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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Empirical predictions of CCN from aerosol optical properties at four remote sites" *by* A. Jefferson

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Jefferson review Review of "Empirical predictions of CCN from aerosol optical properties at four remote sites" by Ann Jefferson ACPD, April 2010

This manuscript introduces a simple method of estimating CCN concentration from common aerosol optical measurements (scattering, backscatter fraction, and single scatter albedo). The method is not physically based, so it does require CCN measurements to "train" the method in different regions because the relationships found at four different sites are not universal. But it performs remarkably well, certainly better than earlier estimates based only on scattering or extinction. The authors attribute this improvement to the added information about mean particle size and composition from backscatter fraction and single scatter albedo, respectively.

1. Title and throughout manuscript: Replace "predict" with "diagnose". Prediction is normally used in the sense of anticipating the future. Please use either diagnose or estimate. 2. Abstract, second sentence, and other places (page 8997, lines 21-22). The phrase "aerosol optical properties of backscatter fraction and single scatter albedo" is awkward. Backscatter fraction and single scatter albedo are optical properties of the aerosol. The sentence makes it sound like aerosol optical are properties of backscatter fraction and single scatter albedo. I suggest instead "aerosol optical properties (backscatter fraction and single scatter albedo)" or just remove the word "of". 3. Introduction, first paragraph. To me, the value of this work is the potential to provide CCN estimates that can be used to explore relationships between CCN and clouds, to evaluate models of the aerosol lifecycle, and to test models of aerosol effects on droplet number. Estimating CCN concentration is just one step in the connection between aerosols and climate forcing. Once we have the CCN spectrum, we still have to determine the supersaturation in the cloud updrafts. We can't measure the supersaturation, but if we have CCN and droplet number estimates we can apply them to an aerosol activation model (which estimates the supersaturation and the number activated) to see if the droplet number from the activation model agrees with the number estimated from remote sensing. Please remove the Ghan et al. (1995) and Khvorostyanov and Curry (2006) references from the last sentence in this paragraph, as they have nothing to do with relating CCN to extinction. Khvorostyanov and Curry use a power law size distribution, but that has little to do with Andrea's power law relationship between CCN concentration and extinction. You should also cite an earlier study of the relationship between CCN concentration and aerosol optical properties: Ghan, S. J., and D. R. Collins, 2004: Use of in situ data to test a Raman lidar-based cloud condensation nuclei remote sensing method, J. Atmos. & Ocean. Technol., 21, 387-394. 4. Page 8997, line 21. Remove "site". 5. Page 8998, first paragraph. Doesn't GRW get dust too? 6. Page 8998, line 28, typo. 7. Equations (2) and (3). Please distinguish the slope and offset parameters with different symbols in each equation. Perhaps add subscripts for m and b. 8. Page 8998, line 20. So the method doesn't work for dust. This should

be stated somewhere. 9. Page 9000, line 4. This statement depends on the supersaturation. Please state the supersaturation range that this statement is applicable to. 10. Page 9000, line 7. Remove “a”. 11. Page 9000, lines 7-10. The second and third sentences do not support the first sentence (“There is much support from this study as well past field studies that small mode particles may have only a minimal contribution to CCN formation.”). Kohler theory, of course, states that smaller particles require higher supersaturation to activate than larger particles. Surely you can find measurements to support this. Whether the CCN concentration is controlled largely by the particles that control optical properties depends on the supersaturation. Some discussion is needed on critical supersaturation vs size. I recommend adding a figure showing critical supersaturation as a function of size for several values of hygroscopicity, to show which ranges in supersaturation we can expect CCN concentration to be controlled by particles larger than the sizes that control optics. In the end the sensitivity depends on the details of the size distribution and composition, but showing such a figure would at least provide a context for the subsequent figures. Figure 2 shows SSA vs BSF, not particle size. I know that figure 1 indicates larger BSF for smaller particles, but BSF depends on other particle properties too. At least rephrase the sentence on line 10 as SSA decreases with increasing BSF, and hence likely decreasing size. 12. Table 1. Please provide the units for the scattering coefficient. 13. Figure 3. What are the units of C/scattering coefficient? 14. Figure 5. Does this figure compare the CCN concentration at all supersaturations? It would be helpful to know if the method works better at low supersaturations, when larger (more optically active) particles control the CCN concentration. Consider showing the comparison for low and high supersaturations separately. 15. I would like to see some discussion of the practical implications of this work. Since the relationships are not physically based and your test indicates that they are not universal, the relationships must be developed for each, or at least at many, location, for a certain period of time before CCN measurements can be removed. Is this a significant advantage over operating CCN instruments full time? Perhaps the relationships can be developed for a small fraction of the sites and then applied to other

sites. Also, CCN measurements are most needed near cloud base, rather than at the surface. Could this approach be used to improve earlier attempts to retrieve CCN concentration at cloud base using vertical profiles of extinction and surface measurements of CCN concentration?

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 8995, 2010.