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7, C1898–C1920, 2014

Interactive Comment

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

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The authors would like to thank the referees for their comments and suggestions. Please find below the comments/answers for each item (in blue) posted by each referee. A revised version of the paper has been prepared.

Full Screen / Esc
Printer-friendly Version
Interactive Discussion
Discussion Paper

Anonymous Referee #1

GENERAL COMMENTS

1. **Page 3115, line 24: "Many ground-based lidar networks. . ." should be replaced by "Several ground-based lidar networks. . ." There are not so many.**

   Done.

2. **Page 3115, line 29: "angstrom coefficient" should be replaced by "Ångström exponent". Note, (extinction, backscatter, scattering) coefficients are extensive properties, whereas the Ångström exponent is an intensive parameter. There should be a clear distinction in the wording.**

   Done.

3. **Page 3117, lines 13-22: This paragraph does not fully describe the idea of the hybrid data set, since it doesn't mention the sun photometer. Without the AOD constraint, it is not possible to get the extinction coefficient at 355 nm with sufficient accuracy. The experienced reader gets confused here, because the extinction information at 355 nm is obviously missing in the described setup. It becomes only implicitly clear later on that this information is "created" by a constraint retrieval making use of the AOT from the sun photometer. The authors should be more precise here and they should also discuss the related shortcomings/errors compared to a direct measure of the extinction coefficient.**

AMTD

7, C1898–C1920, 2014

We first would like to clarify that the term “hybrid” was originally intended to describe the combination of lidar data obtained from dual-platform (ground-based and airborne), dual-technique lidar systems (HSRL and elastic). The sunphometer data was not meant to be an explicit part of this “definition” but, instead, implicit in the dual-technique portion of it, as it is a requirement for obtaining retrievals from elastic lidar signals. With that in mind, we would like to point out that the paragraph in question was part of the Motivation section and therefore we opted for having the full description of the hybrid dataset in the Methodology section. More specifically, the elastic lidar retrievals are described in pages 3120–3122 in Methodology → Hybrid multiwavelength lidar dataset → Elastic lidar retrievals. Prior to this section however, we comment on page 3120 (lines 11–22) about the possible shortcomings of the constant lidar ratio assumption used for elastic lidar systems. We also investigate the validity of this assumption by comparing extinction coefficient profiles obtained from the airborne HSRL system (at 532 nm) with the profiles obtained from our elastic ground-based system (pages 3121–3122, and figure 3). Although the comparison was performed for the 532 nm wavelength, the inversion schemes utilized to obtain the extinction coefficients at 355 and 532 nm were very similar, and therefore the good comparison observed between the airborne HSRL and the ground-based elastic lidar profiles at 532 nm gave us confidence that our elastic retrievals at 355 nm could be used in the microphysical retrieval algorithm.

4. **Page 3119, lines 7-19: This paragraph is misleading. It is not correct that the method described by Wagner et al. (2013) uses backscatter and extinction coefficients obtained with Raman lidar. Instead, this algorithm uses elastic backscatter lidar signals at three wavelengths as input. Therefore, it is not true that there is no temporal collocation with the sun photometer data. For completeness of the discussion, the authors should also refer**

AMTD
7, C1898–C1920, 2014

to Lopatin et al. (2013) who also developed a combined lidar and sun photometer retrieval that does not need Raman lidar observations either.

The authors apologize for the confusion in this paragraph. The new reference was included and the paragraph has been modified to:

