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Atmospheric Chemistry and Physics Discussions

Interactive comment on "CCN concentration and INP-relevant aerosol profiles in the Saharan Air Layer over Barbados from polarization lidar and airborne in situ measurements" *by* M. Haarig et al.

Anonymous Referee #3

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The manuscript presents case study results from a few flights of the SALTRACE campaign, where ground-based Raman lidar measurements were made coincident with airborne in situ aerosol measurements. The Raman lidar backscatter measurements are converted to extinction coefficients by using an assumed lidar ratio, and then these extinction coefficients are used to estimate particle number concentrations using empirical conversion factors from previous literature. It appears from the manuscript that only three different aerosol types are considered, which are largely distinguished by whether the aerosols are depolarizing (indicating dust) or not depolarizing (indicating continental pollution). It's not clear how marine particles are identified, as these particles are likely to depolarizing when dry, but non-depolarizaing when hydrated.

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Discussion paper

Having estimated particle number concentrations, then CCN and INP concentrations for arbitrary cloud conditions (e.g., 0.2% supersaturation) are estimated using additional assumed CCN=f(s) and INP activation functional relationships. All in all, there are a lot of assumptions made to get from Point A (lidar backscatter) to Point B (CCN and INP concentrations) and quite a lot of uncertainties stacking on top of each other. While the mass profile comparisons look great (Fig. 5), the agreement among the number concentration comparisons is much less strong. These relationships have been seen before in prior literature that have used more rigorous retrieval algorithms that rely on many fewer empirical assumptions (e.g., Sawamura et al., ACP, 2017, https://www.atmos-chem-phys.net/17/7229/2017/). While the present paper examines data from a few cases of merit, the methods represent only a incremental science contribution that doesn't really seem to advance the state-of-the-art. I defer to the editor's judgment as to whether this is sufficient to merit publication in ACP.

Specific comments:

1) The statement on Pg. 2, Line 9 that the ground-based lidar is observing CCN number concentration and INP-relevant aerosol properties is not true! No such measurement is being made. Instead, a highly-empirical series of conversion factors are being applied to backscatter observations to retrieve aerosol concentrations that may or may not be relevant for CCN and INP activation processes. In addition, it needs to be recognized that there is already quite a bit of literature looking at relationships between lidar measurements and aerosol extensive parameters. It doesn't seem appropriate to imply that this study is somehow "a first", as to make the case for this, one has to slice the data attributes pretty finely (e.g., use of a specific ground-based Raman lidar and the focus on dust over the remote Atlantic west of the source regions, conversion of particle number concentration measurements to CCN and INP concentrations at specific, arbitrary conditions). There needs to be better truth in advertising in this paper. Please remove the sentences on Pg. 2, Line 9; Pg. 8, Line 29; and potentially elsewhere that imply that this study is a first of its kind and that the lidar is observing CCN and INPs.

2) What is the basis for doing the CCN comparisons at 0.2% supersaturation? Is this a realistic supersaturation for clouds in this region? How would the comparison look for higher supersaturations (e.g., 0.4% or 0.6%)? For lower supersaturations (e.g., 0.1%)?

3) After reading the conclusions section, I'm unclear how this study advances the use of lidar observations to place constraints on CCN or INPs. The outlook that the authors lay out is that more comparisons in other environments are needed. Why? How will more comparisons be helpful? Would we expect the agreement betweent the lidar retrieval and in situ data to be better or the same? What contribution does this study make? I'd like to see more discussion that contextualizes how the present study is an advance upon the state-of-the-art.

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