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

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We wish to thank Martine Michou for taking the time to make valuable comments on the AerChemMIP description.

1 More important remarks/questions

p.14 para 5.1 The authors indicate that there are 'considerable synergies between AerChemMIP and RFMIP'. However the experiments to diagnose transient ERFs are diffently designed, even though authors note that "the impact of different approaches ...have been estimated to be small". Given the amount of work involved in managing these CMIP6 simulations, could not the protocol for these specific simulations under 'prescribed SST experiments' be the same? A similar comment applies to paragraph 5.2 : what is the justification for asking for two different protocols in AerChemMIP and

DAMIP in some coupled model experiments with regards to species fixed at PI levels or historically evolving?

For DAMIP the overlap is between hist-piAer (AerChemMIP) and hist-aer (DAMIP). For RFMIP the overlap is between histSST-piNTCF (AerChemMIP) and piClim-histAerO3 (RFMIP). The RFMIP and DAMIP protocols will not work for interactive ozone chemistry. For historically evolving NTCF and ODS runs the chemistry will need to see historically evolving methane and N2O concentrations in order to reproduce the historical ozone evolution, whereas in DAMIP and RFMIP these are fixed to PI levels. The stratospheric temperature differences between PI and present would also mean the DAMIP setup would fail to reproduce the present day stratospheric ozone when running their hist-stratO3 experiment with interactive chemistry.

p.12 l.8 : the DynVarMIP project is mentioned here: simulations that are of interest to several MIPs are of special interest to the modelling community at large. The AerChemMIP paper should detail both the simulations and the diagnostics that are behind these simulations. I understand this is an additional burden to the authors of the article, but this would benefit to the entire community. If not done in the paper, then each individual modelling team will have this burden, which in the end will result in a much larger community burden. The same comment applies to other parts of the article when other MIPs are mentioned.

The remark in our paper was intended to encourage modellers to also contribute to other MIPs. Diagnostics should be chosen such that all requested output from linked MIPs are included.

Another issue in the data request is the vertical coordinate: in the excel files of the aerocom wiki page, it is mentioned that 3D data should be provided on model levels. In our case, our model has 91 model levels with about half of the model levels in the troposphere. What is the scientific justification to provide tropospheric aerosol

information on stratospheric levels?

Tropospheric parameters are strictly not needed for stratospheric levels, and vice versa. Output for all model levels had been chosen to limit output complications, confusion and inconsistent data. We have added a comment to those variables in AerChemMIP for which we need output of 3d data just in the troposphere. To include all tropospheric data under all conditions of mixing we define troposphere to levels up to ca 20 km altitude.

in the article a distinction is made between models without and with interactive gas-phase chemistry. It would be clearer to distinguish between four types of models (1) without interactive chemistry (2) with interactive tropospheric chemistry only (3) with interactive stratospheric chemistry only (4) with both tropospheric and stratospheric chemistry. Our model includes interactive aerosols and stratospheric chemistry with the chemistry calculated down to the mid-troposphere (560hPa). So for us, so-called NTCF simulations and Aer simulations are the same. But we will rather name our simulations xxxNTCF that are Tier1 simulations. Thank you for any comment you may have on this choice.

We will clarify whether tropospheric or stratospheric chemistry is required: "The suffix "CHEM^T" or "CHEM^S" indicates interactive tropospheric or stratospheric chemistry is the minimum needed for these experiments.". We will also add a comment on the NTCF/Aer simulations: "For models without interactive tropospheric chemistry, the tier 1 . . .NTCF and tier 2 . . .Aer simulations will be identical so only need to be run once."

the names of the experiments in the paper and in the official data request web page (https://www.earthsystemcog.org/projects/wip/CMIP6DataRequest) are not the same, and a few experiments appear in the paper and not in the data request web page or vice-versa. In our case at CNRM, we have chosen to use the data request to build as automatically possible experiment designs (names, list of variables, ...). In the case

here, what are the official experiments IDs? We need this information in the coming couple of weeks as for a number of constraints our CMIP6 simulations will start on 1 November.

