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Climate of the Past Discussions

Interactive comment on "Reconstructing glacier-based climates of LGM Europe and Russia – Part 3: Comparison with GCM and pollen-based climate reconstructions" *by* R. Allen et al.

R. Allen et al.

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I would like to thank M. Sanchez-Goni and an anonymous reviewer for their thoughtful comment on and, recommendations for the improvement of, this paper.

M. Sanchez-Goni discusses in detail an alternative hypothesis for explaining the discrepancy between the proxy and GCM climate reconstructions presented in this paper which relates to climate variations in Western Europe dated to Heinrich events around the time of the global LGM. I was unaware of this idea and will include it in the revised manuscript. The comment is related to that raised by both reviewers of Allen et al, 2007b, mainly the quality and reliability of the glacial-geological evidence. At this moment in time the INQUA dataset (Ehlers and Gibbard, 2004) remains the

most reliable available dataset of glacial-geological evidence and has allowed mountain glacial-geological evidence to contribute to the field of data- model comparison analyses. However, as discussed in Allen et al., 2007b and this paper the dating of the glacial-geological evidence used to create the INQUA dataset is variable and it is certain that some of the evidence used is non LGM; therefore, creating uncertainty in the presented palaeoclimate results. Despite this we believe the presented methodology remains valid and can actively be taken forward to investigate the issues raised by M. Sanchez-Goni when more reliable and refined datasets of glacial-geological evidence become available.

The anonymous reviewer raises a number of points, which will be discussed in turn.

The value of 1.852 in Equation 1 (on page 1205) is the distance in kilometres of 1 arc of the earth8217;s surface. The GCM climates were downscaled onto grids with a 20 km resolution; therefore, the calculations were made in units of kilometres. The variations in temperature anomalies over the Ural Mountains discussed on page 1208 was included as an illustration of how despite predicting similar glacier extents variations in the reconstructed seasonality can produce very different average annual climate anomalies (in this example temperature). A full investigation into seasonality was not performed but the reviewer is correct to mention the importance of precipitation seasonality on total snow falls. The reviewer poses a series of questions about the correction factor simulations presented in Section 5 which will be answered individually.

1. The corrections seem to be applied separately

This is correct; these simulations were designed to test the conclusion in Section 4 that the majority of HadCM3 temperature anomalies were too small to sustain glaciers compatible with the glacial-geological evidence. The alternative hypothesis could be that the precipitation anomalies were not allowing sufficient accumulation. To test this, the following two hypotheses were used; first, the temperature anomaly is correct but the precipitation anomaly is allowing insufficient/excessive accumulation, or second,

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the precipitation anomaly is correct but the temperature anomaly is allowing excessive/insufficient ablation. Therefore, the correction simulations had to be run separately. As the results show the temperature corrections do not create combined anomalies that are outside the extreme values reconstructed by other methods; therefore, I would deem them plausible. In contrast the precipitation corrections (up to 6000 mm/yr) produce extreme precipitation totals; I would deem these as unlikely. The conclusion being that the most likely cause of the discrepancy between the glaciers predicted by the HadCM3 climate anomalies and the glacial-geological evidence is an under prediction of the temperature anomaly.

2. Can one imagine a way of applying both (temperature and precipitation) anomalies at a time

Quite possibly, but as outlined above this was not necessary in this work and so was not considered.

3. How much reasonable precipitation would be possible?

This question is very difficult to answer as it is dependent in what context the question is posed. For the reasons explained above determining a maximum level of precipitation was not necessary in these simulations.

4. Using this strongest possible precipitation anomaly, what would be the conclusions regarding the temperature errors?

Again this is very hard to answer. A speculative answer would be that the conclusion would be the same: the most likely cause is that the temperature anomalies are too small. The annual precipitation totals created by the correction factors are so large and would probably much bigger than any reasonable maximum (e.g. present day precipitation totals?). Therefore, using a reasonable maximum would still not allow sufficient winter accumulation to offset the summer ablation totals predicted by the temperature anomalies.

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The reviewer suggests that *proxy modelling is clearly preferable over inferring past climates from glacial-geological evidence, because the latter cannot distinguish between temperature and precipitation effects*. I would contend that the two approaches are not in direct competition with each other and therefore a preference is not required. Whilst the inferred past climates from glacial-geological evidence are not unique they can be used to guide the potential changes required in GCM (or other) outputs to create model glaciers compatible with the glacial-geological evidence. A simple comparison of the temperature records (as suggested by the reviewer) is a simpler method of determining a cold bias compared to the analysis presented in the paper. The simulations were included because they place this discrepancy into a glaciological context and demonstrate that the differences have a real effect on the glaciological predictions of the present day cryosphere.

Section 5.3 investigated the effect of the model parameterisation had on the glacier predictions made by the HadCM3 output. All the simulations presented previously had used the same model parameterisation (Allen et al., 2007a). The model runs presented in this section were designed to see if the sensitivity of the model to the key parameters was sufficient to enable the HadCM3 output to predict glaciers compatible with the glacial-geological evidence. The results showed that this was not the case hence the conclusion 8216;the model results suggest that the model parameterisation is not preventing HadCM3 climate anomalies from simulating steady-state glacier conditions over LGM glacier profiles reconstructed from glacial-geological evidence8217;.

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

References

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