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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Aerosol–cloud interactions studied with the chemistry-climate model EMAC" *by* D. Y. Chang et al.

Anonymous Referee #1

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This manuscript tests the sensitivity of the simulated clouds to the treatments of solutes in droplet nucleation and to the treatment of cloud macrophysics as well. While most of the presentation is clear, the sensitivity to the treatment of solutes is surprisingly large, which calls for further investigation into why.

General comments

It can be shown that if κ=B and the treatment of the Kelvin term is the same then the two treatments of the solute effect and critical supersaturation are nearly identical, so the differences in the results with STAND and HYB arise mostly to differences in the values of κ and B (and perhaps the Kelvin terms) for the two treatments. While the values of κ are provided for each component, the values of B are not.

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Interactive Discussion

Discussion Paper

More discussion in the text regarding Table 3 is needed, particularly for the limiting case of saturated conditions, when the fractions and the exponentials can be expanded into linear terms to show that the expressions are equivalent if κ=B and the treatments of the Kelvin effect are the same.

Also, the treatments Kelvin effect should be compared to determine to what extent differences in the treatment are driving differences in the global simulations. Please repeat experiments using the same treatments of κ and B and the same treatments of the Kelvin effect. This is needed to determine whether the surprisingly large sensitivity of column droplet number is due to the formulation of activation or just the parameter values.

The parameter D is never identified in Table 3 as the critical diameter for activation. Better to use the same parameter (radius or diameter) for the expressions for both treatments, and provide an expression for the critical size (which is the same for both treatments?). The current presentation sounds like ac is prescribed rather than being dependent on the dry particle size.

Also, the first line in the Table 3 key says SC is the critical saturation (sc = SC + 1) in STN and is comparable to SCk (= sck -1) in HYB. It should say SC is the critical supersaturation (sc = SC + 1) in STN and is comparable to SCk (= sck -1) in HYB.

Section 3.4. I question the value of the synthesis in this section. The manuscript has clearly demonstrated surprisingly large sensitivity of droplet nucleation to the treatment of the solute effect and perhaps also the Kelvin term. This sensitivity drives differences in LWP and other cloud variables that produce large impacts on the cloud radiative forcing. Since simulated cloud radiative forcing, a critical climate variable, also depends on choice of parameter values that also influence the cloud radiative forcing and since we have good measurements of cloud radiative forcing, any climate model contemplated for applications to coupled simulations would have its parameter values adjusted to improve the agreement with the observed cloud radiative forcing. So I think the evalu-

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ation has been carried too far. If the model with the STD treatment of nucleation had been better tuned to produce a more realistic cloud radiative forcing, the impacts of the different treatments could just have easily made the cloud radiative forcing worse. The important point is that the treatment a big difference, and the challenge is to understand why. I would like to see more effort devoted to that task.

Page 21997, lines 4-6. If find this sensitivity to solute effect difficult to accept. Please compare maximum supersaturations, compare κ and B, and compare surface tension for the different simulations. If the CCN concentrations (at a given supersaturation, not at Smax) differ greatly that can influence the maximum supersaturation and hence the AF.

Technical comments

Page 21976, line 2. Define EMAC.

Page 21977, line 8. Replace “The comprehensive” with “A comprehensive”.

Page 21977, line 10. Replace “model and project” with “modeling and projecting”.

Page 21977, line 13. Insert a minus symbol before 1.9.

Page 21977, line 19. Add “on the planetary energy balance” after “(AIE)”.

Page 21977, line 27. Insert “increase cloud liquid water content”.

Page 21978, line 5. Replace “lifetime” with “liquid water content”.

Page 21978, line 8. Should also mention concentration of the aerosol here.

Page 21978, lines 22-23. Neither Cess paper mentions aerosol, so at the very least delete the phrase “and uncertainties in the representation of aerosol–cloud- interactions”. You might want to delete the entire sentence. The problem is there has been little effort to isolate the dependence of AIE on cloud parameterization. Models that have different cloud parameterizations also have different representations of the aerosol.

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This gap could serve as the motivation for your study, so please expand on it.

Page 21979, lines 16-20. Should definitely also cite Ghan et al., 2011: Ghan, S. J., H. Abdul-Razzak, A. Nenes, Y. Ming, X. Liu, M. Ovchinnikov, B. Shipway, N. Meskhidze, J. Xu and X. Shi, 2011: Droplet nucleation: Physically-based parameterizations and comparative evaluation, J. Advances Modeling Earth Systems, 3, M10001, doi:10.1029/2011MS000074.

Page 21980, line 4. Replace “account” with “influence”.

Page 21982, line 5. Define ECHAM.

Page 21983, line 18. Unless Pringle et al. is the only comparison ever expected, replace “the” with “a”.

Page 21983, line 22. Insert “critical” before “supersaturation”.

Page 21985, line 9. You might cite Ghan et al. (2011) here too.

Page 21987, line 17. REF-simulations is mentioned here before it is defined. Perhaps better to wait until the simulations are described.

Page 21992, line 13. Replace “are” with “is”.

Page 21996, line 17. Actually, it starts with diagnosing the maximum supersaturation in the updrafts. It might be worth looking at the mean simulated maximum supersaturation. Does your implementation integrate over a pdf of updraft velocity? If not, how is the updraft velocity determined? It matters.

Page 21996, line 24. Are the AF values in-cloud values only?

Table 6. What are the units for CCN?

Interactive comment on Atmos. Chem. Phys. Discuss., 14, 21975, 2014.