

Interactive comment on “Aerosol optical and microphysical retrievals from a hybrid multiwavelength lidar dataset – DISCOVER-AQ 2011” by P. Sawamura et al.

Anonymous Referee #2

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This paper presents a novel technique to obtain vertically-resolved aerosol microphysical properties from measurements of different, but co-located, lidar systems. The measurements were obtained during the DISCOVER-AQ campaign 2011 in the Baltimore-Washington area of the US. As the authors state in the paper, improvements in the knowledge of the vertical structure of aerosol microphysical properties is needed and requires both development of more sophisticated lidar systems and inversion algorithms. In this study the authors combined ground-based backscatter lidar measurements at 355 nm with those obtained from an airplane by using a High Spectral Resolution Lidar that provided independent measurements of backscattering and extinction

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at 532 nm, as well as backscatter signals at 1064 nm. The authors used then the well-known regularization technique to obtain microphysical properties by lidar. They analyze several days with correlative measurements of both lidar systems, and compare their retrievals with those obtained by AERONET and by in-situ measurements onboard the airplane. Therefore, after major revision, it should be published in Atmospheric Measurement Techniques.

MAJOR REVISIONS

1. The authors use a hybrid method to retrieve aerosol microphysical properties using backscatter signals at 355 nm. As they state in the manuscript, the retrieval of extinction profiles relies on the lidar ratio. I agree with the methodology used to compute the constant lidar ratio for the whole column. But, as the authors show in Figure 4, lidar ratios are not constant with altitude. This assumption introduces errors in the profile and therefore, in the microphysical properties retrieved. Even though the authors only compare column quantities (lidar vs AERONET), it is not clear whether the assumption of constant lidar ratio introduces biases in those comparisons with AERONET. An error study concerning the retrievals by the regularization technique using the $3\beta+2\alpha$ has recently been published. Some such information could be consulted to address whether there is an issue with the constant lidar ratio assumption. Also, please include estimates of the uncertainty of the retrieved microphysical properties. The existence of HSRL and Raman multi-wavelength lidars to retrieve aerosol extinction without assumption of lidar ratio, as the authors recognized, make the retrievals more robust and feasible and are the reference for the retrievals by regularization. Any study using this technique and measurements by backscatter lidar must report the final uncertainty.

2. This paper uses AERONET retrievals of level 1.5 for aerosol microphysical properties. I am not against using these data if it is clearly stated that is not the best product that AERONET provides and if it is well-referenced. The reference that must appear when using those data is Holben et al., (2006). Although the reference is included in the manuscript, of the concerns introduced by using AERONET level 1.5 data need

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to be made explicit. Actually, in page 3125, lines 13-15, the authors say “Retrievals of microphysical and optical properties from inversion of the hybrid lidar dataset were obtained for the days with higher aerosol loading ($\tau > 0.4$ at 440 nm)”. If such is the case, one would expect that AERONET level 2.0 retrievals may have been available. Therefore, it is difficult to understand the use of AERONET level 1.5 data when you have many retrievals using level 2.0. The use of AERONET level 1.5 just adds more uncertainties to the inter-comparisons presented in this study.

3. The technique presented in this paper overall is a curiosity that would seem to have little general utility. The analyses indicate that the retrievals agree well with those of AERONET. But comparisons are only made for column-integrated quantities. It is hard to understand the use of two complex lidar systems, one airborne the other ground-based, in order to retrieve quantities that a simple sun-photometer can provide. To address this concern, I strongly encourage presenting the results of vertical-profiles of aerosol microphysical properties with uncertainty estimates. According to Table 1 you only have five different days, so those profiles can fit in a revised version of the manuscript and that will show much more clearly the value of using lidar for such studies as these.

4. The paper seems not well structured. There is reference to “dissertation” at one point that gives one the impression that this is material cut from a PhD dissertation. Perhaps in the process of cutting and pasting some sense of flow of the ideas was lost. It would be very helpful to have a section that separately describes the instrumentation used. As it is, it is hard to understand the details of the instruments. For example, in section 4.1 ‘Comparison to in-situ instruments’ you describe those instruments when this section belongs to the result sections. Having a separate instrumentation section would improve the presentation. Also, please make clear which instruments are ground-based and which airborne. Are HSRL and in-situ instrumentations onboard of P-3B flight? Moreover, some results are described in the methodology section (example Page 3121, lines 8 – 30 and Page 3122 lines 1-2). On the other hand, in the

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results section the discussions about previous results by other authors is too long and there are graphs that are not even discussed (example graph 6) until much later in the manuscript. Therefore, I strongly recommended to re-structure and revising the text.

MINOR REVISIONS:

5. The Introduction section is quite good but I would like more references.

6. Page 3116 lines 8-12: “In contrast to most radiometers (e.g. MODIS and AERONET) which measure radiance over a large number of wavelengths, it has been demonstrated that from lidar backscatter and extinction measurements at three wavelengths, one can obtain retrievals of the aforementioned aerosol optical and physical properties” Be careful with such statements since AERONET retrievals can obtain more parameters (e.g. phase functions and asymmetry factors) and in a more reliable way.

