

In the responses below, the original reviewer reports are in black, while all our comments are in blue. We have also numbered all the reviewer comments and our replies for clarity. We have quoted text from the manuscript in grey italics.

Reviewer 2 Comment 1

I recommend rejecting this paper for three main reasons:

1. The purpose of this paper remains unclear
2. The robustness of the scientific results remains unclear, and there is too little information in this paper to understand the analyses carried out
3. The logic of a substantial number of sentences remains unclear

These issues are the more surprising given the scientific expertise of the large number of co-authors listed on the title page. Given the importance of the results hinted at here, I encourage a re-submission of this manuscript.

In the following, I provide examples for the three overarching issues. I trust that a detailed listing of all issues is unnecessary given the expertise of the panel of authors.

Reviewer 2 Reply 1

Thank you for taking the time to review our paper. We appreciate the thought and consideration that have gone into your review. We believe we can address these major issues and have done so in our revised manuscript.

In response to your reason 1 and after consulting with the editor, we have now re-written the manuscript to make the purpose clearer. Specifically, we have made the paper a MIP description paper, removing discussion of other non-essential ideas. Whilst we think these other ideas are worthy of attention, we agree that such attention belongs in a separate paper in order to keep the key idea of this paper (i.e. the introduction of a new systematic effort to compare reduced complexity climate models) clear.

In response to reason 2, as part of the revisions we have turned our results section into a sample results section (which are more appropriate for MIP description papers). Accordingly, we have significantly softened the language related to any conclusions to make clear that the results are preliminary only and that further research is required to make robust conclusions.

In response to reason 3, we have significantly revised the paper and hope that the logic now makes much more sense.

Reviewer 2 Comment 2

1. According to the title, this paper provides the protocol, results and initial observations of RCMIP. However, the protocol is described on only about half a page, and the results are listed on only about three pages. In fact, much of these three pages describe possible future research

rather than providing actual results. In contrast, half the paper consists of a description of individual RCMIP models. I encourage the authors to more clearly define the purpose of this paper, and to have the text more directly reflect such purpose.

Reviewer 2 Reply 2

Thank you for the suggestion. We have altered the paper to focus on the MIP description and dedicated much more space for this purpose accordingly. Whilst we feel that a discussion of the state of RCMs is important, we acknowledge that it is too much for this paper and after discussing with the editor have accordingly removed it. We plan to cover study of the participating models in separate future research.

Reviewer 2 Comment 3

2. I was unable to follow how the evaluation of RCMIP models has been carried out, and which conclusions one can draw from any such analysis. Which observational datasets were used? What is their uncertainty? Which CMIP6 models were used for the comparison? Which degree of agreement can one expect given, for example, observational uncertainty and natural variability? Which degree of agreement can one expect given the tuning of RCMIP models? How is the statistical significance of model agreement or disagreement calculated? What is actually shown in the figures for individual RCMIP models? How is the result obtained that "46 % of the difference between CMIP5 and CMIP6 is scenario dependent"? Why is there no uncertainty attached to this number? Which assumptions went into its calculation? etc. etc. etc.

Reviewer 2 Reply 3

Thank you for the comment. We agree that our evaluation section was not as clear as it should have been. Given the request for improved clarity, particularly on the MIP description, we no longer feel we have the space to provide the evaluation requested. Accordingly, we have altered our results section so that it is now a sample results section, softened the language related to all conclusions to make clear that they are only preliminary and not comprehensive and leave further evaluation for future work.

As an example of the change, the previous text read

When run with the same model, warming projections are higher in the SSPs than the RCPs

It now reads

Finally, we present initial results from running both CMIP5 and CMIP6 generation scenarios ('RCP' and 'SSP-based' scenarios respectively) with the same models. In the small selection of models which have submitted all RCP, SSP-based scenario pairs, the RCPs are 0.21\degree C (standard deviation 0.10\degree C across the models' default setups) warmer than their corresponding SSP-based scenarios.

This difference is driven by the 0.42 W m^{-2} \pm 0.26 W m^{-2} larger effective radiative forcing in the SSP-based scenarios, which itself is driven by the larger CO_2 effective radiative forcing in the SSP-based scenarios. As noted previously, these are only initial results, not a comprehensive evaluation and should be treated as such.

Reviewer 2 Comment 4

3. Just some example of unclear logic/grammar/style:

I.23: RCMs do not exchange limited resolution for computational efficiency. They have limited resolution, and are therefore computationally efficient.

