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Atmospheric Measurement Techniques
Discussions

Interactive comment on "Challenges in retrieving stratospheric aerosol extinction and particle size from ground-based RMR-LIDAR observations" *by* Jacob Zalach et al.

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Here is a paper describing a method to analyze monthly mean lidar color ratios to infer: profiles of the median radius of lognormal size distributions which model the measurements, the lidar ratio, and finally extinction from backscatter measurements. Yet no examples of the fundamental data are shown.

The paper moves quickly, and with no justification, from distributions of quantities with respect to color ratio, the measurement, to distributions of derived quantities with altitude. There is no explanation of how this transformation is made, yet the results from the rest of the paper hinge on this.

The method to derive lidar ratio merits almost no explanation, yet it is a method I have

never seen before, and raises questions as to why others have not used this method.

There are errors in some of the equations, and the origin of equation (11) is unclear. I detail these comments and questions in the review below.

10 Budget

17-32 This nice description of the importance of stratospheric aerosol would benefit from some additional appropriate references.

Eq (5) Shouldn't the scattering term k be k(sca)_Ray?

116 For consistency with the ratio on k(sca) on line 115 change to "depend on aerosol/air densities. I don't believe that there is any Mie scattering from air molecules.

118 The scattering cross section, σ, should also be defined here, or above.

130 Why is n0(λ) given only for 532 nm? What about 1064 nm?

142 Probably should add a more standard reference for Mie scattering (e.g. Born and Huffman or Dave), to which the Oxford scattering calculations surely have probably been compared. Perhaps this is even referenced in their code.

177-178 Why do monthly mean data rule out a distribution width of 1.1? If the aerosol signal was from uniformly narrow distributions over the month then this is possible. Background stratospheric aerosol is thought to be from generally a rather well constrained and somewhat stable size distribution. The authors need a better argument to rule out a width of 1.1. The authors could look to the literature. It should be quite straight forward to find a reference to a typical background aerosol size distribution, for example from in situ measurements, which would not be consistent with a narrow size distribution with a median radius near 300 nm. This would clearly rule out a width of 1.1.

180-181 characterise should be characterize.

Figure 2 Why is the ordinate altitude and not color ratio as Figure 1. The factors involved in this transformation of the ordinate are not clear. In any case it seems that for branch one the radius variation range is limited to about 20 nm once the distribution width is assumed. This is quite restrictive.

183-185 For the reader to understand this statement they would have to know how the color ratio varies with altitude. Isn't it enough for both branches 2 and 3 to point out that in these cases approximately half of the color ratio range would not be covered?

190 Change 'reduces' to 'restricts'. It's easy to misinterpret the sentence, as I did, if reduces is used, to mean the application to radii < 150 nm is limited.

196 '. . . eqs (3, 4, and 5) can be solved for . . .'

Figures 2, 3, 4. There is some important information missing which is required to allow the reader to understand and tie Figures 2-4 to Figure 1. That information is the vertical distribution of the color ratio and for figures 3 and 4 the vertical distribution of the scattering ratio. After Figure 1 the ordinate shifts from color ratio to altitude with no explanation of how the two are related. In Figure 1 the color ratio range is 0.1-3.8. So how is this color ratio distributed by altitude? Once this is known then maybe it will be clear how the following figures are generated.

The two altitude dependent quantities in Eq (11) are P_Mie through its dependence on r_m and the scattering ratio, R. But for the lidar ratio the authors claim that only P_Mie is required and the altitude dependence is through r_m and hence the color ratio. All the vertical profiles, except the lidar ratio at 1064 nm, decrease rather significantly at 23 km, right where r_m decreases from 80 nm towards 60 nm for s=1.3. Is this all that's driving this vertical structure? And if that is the case is the lidar ratio at 532 nm really that much more sensitive to a change in radius from 80 to 60 nm than the lidar ratio at 1064 nm. There should be more discussion on these points.

Eq (11) How is this Equation used? The term k_Ray * P_Ray(π) in the numerator on

the RHS of Eq (11) is calculated from the molecular density profiles from ERA-interim, and this same term, handled the same way, appears in the denominator of (R-1). So if Eq (11) is simplified it is a simple statement that k_Mie = k_Mie*P_Mie(π)/P_Mie(π) or k_Mie=k_Mie. Isn't this a tautology? So how is Eq (11) something more than the measured backscatter divided by the phase function for backscatter, which can be calculated once the particle size is assumed and the wavelength known?

205-213 There has been a lot of previous work devoted to determining the lidar ratio, but I have not seen the approach here. Is it really as simple as inverting the backscatter phase function, with the assumption that the backscatter is just the scattering coefficient times the phase function? Don't equations 12 and 13 imply that P_Mie (0) is 1? Earlier, line 114, k_Mie/Ray were defined as scattering coefficients, now here that term is being equated to extinction, the sum of scattering and absorption. Also if the lidar ratio is just the inverse of P_Mie(π,r_m,λ), why isn't that method used by, for example Jaeger et al. (1995), to calculate the lidar ratio from measured size distributions?

217 Or for certain wavelengths, 1064 nm?

230 They are identical because they both use a calculated cross section integrated over the same size distribution, or? It's hard to believe they would be identical if they were derived from measurements. But so far we haven't seen any measurements.

242-245 Why are errors in temperature and pressure stated if they are not required because they cancel out? This is just a waste of the reader's time.

Figure 7 How is this figure different from an expanded version of Figure 2? It is basically the same figure. What are all the error contributions included? It was already stated that temperature and pressure cancel each other out because color ratios are used, so these are not included. It is not explained how a difference in the refractive index affects the retrieved radius.

Figure 8 What kind of a scale is on the abscissa. The minor tick marks cannot be used to state what the precision is exactly, but it appears to be less than 3% for 532 nm. This figure then indicates that a difference in aerosol radius between the min and max distribution width, which is about a factor of two in radius, lead to almost no effect on extinction? This is a surprising result, suggesting that the determination of the median radius is not that critical. There is a much larger effect at 1064 nm but it seems a bit odd that the effect is not symmetric.

254-258 According to Eq (11) the only size distribution information used is the median radius, r_m, which appears in the phase function. Thus I don't follow this argument that the uncertainties in distribution width are compensated for by the opposite uncertainty in median radius. The uncertainty in distribution width leads to the radius uncertainty which is then used in calculating extinction, according to Eq (11).

Figure 9 What is the point of this figure. It is just a repeat of Figure 3 with the per cent uncertainties, already shown in Figure 8, added to absolute extinction, and it is much less helpful than Figure 8 in assessing this uncertainty.

Eq (16) c(z) is not defined. Shouldn't there be a ratio of wavelengths within the exponential term of the desired wavelength over the reference wavelength.

Figure 11 Which lidar extinction profile is used in the Angstrom conversion to the satellite wavelengths.

Jäger, H., T. Deshler, and D. J. Hofmann, Midlatitude lidar backscatter conversions based on balloonborne aerosol measurements, Geophys. Res. Lett., 22, 1729-1732, 1995.

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