**Climate
of the Past
Discussions**

Interactive comment on "A model comparison study for the Antarctic region: present and past" *by* M. N. A. Maris et al.

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Dear reviewers,

Thank you for your suggestions and detailed comments. Shortly after posting this final comment we will post a new version of the manuscript for your reference. Below, a response is given to your comments and questions.

One of your common remarks was that we needed to present (better) arguments for showing detailed output of some of the models. The arguments to show the figures were that some interesting details were visible. However, not all of these details were relevant with respect to the overall performance of the models, which is the interest of our study. Therefore we have chosen another approach in the new manuscript, where

only the output of the best models is shown and discussed in some detail.

A second common comment was that it was not entirely clear how the conclusions were reached and how bias, rmsd and correlation are calculated and used exactly. We therefore added a paragraph to the Method section where the bias, rmsd and correlation are mathematically shown and a ranking scheme is explained by which the model performance is judged.

Thirdly, in the former version of the paper all data were interpolated on the GCM grids. As there is no gain from RACMO's high resolution in this case, and the models are harder to compare when on different grids, we have chosen to interpolate the data onto the RACMO grid instead in the rewritten paper. This does not affect the results significantly, as was expected, but does provide a better basis for conclusions.

Finally, the importance of regional biases has been more thoroughly treated in the revised paper.

From this point onwards the reviewers will be answered individually.

Dear Reviewer #1,

The list of questions and comments you sent was very clear, below we will answer them by number:

3. Other reviewers have commented on this as well, therefore the comment has been treated in the first, common, part of this response.

4. As noted in the first part of this response the methods of ranking have been added to the Method section of the paper. The requirements that have to be met for temperature and precipitation fields to be useful as input in an ice sheet model, are to be as realistic as possible. In this study this means that model output should be close to RACMO output for the present day and close to ice core reconstructions regarding the past.

5. Most of this comment has been responded on in the common part above. A corre-

lation coefficient figure has been incorporated in the manuscript now.

6. We had indeed conducted (erroneous) calculations on the data of Van Ommen et al. (2004). This has been corrected after his comment. In the new manuscript, sources of ice core reconstructions are more carefully treated and referenced in the Method section. The Lenaerts et al. (2012) paper has already been referenced because it was soon to be accepted, and now is accepted by GRL. A few lines and references have been added as to why the output of RACMO was chosen as a reference state. As noted in the first part of this response, the GCM output is now interpolated on the RACMO grid.

7. This has been added to the introduction.

9. The abstract has been adjusted.

11. The imprecise statements have been removed or changed. Uncertainty ranges are given in the tables as you proposed and, where appropriate, discussed in the text. The 'speckled results' from CNRM for the LGM precipitation are no longer shown nor discussed in the paper, as CNRM is one of the worst performing models for this specific variable. However, S.J. Phipps (reviewer #3) pointed out that these speckles are often observed in spectral models, depending on the scheme used for advection of moisture. CNRM-CM33 is such a model, hence the speckles in the precipitation output.

12. This has been changed.

13. The choice of figures is better justified in the revised paper, as only the 'best' models are shown. The uncertainty in the ice core reconstructions is now shown in the tables. In the text we have commented on the sign of change of the EDC and Fuji temperature reconstructions. For ECHAM53 an error was made in the table, 100 years of data were available instead of just 3 years.

14. The Pollard and DeConto paper has been replaced by a more appropriate reference. As for point 6, the Lenaerts et al. paper is now in press and some other

references have been added to justify using RACMO output as a reference. We have looked more thoroughly into the reason for the temperature bias over the two big ice shelves and there is indeed a land mask there, but this is only partly covered with ice, explaining the warm bias of the GCMs there. The 'inverse temperature bias' is no longer of importance as none of the 'good' models show such a problem, hence it is no longer within the scope of this paper. A reference has been added to support the claim that cyclonic systems, or the changes therein, are too small to be simulated correctly by the GCMs.

Dear Reviewer #2,

Your major comments, as well as your first specific point, have been mentioned by other reviewers as well, and are therefore treated in the first, common, part of this response.

The GCM output is now interpolated to the RACMO grid, which is noted in the Method section. Lapse-rate adjustments are not applied for two reasons: âĂć Lapse-rates are local, so when using the same lapse rate over the entire domain, this will introduce errors that are not in the models initially. Using spatially dependent lapse-rates would circumvent this problem, but then the question arises which lapse-rates to use and this would also introduce uncertainties that are not in the GCMs âĂć The same analysis as described in the revised paper has been conducted on GCM-data corrected for a lapse-rate of -11.6 K/km (Masson-Delmotte, Clim. Past, 2011) and the results in terms of ranking of the models remain the same. Biases, rmsd values and correlation coefficients are slightly worse, but remain close to their original values.

In the revised paper the best performing models are shown and discussed.

Ice core locations are chosen such that the climate reconstructions are representative for a larger area. The climate modelled by the GCMs should fit these reconstructions, as they represent the true climate for a certain period, within their own error margins. Those error margins are discussed in the revised paper. Accumulations reconstructions are only available for three ice cores, whereas temperature reconstructions are

easier to conduct and therefore available for five locations. This is explained in the Method section.