Reviewer 2 Reply 4

Thank you for this comment. We agree that there are many ways to describe the trade-offs in RCM design, e.g. one could equally say, 'RCMs are designed to be computationally efficient exploratory tools and hence must have limited resolution'. We will revise the text for clarity.

Reviewer 2 Comment 5

I.32: If it was "unfeasible to perform climate assessments with ESMs", no IPCC reports would exist

Reviewer 2 Reply 5

Thank you for this comment. We agree that taken by itself, this statement would clearly be wrong. We have revised the text to make clear that it would be unfeasible to perform climate assessment of 100s of IAM scenarios with ESMs given the much longer run-times of ESMs and the tight deadlines of the IPCC assessment process.

Reviewer 2 Comment 6

I.40: What is "observationally consistent"?

Reviewer 2 Reply 6

We agree this text is unclear. We have clarified that we are talking about assessing the extent to which model output agrees with the observational record.

Reviewer 2 Comment 7

I.40: Why does only a "large range of projections" provide useful statistics? Later in the paper it is shown that the range of CMIP6 projections is larger than that of RCMIP projections. Does this imply that CMIP6 simulations provide more useful statistics?

Reviewer 2 Reply 7

Thank you for the comment, we agree that the text is unclear. We have updated the text to clarify that the probabilistic distributions derived from RCMs are designed to capture the likelihood that different warming levels are reached under a specific emissions scenario (e.g.

50% and 66%) based on the combined available evidence hence are quite different from an ensemble of multiple model outputs, which have been produced independently with no relative relationship in mind.

Reviewer 2 Comment 8

I.46: Style: "The first is a comparison with observations. These comparisons provide the most direct comparison of model response with the world around us today." What is a 'direct comparison with the world around us'? What is compared with observations? Which observations? etc.

Reviewer 2 Reply 8

We agree this was not as clear as it should have been. We have updated the text for clarity. In particular, to specify that a necessary condition for an SCM is to reproduce historical trends in at least observed global-mean temperature but ideally also ocean heat uptake and carbon content in the atmosphere, land and oceans.

Reviewer 2 Comment 9

I.82: What is "projected warming uncertainty"?

Reviewer 2 Reply 9

We agree this was not as clear as it should have been. We have updated the text to clarify that we mean 'future warming uncertainty'.

Reviewer 2 Comment 10

I.104: "This ensures consistency with CMIP6, albeit at the expense of using the latest data sources". Why is it an expense to use the latest data sources?

Reviewer 2 Reply 10

Our apologies, 'at the expense of' is colloquial english. We have rephrased to 'rather than' for clarity.

Reviewer 2 Comment 11

I.119: "Given their focus on global-mean, annual mean variables we request a range of output variables from each RCM." The logic of this sentence is not clear to me.

Reviewer 2 Reply 11

We have removed this text from the manuscript and have clarified in a new, comprehensive output specifications section.

Reviewer 2 Comment 12

I.129: 'In the climate response to radiative forcing, the models range from two-box impulse response models to...' Probably should read "In their representation of the climate response to radiative forcing."? etc.etc.

Reviewer 2 Reply 12

Thank you for the suggestion, we have updated the text.

Reviewer 2 Comment 13

The description of models in 2.3 should be harmonized (including the level of details provided) to allow the reader to quickly compare characteristics of different models.

Reviewer 2 Reply 13

Thank you for this recommendation. Given the wide scope of RCMs, we do not feel we can provide a sufficient description of all the different models within this paper and simultaneously describe the MIP. We have removed the large discussion of the different model types and will leave such a discussion for future work. We now only present a very brief overview of the models which have participated to date.

Reviewer 2 Comment 14

I do not comment in detail on section 3 as this section needs to be entirely re-written in my view.

Reviewer 2 Reply 14

We have significantly revised this section and hope that provides a much clearer representation of the results of this study.

Reviewer 2 Comment 15

I am sorry that I cannot provide a more positive review at this point. The important results hinted at here are potentially so important that they deserve a more rigorous analysis and description. All the best for revising this study.

Reviewer 2 Reply 15

Thank you for the time taken to do the review. It has been very helpful for us, in particular pointing out where we can improve our manuscript. We hope the revised manuscript better communicates the science we have undertaken, the novelty of our study and the most obvious next steps.