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Interactive
comment

Interactive comment on "AerChemMIP: Quantifying the effects of chemistry and aerosols in CMIP6" *by* William J. Collins et al.

Anonymous Referee #2

Received and published: 19 August 2016

This manuscript will serve as a key reference for those participating in AerChemMIP, a formal CMIP6 activity, which is expected to feed into the next IPCC report. The science goals of this MIP are to address the impact of aerosols and chemically-reactive gases on climate resulting from (1) historical anthropogenic emissions, (2) future policies on climate, air quality and land use, (3) climate feedbacks on natural emissions. AerChemMIP will also address uncertainties associated with anthropogenic emissions. The manuscript lays out the specific simulations needed to address these scientific goals, with a prioritization of which simulations are most critical to ensuring the success of AerChemMIP in achieving these goals.

General comments. Overall the paper is well-written, though the final two sections need some editing to help a less-initiated reader parse the jargon as it seems to assume the reader is immersed in all the details of many MIPs past and present. The tables usefully

organize the key information that a modeling center needs to decide which experiments they wish to perform.

Based on the tiered rankings in the Tables, it seems that some of the science questions listed in the abstract are higher priority than others and it would be useful to indicate that there are goals that AerChemMIP will certainly achieve, and then others that will be possible to achieve if the modeling community responds with a sufficient set of Tier 2 and 3 experiments. It's important then to provide a strong motivation for answering these questions, and the current phrasing of both questions 3 and 4 could be improved unless the authors feel these are best posed as requiring a yes/no answer? Maybe something like, 'How important are climate feedbacks occurring through changes in natural emissions relative to anthropogenic perturbations of the climate system' ? For Question 3, what aspects of uncertainty are addressed (historical?); isn't the scenario approach of CMIP/IPCC designed to span a range of uncertainty in anthropogenic emissions?

While Section 5 is devoted to discussing overlap with other MIPs, it might make it easier for readers and for modeling groups to prioritize their overall contributions to the many CMIP6 MIPs if some of this discussion could be incorporated into the Tables. For instance, it could be noted in a different color or in footnotes which simulations are identical to those requested by other MIPs. Alternatively, the authors may wish to create a new Table based on the information in Section 5 that allows readers to quickly identify simulations from this MIP that overlap with other MIPs. If a group can only perform a limited number of Tier 2 or 3 experiments, they may wish to prioritize simulations that address multiple MIPs and this would ease their task of identifying those simulations, at least for AerChemMIP.

Similarly, it'd be useful to have a table explaining which DECK experiments or simulations from other MIPs are required for participation in AerChemMIP.

Somewhere it would help to articulate the rationale for the Tier categorizations. For

instance, why is N2O lower priority than CH4 in Table 2?

Specific comments.

P2 L5-7. The definition of NTCF given here doesn't seem to align with that from IPCC AR5 WG1 Chapter 8 Box 8.2, which explicitly includes methane as a major motivation for using NTCF versus short-lived climate forcers. It's important to note that methane falls in both WMGG and NTCF categories, at least as defined in the last IPCC report. If the authors are revising this definition, it's important to explain this, particularly as several of the authors were lead authors on this recent IPCC chapter. But on P5 L40, NTCF emissions include methane.

P3 L5-7, "The knowledge base used to manage air pollution to date must be updated...". This seems reversed to me, and in any case the phrasing could be improved. Isn't it rather that air pollution policies are driving major changes in NTCFs and we need to be sure we understand the global atmospheric composition and climate impacts from implementing these policies? With the exception of methane, it's hard to imagine that climate policies are going to have a bigger effect on NTCFs than health-motivated air pollution policies. Or maybe the authors are simply trying to make point here that the CMIP6 scenarios will be more relevant for air quality planning than the CMIP5 RCPs?

P3 17-20. "Undiscovered feedback processes..." It's not clear what this means. Will AerChemMIP discover these processes?

P4 L15-16. How do we know that the climate forcing from stratospheric ozone is improved?

P5 Section 2.1. Are the historical emissions going to be the same as what was used in CMIP5?

