG temperature: the observed early Arctic winter warming is interesting and should be elaborated and included in the summary and conclusions. However, additional analysis and a figure showing seasonal change in sea ice should be included. In particular, it is important to investigate the transient evolution of the sea ice thickness, to assess the impact of summer insolation.

7) The AMOC and the LIG: it is stated that the AMOC has a large impact on oceanic heat transport and the exchange of heat to the atmosphere. This is misleading, as most

of the heat transport and exchange with the atmosphere occurs in the horizontal gyre circulation of the ocean. If this heat exchange is key to the conclusions, an analysis of the gyre circulation and its contribution should be included.

The statement “it seems that changes in sea-ice cover and dynamics of the Southern Ocean play an important role in the simulated climatic changes around 121 ka BP” is speculative and should be clearly documented.

A key issue which must be discussed is the reasons behind the very different response of the AMOC in the models analyzed. E.g. why do the EMICS show large (and abrupt) changes in AMOC whereas the GCMs are stable? Why do LOVECLIM and FAMOUS show the opposite response?

8) The monsoon and the simulated LIG: it should be made clear if the anomalous pattern in the Sahel region and India is only a feature observed in models which can resolve the monsoon. If so, these should form the basis for further discussion (e.g. are these models consistent).

9) Land-Sea contrast: to facilitate a comparison of land-sea contrast requires a plot illustrating the seasonal evolution of the mean ocean and land temperatures through time.

10) Conclusions: a summary of the different specific temperature responses of the different seasons is not a significant contribution to advancing the field. Rather the conclusions should include a summary of clear conclusions of each of the main results discussed in the manuscript and the mechanisms behind. E.g. why are the models different, where do they agree, what is the impact of sea ice, AMOC, remnant ice, GHG, monsoons, land-sea contrast. These results are essential and would constitute a valuable contribution from this paper if given due attention.

11) Figure 2: the figure is very hard to read and should be separated into two separate figures - one with all the individual models (summer and winter) and one with the multi-

model mean and variability, together with the insolation anomalies. At present it is not possible to assess the multi model mean and its variability, and the chosen temperature range does not give a clear separation of the different models presented in the limit space.

the different integration lengths of the model will impact the multi-model mean and variability. Therefore, this analysis should only be done for the period where all models overlap in time (126-115ka).

12) Figure 3: This figure would benefit from removing the data which is not significant (high STDEV)

Figure 4: Should reduced this to JJA and DJF, not necessary to include all 6 months as this does not add essential information. In particular, as manuscript discusses JJA in general (e.g. section 4.4).

TECHNICAL COMMENTS (page.line)

4672.7: an -> a

4682.18: what is a “limit-cycle”, explain.

4683.15: the seasonal impact of remnant ice and weakening AMOC should be quite different, and should be addressed in this context.

4684.5: the anomalous pattern is not confined to the Sahel. Please specify more clearly.

4697.fig.2: According -> corresponding.

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