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 referees,
we like to thank the referees and editor for the time spend on reviewing this manuscript and for the many very helpful comments they provided. We think the referee comments have helped us to substantially improve the presentation of this work. Below we give a point-to-point response to all referee comments, hoping the revised manuscript has now been improved in clarity and is ready for publication.

With best regards,

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

Referee #1

Major Comments:

The authors propose the Monash Simple Climate Model experiment database for understanding climate processes for controlling mean climate, as well as how model cli- mate in response to changes in CO2 or solar radiation forcings. It is an informative and interesting experiment database and I can see the value of it. Therefore, I recommend the manuscript for publication after the authors address the following comments.

Response: We like to thank the referee for the evaluation of our manuscript and the comments that will help us to improve the model. See detailed responses below.

While it is understandable to use a simple model to understand the key processes that controls the climate and their response to different forcings, there are still limitations of what this simple model can achieve compared to the fully coupled global climate models or earth system models. I think it is important to discuss in details for the mean temperature or its seasonal cycle in response to certain processes that are significantly different from observations or previous GCM studies, at least for the processes discussed in this paper. For example, the cloud feedbacks are much more complicated in the full GCMs or in the real world. There is even large uncertainty from observations.

Response: We revised the manuscript to better discuss some of these aspects. We do point out some of the limitations several times in the manuscript. However, we need to keep in mind the space limitations within this journal and can therefore not go into all details.
The cloud feedbacks are indeed important, much more complex and uncertain. We therefore think it is really beyond this paper to discuss this appropriately and have to leave it by saying that the GREB model cannot simulate these.

As the authors also pointed output, the model dynamics are not fully resolved in this energy balance model framework. The authors tried to comment on some of the drawback in the simulations because of lacking model dynamics, such as the midlatitude heat transport due to baroclinic waves. Similar issues of heat and momentum transport in the ocean are also present in this simple model configuration. Therefore, a more detailed discussion on how the mean climate or climate response would be with- out considering these dynamics in the atmosphere and ocean.

Response: We think this is related to the above comment. We revised the manuscript to better discuss some of these aspects, but again we need to point out that it is beyond this paper to give a full discussion of all these aspects.

Another issue is using the word "observed" in many places in the text and figures. Unless I am mistaken, all these "observed" fields are still model simulations. It is misleading to use the word and I suggest to use something like "control" simulations to avoid confusion.

Response: We do compare here to the observed. The surface temperature in observations and the control simulation are identical by construction, due to the flux correction terms and lag of internal variability. This is different from CGCM simulations. Therefore, when we show the observed Tsurf, it is the same as the control simulation of the GREB model. We made some changes to the figure caption of Fig. 4 to improve the clarity.

Detailed Comments:

1. Line 36, uncertainties of what?

Response: We revised the sentence.

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2. Line 38, 10 degree C of surface temperature?

Response: Yes! We included surface temperature in the text.

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3. Lines 267-273, so, there is no other topography effect in this type of simple model simulations other than the effect on emissivity or CO2 concentration?

Response: We indeed forgot to mention that the topography also affects the diffusion coefficient for the transport of heat and moisture. This is now stated in the text. It has no discernible effect on the results that we discussed in this study and therefore we forgot to mention it.
The wind field is otherwise not affected by topography as we are prescribing the wind field and changes in the wind field regarding the topography would require a GCM approach, which the GREB model does not simulate.

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4. Line 364, the eccentricity from 0.3 to 0.3?

Response: Yes! It does sound strange, but eccentricity is between 0 to 1; it has no negative values. But with earth axis tilt (earth rotating around itself) relative to the earth-sun orbit plane or relative to our monthly calendar, it does matter what orientation the orbit has. Therefore, we stated "(Earth closest to the sun in July)".

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5. Lines 429-432 and 496-499, I am not sure I understand why the strong cooling is due to the water vapour feedback. Is it because the water vapour is much less over the desert or mountain regions so that the warming effect due to water vapour is reduced.

