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Interactive comment on "**Airborne pollen observations using a multi-wavelength Raman polarization lidar in Finland: characterization of pure pollen types**" *by* **Xiaoxia Shang et al.**

Anonymous Referee #1

Received and published: 8 September 2020

Thank you for your quick reply to my Referee comment. I now have a better picture of what you are doing. I also believe that your presentation is unnecessarily convoluted. The manuscript should be simplified in the presentation of the method as well as with regard to the used language and parameters. For instance, it would be much easier to follow your reasoning if you were to use the Ångtröm exponent $Å$ in your method rather than the unphysical parameters η, η', η'', and $\widehat{\eta}$. I had to continuously go back and forth to remind myself what all those parameters represent. I also don't agree with your reference to simulations, a direct model, and an indirect model. What your present is a purely analytical treatment of synthetic and measured lidar profiles.

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[Discussion paper]

Here is a description of your method as I understand it:

You are defining a set of synthetic lidar profiled for pollen and background aerosol using the set profile shape and the parameters in Table 3. These profiles are then combined to obtain a profile for the mixture of the two. You use Eq. (S5), which is the same as Eq. (13) in *Tesche et al.* (2009), to get the particle linear depolarisation ratio of the mixture. Your Eq. (S5) is transformed to Eq. (6) / Eq. (14) in *Tesche et al.* (2009) by substituting $\beta_{\text{pollen}} = \beta_{\text{total}} - \beta_{\text{background}}$. You now have full knowledge of the system and can calculate the pollen ratio $\chi = \beta_{\text{pollen}}/\beta_{\text{total}}$. Finally, you show that the relationship between $\mathring{A}$ and χ can also be analytically described to find the value of $\mathring{A}$ related to $\chi = 1$. Per definition in Table 3, $\mathring{A}$ is zero for $\chi = 1$ in your synthetic data.

Comments:

- I understand that your choice of parameters in Table 3 is not critical for presenting the overall approach. Nevertheless, it would be nice to get an idea of why those specific values have been selected. In particular, I find the background Ångtröm exponent of 3 quite large.

- Note that I am using the Ångtröm exponent in my description as I find it much easier to follow the steps using a parameter that bears physical meaning.

- You probably don't even need to include the vertical integration of $\chi(z)$. If you use the profile of $\chi(z)$ from your synthetic data, they will still line up perfectly. In the application to real-life measurements, you might also want to leave out the vertical integral as this would require initial knowledge of the pollen layer extend in the measurements. I have a feeling that values of $\chi(z)$ outside the pollen layer will be easy to recognise and screen out in the display of $\mathring{A}$ over χ.

Next steps in the methodology:

Now that you know everything about your model aerosol, you basically turn around and use the same set of equations in the other direction with δ_{pollen} as the unknown parameter. I would expect an inverse model to be completely independent from the earlier calculations. Instead, your just re-shuffle the equations used before, vary the input value of δ_{pollen}, and iterate until you have found the value of δ_{pollen} for which $\mathring{A} = 0$ at $\chi = 1$. It's as simple as that but it took me quite a while to get there based on your description. I'd therefore encourage you to simplify the presentation of your methodology.

Now some more comments regarding the manuscript:

- I again strongly encourage you to separate the presentation of the methodology from the presentation of the results. This is customary in scientific writing and allows the reader not only to better follow your reasoning but also to separate more general relations from your specific results.

- I am quite sceptical about Section 3.4.2. You have defined no profile of β_{1064} and no $\mathring{A}_{532/1064}$ in your synthetic data set. How could you know how to interpret your findings when applying this extended approach to real-life data? Your retrieval of δ_{pollen} at 355 nm is basically analogous to that at 532 nm. In fact, the choice of values in Table 3 indicates that profiles at 355 and 532 nm should be identical. Why not use the same method at 355 and 532 nm? This should already be discussed in the theory section.

- While the information on pollen type and concentration in Figures 11, S4, S5, and S8 is certainly good to have, it is not needed in those plots. Instead, they distract from the intended message. As stated above, I'd expect that the display would work just the same using all values of $\chi(z)$. The ones outside the pollen layer should be easy to identify as (strong?) deviations from the desired relationship. Using the integrated parameter with the actual measurements might reduce sig-

nal noise. However, it requires knowledge of the base and top of the pollen layer as you don't want to include values of $\chi(z)$ outside of this layer in your integration.

- You might want to state that this method can also be applied to other aerosol mixtures to retrieve the particle linear depolarisation ratio related to aerosol types that are dominated by coarse particles ($\mathring{A}_{355/532} = 0$ needs to be fulfilled), as long as the particle linear depolarisation ratio of the second aerosol types is known or can be reasonably well approximated. An obvious application would be the retrieval of the particle linear depolarisation ratio related to undiluted mineral dust from different source regions. The lidar measurements for such a retrieval could be performed further away from the source regions, which translates into a strong reduction of logistical effort.