Review of ms for ACPD

Review of Paper by Shin, Tesche, Noh and Muller, ``Aerosol-type classification based on Aeronet version 3 inversion products"

In this paper, Shin et al. use some of the Aeronet inversion products to characterize aerosol types and to "investigate their seasonal and optical properties." They apply their method to four East Asian cities and they end up with 9 different aerosol types that differ from each other in one or another of the various Aeronet parameters. Whether or not the attempt is successful, I will leave to the reader to decide. But the paper does shed some interesting light on the problem of identifying aerosol types and I am recommending it be published after some corrections.

The paper focuses primarily on the aerosol measured at four eastern Asian sites, namely, Beijing, Seoul, Gosan and Osaka. There are few anthropogenic sources near Gosan, so the authors believe it represents the background aerosol of the region. For comparison purposes, they also included in their analysis Aeronet measurements from three presumably polluted sites (GSFC, ISPRA, and Mexico City), from three sites dominated by biomass burning smoke (Alta Floresta, Mongu, and Abracos Hill) and from three sites dominated by mineral dust (Cape Verde, Banizoumbou, and Dakar).

The Aeronet properties used in their analysis are the single scattering albedo (SSA), the size distribution (dV/dlnr) (Actually, the identification is based on the fine mode fraction which they denote FMF). These are supplemented with particle linear depolarization ratio (PLDR). They point out that PLDR is a sensitive parameter with respect to particle shape and can be used to determine whether dust particles are present. The PLDR can be obtained from polarization lidar measurements, but also can be calculated from some of the Aeronet data products. The authors mention that the derived PLDR used in their aerosol classification procedure is based on the Aeronet measurements at 1020 nm wavelength. They state that, "Values of PLDR between 0.30 and 0.35 represent non-spherical particles ... while values close to zero indicate the presence of non-spherical particles." (Page 2 line 26) Presumably one or the other of the "non-sphericals" should be "spherical". (On page 4 line 1 we find that PLDR of 0.02 corresponds to "non-dust" and 0.30 corresponds to "Asian dust.")

I do not understand why the author's are calculating PLDR since they seem to be using it primarily to determine the sphericity of the particles. But the Aeronet data set has sphericity as a derived quantity. Why not just use the Aeronet value? I would have expected the authors to compare their sphericity evaluation with that of Aeronet, or at least comment on why they are not using the Aeronet value.

The paper reaches the conclusion that the aerosol in East Asia is mainly due to anthropogenic pollution and that dust aerosols are almost always mixed with other types of aerosol particle.

The introduction is well written and sets the stage for the analysis that follows.

The authors use the three parameters, fine mode fraction, single scattering albedo and polarization to define the type of aerosol. The aerosol types that they find are

Pure dust
Dust Dominated Mixtures
Polution Dominated Mixtures
Non-absorbing Pollution
Weakly absorbing Pollution
Moderately absorbing Pollution
Strongly absorbing Pollution
Biomass-burning Smoke

(It almost seems that a new aerosol type is defined for each variation in the three parameters.)

One of my main problems with the paper is the plethora of acronyms that make the paper difficult to read. For example, we read on page 8 lines 1-3, "The occurrence rate of pure and polluted dust (PD, DDM and PDM) over East Asia is slightly lower (34% -49%) than that of dust-free pollution. PDM is the most frequently detected aerosol type of all types that include dust, i.e., PD, DDM and PDM. The occurrence rates of PDM were…" Some acronyms are introduced and never used again. Thus on page 8 line 21 we read, "…secondary organic aerosols (SOA, Sano et al, 2016). The aged SOA …" The acronym SOA is not found anywhere else in the paper. The paper would be much easier to read and understand if some of the acronyms were spelled out. There is nothing wrong with using acronyms, but when they are piled one upon another, the reader begins to flounder. If the authors insist on using so many acronyms, perhaps they could supply the reader with a look-up table of acronyms.

Section 3 presents their results. Figure 4 shows the values of PLDR vs fine mode fraction. The figure is broken up into 7 regions. It would be very helpful in understanding this figure if the caption would indicate the type of aerosol each region indicates. This information is given in the body of the text in lines 25-27 of page 6, but should be in the caption as well. This is done for Figure 5 and should be done here.

The caption of Figure 4 states that, "The color coding indicates the number of observation data in log scale." The color scale goes from 1 to 900. I suppose this means the number of observations range from 1 to 900. It would seem that most of the "pixels" represent less than about 30 readings with many being less than 3.

Figure 5 shows the size distributions (dV/dlnr vs r) for the seven regions presented in Figure 4. The color scheme makes it hard to figure out what line corresponds to which kind of aerosol. Why not use green and yellow rather than three shades of red?

The second panel of Figure 5 gives SSA vs wavelength. The text (page 6 line 31) states that SSA in Sector B is 0.88. This agrees with the value given in Table 2, but it does not agree with Figure 5 which shows the lowest value of SSA to be about 0.92.

Page 7 lines 8-15. Once again, the values cited do not agree with the SSA values plotted in Figure 5.

