

Meinshausen et al: A perspective on the next generation of Earth system model scenarios: towards representative emission pathways (REPs)

Review by Dale S. Rothman

Preface

In preparing this review, I first went back and reviewed the SPMs from IPCC AR6, the report of the IPCC Workshop on the Use of Scenarios in the Sixth Assessment Report (Masson-Delmotte et al 2023), and the report of ScenarioMIP Workshop: Pathway to Next Generation Scenarios for CMIP7 (van Vuuren et al 2023). Furthermore, I considered the proposal for Representative Emission Pathways (REPs) in the broader context of scenario use in climate change analysis. Specifically, I have adopted the position that evaluating a proposal for a set of representative scenarios needs to keep in mind their potential use for various types of analysis. This points to the importance of being able to interpolate (not extrapolate), both spatially and temporally, the information provided by the representative scenarios in order to meet the needs of these other analyses. I have sub-divided my comments into three parts: 1) Issues with Representation of the RCP-SSP-SPA Framework, 2) Choice to use Emissions Pathways, and 3) Specific Emissions Pathways Recommended.

Issues with Representation of the RCP-SSP-SPA Framework in AR6

My comments here focus on a number of statements that I feel mis-represent the RCP-SSP-SPA framework. Specifically, the statements “the so-called SSP-RCP matrix (Moss et al., 2010; van Vuuren et al., 2014) was used to explicitly present the climate and socio-economic dimensions as independent dimensions” and “Shared Policy Assumptions (SPAs) were used to vary the climate outcomes (Kriegler et al., 2014)” on p. 6 concern me. While these issues are less important to the present paper as my later issues, they do need to be recognized.

The RCPs were developed early on as a quick way to provide quantitative emission/concentration pathways as inputs to ESMs and GCMs. The nomenclature, e.g., RCP8.5, was, unfortunately a bit confusing as 8.5 referred to the associated radiative forcing estimated in the IAMs rather than either the levels of emissions/concentrations. The pathways did have underlying socio-economic and land-use assumptions as inputs into the IAMs, which needed them to produce the emission/concentration pathways, but these were not intended to be examined in any great detail.

The SSPs were subsequently developed by thinking more carefully and consistently about the underlying socio-economic aspects, e.g., population, education, economic, and technological changes. This did help to produce some key quantitative results for each SSP using, among other things economic and education models, but also some more qualitative elements¹. These were used as inputs to the IAMs, which were used to produce, among other things, new quantitative

¹ The qualitative elements were important for the SPAs as noted in the next paragraph, but also for further, usually IAV, studies that needed more details than provided by the quantitative information.

pathways of emissions, concentrations, and radiative forcing, also to be used as inputs to ESMs and (AO)GCMs. The initial SSPs excluded considerations of explicit climate policy, but later versions were developed to produce pathways with lower levels of radiative forcing. Although some studies depicted as using, e.g., SSP1-RCP1.9, did combine the socio-economic elements from an SSP with the emissions/concentrations/radiative forcing pathways from one of the original RCPs, the intention was that studies should actually use the emissions/concentrations/radiative forcing pathways produced from running the outputs of the IAM run with the assumptions from the SSP.

Finally, the SPAs were meant to reflect the fact that different climate policies made more sense in different SSPs and, therefore, make the SSPs including climate policies more internally consistent. For example, global participation did not really fit well with the story being told in SSP4. While this did lead to differences in the climate outcomes, it is inaccurate to say that this was their purpose.

Choice to use Emissions Pathways

Menhausen et al choose to focus on Representative Emission Pathways rather than pathways identified by either concentrations or levels of radiative forcing. They discuss some pros and cons of this choice already, but I would like to add a few additional comments.

On the pro side, using emission pathways would likely lead to ‘cleaner’ pathways coming out of the IAMs, which they note are “likely to be derived from IAMs”. This assumes that the IAMs are able to provide these emission pathways prior to any changes resulting from their own internal carbon cycle and climate components and resulting feedbacks. Otherwise, there could be issues of conflicting effects with the carbon cycle and climate components and resulting feedbacks in the ESMs and (AO)GCMs.

On the con side, there are several issues, two of which I note here:

- Any single REP would likely be associated with any number of concentration, warming, hazard, and impact and risks pathways. The first three of these relate to the models used to estimate concentrations, warming, and hazards. As for the impact and risk pathways, these can differ given that it is likely that there could be a many-to-one relationship between socio-economic/policy pathways and emission pathways, as the former are important considerations in estimating impacts and risk.
- The IAMs are limited in their spatial resolution, with some elements represented at national/regional level and others at grid cell level. The former becomes an issue when considering, for example, non-CO₂ GHG (including particulates) emissions and certain impacts. Some of this might be ameliorated with good downscaling of these elements

Specific Emissions Pathways Recommended

The specific REPs proposed are reasonable, but I do have a couple of concerns.

- In describing the pathways, e.g., in Table 1, the authors need to be clear in the names and the key characteristics that they are meant to be illustrative of ways that the emission pathways might come about. Specifically, the current names and descriptions of the key characteristics include explicit assumptions about socio-economic, technological, and policy elements. This is at odds with their desire that “the REPs should remain separated from the underlying socio-economic scenarios.”
- None of the pathways deal with the possibility of the use of SRM, which would present some of the same, but at the same time quite different, challenges for ESMs and (AO)GCMs as pathways with net negative emissions at some point in the future. It has been argued elsewhere that SRM is not currently part of the climate change policy debate, but this is increasingly inaccurate and likely to be even more so over the time frame over which these REPs are meant to be applied. Not including some consideration of SRM would set up the community to be in a position of doing a lot of catching up in the future, much as has been argued about the need to do a better job of dealing with CDR at this point.

A Final Comment

I enjoyed reading this paper and feel that it is an important contribution to the further development of scenarios for CMIP7 and AR7. I look forward to the final version.

References

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