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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Anthropogenic aerosol forcing ndash; insights from multi-estimates from aerosol-climate models with reduced complexity" *by* Stephanie Fiedler et al.

Anonymous Referee #1

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This manuscript examines the radiative forcing of anthropogenic aerosols in simulations with a small set of global models following the protocol for the Radiative Forcing MIP now in progress as part of CMIP6. The RFMIP aerosol specification, on which the lead authors were also a co-authors, provides a description of the anthropogenic aerosol in purely radiative terms i.e. as those parameters that enter the radiative transfer equation, and as their differential impact to cloud droplet number. Having eliminated model differences in what the aerosols are, the authors examine here how other model differences impact the radiative forcing. This could be considered a prototype for studies that might be done with the larger collection of RFMIP results when these become available. The authors report on the inter-model spread in effective radiative forcing

(ERF) at present-day, show differences in the present-day distribution of background clouds and aerosols, and examine how the shift in the aerosol distribution between the 1970s and present day has impacted the RF from anthropogenic aerosols.

This work is potentially interesting but not yet mature enough to publish. The work lacks an explicit motivating question, in the absence of which the variety of results presented is hard to interpret coherently. Some results, especially the off-line radiation calculations and the cursory comparison of model clouds and droplet number to observations, seem especially unconnected to the rest of the material. There are important methodological errors in how ERF is computed and in how the set of simulations is conceived of. Important opportunities for deeper understanding are also missed, especially in making connections between the background state of each model and the resulting diversity of ERF from anthropogenic aerosols. It is understandable that the lead authors wish to exploit something from the experiments they have helped design. The scientific community will nonetheless benefit more from work that exploits the simulations to answer specific questions.

Structure and focus:

What question do the authors seek to address in this work? One possibility would be "to what extent is the signal from anthropogenic aerosol detectable against the background of uncertainty and natural variability?" (I understand this to be one of the motivating questions of RFMIP although progress could be made without using formal detection and attribution machinery). Another would be "how does the background meteorological and/or aerosol state affect the radiative forcing of anthropogenic aerosols?"

In the absence of a clearly-articulated motivating question it is hard to know how to interpret results. One suspects that not all the material belongs in the same manuscript. If the goal is to understand the range of values of ERF that might be expected from the same aerosol across different models then the motivation for sections 3.3, 3.4, and 3.5 is unclear. If the question is understanding how background state affects ERF

then substantially more work will be required to link the quite cursory characterization of differences across models to the spread in ERF. Neither of these questions would motivate the also-cursory comparison of models and observations.

What is the intent of showing model-observation comparisons in section 3.3, or the offline radiation calculations in section 3.4? One might infer that the authors hope to address the ability to estimate real-world ERF from historical observations but this is not explained clearly.

Methodology:

Effective radiative forcing relates long-term radiative perturbations and long-term response. It does not make sense to look at yearly averages. The protocol for CMIP and RFMIP, following doi:10.1002/2016JD025320, is for 30-year simulations âĂŤ precisely to average out model internal variability.

What motivates the use of multi-model means in 5-7, 9-10? An ensemble mean is the best estimate of the expectation value of some quantity when the samples are independent and uncorrelated, but this is unlikely to be the case in the small set of simulations here (or even in the larger collection to be collected through RFMIP).

Although the authors may well remove the comparisons to observations it is remiss to present inferences of drop number from satellites without mentioning the very many caveats around such estimates. See the careful review in doi:10.1029/2017RG000593.

Section 3.5 seems to illustrate that even a large spatial shift in aerosols has a relatively small impact on ERF. It's not clear why this bears mentioning - is there some surprise here? One might naively expect that the same aerosol burden would have roughly the same impact no matter where it was on the planet.

Smaller points:

The word "comparably" is used incorrectly in several places in the manuscript. The authors likely mean "relatively."

The introduction is so indirect as to be unclear. It would be better to start with motivating questions more specific to this study than "what is the anthropogenic aerosol forcing."

Far more detail is provided about each model than is useful. The only details that are really needed are those that might have bearing on interpreting the results presented here.

The simulations run from 2000-2010 but are treated as a statistically homogeneous set. Is this fair? It certainly deserves from comment.

In section 3,3 readers will appreciate a symbol for top-of-atmosphere shortwave cloud radiative effect that is not a capitalized version of the symbol for cloud fraction.

Do the conclusions in the last paragraph differ from the RFMIP protocol, or from community practice?

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