Figure 6 presents the fraction of aerosol types observed at each site as function of month. The figure would be more informative if it gave the results in terms of the number of measurement rather than as a percentage. Thus, for example, one cannot appreciate the significance of the statement (page 7 line 24) "Pollution particles are detected most frequently at Seoul (67%)." I would suggest presenting the information like this:
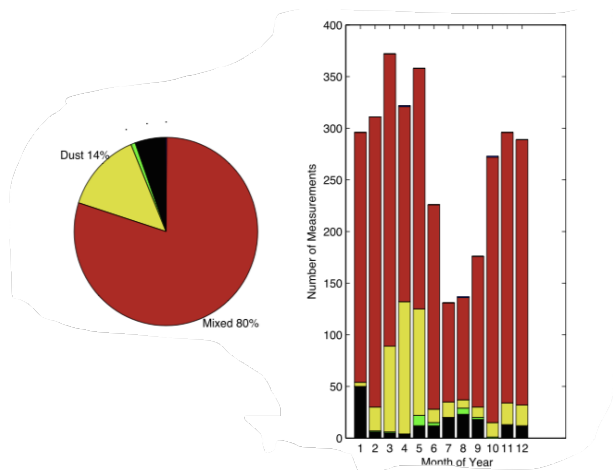
In general the figure captions are not very helpful. They should not just tell us what is being plotted, but also what one is expected to see in the plots.

Specific Criticisms

Page 4 lines 18-19: The authors use Mexico City as a source of anthropogenic particles, that is, urban industrial aerosols. But as pointed out by Carabali et al. (10.1016/j.atmosres.2017.04.035), the Mexico City aerosol is dominated by two different types of aerosol, biomass burning and urban/industrial, depending on the season. (The burning of biomass by farmers in the hills surrounding the city is a major source of particulates.) It is not evident that the authors used the correct time frame for their presentation of Mexico City aerosols in Table 1 and Figure 7.

Page 4 lines 24-26 and Figure 1. The authors state that the plots of SSA vs wavelength for different values of PLDR show "clearly distinguishable patterns." The figure is hard to read and the "pattern" is not really clearly distinguishable. The number of curves in each panel range from 7 to 9, making it hard to appreciate what the authors are trying to show. I would suggest that instead of 9 ranges of PLDR, the point could be made with 3 or 4 ranges. The authors say, "In addition, SSA at 1020 nm is remarkably different compared to SSA at other wavelengths according to the PLDR." (I think they mean

"depending on" rather than "according to.") They go on to say, "Values are in the range between 0.91 and 0.94 for PLDR < 0.1 and between 0.96 and 0.99 for high PLDRs." This does not seem to me to be a significant difference since SSA can range from around 0.8 to 0.99. Finally, the different lines are different colors (representing different ranges of PLDR) but some of the colors are hard to tell apart. There are two shades of red and what appear to be two shades of black.

There is one thing about Figure 1 that I find puzzling. Since the PLDR is used to evaluate the sphericity of the particles, it seems strange that it would be different at 440 nm than at, say, 1020 nm. Does this mean that the particles that respond most strongly at the shorter wavelengths have a different sphericity than the particles that respond most strongly at the larger wavelength? I would think that such an effect would be worth describing and explaining.

Page 5 lines 3-10 and Figure 2. The figure shows the size distributions for the four East Asian sites. The caption should mention that the left column shows the fine mode and the right column shows the coarse mode and the vertical scales are different. Once again, the figure has far too many lines drawn on it, making it hard to understand.

Minor Corrections

Page 1 Line 19, "Radiative forcing of aerosols" should read "aerosol forcing by aerosols."

Page 3 line 14," https://aeronet.gsfc.nasa.gov/.last access: 30 January2019 " I assume the words ".last access...2019" are a typo.

Page 4 lines 1 and 2: The authors define the "Dust Ratio" R_d in terms of δ_{nd} and δ_d. In equation (3) there is also a δ with no subscript which is undefined, unless it is the δ defined in equation (1). They then state that, "We used values of δ_{nd} =0.02 and δ_d = 0.30 for pure dust for Asian dust." I don't know what the authors mean by "pure dust for Asian dust." Perhaps they mean "for pure dust and for Asian dust."

Page 4 line 3, "The spectral SSA is the ratio of the scattering and extinction of light..." This is not the correct definition of SSA.

Page 5 line 18. The word "study" should be deleted.

Page 10 line 9, Referring to Figure 7. "The SSA for NA is higher than SSA at the anthropogenic sites at all wavelengths." According to Figure 7, this is not true at 440 nm. (The thin green curve and the thick green curve are not easily distinguishable.)

Page 10 line13. "Anthropogenic sites contain..." I think the authors meant to say "Biomass burning sites contain..."

Page 10 lines 16-17. "Finally, the spectral SSA of SA resembles the findings at Mongu...We note that the SSA of SA and Mongu are different." Isn't this a contradiction?

Page 10 line 27. "Fine-mode particles contribute strongest to the ..." should read,"Fine-mode particles contribute most strongly to the ..."