Revisions of "The Monash Simple Climate Model Experiments (MSCM-DB v1.0): An interactive database of mean climate, climate change and scenario simulations"

Dear Editor and referee,
Thank you for evaluating this manuscript again. We are really sorry that the referee is still not happy with the manuscript. In the previous revisions we made a number of changes to the manuscript to address the referee's comments, but now we do not really see how we can further improve the manuscript in response to the referee's comment on cloud feedback or model limitations. Below we give a point-to-point response to the referee comments, that explain why we think we have already addressed the referee's comments. We hope that the referee will see that we have indeed taken his/her comments on board and that we have included them in the manuscript.

With best regards,

Dietmar Dommenget, Kerry Nice, Tobias Bayr, Dieter Kasang, Christian Stassen and Mike Rezny

Referee #1

Major Comments:
The authors still did not address my comments properly. I compared the latest revision (V7) and the last version (V6). The only paragraph added in 3b is the following:

In the above discussion on how the individual climate processes affect the climate we have to keep in mind the limitations of the GREB model and the experimental setups. The changing a single climate element is more complex in the real world than simulated in these GREB experiments. For instance, if the ocean heat capacity is turned 'OFF' it will n effective heat capacity, but the resulting changes in surface temperature gradients will also affect the atmospheric circulation patterns and subsequently the cloud cover. Such circulation and cloud cover are neglected in the GREB model, as they are given as fixed boundary conditions. Regionally such effects can be significant and CGCM simulations a effects.

Response: The referee is indicating that the only changes we introduced in the response to his/her comments on the limitations of the model and the cloud feedback is the paragraph mentioned above. However, we have made a number of changes to the original manuscript in response to the referee's comments. Below we will summarise all the changes that we have introduced from the first submission to the last revision:

"**1. Introduction**
…
… It further also does not include cloud feedbacks or adjustments in the atmospheric circulation, as both are given as boundary conditions. However, it does include the most important water vapor, black-body radiation and ice-albedo feedbacks. …"

"2. Model and experiment descriptions
…
… . Subsequently, the experiments of this database neglect any effects resulting from cloud or circulation feedbacks. These experiments should therefore only be considered as first guess estimates. In some aspects of these experiments the missing feedbacks and processes will be important. In the context of some of the results we will discuss some of these limitations.
…
b. Mean climate deconstruction
…
In the discussion of the experiments, it is important to consider that climate feedbacks are

contributing to the interactions of the climate processes. The effect of a climate process on the climate is a result of all the other active climate processes responding to the changes that the climate process under consideration introduces. It also depends on the mean background climate. Therefore, it does matter in which combination of switches the GREB model experiments are discussed. For instance, the effect of the Ice/Snow cover, is stronger in a much colder background climate, but is also affected by the feedback in other climate processes, such as the water vapour feedback. We will therefore consider different experiments or different experiment sets to shade some light into these interactions.
…
The cloud cover in the GREB model is only considered as a given boundary condition, but does not simulate the formation of clouds. Therefore, it does not include cloud feedbacks. However, the mean cloud cover does influence the radiation balance and therefore affects the mean climate and its seasonal cycle. …
…
In the above discussion on how the individual climate processes affect the climate we have to keep in mind the limitations of the GREB model and the experimental setups. The climate response to changing a single climate element is more complex in the real world than simulated in these GREB experiments. For instance, if the ocean heat capacity is turned 'OFF' it will not just have an effect on the effective heat capacity, but the resulting changes in surface temperature gradients will also affect the atmospheric circulation patterns and subsequently the cloud cover. Such effects on the atmospheric circulation and cloud cover are neglected in the GREB model, as they are given as fixed boundary conditions. Regionally such effects can be significant and CGCM simulations are required to study such effects."

"**4. Summary and discussion**
…
… . Here we need to keep in mind the limitation that the GREB model does not consider atmospheric or ocean circulation changes nor does it simulate cloud cover feedbacks. Such processes will alter this picture somewhat and need to be studied with more complex climate models, which may in particular be important for more detailed regional information of future climate change or social-economical impact studies."

In summary, we think that we made significant revisions of our manuscript to address the referee's comments. The referee seems to be indicating that he/she likes to see more discussions of literature related to circulation changes or cloud feedbacks(?) for section 3b. Section 3b is about the "Mean climate deconstruction". The references the referee is suggesting are really not directly related to these experiments. Circulation changes and cloud feedbacks are discussed in the context of CO2 forcing in the literature, but not for the experiments that we discuss here. We therefore think that our discussion at the end of this subsection does provide a good way of incorporating these problems and point the reader to the limitations of these simulations.

My original question remains the same:

The authors should include the discussion of what the readers or users of this model should or should not expect the changes in temperature in response to different forcings w circulation and aerosols) are not included in the simulations.

Response: We think that the current manuscript gives a very good discussion on what the "*readers or users of this model should or should not expect the changes in temperature in response to different forcings*". We really can't see how this could be improved or why the referee thinks that we have not provided an appropriate discussion.
Throughout the manuscript we carefully point out the limitations of the GREB model. We would like to quickly summarise what we have already included in the manuscript:

"1. Introduction

… The GREB model differs, in that it follows an energy balance approach and does not simulate the geophysical fluid dynamics of the atmosphere. It is therefore a climate model that does not include weather dynamics, … . It further also does not include cloud feedbacks or adjustments in the atmospheric circulation, as both are given as boundary conditions. …"

"2. Model and experiment descriptions

… Thus, the GREB model does not simulate the atmospheric or ocean circulation and is therefore conceptually very different from CGCM simulations.