The importance or regional differences is explained more fully in the revised paper. Also the 'Bellingshausen Sea and Amundsen Sea region' has been replaced with 'western side of the Antarctic Peninsula', which is clearer. Furthermore, a map has been incorporated that shows the locations of the ice cores and important geographical areas.

Dear S.J. Phipps,

Some of your comments have also been made by other reviewers, and are therefore treated in the first, common, part of this response. The numbered list of questions and comments you sent was very clear, below they will be answered one by one:

1. Both ECHAM53 and HadCM3 are not removed from the analysis as an error has been made for ECHAM53 (which provided 100 years instead of just 3 years of data) and some other files could be included for HadCM3, which now also has an averaging time of 100 years.

2. The uncertainty in the results, especially ice core uncertainty, has been added to the paper in the Method section as well as in the tables where the model output is compared to ice core reconstructions.

3. The fidelity of RACMO2/ANT is more fully treated in the revised paper in the Method section.

5. The terminology has been checked and improved according to your suggestions.

Specific comments:

1. Intercomparison is indeed more appropriate; this has been changed. 2. The abstract has been revised. 3. The metrics are now mathematically shown in the Method section. 4. This is described in the Method section now. 5. Temperature and precipitation

correlation coefficients are provided in Figures 2 and 3, combined with the bias-rmsd graph. 6, 17 Lapse rate adjustment of the GCM output has not been applied because this would obscure the results (see also the response to Reviewer #2). The simulation of temperature would not be greatly affected however. We have analysed the results after a lapse rate correction, for the difference in topography between the GCMs and RACMO, of -11.6 K/km (after Masson-Delmotte, 2011), but this did not change the biases much and did hardly affect other variables. 7, 9 The choice of which model output to show in detail has been explained now. 8. The 'inverse temperature bias' is no longer discussed in the paper as the 'good' models do not show this behaviour. 10. RACMO is consistent with observations in the peninsula region, this is shown for this specific RACMO data set in J. Lenaerts et al. (2012), which is soon to be published in GRL. 11, 12 The MH model output and ice core reconstructions are not conclusive, as is mentioned in the Mid-Holocene results section, so the timing problem is not discussed anymore. 13, 14 Other, more relevant model output is shown now, so this 'compensational behaviour' is not discussed anymore. 15. This statement has been removed. 16. This has been changed. 18. This statement has been removed. 19. This has been changed. 20. Thank you for pointing this out, however, CNRM is no longer discussed, as it is not one of the best models for LGM precipitation. 21. This has been changed. 22. This is not discussed anymore. 23. This statement was indeed incorrect and has been removed. 24, 27 Due to the ranking of models and providing the method to do this in the Method section, statements like this are now much more objective. 25. The relation between model biases and the modelled changes between the past and the present are more thoroughly discussed in the revised manuscript. However, we feel that a scatterplot (Figure 1) does not add enough new information to incorporate it in the paper. 26. The potential discrepancy that is introduced is certainly not 10 K, but more in the order of 0.1-1 K, this is now discussed in the Conclusions section as well. 28. Different plotting methods and colorbars are used now, so the figures are easier to interpret. The technical corrections have been implemented.
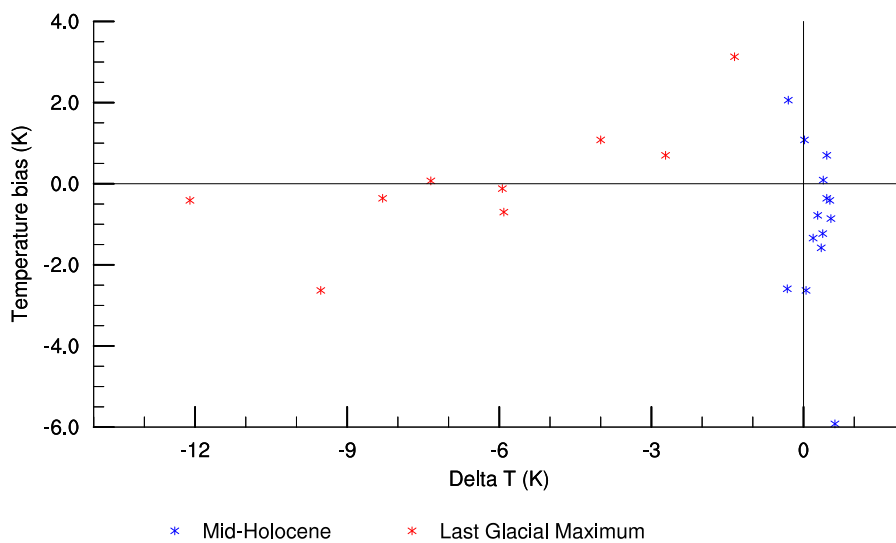
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Fig. 1. Temperature bias (difference between the mean GCM and RACMO temperatures for the present-day) versus the mean temperature difference between past and present for the MH (blue) and the LGM (red).