The names in the paper are the correct ones. We will ensure the data request web page is updated.

a comment similar to the previous one concerns the diagnostics: p.11 l.30: it is mentioned that the diagnostics are assembled in two excel files (https://wiki.met.no/aerocom/aerchemmip/diagnostics), and that the definite request will be found in the CMIP6 Data request web page. At this stage there is no obvious link between the two lists. For instance in the CMIP6 Data request web page the data are not presented in 6 sheets as specified in the article p11 l35. A second example, is that there does not seem to be any request for 2D zonal monthly mean data in the CMIP6 Data request web page while there is the excel files of wiki.met.no. We can hope that the CMIP6 Data request web page will coincide at some point with the wiki excel files but when will that be? In the mean time, I would suggest to add as an appendix to the paper the final list of variables with all their characteristics (CMOR names, units, method of calculation if required, etc...) to which the CMIP6 data request will comply. Some MIP papers do not include this list, but others such as the OMIP or the C4MIP papers do, and in the end the entire community, both the one that puts together the MIP simulations, and then the one that will analyse the simulation outputs will benefit from that.

The updated excel tables on the AerChemMIP wiki pages were unfortunately also not up-to-date earlier in the summer. They have been updated now. We will keep the excel tables updated on the wiki page and they shall be consistent with the data request on November 1st. We prefer to not add an appendix to the paper, because the data request is still under review and in exchange with BADC.

what is the recommendation for the aerdaily data: average from 6hourly data, or in-

stantaneous data once per day, or?

We have added a note to each variable indicating the preferred time averaging method.

p.12 l.19: please detail here which specific CMIP6 variables will come out of this additional call to the radiation call. Please indicate the name, and the method of calculation (equation xx from Ghan 2012 for instance) if appropriate. Such details are presented in other CMIP6 MIP description papers, such as the OMIP paper, and in the end it ensures common grounds for these variables which were not part of CMIP5. Such details should appear at least for all non CMIP5 variables.

For the repeated aerosol-free call to the radiation code we have added the necessary variables in the data request. This was indeed an omission, thanks for the comment.

For the forcing, how are such fields as the swtoaasaer (that appears in the CMIP6 Data request) generated in the course of the simulation? The same question applies to diagnostics such as the swtoaasdust.

We agree these variables are indeed difficult to output during most of the simulations. They have therefore been removed from the standard output request. A remark was added that the ERF simulations for the different anthropogenic aerosol components, in combination with aerosol-free calls to the radiation code, will be used to derive forcing for aerosol components.

For the CMIP5 variables, there could/should be some coordination between AerChemMIP and other MIPs such as DAMIP or RFMIP to ensure that variables are not requested twice under two different names. For instance, ozone is requested as the tro3 and as the o3 CMOR variable, and it is not clear what the justification is for providing the same variable under different names.

These variables are being rationalised with the other MIPs to avoid duplication

as much as possible.

p.9 l.31: Could you explain why AerChemMIP future simulations should end in 2055 ? I admit it would have an additional cost to continue them until 2100, but it could be considered at least for a few simulations.

We will clarify this: "The largest differences between the scenarios in air quality pollutant emissions are found in the first half of the century, therefore AerChemMIP does not require future simulations beyond 2055."

p.13 l.6: 'Speciated AOT diagnostics are suggested': I could repeat here my previous comment. Thank you for listing diagnostics explicitly, describing how to obtain these diagnostics (additional calls to the radiative code, specific simulations...)

The way of computation is now detailed in the paper following recommendations from earlier AeroCom discussions on how to do this.

p.13 l.19: same comment with regards to "with additional radiation calls": thank you for listing diagnostics explicitly

Diagnostics for additional radiation calls are listed now in the paper and in the data request.

p.13 l.23: same comment as above with regards to "Fluxes for this repeated call have to be stored separately" : what are the names of fluxes?

Extra flux output variables have been added to the data request

p.13 p.24: please list explicitly the aerosol-oriented ERF experiments

The aerosol related ERF experiments comprise piClim, piClim-NTCF, piClim-Aer, piClim-BC, piClim-NOX, piClim-VOC, piClim-SO2, piClim-OC, piClim-NH3, piSSTclim-2xdust, piSSTclim-2xss, piSSTclim-2xDMS, piSSTclim-2xfire, piSST-2xNOX, piSST-2xVOC. This has been added to the paper.

p.14 para4.6 : again here, it would be very useful to have a clear list of the diagnostics concerned.

