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Interactive comment on "Lidar profiling of aerosol optical properties from Paris to Lake Baikal (Siberia)" *by* E. Dieudonné et al.

Anonymous Referee #1

Received and published: 2 January 2015

General

The paper contains unique observations with a small Raman/polarization lidar performed during an exotic travel from Paris to Lake Baikal which is located in central Siberia. The paper is clearly appropriate for ACP. However, the paper has to be significantly improved (text, figures) before it can be published.

I strongly recommend to switch from BER (backscatter to extinction ratio) to LIDAR RATIO (extinction-to-backscatter ratio), ... in general! From the literature it becomes obvious that nobody uses BER except lidar groups in France. So please move to the international standard in this point.

The figures are not in a good shape and need to be improved significantly to properly illustrate this unique trip.

Major revisions are required.

Detailed comments:

Abstract:

You say that the average BER is 0.017 +/- 0.009 sr-1. . .. . . from the abstract to the end of the paper, I was continuously forced to translate all these BER numbers into lidar ratios. . .. . . and the majority of interest readers will have to do the same. . ., if not changed! So please move from BER to lidar ratios in general. There is simply no reason to stay with BER!

Average BER is 0.017 +/- 0.009 sr-1 means you found an average lidar ratio = 58.8 sr with a standard deviation from 38.5 to 125 sr. I am surprized because the lidar ratio is the more direct parameter in the Fernald retrieval and should show a well known symmetric behavior around the mean value., i.e., from 38 to 78 sr. I conclude that the error in all the found results is rapidly increasing if the BER values are below 0.012 which is already an unrealistically low number to my opinion. Even in polluted China it is hard to observe any lidar ratio above 80sr (or BER = 0.0125).

Regarding the depolarization ratios presented: Volume depolarization ratios at 355 nm can be well measured even if the laser light always contains a few percent of depolarized radiation. Usually only 98% of the transmitted laser light is fully linearly polarized. One can see this if one looks at the 355 nm volume depolarization ratio in the Rayleigh atmosphere. Here the volume depolarization ratio is typically 2% and not 0.7% as the theory tells you for an ideal polarization lidar receiver unit. Now, taken this source of uncertainty into account how can you then measure volume depolarization ratios below 2% and obtain even particle depolarization ratios close to 1%. This is simply impossible. Furthermore, the uncertainty in the retrieved particle depolarization ratio is especially high at 355 nm (compared to 532 and 1064nm). Please provide uncertainty

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information and may be show a figure with the profile of the volume depolarization ratio, and the related particle depolarization ratio together with the particle backscatter coefficient profile to convince the reader.

A mean BER of 0.011 sr-1 (lidar ratio of 90 sr) for a mixture of dust and smoke. . .? I do not believe! See my comment above!

Introduction

Page 27883, line 4: Please use the latest paper of Pappalardo et al., AMT 2014 (EARLINET special issue, introductory paper) as a reference for EARLINET.

Page 27883, line 11: The appropriate reference for INDOEX is Ramanathan et al., JGR 2001, Introductory paper to INDOEX.

Page 27884, line 1: 12 Mhab is slang. . .., please improve

Page 27884, line 2: We need an improved aerosol-related reference for the ZOTTO tower, e.g., Heintzenberg et al., Mapping the aerosol over Eurasia from the Zotino Tall Tower, Tellus B 2013, 65, 20062, http://dx.doi.org/10.3402/tellusb.v65i0.20062

Section 2

Page 27885, line 22: Why not starting with a simple well-illustrated map, showing the route, the different countries, the different sites for your longer measurements, and the orography: mountains, may be desert areas etc. In this way the reader would become easily familiar with all detailed geographical information along the unique route of the journey.

Page 27886, line 8: Did you check the web page of the Leipzig lidar group for potential comparison? To my knowledge they conduct continuous lidar monitoring with a Raman lidar there. Could be used for comparison, may be to check the BER values and particle depolarization ratios.

Page 27887, line 7: Do we really need to start with the basic lidar equation? A clear:

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NO. . . from my side. Readers of ACP expect atmospheric results. All your theoretical framework is certainly well described elsewhere. So, please provide proper reference and keep all the methodoly sections as short as possible. Note, only if papers are short, compact, and highlight the main findings only, many people will read them.

