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Interactive Comment

Interactive comment on "Reconstructing glacier-based climates of LGM Europe and Russia – Part 2: Adataset of LGM climates derived from degree-day modelling of palaeoglaciers" *by* R. Allen et al.

R. Allen et al.

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I would like to thank the anonymous referees for their constructive comments on, and their support for the publication, of this paper. The two reviewers have highlighted different aspects of the paper for discussion and improvement, as such I will respond to their reviews separately.

Reviewer 1

The first major comment by Reviewer 1 concerns the inclusion of extra variables into the presented palaeoclimate dataset, specifically positive degree day factors (PDD).

The full details of the degree day model (DDM) are found in Allen et al. 2007a, which states that the model was parameterised using PDD measured over European glaciers during the 20th Century. The PDD values of 4.3 mm d-1 °C-1 and 6.5 mm d-1 °C-1 for snow and ice, respectively, were not adjusted in any of the published simulations; therefore, these variables cannot be incorporated into the results as suggested by the reviewer. The work presented in this paper and accompanying two sister papers (Allen et al., 2007a and b) was an initial attempt to incorporate palaeoclimate reconstructions from mountain glacial-geological evidence into model-data comparisons. As such the adopted modelling approach was designed to be easily transferable between the different modelled regions. The idea suggested by the reviewer would increase the contribution that this style of palaeoclimate reconstruction could make and we would encourage others to refine the techniques outlined in this paper.

The second major comment by Reviewer 1 raises the impact of the dating of the glacial-geological evidence on the presented results. The reliability of the dating used to constrain the INQUA database (Ehlers and Gibbard, 2004) is discussed in detail in Section 7 of the paper; where we concede that the dating ranges from very good carbon dates (e.g. Jura Mountains) to no actual dates and evidence is presumed to be LGM (e.g. the mountains of the former Yugoslavia). The issue of poor absolute dating is currently a hindrance to proxy datasets and reduces the current impact of proxy datasets in model data comparison analyses of a fixed time period such as the LGM. However, the INQUA dataset is currently the most comprehensive and complete dataset of LGM glaciers available. There is clearly scope for refinement of the outlined methodology as better dated datasets are produced.

The final major comment from reviewer 1 concerns the effect of isostacy on the results. Isostatic effects were not explicitly considered by the model. By considering only mountain glaciers it was felt that the omission of this factor would not materially affect the results.

Reviewer 2

Reviewer 2 states that s(he) finds the title misleading because the paper presents a constraint not a reconstruction of LGM palaeoclimates as the methodology is unable to create a probability distribution for climate. The methodology used was designed to create new and independent palaeoclimate reconstructions which would be applicable to model data analyses; the limitation of this approach was that it was not possible to constrain the glacier-climate model to a single optimum solution. However, as reviewer 1 highlighted Figures 3, 7, and 8 *can be checked from model output rather than the basic temperature and precipitation taken separately*. The reviewer clearly uses a very strict definition of what constitutes a palaeoclimate reconstruction, and I would contend that the results are a distribution of the most probable LGM climate reconstructions predicted by the model.

The reviewer raises a general concern about the interpretation of the results especially the conclusions of differences in the magnitude of temperature anomalies north and south of the Alps; and is correct to state that the model results it cannot establish the optimum LGM climate and *the assumption of constant percentage (precipitation) difference across all regions has little basis*. It is difficult to analyse proxy palaeoclimate datasets without a degree of assumption; e.g. pollen temperature and precipitation anomalies are derived independently and it is assumed that they combine to form a correct climate. A fixed precipitation anomaly was used to simplify the results into a format from which valid hypothesis-testing of the results could be made. We have tried to present the results in and honest and transparent manner; further explanation of the lack of climatological basis for fixed precipitation anomalies (from which the 2 °C to 5 °C variations mentioned in the abstract are derived) will be included in the revised manuscript to prevent future confusion.

Temperature lapse rates used in the model simulations ranged from 6 °C/km to 10 °C/km. The reviewer quotes work from Ellesmere Island where a temperature lapse rate of 4 °C/km was measured. One hypothesis is that surface lapse rates would have been higher than the present day during the LGM owing to a colder drier climate;

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making the range of temperature lapse rates used sensible. Furthermore, the altitude ranges of the modelled glaciers are generally small; therefore, the omission of lower lapse rates quoted by the reviewer will only have a very small influence on the overall model results.

It is highly likely that there are errors and/or omissions in the INQUA dataset. However, the impact is likely to be low because the main glaciers in each region have been captured, the missing glaciers are likely to be the smaller glaciers most likely governed by local factors which are beneath the resolution of the glacier-climate model. As stated earlier in this comment the INQUA dataset is currently the most comprehensive and complete dataset of LGM glaciers available.

The minor corrections made by both reviewers will be incorporated into the final manuscript.

References

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