"As an alternative to the $3\beta + 2\alpha$ inversion methodology, some studies were carried out in which backscatter and extinction coefficients obtained from a Raman lidar were combined with optical depth measured by sunphotometer in order to derive the microphysical properties of aerosols (Pahlow et al., 2006; Tesche et al., 2008; Balis et al., 2010). However, the main challenge that comes to mind in this type of Raman lidar and AERONET data combination is temporal data collocation. Sunphotometers are fundamentally designed to be operated during daytime while Raman lidars allow for good measurements mostly during nighttime. Alternatives in which Raman lidar data are not utlized have also been explored. Wagner et al. (2013) combined elastic backscatter lidar return signals at 355, 532, and 1064 nm and retrievals of volume concentration and column values of the volume-specific backscatter and extinction values obtained from AERONET as a priori assumptions in an optimization algorithm in order to obtain vertically resolved distributions of optical and microphysical properties of fine and coarse mode particles. Lopatin et al. (2013) describe a new algorithm which also utilizes a combination of elastic lidar signals and AERONET sunphotometer retrievals in order to obtain vertical profiles of fine and coarse mode aerosol concentrations. The algorithm described by Lopatin et al. (2013) is very similar to the one utilized by Wagner et al. (2013) but, in addition to the retrievals of vertical profiles of aerosol concentrations, it also allows for retrievals of size distribution and complex refractive index for each aerosol mode."

AMTD
7, C1898–C1920, 2014

Interactive Comment

5. **Page 3120, lines 11-14: Both HSRL and Raman lidar deliver independent information on extinction and backscatter. While this fact is described here for the HSRL, it has not been explicitly mentioned before when the Raman lidar approach to obtain 3+2 data was discussed. The independent information is the major prerequisite for microphysical retrievals. This fact should be better emphasized and also discussed in the context of the missing fully independent extinction measurement at 355 nm.**

   Paragraph on page 3116 (lines 18-20) of the discussion paper was modified to acknowledge the Raman capabilities of providing independent measurements of extinction and backscatter coefficients:

   "All microphysical retrievals from multiwavelength lidar data obtained to date, however, originated from ground-based Raman lidar systems. Raman lidars are capable to measure elastic backscatter signals due to molecules and particles in the atmosphere as well as inelastic backscatter signals due to molecules (oxygen and/or nitrogen). These systems are, therefore, capable to provide independent measurements of extinction and backscatter coefficients with no need of an assumption of extinction-to-backscatter ratio (i.e. lidar ratio)."

6. **Page 3124, lines 13/14: What do the three numbers with the colon in between mean?**

   The sentence was modified to:

   "The inversion window utilized in this work was $R_{min} = 0.01\mu m$ *to* $0.2\mu m$ *in* $0.01\mu m$ *increments,* $R_{max} = 0.5\mu m$ *to* $5\mu m$ *in* $0.5\mu m$ *increments,* $Re[m] = 1.325$ *to* 1.5 *in* 0.025 *increments, and* $Im[m] = 0$ *to* 0.03 *in* 0.001 *increments".*

7. **Page 3124, lines 20/21: How are the errors created and distributed to the input data?**

   In order to account for measurement errors, the input data elements (i.e. extinction at 355 nm, 532 nm and backscatter at 355 nm and 532 nm and 1064 nm) are distorted randomly and independently within pre-specified bounds. For this study, we're assuming that the measurement errors were within 15%. As mentioned in the manuscript, for each layer, the retrieval algorithm was run 7 times. In one of those runs the input data remained undisturbed, while for the remaining 6 runs, each input data element was randomly disturbed between -15% and + 15%.

8. **Page 3125 ff., Chapter 4: The order of discussion of the results is a bit confusing. First an overview of AOD for the measurement days is presented, but it is up to the reader to relate Fig. 5 to the cases discussed before and listed in Tab. 1 and Fig. 3 and 4. Then, Fig. 6 shows a particular lidar measurement for one day without further discussion. The results for this day are presented in more detail only 9 pages later. Next, the authors discuss findings from another paper of Veselovskii et al. (2012c) which do not help the reader at all in understanding anything, since no results of their own study have been shown yet. Thus, there is nothing to compare or relate at this point. Afterwards, Fig. 7 is mentioned but not discussed, and general results (mean values for the entire campaign, Table 2) are presented. Probably, the idea of this order of presentation would become clearer when Chapter 4 was started with Section 4.1 "Overview of measurement results", with some more general explanation and interpretation, before going into more details in the following sections. I also had a problem with the comparison of averaged data, before knowing more**

about the details of the individual cases.