Pages 27889-27890: The same here, the section should be skipped, the text is lengthy and boring and not needed. And by the way, even if the Raman method is based on the differentiation of equations, in practice all Raman lidar groups use data smoothing, least squares fits or filtering. This is really an old almost 20 year old story and need not to be repeated. You do not have to demonstrate in this paper that you are a lidar expert!

Pages 27891-27892: Again, these sections should be shortened. Provide proper references and then briefly mention all your steps of the methodology.

Pages 27893, section 2.3: The depolarization ratios are clearly of low quality. You obviously were not able to perfom +/- 45 degree measurements from time to time during the trip in order to check, day by day, the polarization lidar performance. This is critical in case of moving platforms (making measurements at dirty roads) with strongly varying temperature and humidity conditions in the reciever unit. Now I shall accept that all your polarization measurements are of high quality? Furthermore, as already mentioned above, the determination of the PDR at 355 nm is most critical. Experience shows that a proper 355nm PDR measurement is only possible down to low particle backscatter coefficients when they reach the Rayleigh backscatter values, so for backscatter ratios around 2, at least 1.5, but by no means down to values as low as 1.005. How did you came to this conclusion (1.005)? This is a so unrealistically low value!

Regarding proper 355 nm polarization lidar measurements, please have a look into the SAMUM paper of Freudenthaler et al. (Tellus, 2009). Freudenthaler has the highest experience with polarization lidars. His lidars in Munich have the highest quality standard possible. But for 355 nm, the PDR values of the Munich lidars have typical uncertainties of 20-50%! Even within pronounced dust layers close to the Sahara! So please come up with a realistic view on the quality of your PDR observations, and afterwards, just show the most reliable values (in mixed dust and pure dust layers)..... please come up with realistic uncertainties and a realistic range of backscatter ratios for which the PDR values of your lidar are roughly trustworthy.

Section 3

Page 27896, lines11....: PDR < 1%, nobody can measure that at 355 nm! All values in this paragraph are questionable!

Page 27896, line 24: PDR dust values at 355 nm are typically 25% or less (see papers of SAMUM papers of Freudenthaler et al. and Gross et al., Tellus, 2009, 2011). Your dust 355 nm PDR value of 37% for desert dust is clearly too high.

Page 27897, lines 17-22, all the BER or lidar ratio numbers, you present, are simply dangerous. Lidar ratio values of 171 sr!!! Who shall believe that? As already mentioned it is hard to find lidar ratios above 80sr in the literature. Even in such high aerosol pollution cases, the aerosol particles must be rather small and highly absorbing. And now you come with with values even a factor of 2 higher...., at conditions with omnipresent road dust (coarse particles), always mixed upward in the convective boundary layer. And then you state: mean value is 58 sr with a standard deviation of 41 sr. How is it possible to observed particle lidar ratios down to 20, 10 or even 0 sr..., over a polluted dusty continent, far away from any marine particle sources....? So, all this is simply not convincing, not trustworthy.

All in all, I do not have a good feeling with all the results presented. I was close to the point to recommend: rejection!

Page 27899: Again (and again) these large lidar ratios of 166 sr or these rather low PDR values = 0.5% to 1.3% or 1.7% or 1.8%, ... Not trustworthy at all!

Pages 27900-27902: Length and boring description... Please try to present a compact

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text, the shorter the better!

Section 4

Page 27903-27905: This section is ok, but please check all the numbers for BER, lidar ratio, PDR, I do not want to repeat all my statements above.

Page 27905-27906: section is boring, please keept the information short! I will discuss all figures below. . .. Who is interested in roughness lengths? Just state what the satellites observed over the arid regions!

Page 27906-27908: section 4.2 dust and biomass burning: There is a new paper of Nisantzi et al. (ACP, 2014). The authors discuss the possibility of soil dust injection into the atmosphere during biomass burning events. This option may hold even here, for Russia. Again check all the numbers for BER, lidar ratio, PDR. Provide a save discussion considering the large uncertainties in the values. Keep the discussion short and interesting, at the monent it is lengthy and cumbersome. . ..

Page 27909-27913: I stopped to read all this . . ., the text is simply too long, nobody is really interested in all these details.

