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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Revisiting Twomey's approximation for peak supersaturation" *by* B. J. Shipway

Anonymous Referee #2

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General Assessment

This work presents an alternative method of computing the activation fraction of cloud condensation nuclei in an adiabatic parcel, with the goal of developing a new parameterization for atmospheric models. An improved expression to the so-called Twomey's lower bound approximation for the condensation integral is developed. Although itself it is not a substantial novel contribution, the manuscript is well written and it is of interest to the atmospheric community. Aerosol activation still lies at the center of the uncertainty in the determination of the aerosol indirect effect. The paper would be suitable for publication in ACP after some clarifications regarding the limitations of the proposed approach are introduced.

General Comment

In general the expression developed is only useful for an idealized case where kinetic limitations to droplet growth are not significant. Other parameterizations have tried to incorporate these effects which may have an impact on the formation of cloud droplets in non-idealized conditions. Thus, besides the arguable mathematical simplicity of the proposed approach it is hard to see novelty or even a substantial new contribution in this work. Even though some of these limitations are mentioned in the work the authors should be more self-critical of their own work and explicitly mention in the abstract and in the conclusions the idealized conditions for which the proposed parameterization is applicable.

Specific Comments

Page 25902, Line 15. This line is misleading. It is true that the lookup table is independent of chemical characteristics of the aerosol, however a multimodal aerosol population with N species still requires 2N +1 inputs to find the activation fraction. It must be emphasized that this statement refers only to the condensation integral.

Page 25902, Line 17.The authors should explicit mention here that the parameterization is only applicable to cases where kinetic and inertial limitations to droplet growth are negligible and when the particles are in true equilibrium with their environment prior to activation.

Page 25903, Line 25. It must be mentioned, not only in the appendix, what the underlying assumptions are: non continuum effects are neglected, and the initial size of the particles is negligible compared to the droplet size, and all particles are in true equilibrium with their environment.

Page 25904, line 11. It must be simply.

Page 25904, Line 15. It must be mentioned that this only applies to those particles in true equilibrium with their environment. The expression is not applicable for cases

where giant CCN or surface adsorption are significant.

Page 25096, line 20. The hygroscopicity parameter (kappa) is nowadays a very common way to express these relations. This should be at least mentioned.

Page 25907, line 24. Using t as a dummy variable and also as time just brings confusion. Please clarify.

Page 25909, line 6-8. "Accurate" here is quite ambiguous. Since the only way to achieve the form of Eq. 14 is by introducing assumptions that other authors do not use and that have been proven to lead to systematic biases (see for example Betancourt and Nenes, 2014 and Simpson et al. 2014), it is hard to see whether the proposed approach is indeed more accurate.

Page 25912, line 5. This is agreement by design as the same data was used to fir Eq. 16.

Page 25913, line 6. Again this is agreement by design.

Page 25914, line 15-20. It is no clear how the proposed approach could be modified in the future to account for these effects.

Page 25915, line 9. It is not clear that the proposed parameterization is much more computationally efficient than others. For example, the (Abdul-Razzak and Ghan, 2002) parameterization is simply an algebraic expression that does not require iteration.

Page 25915, line 10. The accuracy of the method is relative. The proposed approach may be better than other parameterizations only under highly idealized conditions. For other cases it is expected that parameterizations that account for lack of equilibrium and kinetic limitations would perform better.

Page 25915, line 18. As mentioned above, the authors should comment on the idealized conditions used in the development of the new parameterization.

Page 25919, line 14. The activation time is ambiguous. Does τ refer to the activation time of the smallest or the largest particle in the population?

Interactive comment on Atmos. Chem. Phys. Discuss., 14, 25901, 2014.