Order of text was rearranged. Please refer to the revised manuscript.

9. **Page 3126, line 18: "subset 1 contains subset 2" is unclear. I guess you mean the cases are contained. However, Level 1.5 and Level 2.0 might be different in terms of the values. Please clarify.**

That is correct, level 1.5 and level 2.0 might have different values. However I ran a comparison for each of the cases considered in this study, comparing values across both levels and the values were the same. I modified that sentence to acknowledge that. "It should be noted that for the cases utilized in this study subset 2 is part of subset 1 since there were no differences in values between level 1.5 and level 2.0."

10. **Page 3128, line 11: Why is the ALH not determined separately for each measurement case?**

The algorithm utilized at UMBC is tuned to detect PBL heights, which are usually lower than what we are referring to as ALH in this study. In order to compare our size parameter retrievals to AERONET's we had to estimate an aerosol layer height which would represent the height below which most aerosol particles could be found since AERONET's size parameters are all reported per unit area. The following paragraph was added:

"Here it is important to emphasize that the comparison of lidar retrievals of size parameters to AERONET retrievals was not meant as a validation tool for

AMTD
7, C1898–C1920, 2014

either technique since one simply cannot compare a total column retrieval to a retrieval that was performed for individual layers and expect a 1:1 agreement. Instead, this comparison serves as a way of checking if a reasonable agreement could be observed between AERONET and lidar retrievals by using a reasonable ALH to convert a per unit area to a per unit volume quantity.
Figure 6 shows that reasonable agreement is observed in many cases. In this figure the values obtained from the lidar retrievals for each layer (i.e. values found between x-axis ticks A-K) are representative of retrievals at different altitudes. AERONET retrievals on the other hand, being a total column retrieval, are repeated (between x-axis ticks) so all layers analyzed for a particular day and time are compared to the same AERONET "volume-converted" value."

11. **Page 3129, line 3, lidar retrievals at 532 nm: The lidar retrievals assume a wavelength independent value for refractive index and single-scattering albedo. Why should they hold exactly for 532 nm?**

The following paragraph was added to section "Comparison to AERONET retrievals ":

"The lidar retrieval algorithm assumes a wavelength independent refractive index. The combination of refractive index and the retrieved size distributions allows for the calculation of scattering and absorption coefficients at the lidar wavelengths (355, 532, 1064 nm), therefore also allowing to compute single scattering albedo at those wavelengths despite the assumption of a wavelength independent refractive index. Since 532 nm is the mean wavelength utilized in the retrievals and, in this particular case, the only channel in which backscatter and extinction coefficients are independently measured (with HSRL technique),

AMTD
7, C1898–C1920, 2014

it was decided to only utilize the single scattering albedo retrieved at 532 nm in the comparisons.
We also compare the refractive index to the AERONET retrievals interpolated at 532 nm. However, as AERONET provides wavelength dependent retrievals of m (i.e. at 440, 675, 870, 1022 nm), we were able to look into the differences between the values of both real and imaginary parts of m interpolated at 532 nm and the values obtained from the average of the wavelength-dependent m across the four wavelengths. The 90th percentile ($p90$) of those differences were calculated using all the available AERONET retrievals obtained during the month of July 2011 at UMBC, GSFC, Padonia, Essex, and Beltsville stations. Regarding the real part of m, the differences were less than 0.03 for all stations. For the imaginary part the $p90$ values were all below 0.0038. These differences may be interpreted as an additional error in the comparison of refractive index for using the AERONET retrievals at 532 nm instead of the average values calculated over all wavelengths."

12. **Page 3137, line 20, "The work presented in this dissertation. . .": Seems to be copy and paste. The paper, and in particular the conclusion, suffers from the somewhat lengthyand tedious explanatory style of a dissertation. It would be worthwhile to condense and focus the discussion in order to make the paper better readable.**

Order was rearranged. Please refer to the revised manuscript.