… , but an important limitation of the GREB model is that the response to external forcings or model parameter perturbations do not involve circulation or cloud feedbacks, which are relevant in CGCM simulations [Bony et al. 2006]. Subsequently, the experiments of this database neglect any effects resulting from cloud or circulation feedbacks. These experiments should therefore only be considered as first guess estimates. In some aspects of these experiments the missing feedbacks and processes will be important. In the context of some of the results we will discuss some of these limitations."

"a. **Experiments for the mean climate deconstruction**

Hydrological cycle:

…
It needs to be noted here, that the atmospheric emissivity in the log-function parameterization of eq. [A9] can become negative, if the hydrological cycle, cloud cover and CO_2 concentration are switched OFF (set to zero). This marks an unphysical range of the GREB emissivity function and we will discuss the limitations of the GREB model in these experiments in Section 3b.

…

Model Corrections:

…

It should be noted here that the model correction terms in the GREB model have been introduced … . They are meaningful for a small perturbation in the climate system, but are less likely to be meaningful when large perturbations to the climate system are done (e.g. cloud cover set to zero)."

"3. Some results of the model simulations

…

a. GREB model performance

[the whole section]

…

b. Mean climate deconstruction

…

… However, we need to consider that the experiment with switching OFF the hydrological cycle is the only experiment in which we have a significant amount of global cooling (by about -44˚C). As a result, most of the earth is below freezing temperatures and therefore has a much stronger ice-albedo feedback than in any other experiment. This leads to a significant amplification of the response.

It is instructive to repeat the experiments with the ice-albedo feedback switched OFF …

…

… However, as mentioned in the appendix A1 the log-function approximation leads to negative emissivity if all greenhouse gasses (CO_2 and water vapour) concentrations and cloud cover are zero. The negative emissivity turns the atmospheric layer into a cooling effect, which dominates the impact of the atmosphere in this experiment (Figs. 8b, c). This is a limitation of the GREB model and the result of this experiment as such should be considered with caution.

…

…

In the above discussion on how the individual climate processes affect the climate we have to keep in mind the limitations of the GREB model and the experimental setups. The climate response to changing a single climate element is more complex in the real world than simulated in these GREB experiments. For instance, if the ocean heat capacity is turned 'OFF' it will not just have an effect on the effective heat capacity, but the resulting changes in surface temperature gradients will also affect the atmospheric circulation patterns and subsequently the cloud cover. Such effects on the atmospheric circulation and cloud cover are neglected in the GREB model, as they are given as fixed boundary conditions. Regionally such effects can be significant and CGCM simulations are required to study such effects."

"**4. Summary and discussion**

… The GREB model is a simple climate model that does not simulate internal weather variability, circulation, or cloud cover changes (feedbacks). …

…

The GREB model without flux corrections simulates the mean observed climate well and has an uncertainty of about 10˚C. The model has larger cold biases in the polar regions indicating that the meridional heat transport is not strong enough. Relative to a bare world without any climate processes the RMSE is reduced to about 20-30% relative to observed. Further, the

GREB models emissivity function reaches unphysical negative values when water vapour, CO_2 and cloud cover is set to zero. This is a limitation of the log-function parametrization, that can potentially be revised if a new parameterization is developed that considers these cases. …
…
… Here we need to keep in mind the limitation that the GREB model does not consider atmospheric or ocean circulation changes nor does it simulate cloud cover feedbacks. Such processes will alter this picture somewhat and need to be studied with more complex climate models, which may in particular be important for more detailed regional information of future climate change or social-economical impact studies.
…"

We really think that this is a quite extensive discussion of the model limitations and the reader will indeed be well informed on the limitations of these simulations. If the referee still thinks that this is not the case, we would appreciate a more specific comment on what aspect, in which subsection, we may have been misleading the reader by not pointing out the limitations of these simulations correctly. We simply can't see what has not been covered sufficiently.

There are so many literatures discussing cloud feedbacks. The last IPCC report even have a chapter for clouds (https://archive.ipcc.ch/pdf/assessmentreport/ar5/wg1/WG1AR One of the WCRP grand challenges also focuses on clouds, circulation and climate sensitivity (https://www.wcrpclimate.org/gcclouds). The authors can start from here and re to have a better discussion to address my comments.

Response: The referee asks us to discuss more on "*cloud feedbacks*". We do not understand why, in which context, or what part of the manuscript has not addressed this. We simply can't see how we would improve the presentation by discussing more on "*cloud feedbacks*" other than what we have already included in the manuscript. In what subsection would more discussion on cloud feedbacks be useful? We simply do not see that.
The references/discussion the referee is pointing out is about cloud feedbacks in the context of climate sensitivity (e.g. IPCC report and related references), thus in the context of CO2-forcing. The vast majority of the experiments that we discuss are not directly related to these experiments (e.g. section 3a, b and d). Only section 3c ("2xCO2 response deconstruction") and partly 3d are somewhat related to this. However, here we only discuss aspects of the response pattern with specific limitations (e.g. isolated ice-albedo or water vapor feedbacks). It does not address cloud feedbacks or the connection to this fairly loose.
The reference DF11, on which this current paper is based on, discusses the GREB response to CO2-forcing. In the context of DF11 a more detailed discussion of cloud feedbacks may seem appropriate, but we can't rewrite the DF11 reference in this manuscript. This would seem inappropriate to us. We therefore think we have to limit this discussion to the caveat notes that we have already made very clearly in the text.

Again, I am returning it back for another round of major revision. The authors MUST address this particular issue or I CANNOT recommend for publication. Also, the authors sh change

version of the revised manuscript showing what paragraphs are added to address my comments.

Response: We are sorry, but without more specific comments about what we have not discussed sufficiently in the text (see our responses above), we are unable to make major revision to the manuscript. The only change that we have made to the text is to include a few more references on cloud feedbacks in section 2; 3rd paragraph. We will be happy to make further revisions if we are provided more detailed guidance on what hasn't already been addressed.