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Atmospheric Measurement Techniques Discussions

Interactive comment on "Retrieval of aerosol backscatter, extinction, and lidar ratio from Raman lidar with optimal estimation" *by* A. C. Povey et al.

Anonymous Referee #1

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1 General comments

The authors propose a new approach based on Bayesian statistics to retrieve aerosol backscatter extinction and lidar ratio from Raman lidar.
The proposed retrieval scheme is applied on both synthetic and real lidar data and some comparisons with the traditional lidar retrieval approach are provided.
The authors give also details about the uncertainties of the retrieved aerosol optical products and the estimation of their effective vertical resolution as well.

I suggest the publication of the manuscript in Atmospheric Measurement Techniques. However, the manuscript needs the revisions reported below.

2 Specific comments

1. Not all the quantities in the formula (9) on page 9304 are well described.
   If we call N_r the number of real count, N_m the number of measured counts and N_s the number of laser shots integrated we should have (for a not-paralyzable counting system) (see for example Evans (1955)):

$$N_m = \frac{N_r}{1 + \frac{\tau_d N_r}{\tau_b N_s}}$$

   which seems different from what the authors have written.
   What exactly E_i and φ_i represent in that formula?
   Moreover the authors should clearly specify that the formula refers to the "not-paralyzable" counting systems in which the dead time is assumed independent by the input count rate. The explanation they provide at lines 10-12 on page 9304 seems a bit confusing.

2. Page 9304 Lines 17-21
   Usually the detected dynamic range in lidar systems is extended by gluing analog an photoncounting (PC) signals. The authors should clarify their forward model contains only PC signals and could be inappropriate to describe glued signals especially at very low altitude ranges where the count rates are typically too high to be detected with any real photoncounting system and usually the analog signal is used. Moreover in such kind of region the dead time correction cannot be used to provide reliable results even if the value of dead time is known with high accuracy as the assumption to use not-paralyzable (or paralyzable) model to represent real counting systems is critical for high count rate (typically above 100-200MHz).

3. Page 9308 Lines 5-6
   The authors stat "Aspherical particles produce an effectively identical distribution"

AMTD
6, C3650–C3654, 2013

but it is not clear how they have handled aspherical particles to say that (do they use T-matrix code? what aspect ratio they have assumed?). In my opinion the authors should give more details about that and they should provide also the distribution they have calculated for aspherical particles.

4. Section 3 Simulations
   I fully agree with the suggestion given by V. Shcherbakov to use the EARLINET synthetic lidar signals (already used by other aerosol retrieval methods in literature) to demonstrate the performance of the proposed method. Moreover it will be very useful for the reader to compare the performances of the proposed method with respect to the existing ones when a common and independent data set is used. So in my opinion the authors should include also this part in the paper to make it really complete.

5. Page 9313 Lines 5-16
   The authors should provide the maximum count rate of simulated signals because the dead time correction is highly dependent on that. For example I would not expect too much convergence troubles if an error of 0.1ns is assumed on a dead time of 50ns but the count rate is not very high (less than 10MHz for example). The maximum count rate of simulated signals moreover can also give to the reader a better idea on how well the synthetic signals simulate the real ones.

6. Section 3.2.4 Further errors
   I suggest to provide in this section also some information about the sensitivity of the optical products to the changes in x_a and S_a. For example how the solutions change if the mean values of the assumed distributions are changed by let's say of 10% or similar? In my opinion this information can help the reader to understand the real role of the selected a priori in the proposed method.

7. Page 9318 Lines 18-21
   The authors should provide also the value of lidar ratio obtained with Ansmann

AMTD
6, C3650–C3654, 2013

method for the same ash layer. In my opinion the authors can assume the differences with respect to the ranges reported in literature for ash layers are due to different properties of the atmospheric particles only after they have evaluated this comparison.

3 Technical corrections

1. I suggest to use more standard notations in the formula (6) on page 9302. I suggest to use α and β greek letters to indicate the total extinction and backscatter coefficients and to use $\alpha^{(p)}$ and $\beta^{(p)}$ to indicate the corresponding particle quantities (following the notation the authors already have used to indicate molecular quantities). The symbols chosen by the authors are in general used to indicate mean values. Moreover the overlap function in the formula is function of R and λ while in the text it is written as function of only R.

2. Page 9306 Formula 13
   The quantity B should be defined in the text.

3. Figure 2
   The authors should use a better representation of the axis labels as they seem to large with respect to the corresponding plot dimensions. Moreover I suggest to change labels like $1 \bullet 10^5$ and 6000 in something like 1×10^5 and 6×10^3 respectively or even better to define one time the power of ten (for example in correspondence of only the upper label) for which all other label values should be multiplied to.

4. Page 9318 Line 15-18
   The author should specify they are referring to the particle depolarization ratio.

5. Page 9319 Lines 14-15
   What exactly means "... for all points with a depolarization ratio measured to

AMTD
6, C3650–C3654, 2013

better than 100%"? Moreover, again, are the authors referring to volume or the particle depolarization ratio?

6. Figure 8
   It is not clear if the values shown in the plots (a),(b),(f) and (g) are the differences with respect to the solutions or the diagonal elements of covariance matrix. By the way it could be useful to see both these quantities plotted in the same graph.

References

Evans, R. D., *The Atomic Nucleus*, McGraw-Hill, New York (1955)

AMTD

6, C3650–C3654, 2013