

## ***Interactive comment on “The Scenario Model Intercomparison Project (ScenarioMIP) for CMIP6” by Brian C. O’Neill et al.***

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We thank the reviewer for the comments on the paper. While we disagree with some of the critique, as detailed below, we nonetheless believe they have led to important clarifications of the manuscript.

Comment:

This paper describes the process for, and the selection of, policy-relevant scenarios for CMIP6. This is a major high-profile MIP that directly feeds into assessments of future climate change, such as those that will be produced by IPCC AR6. The scenarios trickle down to national assessments and hence have a relatively long lifetime and a wide reach.

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I am afraid I have some rather fundamental problems with the approach this group are taking. The COP21 Paris Agreement represents a major global policy response to the issue of climate change. It perhaps represents the biggest and most high profile impact of science on policy in history. Yet this project barely mentions it. The only account taken is in some low-priority Tier 2 experiments described on page 14.

I think this sends out a very poor message to world from the science community. It could be interpreted as a scientific disbelief in limiting warming to 1.5 or 2 degC . It says that we believe that the Paris agreement will ultimately fail and that ‘business-as-usual’ is the most likely scenario for the future. Having fought so hard to get the politicians to recognize the value of our science, we do not believe in their policy response.

I am sure that it will be a challenge for the world to hit the Paris targets, so maybe the group is being realistic in selecting some of the very high-end scenarios. However, I stress again that this sends out a very poor message. Modeling groups will invest considerable time and effort into running these scenarios and they will be a major feature of IPCC AR6. Funders will ask why there is such a disconnect between policy and the scenarios. Perhaps the timing of the Paris Agreement was not ideal for this group, but to give it such a low billing shows disdain for the political process.

I expect the authors will argue for consistency between CMIP5 and CMIP6 in adopting the RCP levels of radiative forcing. But, in terms of comparing generations of models, there are plenty of experiments that have been run across many generations of CMIPs that enable this. The argument for consistency would have to relate to some consistency within policy discussions. I do not see why a policy maker would be spending their time worrying about the difference between SSP5-8.5 and SSP3-7.0 when they will be putting all their effort into worrying about how to limit warming to 1.5/2 degC.

I am also sure the authors will argue robustly against any fundamental change of approach at this stage of the whole complex CMIP6 process as there is virtually no time to produce an alternative plan. If they do then I think the paper needs some pretty clear

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and strong arguments for going with the very high-end scenarios and also why it does not consider scenarios that would limit warming to 1.5 and 2 degC.

Response:

We disagree with the reviewer in several ways and stress again that the ScenarioMIP design includes scenarios that would limit warming to 1.5 and 2 degC. These can be used to inform climate targets introduced in Paris, as we discuss below. However, it is also very important that the scenarios cover a wide range of forcing targets because they support different types of climate research, dealing with questions related to the effectiveness of climate policy but also the consequences of inaction.

First, we don't agree that the paper communicates a message that scenarios leading to 2 C or lower are not achievable, or that such scenarios are either not considered in the design at all or given low priority (the reviewer argues both). Scenario SSP1-2.6 is anticipated to lead to about 1.6-1.7 C of warming (see figure 3; similar to the temperature outcome for RCP2.6 in CMIP5) and is a Tier 1 scenario. Scenario SSPx-y (now referred to as SSPa-b, and leading to about 1.9 W/m<sup>2</sup> in 2100) is designed explicitly to have a high probability of 2100 temperature below 1.5 C, as is already described in section 3.2.2. Thus the design includes scenarios that directly address both of the goals mentioned in the Paris Agreement. In addition, as discussed in Section 3.1.1 we do not make a judgment about the real-world feasibility of the scenarios in the design. Rather we require scenarios "to be feasible in a narrow sense: that specific scenario outcomes could be produced with an integrated assessment model."

Some of this misperception of the content of the design may be due to the text not being explicit enough about the relation of the design to the Paris agreement. We have therefore added text to section 2.2 (on ScenarioMIP objectives) on p. 3 and also to section 3.2 (the descriptions of overall design and the individual scenarios) to make this connection clearer and more prominent. In addition, we have added text to encourage research groups interested in the difference in climate outcomes between these

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two scenarios (and by extension, the 1.5 and 2 C targets) to run additional ensemble members of both (section 3.2.2, in the SSPa-b description).