TECHNICAL CORRECTIONS

13. **Page 3117, lines 28: Washingtion → Washington**

AMTD
7, C1898–C1920, 2014

Done.

14. **Page 3119, lines 4-5: European Aerosol Lidar Research Network → European Aerosol Research Lidar Network**

Done.

15. **Page 3119, lines 25 and 26: add nm after the numbers 532 and 1064**

Done.

16. **Page 3123, line 1: distributions → distribution**

Done.

17. **Page 3123, line 13/14: spherical aerosols → spherical aerosol particles**

Done.

18. **Page 3124, line 4/5: Weitkamp, 2005 – do not cite the editor, better cite the specific chapter and its authors.**

Done.

19. **Page 3128, line 20: contains →contain**

    Done.

Anonymous Referee #2

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. AI 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 + 2 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**

AMTD
7, C1898–C1920, 2014

backscatter lidar must report the final uncertainty.

There is an important detail about the cases that were analyzed for this study that was perhaps not properly highlighted in the original manuscript. The inversion of the hybrid lidar datasets was performed for the discrete layers listed on Table 1. The layers were chosen in areas where the intensive parameters, lidar ratio in particular, did not vary much. Within each layer listed in Table 1, the lidar ratio (based on HSRL data at 532 nm) varied between 2% and 20%. In most cases the variation, in terms of percentual standard deviation, was less than 10%. (A paragraph was added on Section "Lidar inversion algorithm for retrieval of microphysical and optical properties of aerosols" with a similar discussion.)
With respect to estimates of the uncertainty of the retrieved microphysical properties for this study, we are only able to provide the statistical error that originates from the solution averaging process which are reported in Figure 7. We will make sure to include a reference regarding the systematic error study that has been performed and published by Ramirez et al. (2013)

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 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 ($>$ 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**

AMTD
7, C1898–C1920, 2014

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.

Due to the strict screening process involved in quality assuring a data product to level 2.0, the amount of level 2.0 retrievals is greatly reduced compared to the amount of level 1.5 data. Even more so in the case of single scattering albedo and complex index of refraction retrievals which has the additional requirement of $\tau_{440} \geq 0.4$. We chose to include level 1.5 retrievals in our comparisons, but we did so carefully. Tables 3 and 4 show the July mean values of effective radius and single scattering albedo obtained at different quality assurance levels (i.e. levels 1.5 and 2.0) at all AERONET/DRAGON stations considered in the study, and for different aerosol loading scenarios. What tables 3 and 4 show is that level 1.5 retrievals of size parameters (effective radius, in particular) and single scattering albedo are comparable to level 2.0 retrievals for cases when $\tau_{440} \geq 0.4$, which is true for the cases we show in this study. UMBC is negatively biased compared to other stations and that issue is also discussed in the manuscript.

The following paragraph was included in the beginning of section “Comparison to AERONET retrievals”:

Level 1.5 retrievals are only cloud-screened, and not quality assured like level 2.0 retrievals. In order to use level 1.5 retrievals in the intercomparison with in-situ measurements and lidar retrievals, we first compared their range of values to those found in the level 2.0 retrievals. We used the statistics obtained from July 2011 data to judge whether level 1.5 retrievals could be used in the comparisons.

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 groundbased, 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.**

With respect to the technique, we acknowledge that it would probably be not feasible to plan another experiment to use the setup that we utilized for this work (e.g. aircraft + ground based lidars) to obtain the dataset necessary to run the lidar inversion scheme to obtain microphysical properties of aerosols. It is, however, important to emphasize that none of the systems utilized in this study, HSRL-1, ELF or ALS-450, would have been able to provide the 3+2 dataset if operated alone. DISCOVER-AQ 2011 provided us with the opportunity of combining these measurements and this study was built on that opportunity. The data was available to try something new in terms of microphysical retrievals utilizing data combination, and we seized the opportunity to test the feasibility of doing so.
Regarding the second part of the question, it is not completely true that the comparisons are made only for column-integrated quantities. The retrievals, as mentioned earlier, were performed for discrete layers, but they are not total column retrievals, like AERONET retrievals. The comparisons to in-situ spiral data, for instance, were performed by averaging the in-situ measurements within the same layers considered for the lidar retrievals. The comparisons with

