Authors' response to Referee #4' comments

Paper No.: ACP-2014-1030

Title: Vertical variation of optical properties of mixed Asian dust/pollution plumes according to pathway of airmass transport over East Asia

We would like to give many thanks to you for the invaluable comments. We found your comments provided significant value to us in preparing the revised manuscript. The criticism and suggestions by you were appropriate and improved the quality of our manuscript. We therefore responded and will revise our original manuscript to address all of the concerns raised.

A point by point response is given below.

Thank you very much for reconsidering this manuscript

Anonymous Referee #4

General comments:

This paper describes dependence of optical properties of Asian dust observed with a multi-wavelength Raman lidar in Gwangju, Korea on the dust transport path. The paper presents interesting results on mixing of Asian dust and air pollution particles, and it merits publication in ACP. However, revisions are recommended.

Specific comments:

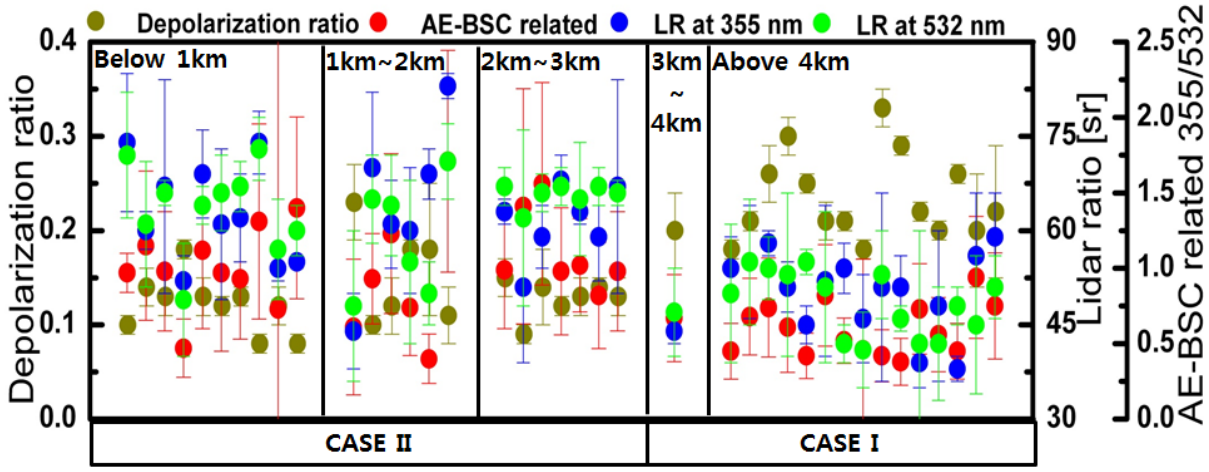
Fig. 8: There are no explanations of the solid lines in Fig. 8. They look misleading and should be removed.

Response: The line was supposed to show that we may not be able to find values to the right side and these lines seem to be tilted always in the same way. In any case of misleading this

line will be removed in the revised manuscript.

An analysis in a multi-parameter space would provide more information. In other words, it would be better to give the depolarization ratio, AE-BSC, lidar ratios at 532 nm and 355 nm, at the same time for each data point. It would be useful, for example, to put numbers to typical data points in Fig. 7 (and/or in Fig. 8) for identifying internally mixed cases, though it looks most of the data can be explained by external mixing. Internal mixing of Asian dust and air pollution particles is discussed in a recent JQSRT paper (Sugimoto et al., J. Quantitative Spectroscopy & Radiative Transfer 150 (2015) 107–113, http://dx.doi.org/10.1016/j.jqsrt.2014.08.003) They discussed using a depolarization ratio vs. backscattering color ratio plot. This paper might provide further information including the lidar ratios.

Response: The figure 7 will be changed reflecting your comment as below (the optical properties of Asian dust we observed is presented at the same time)



The corresponding values will be given in table 4. The caption for figure 7 has been changed as "Figure 10. (top panel) (a) transport path and classification of East Asian dust layers with respect to (b) their altitude above ground when they passed over industrial regions of China. (bottom panel) transport path and corresponding altitude of Asian dust layers are distinguished by color. (black: 0 km – 1 km; green: 1 km – 2 km; purple: 2 km – 3 km; blue: 3 km – 4 km; red: above 4 km). Scatter plots of the linear particle depolarization at 532 nm (dark yellow), the backscatter-related Ångström exponent (355/532 nm wavelength pair, red), the lidar ratio at 355 nm (blue), the lidar ratio at 532 nm (green) in dependence of the 5

altitude categories (c). The height of the Asian dust layers above ground is separated by vertical lines. Case I included the layers from 3 – 4 km and above 4 km. Case II includes the layers from 0 - 1 km, from 1-2km, and from 2-3km height above ground.
"

To explain the state of mixing (internal or external)

The statement "The optical properties of Asian dust layer observed in our study reflect mixtures between different aerosol types. We notice that these variations of the optical properties of Asian dust layers may not only result from external mixing. Hygroscopic growth, aging and deposition during transport, and internal mixing might be also affect dust properties (Burton et al., 2014). The interpretation of the mixing state of Asian dust is a challenging task. The mixing state depends on many variables which are poorly known. Sugimoto et al. (2015) tried to identify the mixing state of Asian dust (internal mixing or external mixing) by using analytical relationships inferred from lidar observation. However, we will not go into details here. We assume that most of the Asian dust observed in this study was externally mixed." will be added in revised manuscript

The references to support this statement will be added in the revised manuscript as