Response: Hmm, yes and no. The response of the climate system to any external forcing or change in boundary conditions is dominated by internal positive feedbacks. The most important positive feedback is the water vapor feedback, and, yes, the much less water vapor in deserts and mountain regions will make those regions more sensitive to the water vapor feedback. Thus, the water vapor feedback is stronger here.
Our text was indeed not clear enough to explain this properly. We tried to extend the text in

this passage to better highlight this.

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6. Line 473, what is "it" that dampens the seasonal cycle.

Response: The hydrological cycle. We revised the text.

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7. Line 532, what do you mean by slow down the seasonal cycle?

Response: Slow down is indeed a bit confusing. We now say "reduce".

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8. Figure 11c, what are the red line and blue line? It's not explained in the caption.

Response: They are two different experiments, which are now mentioned in the figure caption and also listed in Table 3.

Referee #2

1) I think the major focus of this paper is more about to provide a simple GCM model output dataset for outreach purpose and less about model development and researches issue. I strongly suggest that this paper should be submitted to other journals or reports more focusing on dataset sharing or downstream applications. It also looks to me that present version of this paper is more like a report style for documenting purpose of the simple model experiments and datasets. It seems not a research article suitable for GMD.

Response: The MSCM database has some teaching aspects and may potentially also be useful for outreach. However, the focus of this work is on the research aspects of this database. We therefore think the GMD journal is the best journal for this work. From our perspective, a paper that focus on "outreach" would be very different from the study that we presented.
We tried to revise the presentation the best we could to better high-light the research value to this database. Please, see also our response to the other comments.

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2) Surface air temperature turns out to be the only climate variable in the model experiment dataset …

Response: The GREB does simulate more than just the surface temperature. It simulates four prognostic variables: surface, atmospheric and subsurface ocean temperature, and atmospheric humidity (column integrated water vapor). It further simulates a number of diagnostic variables, such as precipitation and snow/ice cover.
We now explicitly state this in the model section 2 and in the code availability section 5.

… and the model tool and interactive webpage seems more useful for other application fields such as policy making, heat-wave, and agriculture as well as social-economical impacts resulted from air temperature change under different warming scenarios (using different CO2 concentration in the simulations of this dataset). Therefore, it looks to me that the dataset is more suitable published in other more relevant journals.

Response: We think that the model experiments described here are primarily of interest to climate scientists. The three sets of experiments that we discuss (mean state, climate change and scenarios) are primarily focused on understanding the physical processes of the climate system. The focus is on how different climate processes interact to create the climate as we know it and how it would respond to external forcing.
A climate model for policy making, agriculture or social-economical impact studies would probably not focus so much on the physical climate process interactions, but more on the impact of climate. But these are not simulated in these GREB model experiments. An example for such a model would be the MAGICC climate model, which aims at fast simulations of different climate change scenarios. It does not simulate the details of the physical processes as the GREB model does.
While the GREB model maybe useful for such studies, it is not the aim of this study. We hope that the revised manuscript does make it clear that this is a study or database for the physical understanding of the climate system.

3) Abstract could be more specific in delivering the advantages and limitations of the experimental datasets. Moreover, the authors could elaborate more on their major findings from the thousand runs via using the simple model to draw the attention of readers for understanding how it can help with their studies.

Response: We changed the abstract to better guide the reader in what these model experiments are useful for. However, we have to keep in mind that the space limitations in this journal and can therefore not elaborate much about the findings of all of these experiments. The main aim of this study is to give an overview about the scientific robustness and limitations of the database, but not to discuss the results in each of these experiments.

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4) (Section 2) It seems strange that GREB actually did flux corrections to constrain the model results close to observed mean climate while the focus of the model design and dataset is put on comparing mean climate. Moreover, several parameters are input from climatological values e.g. cloud cover. Such strong constraints from climatological inputs will render the applications of the simple model for future prediction under global warming even the authors just care about air temperature.