AMTD
7, C1898–C1920, 2014

AERONET retrievals, on the other hand, were more redundant in the sense that the same AERONET value obtained at a particular time had to be used to compare with the lidar retrievals obtained at different layers/levels (see comment 10 addressed to referee # 1). Profiles were not presented mainly because the retrievals were not run for the entire profile, but also because profiles for each parameter, and for each case would take too much space. Instead, we decided to condense the results in Figure 6, which although not obvious, contained vertical information. In order to make that clearer, we have added an additional plot to Figure 6 that shows the altitude of the layers considered for the inversion. The new figure is presented at the end of this document as Figure 1.
Although only 5 days were analyzed, we were looking at different times of the day (for some cases) and also looking at 6 different parameters and comparing these results with in-situ data obtained at 1-3 different locations, and AERONET retrievals obtained at 1-5 different locations. One vertical plot for each day would contain too much information and it would make it very difficult for the reader to discern data from different locations and different times.

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,**

AMTD
7, C1898–C1920, 2014

Interactive Comment

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 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.

A subsection named "DISCOVER-AQ and case studies selection" was added to the Methodology section. This new subsection briefly describes the scope of DAQ, and also makes the distinction between the instruments onboard the P-3B and UC-12 aircraft. Text was revised and restructured. Please refer to the revised manuscript.

MINOR REVISIONS

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

   We added a few 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.**

The sentence was removed.

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

   The remark "August/September 2006 at GSFC" was removed as the extra information was not really necessary.

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

   Done.

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

   Please refer to the revised manuscript.

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 + 2 have been studied and include appropriate references.**

    Section was shortened. Please refer to the revised manuscript.

AMTD
7, C1898–C1920, 2014

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.**

    Figure 6 has been moved to the pertinent section.

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 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.**

    This paragraph was changed and references therein updated. The comparison between Veselovskii et al. (2013) results and the lidar retrievals was removed due to the time difference in the measurements (daytime vs. nighttime). But we kept a paragraph acknowledging their contribution.

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?**

    Please refer to comment 11 addressed to referee # 1

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

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Interactive Discussion

Discussion Paper

We present results from Padonia station because the retrievals obtained at higher aerosols loadings seemed consistent with the values obtained at other stations (Tables 3 and 4) despite the fact that the data was never "upgraded" to level 2.0.

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.**

    The instrument we are referring to is the AERONET sunphotometer at UMBC. The retrievals of single scattering albedo and imaginary part of the complex index of refraction obtained at UMBC AERONET station were clearly biased when compared to the other stations considered in this study (See Table 4). It is not clear why this bias appears only in the absorption-related parameters at this particular station. The values retrieved for single scattering albedo at other stations were higher (and values for the imaginary part of the refractive index were lower) when compared to those obtained at UMBC station and that is the reason why we believed that there might have been calibration issues.

16. **Page 3132, lines 5-10: Please define what are g3(RH) and f(RH) and provide references.**

    The definitions of $f(RH)$ and $g(RH)$ are provided in the paragraph before, page 3131 lines 25–29 of the discussion paper, where a reference was provided.

AMTD

7, C1898–C1920, 2014

$\bar{g}(RH)$ is defined in that same paragraph as the *"average of effective growth factor for the entire range of particle diameters"*. Since $g(RH)$ is a diameter growth factor, $g^3(RH)$ would be a first order approximation for the ratio of volume concentration at a certain RH value to the volume concentration at dry conditions (also described in the manuscript).

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.**

    Reference Schafer et al. (2014) was added.

