Interactive comment on "Airborne high spectral resolution lidar observation of pollution aerosol during EUCAARI-LONGREX" by S. Groß et al.

Anonymous Referee #2
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We thank the anonymous reviewer for the useful comments and suggestions which help us to improve the clarity and scientific quality of this paper. The answers to the comments are given in a direct response (bold, italic).

The paper "Airborne high spectral resolution lidar observation of pollution aerosol during EUCAARI-LONGREX" by Gross et al. presents results from high quality data collected during an international measurements campaign. The data are undoubtedly valuable. The investigation about the intensive aerosol properties as lidar ratio and depolarization ratio, retrievable through an HSRL, is timely and appropriate as they are input parameters for the retrieval of optical properties by simply elastic backscatter lidar as CALIOP, the currently lidar on board CALIPSO satellite.

However, the collected data should be investigated in more details, discussion should be more appropriate and better referenced.

Authors refer to air masses satisfying the 3 criteria reported at page 26849 as "pollution" aerosol. This nomenclature is probably due to the assumption that everything is below a certain altitude (authors indicate 2.5 km asl, they should explain the choice of it or insert appropriate reference) is polluted. What about continental aerosols? The paper from Evans cited in this manuscripts report also values for the continental aerosols and Ferrare et al., JGR 2001 reported lidar ratio values for continental aerosols, even simulation studies are present in literature (e.g. Ackermann 1998)."Pollution" aerosol should be identified not only for the location but also as results of pollution events/sources. However, I suppose during this valuable campaign, many data from other instruments could support this pollution identification. Authors should refer to these data for a correct identification of polluted cases.
For filtering the HSRL measurements according to the 3 criteria stated in section 3.1 we used LAGRANTO trajectory analyses in combination with ECMWF data. This analysis is described in detail by Hamburger et al., 2012. Furthermore Hamburger et al., 2012 applied the trajectory analysis to in-situ observations performed onboard the FALCON aircraft. We inserted a reference to this publication. A direct comparison of scattering coefficients derived from HSRL and in-situ measurements was performed by Kulmala et al., 2011 which showed good agreement. We refer to this publication as well.
We inserted a reference to the simulation studies by Ackermann 1998. We did not consider the study of Ferrare et al., 2001 as they performed measurements at a different wavelength.

One study case is reported as example of the applied methodology and results, but related observations are not discussed in details. Some (not exhaustive) points that should be discussed would be: - measured values of lidar ratio and depolarization - altitude dependence of these values - which are the layers identified as "pollution" aerosol layers according to the 1-2-3 criteria reported in the manuscript?
We extended the description of our results concerning measured values and discussion on altitude dependence. Furthermore we indicated the pollution layers in the vertical profiles shown in Figure 7.

Figure 7 is not really readable. However, which are the "pollution" aerosol layers identified by the authors? Or the whole profile is considered for this study (for example fig 8).
We modified Figure 7 and indicated the corresponding aerosol layers considered as pollution layers.

Lidar ratio values reported by the authors for "pollution" aerosols are typically between 50 and 65 sr (Figure 9). Authors cited in the manuscript several papers about polluted aerosol values measured in different sites, values in fair agreement with the ones measured during this campaign. It is right mentioning that different aerosol types as dust, volcanic and continental aerosol also correspond to lidar ratio within this range of values. Lidar ratio therefore cannot be use alone for the typing of these types of aerosol. Authors should clearly state that lidar ratio at 1 wavelength is not sufficient for an accurate aerosol typing.

We agree; the lidar ratio (especially at only one wavelength) is not sufficient for an aerosol type classification. We removed the sentence "Previous studies show that the lidar ratio is a suitable measure to classify different types of aerosol (Müller et al., 2007; Mattis et al., 2004)" in the introduction. Furthermore we refer to the publication of Burton et al., 2012 and Groß et al., 2011, 2012, showing the potential of coordinated lidar ratio and depolarization measurements for aerosol type classification.

The reported particle depolarization ratio values (3-11%) are very low values, probably lower than the possible accuracy on it. So that, it is highly questionable a discussion in details about differences between 5% and 7%, but the only indication that these measurements could give about depolarization ratio is that for this "pollution" aerosol the depolarization ratio is low (typically below 10%).