Response: The model indeed uses flux correction in some of the experiments, but not in the ones we use to discuss the mean state climate. The referee may have overlooked this. The experiments discussed in section 3a,b do not use flux corrections. We have explicitly stated this in section 3a and now also state it again in section 3b. It is also mentioned in the figure captions.
In some experiments flux correction are useful when changes are considered small, such as the response to increased CO2 concentrations. Therefore, the response to 2xCO2 forcing and some of the scenarios use flux corrections. This assures that the response discussed are relative to the observed control climate. This is the same approach as in DF11.
The limitation of the GREB model in not simulating the atmospheric circulation nor the cloud cover formation is important, and indeed limits the results of the GREB model experiments. We have made these limitations clear in the manuscript. We hope that the revised manuscript does give a fair representation of the GREB model's skill and limitations.

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5) The lack of considering circulation and cloud feedback in the GREB model is a big concern for climate model prediction. This limitation seems render the applications of the GREB for (2) the response of the climate to a doubling of the CO2 concentration, and (3) scenarios of external CO2 concentration and solar radiation forcings as discussed in the manuscript.

Response: We agree with the referee. This is why we think the main aim of this database is a conceptual understanding and a first guess. It should not be considered as a best guess for future climate change projections. It does not replace or improve the projections of CGCM

simulations as such.
We revised the manuscript to better discuss some of these limitations and illustrate the purpose of this database. See also our reply to a similar comment about the role of the atmospheric circulation and cloud feedback from referee one.

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6) (Mean climate) Clouds and hydrological cycle turn out to be the two most important factors as shown in controlling the annual mean as shown in Figure 7. However, these two major factors are highly related to cloud and precipitation processes which are not explicitly simulated in the atmospheric layer of present model. Also, I am wondering how the GREB model deals with precipitation. I guess it is also from reanalysis model output. I think these missing processes will significantly affect the estimation of air temperature under global warming via setting different CO2 concentrations.

Response: The GREB model does simulate the hydrological cycle including precipitation. This is stated in section 2, but may have been missed by the referee. The hydrological cycle is indeed one of the most important aspects of the climate system and is therefore an important process that a climate model needs to simulate. This is why the GREB model does simulate this process. The atmospheric humidity is a prognostic variable (eq.A4) and precipitation is simulated in respect to the atmospheric humidity, see DF11.
The cloud cover is also simulated in terms of its impact on short and long wave radiation. These are the mean effects it has in the context of the mean climate. Cloud feedbacks, that is, changes in response to the climate, are indeed not simulated and are a limitation of the model. We tried to improve the presentation of manuscript to better reflect these limitations.

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7) More relevant references from comprehensive GCMs to backup the findings of figure 7 or discussions regarding to mean climate can increase the scientific merit of the present version as the authors did for double CO2 and scenarios simulation part. Also, the comparisons to previous literatures mentioned in the double CO2 and scenarios part could be more detailed e.g. more discussions on sources of uncertainties from the usage of the simple model versus the comprehensive GCMs.

Response: We do acknowledge the referees need for more reference from *comprehensive GCMs to backup the findings.* We therefore did add a bit more discussion of these results in respect to some previous publications in section 3b. However, we have to keep in mind the limitations within this format and the aim of the study to only introduce this database. More in-depth discuss must be left for future studies.

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8) I agree that such simple model for air temperature simulation can be useful for rough estimation purpose or primary understanding of the role of possible processes but not so applicable for the future climate projections. Similar to my concern 1), I also suggest that probably more high horizontal resolution version of the GREB experimental simulations can be more useful for other communities interest about effects associated with increase of temperature.

Response: The focus of this study is indeed on the physical process in the climate system and the understanding of their interactions on the large scale. We think that detailed future climate change projections, in particular on higher regional resolutions are not the main application of this database. This model is more for fast first guesses and conceptual understanding. We hope that the revised manuscript does make this point. In particular, we tried to improve the abstract and summary section to highlight this.