

Clim. Past Discuss., referee comment RC1
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Comment on cp-2021-70

Pepijn Bakker (Referee)

Referee comment on "An energy budget approach to understand the Arctic warming during the Last Interglacial" by Marie Sicard et al., *Clim. Past Discuss.*,
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Review of manuscript by Sicard et al. entitled "An energy budget approach to understand the Arctic warming during the Last Interglacial"

The manuscript present a thorough analysis of the changes in the Arctic climate simulated for the LIG. By doing so they manage to pinpoint the causes of the changes. The manuscript is well written and the authors have managed well to ensure that it reads well despite the lengthy and technical results. In the following I will list my comments and suggestions.

Main comments:

On lines 157-158 'similar behavior' is mentioned when it comes to simulating the LIG climate with the IPSL-CM6A-LR odel or with the PMIP4 models presented by Otto-Bliesner et al. (2021). This is an important statement because it would imply that the results presented in this manuscript are more widely applicable to the PMIP4 LIG simulations. First of all, it should be made more clear in the manuscript what is meant with 'similar behavior' . Moreover, when looking at temperature and sea-ice changes for the PMIP4 ensemble in Otto-Bliesner et al. (2021), I see large differences. The magnitude of JJA and SON sea-ice anomalies varies widely and for winter (DJF) models even differ in the sign of the sea-ice anomalies. I think a short summary of the findings of Otto-Bliesner et al. (2021) related to sea-ice and the Arctic is needed in the current manuscript to put the results and analysis of the IPSL-CM6A-LR model in perspective.

Related to the comments above, I have a further comment on the role of clouds, the difficulty to model them and the 'robust' PMIP results for the LIG. A large role is determined here for the radiative effects of clouds. The role of clouds in the climate system is one of the things that are generally seen as very uncertain in models, so it seems surprising that PMIP3/4 models would show similar cloud effects for the Arctic in the LIG. How does one reconcile that? Does it imply that certain cloud feedbacks are in fact quite robust in models?

Minor comments:

As we know, the LIG is not a direct analogue for the future. Most importantly, insolation in winter was lower, quite different from ongoing and future CO₂-driven warming. However, this study suggest that it is mostly the summer and autumn seasons that determine the differences in the Arctic climate compared to PI. Does that mean that in this specific context, the LIG does provide a rather good analogue? Can such a statement be made?

It seems that in Otto-Bliesner et al. (2021), the winter sea-ice area is increasing for the IPSL-CM6A-LR model while in the current manuscript a decrease is presented. Please clarify this difference.

Lines 108-114: two phases of the lig127k experiment are mentioned, one 350 years long and another one 550 years long. What is the difference between these two? Try to explain this more clearly.

Lines 153-156: a cold bias over Greenland in the PI simulation does not need to correspond to a too small temperature increase due to the 127k forcings. The relationship between biases in the present-day climate and the response of a model to a given forcing is often far from straightforward. The authors nicely show and discuss this in the discussion section, but these lines seem to indicate otherwise. Please clarify.

Lines 226-227: The authors mention that the drift in deep ocean temperatures are not negligible, however, they are not discussed at any point later in the manuscript. Please clarify.

Line 239: Are these atmospheric surface air temperatures, SSTs? Please clarify.

Line 242: Comparing the simulated Arctic LIG warming with other PMIP3/4 models seems more relevant than global means in light of the topic of this manuscript.

Lines 253-255: Clarify if these are regional, ocean or continental averages.

Technical comments:

Line 14: radiation instead of radiations

Lines 26 and 28: too many brackets?

Line 46: another instead of an other

Line 98: check brackets

Line 119: To prevent such so-called "paleo-calendar effects"....

Line 123: cloud

Line 141: but it does not reproduce

Line 153: saptial is spatial?

Line 266: One bracket too many

Line 271: Be careful with the usage of 'near surface air', 'surface air', these things normally have different meanings. Clarify ones what you mean with it and consistently use the term thereafter.

Line 306: is advected way from the Arctic basin; or advect out of the Arctic basin

Figures 4 & 5: clarify if these results are for the PI or LIG simulations.

Figure 8: these are all temperature anomalies?