Page 27912: Better references to 355 nm PDR: Freudenthaler et al. 2009 and Gross et al. in Tellus 2011 and ACP 2013-2014.

Page 27912: Besides Cattrall et al. 2005, there is now a much better AERONET paper on desert dust lidar ratios available: Schuster et al., ACP, 2012,

Page 27913: For Arabian dust lidar ratios, please have look into Mamouri et al., GRL, 2013, too.

Page 27914: for smoke-dust mixtures, again the hint on Nisantzi et al., ACP, 2014.

Page 27915-27916: Very long and exhausting, please shorten, provide the most interesting numbers and facts.

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Section 5

Rewrite later on the conclusions, after improving the paper.

Tables:

Table 1: As mentioned, please update the Table: Schuster et al., ACP, 2012, Mamouri et al., GRL, 2013, Gross et al., Tellus, ACP, 2011, 2012, 2013. . ..pure dust PDR values of 16-20% are simply wrong (at least misleading), these authors obviously measured mixtures of dust with smoke, urban haze and/or marine particles. . .

There are many lidar ratio papers over the Mediterranean (EARLINET) for dust: Amiridis et al., JGR, 2005, Mona et al., JGR 2006, Papayannis et al., 2008, and references therein. . ..

Table 1: Switch to lidar ratios, at least provide another column for lidar ratios.

Table 2: Please check the papers of Franke et al., GRL, 2001, and JGR 2003 for lidar ratios over the Indian Ocean during INDOEX. . .

Table 3: Mattis et al., JGR, 2004 summarized 355 nm lidar ratios for Leipzig (EARLINET period from 2000-2003), please have a look!

Figures:

The journey with the lidar is a unique story. Besides the requirement to check and discuss all the results and numbers carefully, an important point is to improve the figures significantly. At the moment, the figures are partly rather small, not readable, or simply of low quality. . ..

Figure 1: I would suggest to show a larger part of Europe and Russia, use a thick black line to indicate the route, stars (larger symbols!) can then be used to indicate main stations or cities.

The figure has simply to be improved, to make everything mode clear, more readable!

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Figures 2 and 3: We do not need such Figures in an ACP paper. Please concentrate on the essential findings.

Figure 4: Again, everything is so small, please enlarge the symbols. However, may be show the map as top plot, and below (bottom plot) show a bar chart for the optical depth, the length shows the AOT value. This is better than color coded small circles. Or use the layout for AOT as in Figure 4, at least color coded is not of advantage here.

Figure 5: Again, all the symbols are too small, you may better use clearly different symbols for PBL and FT, may be circles and crosses (or stars). Detailed information on PDR below 3% is useless.... What about linear scale?

Figure 6 for Extinction-to-backscatter ratio (so the inverse values of BER) would be better. 50% of all cases show lidar ratios above 66 sr! This is quite unusual. Are you sure that there is no overlap effect for the lowest 700 m of the atmosphere in your Raman lidar solutions so that the extinction values are overestimated or underestimated, when you correct for overlap effects. You have to correct for overlap effects, for sure! Do you know the overlap function?

Convincing would be to show case studies (lidar-photometer comparison) for several stable conditions.... around sunset or sunrise, ok we have Figure 8.

Figure 7: This figure is to my opinion useless, keeping the large uncertainty in all PDR values in mind, and here you show the range up to PDR = 6% only... I do not see a clear message!

Figure 8: again, rather small...

Figure 9: can be skipped.

Figure 10 All values below 1500m are rather questionable. Below 1500 m, all lidar ratios are between 100 and 200 sr or even higher. This is unrealistic. .... and puts a question mark to all values of the tour for heights below 1500 m.

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Figure 11 and 12 should be shown together (top plot and bottom plot).

Figure 13: These trajectory plots are not helpful. The information content is close to zero for readers. Why not simplify the message? Just show a few representative trajectories including height information as in these typical HYSPLIT plots and then indicate the desert areas, too. You do not have to demonstrate that you are a critical user and expert of trajectories. Please provide a clear message! .... is the most important task!

Figure 17: Again confusing and not helpful.

Interactive comment on Atmos. Chem. Phys. Discuss., 14, 27881, 2014.

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