

Reply to

Editor

*Russo, E., Buzan, J., Lienert, S., Jouviet, G., Velasquez, P., Davis, B.,
Ludwig, P., Joos, F., Raible, C.C.: **High resolution LGM
climate over Europe and the Alpine region using the
regional climate model WRF***

Dear editor,

thank you very much for your latest comments on our new version of the manuscript and for the time you dedicated to its review.

Below we go point by point through your technical corrections, presented in *italic*, detailing how we dealt with your concerns reported in **Bold**.

Sincerely (on behalf of all the authors),

Emmanuele Russo

- *It is not very clear from the text that the DEF, xICE and BIOME experiments are part of the 5-member ensemble. Given the significant impact of the ice-sheet height on the European climate (as shown in Fig. S1-S4), does it make sense to include all these experiments in an ensemble? If you still want to proceed this way, I think that i) you should clearly explain your rationale in putting together experiments with different ice-sheet/vegetation forcing and ii) should also show and discuss the results of the different experiments alongside the “ensemble” in the main manuscript. It is indeed a pity to have performed all these experiments with different ice-sheet height and not discuss the broad impact it has on European climate.*

Thanks for your comment. We actually agree with the editor that in the text it still results not clear that the DEF, xICE and BIOME experiments are part of the same 5-member ensemble. In fact, we have realised that we currently talk about the ensemble only starting from the results section. Following the editor’s comment, we have now made it clear already in the methods section

that the sensitivity experiments make part of a 5-member ensemble. The rationale for putting together the experiments with different boundary data and forcing into an ensemble is that we want to use them to quantitatively evaluate model results against the pollen-based reconstructions. In this context, we use the different sensitivity experiments to provide a measure of model uncertainty (here referred to as simply the range of possible model outputs obtained using the same model, but applying changes in its boundary conditions and forcing) when running an RCM for this case study. For this reason, in line with the main objectives of the paper, we still find it very appropriate to include all the experiments in the same ensemble when comparing model results against reconstructions. However, following the referee's comment, we have realised that the reasons for this choice are not clearly stated in the current version of the manuscript. Consequently, we have now specified in the methods section of the paper that the different sensitivity experiments are joined together in an ensemble in order to conduct a more quantitative evaluation of WRF against the pollen-based reconstructions, taking into account different model uncertainties. Additionally, also connected to one of your following questions, we have now specified in the methods section that by model uncertainty we refer to the range of outputs obtained with the same model, but applying changes to the model chain setup (i.e. boundaries + forcing in the case of an RCM) inherent to land cover and ice height. Concerning the comment on showing and discussing the results of the different experiments alongside the ensemble, discussing in particular the impact of changes in ice sheet height on the European climate, we do not think that this represents a research question that can be really tackled given the current design of the presented experiments. In fact, in our study the ice-sheet changes are applied each time consistently both on the RCM as well as on the driving GCM. This does not really allow us to exhaustively discriminate between the role of changes in continental ice-sheet height and changes in the large-scale atmospheric circulation generated in the driving GCM. Basically, with the performed experiments we cannot really determine whether the different model responses for the experiments with different ice-sheet height are simply due to different imposed forcing in the RCM or to changes in the boundary conditions. For this reason, as already specified in one of the answers to the reviewers, in the

manuscript we have carefully specified that we use the 5-member ensemble to provide a measure of model uncertainties resulting from changes in the simulations setup relative to land cover and ice height rather than for discriminating the role of single changes in ice-sheet height. More specifically, when introducing the paper's main objective we have stated that: "taking into account the role of different large-scale and surface model error sources, we aim to assess the general performance of the model. At the same time, we quantify the possible effect of changes in the model setup on the obtained results, highlighting where results of RCMs can be considered more robust and where factors such as error in the representation of surface features could play a major role in the reconstruction of the European LGM climate". In conclusion, for the given reasons, and also considering that with the figures currently presented in the main manuscript we are able to exhaustively answer all the 3 main proposed research questions, we have finally decided to keep the figures for the single sensitivity experiments in the supplementary part of the manuscript.

- *Is there a similar WRF experiment for pre-industrial or present-day conditions that could be used to compare your LGM results with? Comparing simulated LGM anomalies with anomalies estimated by proxy records would provide more information on the LGM climatic change and the processes leading to them.*

Thanks for your suggestion. We find this point very interesting in order to possibly shed more light onto the drivers of changes in LGM climate with respect to present-day conditions. However, currently we do not have enough resources for tackling this point, since for performing such a comparison we would need to run a present-day simulation consistent with the present-day observational dataset used for calculating anomalies in the considered pollen-based reconstructions. Consequently, we could only be able to consider this point in a possible future work.

- *Please show the ice-sheet forcing for the DEF and xICE experiments either in the main manuscript or SI.*

Thanks. We have now included a figure with the difference in

topography resulting from the changes in ice-sheet height of the different xICE experiments with respect to the default simulation in the main manuscript.

- *Please move Fig. 2 to the supplementary as it does not seem to be central to the manuscript, and you do not compare your results to the ones obtained with experiments performed with present-day orbital parameters.*

Thanks for your comment. We have followed the editor’s suggestion and included previous Fig.2 in the supplementary section of the manuscript.

- *In the methods you discuss the experiment “BIOME” whereas in figure 3 you present BIOME1 and BIOME2. Please adjust the methods, so that BIOME1 and BIOME2 are accurately introduced.*

Thanks. We have now changed the subtitles of each panel of Fig. 3 following the referee’s comment.

- *Conclusions, L. 23 (tracked changes): I think you are referring here to “uncertainties related to the LGM ice-sheet height and extent as well as LGM biome distribution” and not “model uncertainties”. Please make sure this is also clear in other parts of the manuscript.*

Thanks. Following the editor’s comment, as already specified in one of our previous answers above, we have now made clear in the methods section of the main manuscript that by model uncertainty we refer to the range of outputs obtained with the same model when applying changes to the model chain setup (i.e. boundaries + forcing in the case of an RCM) inherent to land cover and ice height.

- *Figure 7: I think here you are showing “anomalies” and not “bias”.*

Thanks for pointing this out. Actually we think that the best option would simply be to call this differences between the two simulations. We have now modified the manuscript accordingly.