Review of Rothenberg et al. for Atmospheric Chemistry and Physics

General Comments

In "On the representation of aerosol activation and its influence on model-derived estimates of the aerosol indirect effect", Rothenberg et al. integrated multiple droplet activation schemes into the Community Earth System Model (CESM) with a well-established, more-detailed aerosol module to quantify the influence of these parameterizations on the calculated aerosol indirect effect (AIE). The aerosol module tracks the evolution of number and mass for lognormally-distributed sulfate (three modes), black carbon, organic carbon, mixed modes, dust, and sea salt. The aerosol and droplets are coupled with radiative transfer and cloud microphysics, which are representative of stratiform clouds. The authors integrate three activation schemes as well as derivations of each scheme that employ a heuristic for more quickly calculating activation based on the dominant mode. They evaluate the predicted cloud droplet number concentration (CDNC) against in situ and satellite-based observations and demonstrate that these observations are insufficient for identifying a singular scheme as successful. Then, they comprehensively and clearly assess the AIE, in which they find a doubling of the strongest compared with the weakest result, and the parameters influencing AIE. Comparing the dependence of the change in cloud radiative effect (CRE) on other parameters and the degree of spread in the AIE in these simulations to the range of AeroCom and IPCC, the choice of activation scheme is shown to produce a similar degree of variability as previous inter-model comparisons. The model results were consistent with the idea in the literature that the CDNC in the pre-industrial run will more strongly influence the AIE than the activation scheme itself.

The authors contextualize the specific aim of this paper in an ongoing effort to quantify the AIE and uncertainty in the calculation of it. The comparison of the AIE from these three schemes as well as the heuristic for each is novel. The evaluations of model performance against measurements as well as inter-model experiments are very strong aspects of the manuscript. One limitation that the authors could more fully address is that CDNC are consistently underpredicted by MARC; although noted, the implications of this characteristic of the aerosol and activation schemes are not conveyed. Another area that could be strengthened is the introduction of and discussion about the minimum-maximum supersaturation heuristic. although the value of it as a simple scheme to introduce more variability in the activation schemes is noted, discussion about how distinct the results are for the comprehensive and heuristic Abdul-Razzak and Ghan and Morales Betancourt and Nenes schemes is lacking. I recommend this manuscript for publication in Atmospheric Chemistry and Physics with only minor changes including responses to the issues noted above and addressing the specific comments below.

Specific Comments

Line	***Comment***
p. 3, l. 27-33	The chemical constituents may need to have subscription of the numbers unless the variable names representing these compounds are being used. These also occur elsewhere (e.g., p. 5, l. 8), so please change throughout the manuscript.
p. 4, l. 28-29	Please elaborate on the minimum-maximum supersaturation approach, note the description in Appendix A4, and state the motivation for implementing it.
p. 5, l. 8-9	Please cite the default CESM inventory.

p. 5, l. 20 Please cite “maximum-random overlap hypothesis” or explain it more thoroughly.

p. 6, l. 3 Please communicate whether bias may be introduced through the regridding required of the CERES dataset.

p. 10, l. 11 Please identify the particular model result when referencing a result by its qualities (and again at p. 13, l. 14).

p. 10, l. 14 “CCN” is likely intended to be “CCN.”

p. 11, l. 16 “change PI and PD” is likely intended to be “change in PI and PD”.

p. 11, l. 28 “couplings, and therefore different” would be better as “couplings and, therefore, different”

p. 11, l. 16 “change PI and PD” is likely intended to be “change in PI and PD”.