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.**

    Given that inter-comparison studies of single scattering albedo and refractive index values are scarce, the authors felt that some literature review on that subject was necessary. But at the same time, we acknowledge that it was longer than necessary, so the section was shortened.

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.**

    % symbols were added.

AMTD
7, C1898–C1920, 2014

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.**

Done.

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.**

Done.

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.**

Figure 4 is called on page 3121 and 3122 of the discussion paper and the shaded areas are explained then. The caption explains the colors. Blue: 355 nm (elastic, ground-based), Green: 532 nm (HSRL, UC-12), Red: 1064 nm (elastic, UC-12). All profiles shown in figure 4 were used in this study.

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**

AMTD

7, C1898–C1920, 2014

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?

The purpose of this graph was to help visualizing the aerosol loading observed on the days when synergistic measurements from P-3B, HSRL, and ground-based lidar were obtained. Since we used aerosol loading as the criteria to choose which days were to be analyzed, an AOD plot was thought to be appropriate. This plot also helps visualizing which days had level 1.5 and 2.0 inversion products available, which in this case, it would make sense to use AOD values that were representative of the times for which inversion products were available.

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

AMTD

7, C1898–C1920, 2014

Interactive Comment

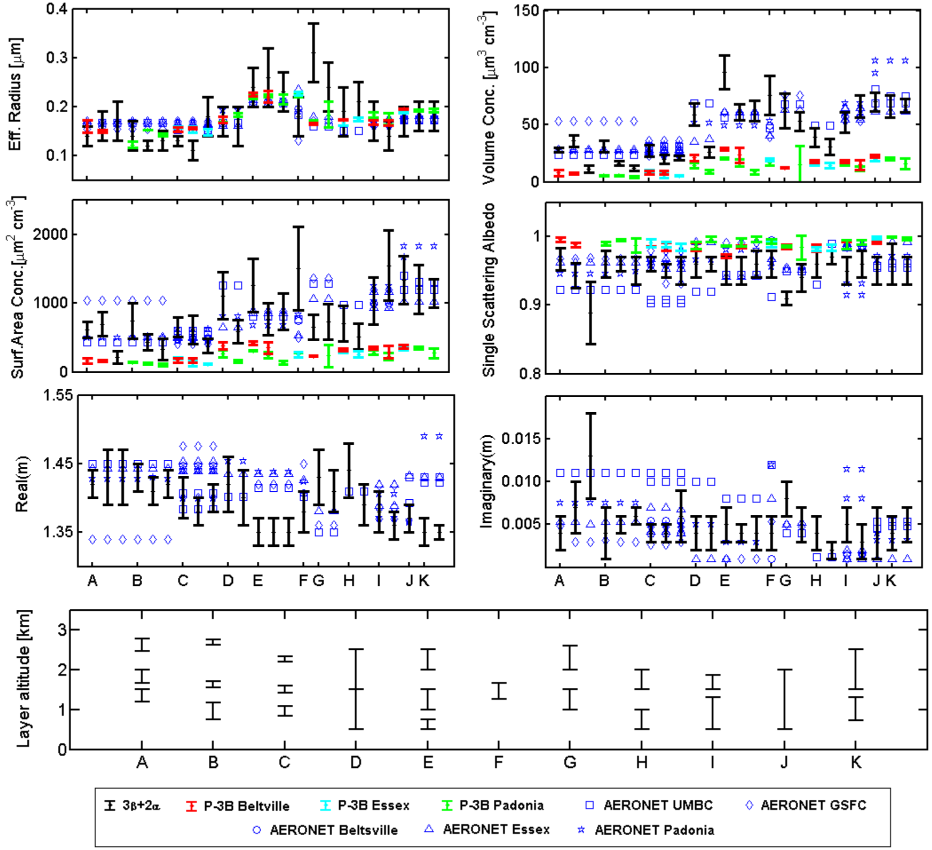

Fig. 1. Figure 6 (new)

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Interactive Discussion

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