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Ocean Science Discussions

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Interactive Comment

Interactive comment on "The low-resolution CCSM2 revisited: new adjustments and a present-day control run" *by* M. Prange

M. Prange

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I am very grateful to Steven Griffies and the anonymous referees for their very constructive comments. Taking all their helpful suggestions into account, the manuscript has been revised thoroughly (the revised manuscript has been resubmitted). The major bones of contention were that there was no clear motivation why the reader should care about the model, the manuscript was written too technical, and referencing was not thorough enough. To eliminate these weaknesses of the manuscript, the Discussion section has been enlarged in order to "put more science" into the paper and to make clear why this model could be an interesting alternative to, e.g., CCSM3/T31 for many applications. Referencing has strongly been improved by including 45 new references.

Detailed response to Referee #3:

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Referee: "As written above, no in-depth scientific questions are raised and answered."

–> Some scientific aspects have now been included in the revised manuscript through the little model intercomparison in Section 5.3.

Referee: "I am not personally convinced to choose this modified model (CCSM2/T31x3a) with flux adjustments over CCSM3/T31 without flux adjustments just to save a maximum of about 20% computational expense. As the author concludes, however, this is a users' choice after all."

–> The 20% cost saving argument has now been removed from the abstract and the conclusions (although I kept a little remark at the end of the discussion section). Instead, a new section has been included in the discussion (Section 5.3). Here, examples are shown where CCSM2/T31x3a has a better simulation skill than CCSM3/T31 (North Atlantic hydrography, West African monsoon). It is argued that depending on the phenomenon under investigation and its geographical location, CCSM2/T31x3a may be superior to CCSM3/T31 or vice versa. This is probably a much better motivation for many readers than the 20% cost saving point. The conclusions have been modified accordingly.

Referee: "It would be useful to show the difference in bathymetry before and after the modification near the area of changes."

–> A new Figure 4 has been included in the revised manuscript to show the changes in the bathymetry.

Referee: "In Fig. 4, is it possible to display actual amount of freshwater flux adjustment used rather than just area?"

–> In the revised manuscript some additional information concerning the freshwater flux adjustment are included in the text (Section 4.1): "In this stable climatic mode, the northern high-latitude freshwater flux correction totals 0.107 Sv (averaged over the last 100 years of the integration period); 69% (i.e. 0.074 Sv) of this amount is due to river

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runoff, while 31% (i.e. 0.034 Sv) is due to precipitation over the ocean. For comparison: Actual climatological river discharge into the Arctic Ocean is about 0.1 Sv (e.g. Prange and Gerdes, 2006)."

Referee: "A realistic Atlantic MOC is achieved in CCSM2/T31x3a with a substantial weakening of AABW northward intrusion. Also the overturning cell seems to be too shallow. While these points are stated in text, it may also be useful to re-state in the conclusion as a caution for potential model users."

–> A remark has been included in the Conclusions section of the revised manuscript ("The overall goal of these model adjustments, i.e. the improvement of the AMOC, has been achieved. Even though the flow of NADW is relatively shallow and the total formation of AABW is weaker than observation-based estimates suggest, CCSM2/T31x3a appears to be a suitable tool for (paleoclimatic) studies concerning the role of AMOC variations in global climate change.").

Referee: "In Fig. 9 (top), there is a strong sinking around 40N, in addition to 60N. This seems to be seen more or less in all versions of CCSM2 and CCSM3, but most pronounced in CCSM2/T31x3a and CCSM3/T31. I do not recall that other models show this. It might be useful to state this difference with other models, and even better if the author can provide some insight."

–> A new figure (Figure 11) and a new paragraph have been included in Section 4.2.1: "A rather unusual feature of CCSM2/T31x3a's NADW overturning cell is the strong sinking around 40N in addition to the common sinking branch around 60N (cf. Stouffer et al., 2006). A quite similar pattern is produced by CCSM3/T31 (cf. Yeager et al., 2006). Showing vertical velocities at 750 m depth in the North Atlantic, Figure 11 provides some insight into the three-dimensional structure of the overturning circulation. It is clearly visible that the mid-latitude sinking branch of the AMOC is associated with a wide area of downward motion along the path of the North Atlantic Current. It is unclear why other models show this behaviour only to a lesser extent or not at all. Surface

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heat fluxes and oceanic mixing processes are likely to play a role. However, extensive sensitivity studies were required to better define and resolve this problem."

Referee: "CCSM3/T31 does not require flux adjustments while CCSM2/T31x3a appears to do. Does this mean that the atmospheric component of CCSM3/T31 is better than CCSM2/T31x3a in simulating the hydrological cycle? Does this also mean that it is better to use CCSM3/T31 if one wants to study paleoclimatic hydrological cycles? This question is probably beyond the scope of the paper, but some readers may wonder if such an interpretation is implied."

–> This is a very good question, and the answer is: It depends on the region whether CCSM3/T31 or CCSM2/T31x3a is superior in simulating precipitation. In the revised manuscript, one example is shown in the new Section 5.3: The West African monsoon. Obviously, CCSM2/T31x3a has a much better skill in simulating West African precipitation patterns than CCSM3/T31.

Referee: "p. 1308: Difference in global average values between observations (1950-1999) and 1990 present-day control is not necessarily considered as errors. The former represents rapidly changing climate while the latter represents the equilibrium solution. The difference in spatial patterns is important, but root-mean-square error may not necessarily mean "error" if it includes global-mean bias."

–> I agree. The corresponding paragraph in Section 4.2.3 has been changed accordingly (actually it has been shortened by removing the "error" numbers).

Referee: "p. 1311: In discussion, the author describes the reaming model deficiencies as "most of these shortcomings are well known as typical problems in climate models". I would like to just point out that the Atlantic MOC problem could also be "typical problems" for low-resolution ocean model. There is a risk to tune the model if the problem were due to the resolution: a risk of getting a right answer for wrong reasons."

–> Ok.

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Referee: "p. 1313-1314: The author argues that flux adjustments are used only for limited regions and thus the model behaves like a non-flux-corrected model. It is "particularly crucial when ENSO dynamics are considered". The spectral behavior of ENSO simulation is not, however, realistic in this model. In addition, the side effect of uniformly distributed freshwater fluxes in the Pacific is not investigated, and thus this statement sounds a bit speculative."

–> This statement has been removed in the revised manuscript.

Interactive comment on Ocean Sci. Discuss., 3, 1293, 2006.

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