

**Reply to reviewer comments for RC2**  
**<https://doi.org/10.5194/egusphere-2025-5669-RC2>**

Thank you for your review of the AerChemMIP2 experiment protocol. Your comments are helpful in further improving the written presentation. Our replies are in blue beneath the comments in black.

This paper presents the AerChemMIP Phase 2 simulation design for CMIP7, clearly outlining its scientific goals and experimental framework. It is exciting to see the new experimental designs in AerChemMIP2 compared to Phase 1 and the scientific opportunities they enable. The paper provides detailed and practical guidance for modeling centers and offers a clear overview for future users of the resulting multi-model dataset. I only have a few comments:

Line 249, how is the nitrate aerosol treatment expected to change in CMIP7 models? Could the authors provide more details?

In AerChemMIP, 2 models performed the piClim-NH<sub>3</sub> experiment and 11 models piClim-SO<sub>2</sub> and piClim-BC (Griffiths et al., 2025). We are aware of at least one additional model that can interactively simulated nitrate aerosols. We change the text to: „additional models with the capability of interactively simulating nitrate aerosols“

Line 277, the NMVOCs experiment is only designed for pdClim-X (table 2) but not for piClim-X (table1). The rationale for this choice is not clear and should be explained.

Thanks for spotting this. We remove NMVOCs in this line referring to both piClim-X and pdClim-X experiments. The choice for using pdClim-X experiments for NMVOCs is now explained in Section 3.1.5: „We choose here pdClim-X experiments for enabling direct comparison to observational data sets for present-day conditions.“

Line 345, the -2X experiments are designed for piClim but not for pdClim. Could the results be affected by state dependence if similar perturbations were applied under PD climatological conditions? Please consider adding a brief note discussing potential state-dependence issues here.

As you rightly point out, we have included the -2X experiments for the piClim experiment and not for pdClim. The piClim-2X experiments here give some traceability back to Phase 1. Given the non-linearity of aerosol-cloud interactions, for example, we may well expect the radiative effect of doubling aerosol emissions in an anthropogenically-perturbed present-day state to be different to that in a pre-industrial state. As much as we might have wanted to include pdClim-based doubling experiments to address state dependence, we had to strike a balance between that and the total number of experiments. However, with modelling centres setting up and running pdClim-control, there is potential for modelling centres to independently investigate such state dependence by running pdClim-2X experiments.

We've added the following to the manuscript: „The state dependence of the interactive emissions (if any) is not yet well understood. To what extent the interactive emissions change due to a simulated warmer climate state compared to the preindustrial can be addressed with the newly added *piClim-p4K* experiment, (...). Output from *piClim-p4K* can be used to isolate the response of emission changes to a temperature change and to eliminate any conflation between the biophysical and radiative effects of CO<sub>2</sub>. “

Line 392/398, “Aerosol precursors” and “O<sub>3</sub> precursors” are discussed as early in Table 1 but are not defined until this paragraph. I suggest defining these terms earlier in the paper. Also, it is somewhat confusing that NO<sub>x</sub> and VOCs are categorized only as O<sub>3</sub> precursors but not as aerosol precursors, given that they also contribute to aerosol formation. Please clarify and justify this categorization. Relatedly, how are interactions between aerosol and O<sub>3</sub> treated or separated in the AerChemMIP2 experimental design?

We now introduce *aer* in Section 3.1.1: „The experiment *piClim-aer* in AerChemMIP2 uses aerosols and aerosol precursor emissions of BC, organic carbon (OC), ammonia (NH<sub>3</sub>), and sulphur dioxide (SO<sub>2</sub>), and omits changes in anthropogenic NO<sub>x</sub> and VOC emissions. Although these latter species may act as aerosol precursors and influence oxidising capacity and secondary aerosol formation, they are omitted here to be consistent with the same experiment in

RFMIP2 (Kramer et al., 2025) and to maximise potential contributions from models with AER capabilities.”

Table 5, I suggest explicitly listing the reference experiments in the table (e.g., hist-piControl, esm-scen7-h, and esm-scen7-vllo). In addition, the reference for the –h and –vllo differs, but the same label (“Ref”) is used in the table, which may be misleading. Using distinct labels, as done in Table 8, would improve clarity. A similar issue also applies to Table 7.

Good point, we list the scenarios explicitly rather than ref in Table 5 and 7.

During the revision of the manuscript, we would also like to update the names of the scenario VLLO to VL, Figure 7 to be qualitatively rather than quantitatively to better reflect the preliminary nature of the scenario data, and clarify the nature of the illustrative scenario data in the acknowledgement.