7. Page 3117, line 3: What is GSFC? Please define.

8. Page 3117: Can you split the references between those corresponding to measurements in Europe and those to Asia.

9. Page 3120, lines 14-22: Please clarify the influence of the constant lidar ratio assumption can induce systematic errors and cite pertinent references.

10. Section 3.1.2. Lidar inversion algorithm for retrieval of microphysical and optical properties of aerosols: Please shorten this section because the technique is well-known in the literature. But regarding my first major point, please clarify that the effects of uncertainties in the input optical data have in the retrievals for $3\beta + 2\alpha$ have been studied and include appropriate references.

11. Page 3125, lines 17-19: Figure 6 is out of context here. You do not mention anything about this graph until section 4.4.1 in page 4134.

12. Pages 3125 and 3126: You make reference to a case study performed by Veselovskii et al., 2012 during DISCOVER-AQ. First, you should correct the references

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as all these results are available in a manuscript (see below and merge Veselovskii et al., 2012 b,c in Veselovskii et al., 2013). Also, why not show your backscattering coefficient time-series for this day? It would be easier for the inter-comparisons you propose.

13. Page 3128, line 11: Why do you use an aerosol layer height fixed of 1.5 Km when your lidar measurements can give you the real one?

14. Page 3128: Why do you present the results of a station (Padonia) that you state is not reliable due to calibration issues?

15. Page 3129, lines 24-25: "The origin of this bias is still unknown but it has been speculated that calibration issues might be at fault ". Which instruments are you referring to have problem in the calibrations? I believe that the differences you find are within the uncertainties related to the different methodologies and instruments. An uncertainty assessment, as earlier requested, would help to address this question.

16. Page 3132, lines 5-10: Please define what are $g_3(RH)$ and $f(RH)$ and provide references.

17. Section 4.4 Single-scattering albedo and complex index of refraction: Please update the references and take into account recent results of Schafer et al., (2014) for your inter-comparisons.

18. Pages 3133 and 3134: In my opinion, there is too much text describing previous results. Please make more concise and get on to your own results.

19. Page 3134: I really like your conclusions about the comparisons between in-situ aircraft instruments and those data obtained by remote sensing techniques. But please, correct the mistakes in the units (percentages?) of RH.

20. Section 4.4.1: If you still want to keep Figure 6, here is when it should be introduced. Please mark on Figure 6 the period of time when your retrievals of microphysical properties are available.

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21. Table 1 caption: Last line " Figure 1 shows the AERONET and P-3B spirals locations". Please remove this sentence; it is out of context here.

22. Figure 4 is confusing according to its caption. What are the wavelengths of the lidar ratios? Is blue corresponding to 355nm and green to 532? What is the meaning of the shadow area? Also are all the profiles needed to get your point across? As the figure stands, it is hard to discern what is happening. I suggest removing most of the profiles and leaving a few that you then describe to get your points across.

23. Figure 5: I do not understand the purpose of this graph. For AOD, why are you using data from the AERONET dubovik file? Why not provide just the AOD time-evolution obtained from direct sun irradiance measurements? You will have then a better perspective of the daily time-evolution of aerosol. If the purpose is just to represent the aerosol optical depths at the exact time of lidar measurements, why not just include the average values in table 1 or table 2?

BIBLIOGRAPHY

Pérez-Ramírez, D, Whiteman, D. N, Veselovskii, I, Kolgotin, A, Korenskiy, M and Alados-Arboledas, L.: Effects of systematic and random errors on the retrieval of particle microphysical properties from multiwavelength lidar measurements using inversion with regularization, *Atmospheric Measurement Techniques*, 6, 3039–3054, 2013.

Schafer, J. S., Eck, T.F., Holben, B.N., Thornhill, K.L., Anderson, B.E., Sinyuk, A., Giles, D.M., Windstead, E.L., Ziemba, L.D., Beyersdorf, J., Kenny, P.R., Smirnov, A., and Slutsker, I.: Intercomparison of aerosol single scattering albedo derived from AERONET surface radiometers and LARGE in-situ aircraft profiles during the 2011 DRAGON-MD and DISCOVER-AQ experiments, *Journal of Geophysical Research*, doi: 10.1002/2013JD021166, 2014.

Sinyuk, A., Holben, B. N., Smirnov, A., Eck, T. F., Slutsker, I., Schafer, J. S., Giles, D. M., and Sorokin, M. : Assesment of error in aerosol optical depth measured by AERONET

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due to aerosol forward scattering, *Geophysical Research Letters*, 39, L23806, 2012.

Torres, B., Dubovik, O., Toledano, C., Berjon, A., Cachorro, V.E., Lapyonok, T., Litvinov, P. and Goloub, P.: Sensitivity of aerosol retrieval to geometrical configuration of ground-based sun/sky radiometer observations, *Atmospheric Chemistry and Physics*, 14, 847-875, 2014.

Veselovskii, I., Whiteman, D.N., Korenskiy, M., Kolgotin, A., Dubovik, O., Pérez-Ramírez, D.: Retrieval of height-temporal distributions of particle parameters from multiwavelength lidar measurements using linear estimation technique and comparison results with AERONET, *Atmospheric Measurement Techniques*, 6, 2671–2682, 2013.

Interactive comment on *Atmos. Meas. Tech. Discuss.*, 7, 3113, 2014.