P5 L 28-30 vs L32-33 seem like contradictory statements?

P6 L5 How do these SSP emission scenarios for air pollution compare with those used

from IIASA in the ECLIPSE project (e.g., Stohl et al., Evaluating the climate and air quality impacts of short-lived pollutants, ACP, 2015)?

P6 L12. Please elaborate on what is meant by 'mixed results'.

P6 L14. What are the statistically significant differences between? (2015 versus 2055 or between SSP3-7.0 and SSP3-7.0 with maximum feasible reductions applied?)

Section 2.3. How will artificially increasing present-day emissions help with quantifying uncertainty? Isn't there more uncertainty associated with the time-evolution of emission changes (i.e., when BC emissions versus SO2 emissions peak)? This question and approach to answering it should be elaborated on.

Section 2.4. It would help to provide more rationale for the selection of the 6 sensitivity simulations proposed. While marine biogenic aerosols are noted, only DMS (not organics) is considered. A large climate feedback is likely to be through methane from wetlands and yet that is not mentioned. What about feedbacks via N2O or halogens on stratospheric (and tropospheric) ozone? Maybe this is limited to what processes are typically included in current climate models, or some of these processes are addressed in other MIPs, but this should be stated.

P7 L12-15 Include this point in the tables so it's very clear that the more complex configuration is always encouraged for AerChemMIP as opposed to preferring minimum configuration for inter-model consistency.

P7 L35. How realistic are these requests? Is it possible to further prioritize some of the Tier 1 into lower Tiers? How many years are needed for DECK + other MIP simulations needed for entry to AerChemMIP?

P8 L13-14. But does the net impact of NOx emissions depend on how it affects nitrate?

P8 L20. Where is 'historical' defined?

P9 L8-11. Confusing. Is this assuming everyone is also participating in DAMIP? Ex-

plaining this in the tables, or with a new table, would help here.

P9 L20 explain the 7.0 next to SSP3. Will this paper be updated to reflect the ongoing discussions with ScenarioMIP? Otherwise should be sure to encourage readers to check the AerChemMIP website.

P10 L5-6. What exactly is being compared from the previous coupled model simulations with the magnitudes and patterns of ERF?

P10 L7. What are the different groups of NTCFs?

P10 L8-9. Methane isn't Tier 1 – why?

P10 L13. How is land use affecting NTCFs? Do these models have their NTCF emissions tied to specific land-use categories imposed in the model? How would this work for groups using MEGAN driven by present-day base emission capacity maps?

General question on Section 3.2.2 versus 3.3. What is the difference between ERF simulations and prescribed SSTs? Can these terms be used interchangeably?

P11 L9-11. How good is the assumption of the same climate response to ERF from any species?

Section 4 is clearly written assuming the reader has some knowledge to parse all the jargon and may benefit from re-organization. It might help to include a table translating 'Mon3d', 'Mon2d', etc. What is 'MonDay2d' – typo? It gets even worse in Section 4.1 P12 L5-6. What is COSP simulator data? Similarly, the long section 4.2 might be possible to shorten by moving information there to an appropriate table.

P12 L35-38 seems to jump from talking about quantifying natural emissions to anthropogenic. Aren't separate diagnostics needed for natural versus anthropogenic? Please clarify.

P14 L9. What are these new transport tracers? Define them in a table or a separate section to call attention to modelers that they may need to add some new development

to participate in some of the science for this MIP?

P14 L9 and L15-16 repeat requests for loss rates of methane, CO, N2O.

P15 L26-30. Why can't the DAMIP and AerChemMIP requests be the same to reduce the number of requests to modeling groups?

P16 L20 what is 1pctco2 / abrupt4co2?

Figure 1. Not sure the figure adds much beyond what is in the Table, and it's hard to read. Consider converting to a regular table.

Figure 2. This implies that the net impact of air quality controls are to lower surface temperature, but wouldn't reductions in aerosols actually warm in the near term? Is warming from aerosol reductions being offset by substantial methane controls here?