Regarding the critique that the high forcing scenarios need more justification to be included, we point to the fact that the design is responsive to a wide range of objectives addressed by ScenarioMIP (see section 2.2). The 1.5 and 2 C targets agreed to in Paris are relevant but only one of several motivations for the ScenarioMIP experiments. Section 3.1.1 already indicates that the design aims to represent the range of scenarios used in the literature, which extends up to (and beyond) 8.5 W/m<sup>2</sup> by 2100. As indicated in the description for SSP5-8.5, the highest scenario is planned for use by a number of MIPs interested in investigating climate science questions that benefit from a relatively strong signal in terms of forced response (see Table 2, indicating that four other MIPs will use it). As indicated in the description for SSP3-7, the next highest scenario: "Baseline scenarios will be very important to IAV studies interested in quantifying "avoided impacts," which requires comparing impacts in a mitigation scenario with those occurring in an unmitigated baseline scenario." As the reviewer indicates, an additional motivation for running updated versions of the RCPs (including at the high end) is continuity. But that continuity is not limited to the evaluation of climate models and their outcomes. It also applies to impacts and mitigation literature based on the RCPs. Starting a new literature based only on new forcing pathways would be ineffective from the point of view of the broader research community and for assessment processes.

Further Comments

Comment:

Section 2.1 is perhaps interesting if you are into committee structures, but I do not think it is particularly relevant for the paper as a whole. It could be reduced considerably.

Response:

We believe some description of the process is important given that ScenarioMIP has

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multiple audiences rather than a single, narrowly defined scientific community. In such a case, with competing interests about which scenarios should be chosen and prioritized for the design, the legitimacy of the outcome and its acceptance across multiple audiences depends in part on transparency and inclusiveness of the process. This section describes the participation of multiple communities in the development of the design. It also indicates a number of scientific issues that were considered in producing the final outcome, addressing questions that are frequently raised about why alternative designs may not have been pursued. The section is only about a page long and does not add significantly to the length of the paper, and given the purpose it serves we do not feel reductions in its length are warranted.

Comment:

Section 2.4. Many of the scientific questions addressed here are perennial; differences between similar scenarios, pattern scaling, emergent constraints. These can be addressed using CMIP5 models and, in some cases, the 1% per year CO<sub>2</sub> experiments. What is new here? I would have liked to have seen a new set of scientific questions articulated and, moreover, a set of questions that have direct relevance to the policy landscape. This is arguably the most policy-relevant MIP but it seems to be addressing questions that are of more interest to a climate scientist like me.

Response:

The ScenarioMIP design is indeed intended to allow policy relevant questions to be addressed. The approach is to provide relevant climate model simulations to the entire climate change research community, so that they can be used to support many studies of many different policy relevant questions. The aim is not to pick a few questions to answer within ScenarioMIP itself. This facilitation of a broad range of integrated research is spelled out as the “highest priority” objective for ScenarioMIP in section 2.2: to “Facilitate integrated research leading to a better understanding not only of the physical climate system consequences of these scenarios, but also of the climate impact

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on societies, including considerations of mitigation and adaptation.” To clarify the scientific relevance of this integrated research, we have added to the start of section 2.4 a restatement of this objective as responding to its own overarching scientific question.

At the same time, the design also aims to provide climate simulations that can address specific climate science questions that are of particular relevance to scenario analysis. These are the (now additional) questions listed in section 2.4, and while they have been asked before, they remain relevant, including in the context of the new generation of ESMs (continuing analysis with CMIP5 models is also relevant). Pattern scaling has been singled out as a possible means of providing climate projection information for integrated analysis without requiring ESM simulations, but requires further development to be useful. Distinguishing closely spaced scenarios is becoming more important as policy goals become more finely differentiated. While 1% CO<sub>2</sub> experiments can be helpful, for relevance to plausible scenarios these questions need to be addressed in a multi-gas framework including aerosols and land use.

Comment:

Will SSPx-y include BECCs and geoengineering aspects?

Response:

The scenario will surely have a considerable amount of negative emissions, although the precise nature of this scenario remains to be defined. The negative emissions will mostly likely consist of a combination of reforestation and BECCS. The scenario will not include solar radiation management. We have added text to the description of this scenario in section 3.2.1 that indicates the basic features of its emissions pathway. It is now called SSPa-b (see response to first comment) and a preliminary candidate is SSP1-1.9 (updated from SSP1-2.0 in the original text based on recent progress in IAM modeling of this scenario).

Comment:

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The initial condition ensemble is targeted at the wrong scientific questions. The most pressing scientific question around signal-to-noise is the difference between a 1.5 and 2 degC warming scenario. The policy implications of the two scenarios are quite different so it would be useful to know if we can actually distinguish between the climate impacts of them.

Response:

We believe the best choice for the ensemble is the SSP3-7 scenario given its planned role in investigating the effects of land use and aerosols on regional forcing and climate change, which poses a detection problem. The scenario will be used as a point of comparison for experiments in two other MIPs (LUMIP, AerChemMIP). These effects are critical to the overall scenario matrix approach as described in section 2.4. Individual modeling groups may decide to run additional ensemble members for the 1.5 and 2 C scenarios if they are interested in the question of differentiating outcomes between those two scenarios, and we mention this in the revised manuscript in section 3.2.2.

Comment:

Section 3.3.3 on relationships to other MIP projections may be premature as these groups would not have finalized their experimental design yet.

Response:

We have added a footnote that these relationships will need to be checked against final formulations of the protocol of other MIPs.

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