

Interactive comment on “Linear estimation of particle bulk parameters from multi-wavelength lidar measurements” by I. Veselovskii et al.

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This paper describes a new method to retrieve bulk particle properties using multi-wavelength lidar measurements of aerosol backscatter and extinction. The retrieval technique does not attempt to retrieve the detailed particle size distribution (PSD) but rather focuses on the bulk properties of particle effective radius, volume density, and real refractive index. The retrieval has a significant advantage in terms of speed over the inversion with regularization approach, which has been extensively discussed and demonstrated in the literature. The authors also show that this new technique can retrieve these bulk particle properties with a reduced set (3 backscatter – 355, 532, 1064 nm and 1 extinction – 355 nm) of multiwavelength lidar measurements. Overall,

C2728

the paper presents a good description of a potentially useful technique for retrievals of particle properties using remotely sensed measurements. I recommend publication. The authors may want to consider the following comments:

1. (abstract) The paper states that the retrieval technique is “validated” using the results from the full regularization scheme. A more appropriate word would be “evaluated”; a much better means of validation would be achieved through comparisons with other techniques using independent measurements such as from airborne in situ instruments.
2. (page 7509, line 20) The retrieval method assumes that the measurement errors for all channels are the same, and that the refractive index is spectrally independent in this wavelength range. These assumptions should be mentioned also in the abstract and conclusions. Regarding the first assumption, is it true that both random or systematic errors are assumed to be the same for all channels? In terms of calibration errors, this is rarely true. In particular, the 1064 nm aerosol backscatter channel likely has a larger relative calibration error than the other wavelengths. I suggest the authors comment on how strong this assumption is and how different measurement errors in the various channels impact the retrievals.
3. (Section 3) In the estimations of retrieval uncertainties, it appears that the computation of retrieval uncertainties (if not the retrieval itself) assumes that the aerosol size distribution is monomodal. Is this true? What happens if this is not true (which is often the case)? For example, what are the uncertainties when a PSD is used that combines both $r_0=0.2$ and $r_0=2.0$ particles in Table 1? This also has a bearing on the results discussed later in the paper in that the examples show cases where the aerosols appear to be dominated by fine mode particles. It would be nice to know what happens when both fine and coarse mode particles are present in significant numbers.
4. (p 7512, line 24) this should read “The real part of particle refractive index can be retrieved ...”

C2729

5. Fig. 3 shows only the impact on volume distribution. Is the impact similar on the other parameters?

6. (p 7514, line 9) The previous paper (Veselovskii et al., 2009) that compares AERONET and multiwavelength lidar retrievals used data from Aug. 16, 2010 and not August 15 as done in this paper. I am curious as to why the authors did not choose to use the same day (August 16) for the analyses and example shown in the current paper. The results from the current analysis could then be more directly compared to AERONET results on August 16 as shown in Table 1 of the previous paper.

7. Fig. 5 shows the real part of the refractive index increasing with height. This would imply that the relative humidity is decreasing with height. The previous paper showed water vapor profiles and commented on how the refractive index varied with water vapor. It would be nice if the authors could also show relative humidity profiles discuss these in this paper, especially if a different day was chosen (see item 6 above).

8. What are the uncertainties in the lidar measurements shown in Figures 4 and 5 and how do they compare to the uncertainties used in Table 1 and Figures 2 and 3?

9. (p 7516, line 23) The abstract and conclusion should also state that the retrievals as discussed here apply to spherical aerosols and that further work (similar to what was done in the Veselovskii et al., 2010 paper) is required to consider the case of nonspherical aerosols.

10. (p 7516, line 25) This paper and a previous paper (Veselovskii et al., 2010) indicate that significant uncertainties arise when attempting to retrieve nonspherical particle properties using retrieval techniques that assume spherical particles. This paper indicates at this point that the real part of the refractive index is significantly underestimated in such cases. Given this, and that Figure 6 shows that nonspherical aerosols are dominant above 2 km, I suggest that it is inappropriate to show results of the retrieval (especially for effective radius) above 2 km as shown in Figure 7 when it is known that the results are most likely incorrect. I recommend Figure 7 should be changed to

C2730

show results only below 2 km.

11. (p 7516 and Figure 7) This lidar also measured water vapor. Can the authors also show water vapor or relative humidity profiles to see if variations in these parameters are correlated to the variation in refractive index (below 2 km) shown in Figure 7?

12. (p 7518, line 9) The conclusion indicates that removing the 355 nm extinction enhances uncertainties. This was not discussed anywhere in the paper. It would be nice if the paper provided more discussion about the impacts on the retrievals of adding or subtracting wavelengths and/or channels.

13. (p 7518, line 12) The paper states that "To demonstrate the efficiency of the method long-term series of aerosol physical properties derived from lidar observations performed in Turkey in May 2010 were processed." The sentence is confusing but seems to say that a long term series of measurements were used to demonstrate the efficiency of the method. Since the paper shows data from only one night, the authors should discuss why this single case does provide such a demonstration. Some readers may feel this is too short of a period for such a demonstration.

14. (p 7518, line 18) The conclusion mentions that the full inversion (regularization) technique that uses 3backscatter+2extinction data is required for retrievals of the particle size distribution (PSD) which the current technique cannot obtain. Is it also true that the full inversion (regularization) technique that uses 3+2 data is also required to get more (and sufficiently) accurate retrievals of the imaginary refractive index and consequently single scattering albedo? It would be very helpful if the authors could discuss the applicability (or lack thereof) of this new technique to retrieve the imaginary refractive index and single scattering albedo.

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C2731