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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Cold and transition season cloud condensation nuclei measurements in western Colorado" *by* D. S. Ward and W. R. Cotton

Anonymous Referee #1

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The paper discusses particle measurements (CN and CCN) from a high elevation site in SW Colorado and the U. Wyoming King Air aircraft in western Colorado. The motivation is to characterize the CCN properties of the aerosol in this previously undocumented region for the purpose of providing context for studies of how aerosols affect orographic precipitation in western Colorado. A CCN closure study is done with data from the aircraft, but the relatively high uncertainty in the CCN measurements prevents satisfactory closure. Closure from the high-elevation site is not possible due to the absence of particle size distribution measurements. The interesting aspect of this paper is the regression analysis of the particle number concentrations with geopotential heights. From my perspective, it is unfortunate that the authors do not carry that

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analysis further.

Specific Comments:

1. Page 27633-27634 - I think it is important to place the issue of anthropogenic effects on precipitation in perspective. For example, Zhang et al., 2007 (Detection of human influence on twentieth-century precipitation trends, Nature, 448, doi:10.1038) estimate that anthropogenic forcing contributed significantly to observed increases in precipitation in the Northern Hemisphere mid-latitudes. That result contrasts with our aerosol particle theories that suggest that precipitation initiated via collision-coalescence should decrease with increasing pre-cloud aerosol. But this raises another issue. Is the orographic precipitation initiated through the ice phase and, if so, how are the CCN important?

2. Page 27634 - Lines 7-9 – Elaborate.

3. Page 27635, lines 9-15 – Why not indicate the power plant positions in Figure 2. Also, figure 1 needs a map; perhaps an adjacent map of Colorado indicating where this figure is positioned.

4. Page 27636, lines 2-4 – The IMPROVE filters are only sampled for 24 hours, once every three days, so why would you show the centre of the 3 days rather than just the day of the sample?

5. Figure 3 is nice, but it would also be helpful to have the same figure repeated with a linear y-axis to make the relative changes more evident.

6. Page 27640, line 7 – “used” for?

7. Figure 4 – The caption refers to the 500 mb height, whereas in the text it says the 700 mb height (page 27641, lines 10-25)?

8. Page 27640 – Simply labelling Section 2.3 as “Regression analysis” is not very informative. Rather, something like “Particle-Geopotential Height Regressions”?

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9. Section 2.4 – The particle regressions with geopotential height are interesting, but no physical interpretations are offered and I am a little disappointed that this analysis is not carried a bit further. Although not significant at the 95% level, higher CCN are associated with higher pressure, whereas the association of CN with pressure is apparently the opposite. The motivation of this paper is the potential impact of the aerosol on precipitation but of course precipitation is a major factor in the reduction of aerosol in the atmosphere as well. Are these patterns related to precipitation? E.g. the removal of CCN by precipitation might lead to the positive correlation(?) and the probability of the formation of smaller particles, measured as CN, after those larger condensational sinks are removed would increase. Are back trajectories consistent with these observed correlations?

10. Page 27644, line 20-21 – There is more than diffusion going on. Initially, when the chamber is sealed off, there will be some eddies left from the sudden stop of the rapid flow in and out of the chamber. As the eddies subside and the supersaturation profile develops, then the particles will start to grow and there will be some settling. I doubt that particle diffusion is of much consequence in the Wyoming CCNC.

11. Page 27646, lines 10-15 – Is a Poisson distribution appropriate for droplets growing and falling out in a static chamber? Is that a random process?

12. Page 27650, lines 12-14 – Does the sampling across 40-60 km truly create a bias? If wind speeds did not change with altitude, then a bias due to the CCN sampling might be a factor, but I assume that your winds varied in speed with altitude and so how do you define a bias in the sampling?

13. Page 27650, line 24 – An earlier effort at CCN closure was discussed by Liu, P.S.K., Leaitch, W.R., Banic, C.M., Li, S.-M., Ngo, D. and Megaw, W.J., 1996: Aerosol observations at Chebogue Point during the 1993 North Atlantic Regional Experiment: Relationships among cloud condensation nuclei, size distribution and chemistry, J. Geophys. Res, 101, 28971-28990.

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14. Page 27653, lines 15-20 – This was also shown with a larger dataset by Chang, R.Y.-W., P.S.K. Liu, W.R. Leaitch and J.P.D. Abbatt, 2007: Comparison Between Measured and Predicted CCN Concentrations in a Semi-Rural Environment: Focus on the Organic Aerosol Fraction, Atmos. Environ., 41, 8172-8182.

15. Page 27653, Line 1 – The following 2008 study used kappa and a Wyoming CCNC: Shantz, N.C., W.R. Leaitch, D. Toom-Sauntry, M. Mozurkewich, and L. Phinney, 2008: The effect of organic compounds on the growth rate of cloud droplets during a marine and a forest field study. Atmos. Chem. Phys., 8, 5869-5887.

16. Page 27653, Lines 16-18 – As you later discuss, the IMPROVE data suggest equal amounts of sulphate and organics, so I would also include a plot with the kappa value between that of sulphate and the organics (e.g. 0.3).

17. Page 27654, Lines 5-7 – Because the Wyoming CCNC is based on volume light scattering, the calibration is also a function of the chemical composition of the particles. If your aerosol is more hygroscopic, the droplets will grow larger and for a single calibration factor a certain concentration of CCN will be indicated. If the particles are less hygroscopic but still large enough to activate then the droplets will grow smaller and for the same number of particles relatively fewer CCN will be indicated. Thus, if your calibration was done with a pure ammonium sulphate aerosol but you were sampling an organic-sulphate mix (as suggested by the IMPROVE data) then a bias towards lower measured CCN could result (e.g Shantz et al., 2008), and that may explain why your closure is better for a kappa of 0.1 rather than 0.3. Also, are the sample volumes of the CCNC and the PCASP both referenced to the same pressure and temperature; I don't think that is discussed?

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 27631, 2010.