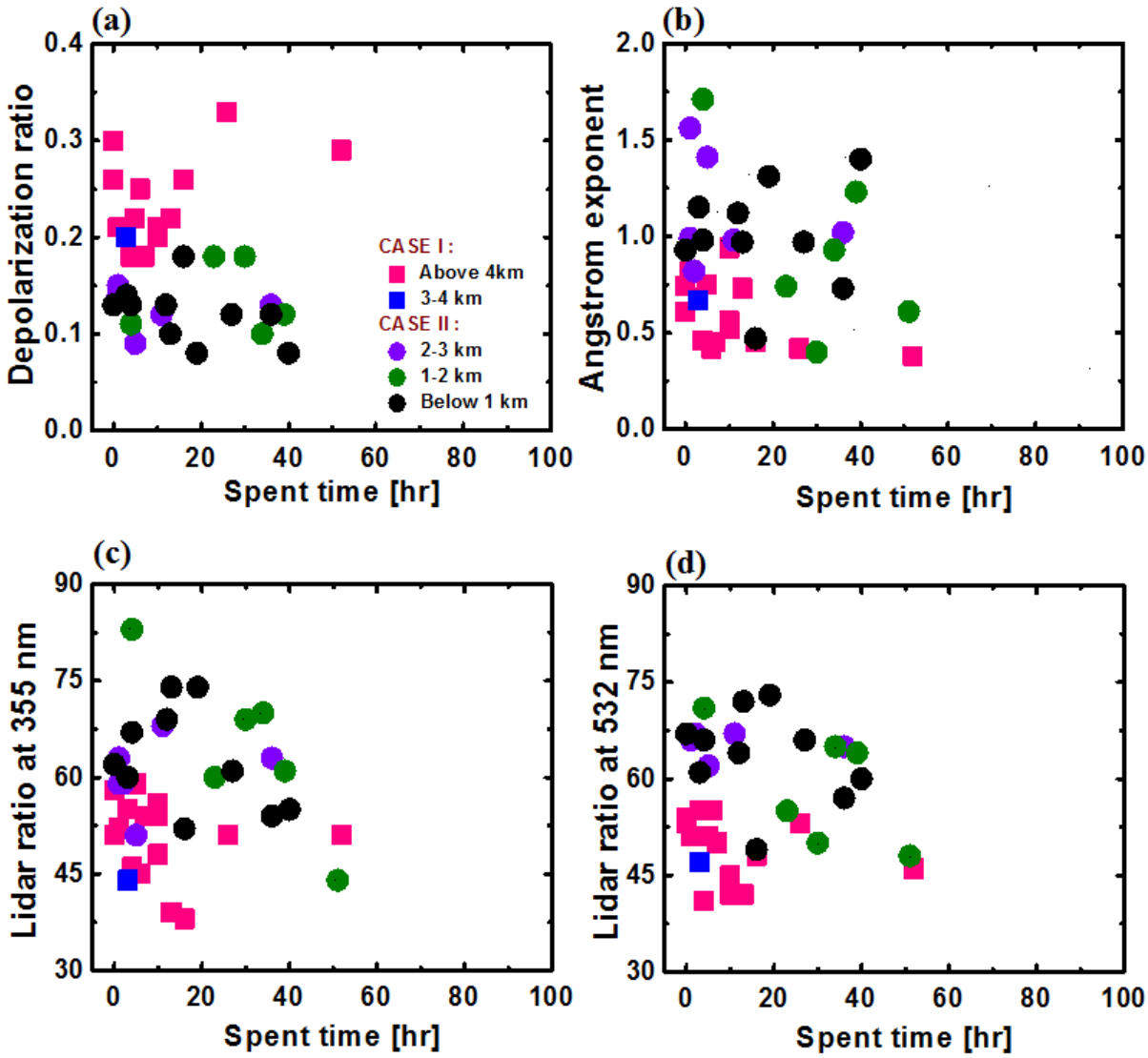
Burton, S., Vaughan, M., Ferrare, R., Hostetler, C.: Separating mixtures of aerosol types in airborne High Spectral Resolution Lidar data, Atmospheric Measurement Techniques, 7, 419-436, 2014.

Sugimoto, N., Nishizawa, T., Shimizu, A., Matsui, I., and Kobayashi, H.: Detection of internally mixed Asian dust with air pollution aerosols using a polarization optical particle counter and a polarization-sensitive two-wavelength lidar, Journal of Quantitative Spectroscopy and Radiative Transfer, 150, 107-113, 2015.

It would be better to plot the data in the lower heights in the foreground in Figs. 7 and 8.

Response: Figure 7 will be changed as shown earlier and figure 8 also will be changed

reflecting your comment as below, (the data in lower height has been moved in the foreground)



The depolarization ratio is defined by (Pperpendicular/(Ppaerpendicular+Pparallel)) in this paper. However, some of the authors of the cited papers use the (Pperpendicular/Pparallel) definition. It seems they are mixed in the manuscript. More accurate descriptions are required, and the values must be converted if needed.

Response: We agree with the reviewer. We used P/(P+S) as depolarization parameters and some of the author we cited used (P/S). As shown in Cairo et el., (1999) "Comparison of various linear depolarization parameters measured by lidar" published in optical society of

America, These two parameter has the advantage of requiring little processing on the raw signals. And the values of different depolarization ratio are not that large however, more descriptions are needed .

The statement "The $\boldsymbol{\delta}$ can be also defined as $P_{\perp}/P_{\parallel}$ (Cairo et al., 1999). We calculated the $\boldsymbol{\delta}$ by using both definitions and compared the difference between the derived values. The results from each individual definition agree within the uncertainty of our depolarization ratio measurements (Tesche et al., 2009; Shin et al., 2013)." will be added from line 148 to 153 of the revised manuscript to prevent any misleading.