Clim. Past Discuss., 8, C2555–C2558, 2012
www.clim-past-discuss.net/8/C2555/2012/

Climate of the Past Discussions

CPD
8, C2555–C2558, 2012

Interactive Comment

Interactive comment on "A new global reconstruction of temperature changes at the Last Glacial Maximum" *by* J. D. Annan and J. C. Hargreaves

T. Schneider von Deimling (Referee)

schneider@pik-potsdam.de

Received and published: 27 November 2012

General comments

In their study Annan Hargreaves estimate that the world during the maximum of the last ice age was about 4 (+-0.8) °C colder as compared to modern climate. This range is based on a set of state-of-the-art model simulations (PMIP-2) and latest data reconstructions. By multiple linear regression the authors minimize the discrepancy between observations and model results. To test the robustness of their findings Annan and Hargreaves have performed several sensitivity tests where they show that their results do not rely on specific details of their chosen statistical approach. The presented work can be considered the most up-to-date and comprehensive estimate of global LGM cooling – given their choice of reconstructed glacial cooling and given the set of glacial climate model simulations available for analyses. The performed analyses are described in a concise way and I do not see much space for methodological improvements for this solid piece of analyses. My main criticism of the work concerns the rather narrow range of the inferred uncertainties. The key issue here is the choice of paleo data and the related question of which reconstructed temperatures ranges should be considered most reliable. To my knowledge (not being a paleo data expert) there are still large and unresolved discrepancies between different proxies – e.g. seen in reconstructed temperatures from microfossils and from geochemical methods (the latter yielding systematically stronger cooling). The authors performed some insightful additional analyses by constraining the models by either ocean or land data only. The resulting difference between the two mean estimates of LGM cooling is 1.1°C, implying a bias of about a degree for the withheld data. I am not convinced that the majority of paleo data experts would agree on the statement made in the manuscript that "Biases of this magnitude seem unlikely given the comprehensive multiproxy consensus..." Given concerns that forams might underestimate sea surface cooling over vast areas of the tropical oceans, I think that the issue of discrepancy in different proxies should be stressed more in the manuscript – along with discussing implications for constraining LGM cooling. This is a critical point given the strong weight from reconstructed tropical SSTs for constraining the models – and given the abundance of foraminifer based estimates in the MARGO data. Some proxies suggest a cooling of more than 3°C in the glacial tropics. As long as the discrepancy between individual proxies remains large, a proxy constrained estimate of global LGM cooling will be conditional on the (subjective) choice of which proxy data are considered most trustful. A potential future revision of paleo proxies towards a larger tropical SST cooling (which will lower the large discrepancy between reconstructed tropical SSTs and land temperatures) will go along with a revision of climate feedback strength towards larger values. This aspect should be mentioned when discussing the rather low range of the first-order estimate for climate sensitivity of 1.2 – 2.4°C. In the current manuscript the sensitivity range is only discussed in the context of a potential asymmetry in the feedbacks between colder and warmer climates. In this regard one could also discuss a correction towards even lower climate sensitivities as latest model simulations (PMIP2, PMIP3) do not agree even on the sign of the asymmetry. I do not suggest to discuss such very low numbers in the manuscript (as these are hard to reconcile with current knowledge about the strength of individual feedbacks) but rather want to point to a possible alternative interpretation of these low sensitivities. To summarize I think the work by Annan and Hargreaves is a very welcome contribution to the question of how cold the LGM had been and their estimate of global LGM cooling can be considered the best attempt made so far of accounting for information from model simulations and data reconstructions. How close the range of 4+-0.8°C is to the "real" LGM cooling (probably) can only be evaluated when discrepancies between different proxy reconstructions will be resolved by future work. The uncertainty spread of +-0.8°C seems to me to suggest too much confidence in the paleo data available today.

Specific Comments

1) Scaling/Regression of model responses

a) Annan Hargreaves stress that dust and vegetation forcings are missing in the PMIP-2 protocol. For optimizing the consistency between model results (based on model outcomes which ignored these forcings) and proxy data (which were subject to the forcings) the authors apply a multiple regression scheme to the simulated temperature anomaly fields. It is unclear to what extent the pattern of scaled temperature anomalies differs from anomaly patterns inferred from model runs having been forced by a more complete description of glacial forcings (such as anticipated in PMIP-3). The performed sensitivity tests by Annan and Hargreaves suggest that these potential model biases are likely to not strongly affect the presented results (at least given their choice of the proxy data). Yet the above issue could be stressed in the manuscript when discussing the omission of forcings and the assumptions made for the applied regression approach.

b) The authors (implicitly) assume that the simulated temperatures from the PMIP-2 models can be considered being equilibrium values. Has this assumption been tested based on the data available? If the simulated data showed transient characteristics, the scaling is likely to yield (slightly) different cooling patterns compared to the full equilibrium response (such an effect should especially concern the inferred land-ocean cooling contrast).

Technical comments

In the abstract a range of 4.0 +- 0.8°C is given. In the remainder of the manuscript the authors instead refer to a range of 3.9 +-0.8 °C.

Interactive comment on Clim. Past Discuss., 8, 5029, 2012.

CPD

8, C2555–C2558, 2012

Interactive Comment