

Interactive comment on "A comparison of lognormal and gamma size distributions for characterizing the stratospheric aerosol phase function from OPC measurements" by Ernest Nyaku et al.

Anonymous Referee #1

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General comments:

This manuscript deals with the nature of the particle size distribution of stratospheric sulfate aerosols. The main motivation is to improve assumptions on the aerosol scattering phase function required to retrieve aerosol extinction coefficients from satellite limb-scatter measurements. The study presents a re-analysis of balloon-borne measurements of the aerosol size distribution with optical particle counters. Specifically, two different size distributions (uni-modal log-normal and gamma distributions) are used to model the observed cumulative distributions. The manuscript is interesting,

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presents relevant new information and should eventually be published in my opinion. The paper is very well written and generally easy to follow. There are several points I ask the authors to consider. Specific comments (often minor) are listed below. In addition, I have one more general comment:

The analysis is based on a more limited number of OPC channels than previous analyses of the measurements. In particular, the channels corresponding to large particle sizes are now not considered. These channels provided evidence for a second mode of the particle size distribution, even under background conditions. The second mode is now entirely neglected and the reader wonders, whether the authors now believe that the second mode does not really exist? I think this aspect should be explicitly addressed in the paper. The small number of large particles contributes substantially to the overall aerosol scattering signal and will probably also have a non-negligible effect on the scattering phase function. This is particularly relevant, because the gamma distribution systematically underestimates the number of particles for the largest size bin (top right panel of Fig. 6.).

Specific comments:

Page 2, line 31: "using Mie theory (Deirmendjian, 1969)"

I suggest citing the original paper by Mie here (Mie, 1908).

Page 2, same line: "Here we make the assumption that the aerosol particles in the stratosphere are spherical .."

If Mie theory is used this assumption is implicitly made anyway. Perhaps this could be explicitly stated.

Page 3, line 61: "to correct the ASD" -> "to retrieve the ASD" ?

Page 3, line 66: "and found out that even if the particles were assumed to be spherical .."

I don't understand this part of the sentence, because (a) if Mie theory is used the particles are implicitly assumed to be spherical anyway, (b) if the HG phase function is used no explicit assumptions on the particle shape have to be made, right?

Page 4, lines 108/109: coagulation is certainly also an important process for the growth of stratospheric sulfate aerosols.

Page 6, line 162 and equation (3): If O_i is already the "frequency" in each size bin, i.e. normalized to the total number of observations, then the multiplication of the expected probability values \zeta_i with n in equation (3) is not required, is it? O_i corresponds to a probability then, and so does \zeta i.

Page 7, lin 185: "The LPC data consists of 20 months"

Table 2 lists more than 20 months.

Page 10, Figure 1: I think it would be quite interesting for the reader to see plots of the non-cumulative versions of the gamma and UMLN distributions for these cases.

Same Figure: It is also worth mentioning in the text that two ASDs differ substantially for radii > 300 nm. At 600 nm or so the difference reaches one order of magnitude.

Page 11, line 242: "This is shown in Figure 5, where one observes a considerable change in the magnitude of the phase function, especially in the back-scattering directions ($\$ theta >= 90) for this X value"

I don't think this statement is correct. Looking at the Figure, the phase function for X=1 is almost constant for scattering angles > 90 deg. Perhaps you intended to make another point?

Page 12, caption Figure 5: "increase .. complexity of the phase function"

The complexity (e.g. for X=10) is mainly due to the fact that a monodisperse aerosol is assumed here. If you assumed a UMLN or a gamma distribution then the oscillations will be damped.

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Page 13, Figure 6 and related discussion in the main text: I certainly agree that the differences between the OPC-like and LPC-like fits are smaller for the gamma distribution than for the UMLN distribution. However, both gamma distributions systematically underestimate the number in the largest size bin. If larger size bins would be considered this low bias would probably be even larger. So, the two gamma distributions are in good agreement, but they are also both systematically wrong. Perhaps their phase functions deviate even more from the actual phase function compared to the phase function based on the UMLN distributions? Looking at Chi², the UMLN distribution without the extra measurement still shows the best performance. I'm not asking for any more analysis here, but I think it should be clearly stated that the gamma distributions fail to capture the OPC measurements for the largest sizes, which will lead to a systematic error in the derived phase functions.

Page 14, line 287: "The gamma distribution does not have the same tendency to overestimate the larger particles."

This is now different from the earlier analysis of the OPC/LPC measurements, where the gamma distribution systematically underestimated the large particles.

Page 16, Figure 7: "The blue data points"

I can't identify blue points on my printout.

Page 18, line 325: "Additionally, it has been shown that whenever OPC-like concentration measurements are made, the gamma distribution is the best distribution to be fitted"

I don't agree with this statement, because chi² for the OPC-like measurements is significantly smaller for the UMLN distribution than for the gamma distribution. Please rephrase this statement to eliminate this apparent contradiction. As mentioned above, the difference between the gamma-fits for the OPC-like and LPC-like measurements is admittedly very small, but the gamma distribution systematically underestimates the

measurements for radii > 300 nm. Since the large particles dominate the scattering signal, they will have a non-negligible effect on the phase function. It may even be possible that the OPC-like UMLN distribution yields a phase function that agrees best with the actual phase function.

Page 18, general comment on the conclusions: the 2nd mode reported in earlier studies is now entirely neglected. The earlier OPC measurements showed indications for the second mode even under background conditions. I guess these measurements are still valid – they are also based on more channels at larger radii. It would be good if the authors would comment on how to treat the second mode in future studies. The large particles with radii of several 100 nm may have a substantial impact on the overall scattering properties and the phase functions of stratospheric sulfate aerosols.

Typos etc.:

Page 2, line 7: "Philippines, 1991" -> "Philippines, 1991"

Page 2, line 35: ",longitude" -> ", longitude"

Page 3, line 58: "occulation" -> "occultation"

Page 3, line 58: "was began" -> "was begun"

Page 3, line 59: I think "that" in "that provided" can be omitted.

Page 3, line 67: "calculations .. was" -> "calculations .. were"

General comment on spelling of "Angström": sometimes you use "A" as the first letter, sometimes "\AA". I think the latter is correct and should perhaps be used throughout the manuscript.

Page 3, line 75, equation (1): "nm" can be omitted here (4 occurrences)

Page 4, line 86: "on measurements from Laramie, Wyoming optical particle counter (OPC) measurements"

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Please rephrase

Page 4, line 98: "by (Deepak .." and next line "or (Hinds"

Wrong cite command used (\citep -> \cite}

Page 4, line 10: "Sparc" -> "SPARC"

Page 7, line 183: "following (Kovilakam"

\citep -> \cite

Page 9, line 226: add space after "shape parameter"

Page 12, line 260: ".This" -> ". This"

Page 14, lines 264 and 266: \citep -> \cite

Page 18, line 309: "in the along the" -> "along the"

Page 23, line 471: "Sparc" -> "SPARC"

Same line: add space in "(eds.), SPARC"

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