We agree; in the discussion section of the presented work we did not intend to discuss differences between 5% (reported by Müller et al., 2007) and 7% (reported by Xie et al., 2008). We compare our measurements (mean values 5-8%; mean uncertainties 1-2%) with values of former measurements. The only conclusion we get is that considering the uncertainty range of the single measurements the differences are not significant and thus the results agree within the uncertainty range. We modified the text for more clarity.

The reported typical resolution of aerosol extinction and backscatter are significantly different. Are backscatter profiles correctly reported to the same resolution of aerosol extinction profiles for the determination of lidar ratio values? For the comparison/ discussion, lidar ratio and depolarization value have the same resolution?

The resolution of the backscatter measurements was reduced to the resolution of the extinction measurements for the determination of the lidar ratio. We modified the text for more clarity. For the comparison of lidar ratio and particle linear depolarization ratio we used the layer mean values.

I agree with referee #1, authors stated that there is no dependence on place for lidar ratio and depol values, but they did not analyzed this aspect. The altitude dependence was not analyzed as well. These are relevant aspects that could be addressed with the valuable dataset collected by the HSRL during the campaign.

We extended the section on general findings to discuss differences in the intensive aerosol properties found for the different days and different heights.

Finally, Conclusions are too strong and not well supported by the analysis reported in the manuscript. The no dependence on location and aerosol age are not well assessed; the "characteristic" values observed for this aerosol type are not compared to the other aerosol type. Authors should better address these points in the revised paper and correspondingly revise the conclusions section.

We modified the conclusion.

Specific comments

Abstract: “show virtually no variations” what does it mean virtually? However as referee 1 noted there are variations with the altitude case by case but this aspect is not investigated at all in the current version of the manuscript
See comment above.

Page 26845 line 26: typo Current Page 26845 “the retrieval of ...” not only extinction but also backscatter retrieval by simply elastic backscatter lidar needs for assumptions about lidar ratio. This should be better explained in the revised manuscript. Page 26846 please check the sentence ”Both quantities only depends on the particle properties of the aerosol type...”
We agree; not only the extinction profile but also the backscatter profile depends on the assumption of the lidar ratio. Therefore we changed the text to ‘The retrieval of vertical aerosol backscatter and extinction profiles relies on a-priori assumptions on the lidar ratio.’ We do not agree that a more detailed description of the lidar retrieval is necessary at this place. However, we inserted a reference to the paper of Wandinger et al., 2010 showing that a wrong assumption of the lidar ratio may cause large errors in the retrieved extinction profile and aerosol optical thickness. Furthermore we modified the sentence ‘Both quantities only depend on the aerosol type …’.

Page 26846-26847: statistical errors are reported regardless of the aerosol load.
The statistical errors are dependent on the aerosol load. However, for measurements capable for lidar measurements the typical statistical errors are in the range or even below the stated values. For the single measurement profiles in Figure 6 and7 the respective specific errors are calculated and shown. To give more information of the retrieval of the specific errors we refer to the publications of Esselborn et al., 2008 and Freudenthaler et al., 2009.

Please provide information about the altitudes and the typical aerosol load you are referring to.
We indicated the altitude range we used for the analysis in Figure 7.
Page 26849: “the observed air masses were transported from western directions...” if figure 2 reports backtrajectories it should be eastern directions, isn’t?
We corrected this typo.

Page 26849: about the case study see general comment above Section 3.2: colour ratio is used in CALIPSO retrieval scheme, but the backscatter related Angstrom exponent could be more suitable for a wider community use. Moreover the Angstrom exponent has the advantage to be less dependent on the wavelengths pair.
For the general comments see answers above.
We used the color ratio as it is a common property in lidar applications, e.g. the CALIPSO retrieval scheme. We agree with this reviewer that the Angstrom exponent is less dependent on extending the range of the considered wavelengths. But we do not think that this problem plays a major role in lidar applications as it is applied to a fixed wavelength range. Furthermore the Angstrom exponent can be easily retrieved from the color ratio.

Page 26853: which depolarization ratio value do you expect for marine aerosols? Add references
We expect a lidar ratio of about 3%. We included this in the text and added a reference.