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Interactive Comment

Interactive comment on "Estimated variability of below-cloud aerosol removal by rainfall for observed aerosol size distributions" *by* C. Andronache

C. Andronache

andronac@bc.edu

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I would like to thank Kevin Noone for his comments and suggestions that were useful during manuscript revision. My specific answers to his concerns are described here:

1) Concerning more citations of the original references: Since many of the results related to the collision efficiency between falling raindrops and aerosol particles, as used here, were published by W. G. N. Slinn, I make more reference to his work in the revised manuscript.

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2) With regard to the raindrop terminal velocity expression: The dependence of the raindrop terminal velocity on raindrop diameter was included in the revised manuscript in the section Method.

3) Regarding the in-cloud scavenging process: The in-cloud scavenging (ICS) was illustrated in this paper only to contrast with the below-cloud scavenging (BCS) and I used an example based on Scott (1982) model. Many specific details of the ICS processes would require a lengthy treatment and are not included in this paper. Comparisons between Scott's model and other results (from observations) show that the model is appropriate for ICS treatment of soluble aerosols and such results compare well with other published data. There is significant spread of values from observations due in part to variability in collision efficiency and precipitation type. In the revised manuscript I included two more recent evaluations of the ICS coefficient estimations from Okita et al (1996) and Jylha (1991). Choice of other typical ICS coefficients values do not change the observation made in paper that BCS is generally less intense than ICS.

4) Concerning the variability of BCS coefficients with raindrop size distributions: In the revised paper I included a discussion on BCS coefficient dependence on raindrop size distribution. Calculations presented in this paper are based on the Marshall and Palmer (MP) raindrop size distribution (which for the following discussion is called the standard distribution). The MP raindrop size distribution describes well the population of raindrops under a wide range of rainfall rates and rain types, provided that sufficient averaging on measured data is performed. The MP size distribution tends to overestimate the number of very small raindrops ($D_p < 0.1$ mm) but the contribution of these drops to the total rainfall rate R is generally small. To capture the role of very small raindrops, it is more appropriate to use a raindrop size distribution approximated by a gamma function (Ulbrich, 1983). Also, for the description of raindrop size distribution

from measurements taken with a frequency of 1 min or less, a gamma function is a better approximation. For the problem treated here, the average raindrop size distribution is a good approximation and this is generally well described by the standard MP fit. To address the sensitivity of the BCS scavenging coefficient to assumed raindrop size distribution, I included calculations for several MP type distributions from observations. Figure 3a shows several MP size distributions compared with the standard MP fit. We note that the drizzle case has more small raindrops per unit volume, while the thunderstorm cases tend to have smaller number of larger raindrops per unit volume. The dependence of the scavenging coefficient on raindrop size distribution is illustrated in Fig 3b for the cases presented in Fig 3a (for $R = 1$ mm hr^{-1}). Calculations for other rainfall rates show similar variability. We note that $L(d_p)$ becomes enhanced for drizzle case and less efficient for thunderstorm cases (for a given rainfall rate), which is consistent with the dependence on the raindrop size. Overall, we found that $L(d_p)$ has a weak dependence on the particular raindrop size distributions used in calculations. On the other hand, the dependence of $L(d_p)$ on rainfall rate and aerosol size are the most important factors of BCS variability as it is illustrated in this paper.

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