Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2019-1212-RC1, 2020

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Effective radiative forcing and adjustments in CMIP6 models" *by* Christopher J. Smith et al.

Anonymous Referee #1

Received and published: 21 February 2020

General Comments:

The paper presents a comprehensive analysis of the diagnosed values of effective radiative forcing (ERF) for the CMIP6 models, and breaks down the contributions of this forcing from greenhouse gases, aerosols, and land-use. The use of ERF has continued to grow and it is now at least as widely-used, if not more so, than traditional metrics of forcing such as instantaneous forcing or stratospheric-adjusted forcing. It is an important paper for benchmarking the performance of CMIP6 models, and its findings will hopefully be used in upcoming assessment reports. That being said, there are many different findings in this paper and it would likely be more digestible if the findings were explored in more detail in separate papers. This is something of an omnibus paper. However, despite its size, the paper has important findings and only

requires minor revisions before being acceptable for publication.

Specific Comments:

The last point made by the authors in the abstract, which appears to be supported in Figure 8, namely that they see no evidence that aerosols are contributing to the spread in ECS, is striking and bears more discussing. The range and change in ECS for CMIP6 is and should be of great concern to the large numbers of individuals involved in CMIP6 and to the scientific community as a whole, since an explanation is required. I hope that a body of literature will emerge (and quickly) to develop this explanation, and to the extent that this paper can contribute to that body, it is important that the lack of correlation between present-day aerosol forcing and ECS is promulgated. Is it fair to say, then, that the mystery of CMIP6 ECS persists or, perhaps, deepens?

The paper notes that the spread in ERF between models is narrowed relative to CMIP5. This is a most welcome finding, given the poor specification of forcings in CMIP5. I recommend that the paper indicate that the result is consistent with a high-level recommendations from the Stouffer et al, 2017 paper (doi: 10.1175/BAMS-D-15-00013.1).

The narrowing of the range in aerosol forcing is particularly notable and welcome. That being said, the authors should point out in the abstract the importance of the aerosol forcing adjustments and large range in model results, especially with respect to clouds. The finding is included in the paper already and is notable in that it highlights challenges for the scientific community that studies aerosol-cloud interactions.

The limited importance of land use for forcing is surprising, and the spatial patterns there appears to be strong, with some overlap with aerosol forcing. Is there cancellation or reinforcement for these effects?

The final point made by the authors in the conclusion, which is that there is a need to constrain cloud responses to forcing since they contribute to the largest uncertainty in forcing, is well-taken but disturbing. Clouds appear to be not just a problem for

feedbacks, as is widely accepted by the community and has motivated a sustained focus on constraining cloud feedbacks, but they are a problem for forcing as well. This point should also be in the abstract and discussed in the abstract

However, the recommendation of the authors is vague and it is highly unclear to me how on how cloud responses can be constrained. Through process studies? Developing observational constraints? There are strikingly strong spatial patterns of ERF. Can some type of fingerprinting be used? The authors should indicate in the paper whether or not there even is a path forward for actually constraining these cloud responses or if the community needs to develop one before even being able to go down it to actually develop those constraints.

Minor points:

The x-axes on Figure 4 need fixing.

Figure 5 has lots of information but is confusing in there is concurrence between models in the spatial patterns of ERF but there appears to be little concurrence in some of the spatial patterns of adjustments and cloud contributions, even though when summed up, they are significant across models. This is even more the case for Figures 7 and 11, and some explanation of how this is achieved is needed for readers.

Line 386: Should be “equivalent” not “equalivent”

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