This section will include more details on the diagnostics and references to CCMI and aerocom. We have complemented the text by explaining better the most relevant diagnostics, however the full detail is contained in the CMIP6 data request and our excel tables."

2 Additional remarks/questions

abstract l.32: please indicate that a number of additional simulations, and not only specific diagnostics, are part of AerChemMIP

We already mention the extra simulations in the abstract.

p.2 l.16: please indicate a reference for the ERF here

We will move the Myhre et al. reference up here.

p.3 l.10: the contributions listed appear rather different from the ones in the abstract. Why is it so?

We will remove the numbering so it is clear this is just a description, not a list.

p.3 l.21: "Finally, additional..." : the sentence does not appear to be logical with the rest of the paragraph. A reformulation would certainly facilitate the reading.

We will rewrite this: "Finally, evaluation of the models will expose systematic biases and better constrain the role of aerosols and reactive gases on climate forcing."

p.3 l.36: "the model setups for CMIP5 and ACCMIP tended to be different". Could you give more details on these differences ?

We will clarify this: "In practice, the model setups for CMIP5 and ACCMIP tended to be different (in terms of resolution and complexity)"

p.6 l.18: I may be wrong, but I have not seen in this paper any simulation with an increase of 10%. Please include here simulation names for the sake of clarity.

We realise that the 10% perturbations would have imposed extra work on the modelling groups. We have instead added extra single species simulations in section 3.3 in order to cover the main NTCFs. These simulations are also necessary to characterise the individual ERFs fully. This will generate sufficient data to answer the question whilst limiting the computational requests. This section will now read: "The primary focus of this question is to understand the sensitivity of present-day ERF to uncertainties in estimates of the historical NTCF emissions. Indeed, while all proposed simulations rely on the usage of a central estimate, it is clear that there is a range of emission estimates (as discussed in Granier et al., 2011; Smith et al., 2011; Bond et al., 2013) that needs to be considered. While this uncertainty will clearly be region, sector and species dependent, it would be unrealistic to explore the full spectrum of variations. . For that purpose, we will make use of the perturbations (pre-industrial to present-day) simulations. This is likely to provide an upper bound on the impact of uncertainties. Results from the simulations can be directly compared to the simulations in section 3.1 and analysed for differences in radiative forcing as well as air quality and overall atmospheric composition. Inter-model differences will document their varying sensitivities to emissions."

p.6 l.24: As far as volcanic SO2 emissions are concerned, is there any work on these emissions considered in AerChemMIP ? Or at least any dataset provided ?

Volcanic emissions have no specific focus in AerChemMIP, but are one of the forcing datasets for CMIP6 (see https://pcmdi.llnl.gov/projects/input4mips/). There is also a CMIP6-Endorsed MIP that specifically looks at volcanic emissions (VolMIP).

p.8 l.41: could you precise if there is any specific spin-up period for the simulations

beginning in 1950 ?

The simulations beginning in 1950 should start from the appropriate date in the historical as specified in the paper.

p.10 para 3.2.2: the experiment concerning CH4 should be mentioned in this subsection, as it appears in Table 4

Thank you. This will be added.

p.11 l.20: the article indicates that "the data request is structured according to overarching analysis subjects": please indicate that these categories are presented later in the paper.

We will not use these labels anymore, but instead refer forward to the relevant subsections of section 4.

p.11 l.36: as of today, there is no reference to the 6 sheets listed in the article in the CMIP6 Data request web page.

The data request web page is being updated to be consistent with this paper.

p.12 l.6 : in which document can we find these tables? The tables in the CMIP6 Data request web page are different (Amon, AmonAdj, Lmon, OMon, aerannual, aerdaily, aerfixed, aerhourly, aermonthly, cfDay, cfMon, cfSites, day)

The data request web page is being updated to be consistent with this paper.

It seems to me that almost all specific AerChemMIP variables are given in Priority 1. Is there any possibility to share out these variables between the three priorities? Or at least in terms of temporal frequency or number of vertical levels?

We have already removed tier 2 and 3 variables from the official data request for simplicity. These may be added later through specific requests from AeroCom and CCMI to participating modellers. Requesting specific output for specific

experiments will make the data request for the modellers too complicated.

in tables 5 and 6, it is said "using pre-industrial climatological average SSTs": what is the time length recommended for the average?

We will clarify that these are 30 year averages for consistency with RFMIP.

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