Authors' response to Editor's 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

Dear Professor Matthias Tesche,

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. 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 helping to improve this manuscript.

Editor's comments

Minor comments:

Make sure to give the unit sr whenever values of the lidar ratio S are presented

Response: The unit (sr) for lidar ratio in whole manuscript including abstract has been added.

Clarify that you refer to the linear particle depolarization ratio where appropriate ; particularly in the introduction and the methodology section.

Response: We agree with your comments. The statement "In this contribution we used the linear particle depolarization ratio to these dust layers." will be added up in line 112 of revised manuscript to clarify that we used the linear particle depolarization ratio. (Introduction section)

and we have clarified that we use the linear particle depolarization ratio in this contribution as the sentence in line 195 (Methodology section) as "In this contribution we use the linear

particle depolarization ratio ($\delta_{p)}$ according to the definition by Shimizu et al. (2004):"

Figure 3e-f and 10-ab present exactly the same thing. The latter is more useful due to the color coding of the height level. I suggest to omit Figure 3e-f and to revise the discussion accordingly.

Response: We agree with your comments. The figure 3e and 3f will be removed. The corresponding explanation at line 265will be changed as "Figure 3 shows the frequency distribution of δ_p, S, and $Å_\beta$ of Asian dust plumes observed during the observation period." and "see fig 3" will be removed at line 282 in the revised manuscript.

The corresponding caption for figure 3 is revised as "Figure 3. Frequency distributions of optical properties of Asian dust observed between 2009 and 2013. Shown are (a,b) lidar ratios at 355 and 532 nm, (c) linear particle depolarization ratios at 532 nm, and (d) Ångström exponents for the wavelength pair 355/532 nm. The numbers in each plot indicate the mean value and its standard deviation, the median (shown in brackets), and the minimum and maximum value of each distribution."

Line 137 : I am aware that one reviewer wanted to see frequency distributions of your results. Nevertheless, I think that Figure 7,9, and 11 could be omitted. They add no extra value to the paper as they are just referred to in the text but not really discussed. In addition, basically the same information is transported in Tables 103. These could be combined to a single comprehensive table that summarizes all findings. If you decide to omit the figures, please don't forget to also omit the lines referring to these figures.

Response: We agree with your comments. The figure 7,9, and 11 will be removed. The corresponding sentences in the manuscript will be also removed. The number of figure in caption and main script will be re-ordered.

The new table which summarize the all results from each classification will be added up as below

Classification		Number of observed layers	δ_p	*S* [sr]		$Å_\beta$
				355 nm	532 nm	
Pollution level[(a)]	Less Polluted	25	0.17±0.02	57±7	55±7	0.82±0.37
	More Polluted	13	0.17±0.02	58±6	59±8	0.89±0.38
Vertical positon[(b)]	Case I	16	0.21±0.06	52±7	53±8	0.74±0.31
	Case II	22	0.13±0.04	63±9	62±8	0.98±0.35
Pollution leve & Vertical position[(c)]	LP_below 3 km	12	0.13±0.03	64±9	62±8	1.00±0.38
	LP_above 3 km	13	0.21±0.05	51±8	49±9	0.65±0.20
	MP_below 3 km	8	0.13±0.04	61±10	64±7	1.09±0.30
	MP_above 3 km	5	0.24±0.05	53±5	53±2	0.58±0.14

The caption for table 1 will be changed in revised manuscript as

"Table 1. Summary of the linear particle depolarization ratio at 532 nm, lidar ratios, and backscatter-related Ångström exponents of Asian dust layers for each classification. Asian dust layers were classified according to (a) levels of anthropogenic pollution emission; LP denotes that Asian dust layers which are considered as less polluted and MP denotes that Asian dust layers which are considered as more polluted, (b) their vertical position at polluted region; Case I indicates Asian dust layers passed over China at high altitude (> 3km) before they arrived over Gwangju, and Case II indicates Asian dust layers were transported at low altitude (< 3km) over industrialized areas before they arrived over Gwangju, and (c) their vertical position (below 3 km or above 3 km) and level of pollution (LP or MP) when they passed over China"

The number for table will be re-ordered. The corresponding sentence for the explanation of table will refer to table 1.

The table style will be unified as

Height of dust layer at pollution regions		Number of observed layers	δ_p	*S* [sr]		$Å_\beta$
				355nm	532nm	
Case I	Above 4km	14	0.23±0.02	50±7	49±8	0.60±0.27
	3km-4km	1	0.20±0.04	44±2	47±7	0.67±0.29
Case II	2km-3km	7	0.13±0.02	61±7	66±5	1.11±0.47
	1km-2km	6	0.15±0.03	65±7	59±9	0.94±0.42
	Below 1km	10	0.12±0.01	63±7	64±6	1.00±0.43

line 275-279 : I guess the intention of this paragraph is to discuss the occurrence of situations that are different from pure-dust conditions. Please reformulate if that is the case. Otherwise it is not clear where the chosen ranges of values come from

Response: You are correct. The paragraph will be reformulated as

"In contrast with these values, low values of δ_p and high values of S and $Å_\beta$ are also measured. We find that the minimum value of δ_p is 0.08 at 532 nm. The maximum values of of S at 355 nm and 532 nm are 83 sr and 73 sr, respectively. The maximum value of $Å_\beta$ is 1.71. These values are remarkably different from the values of optical properties of pure dust."

Specific comments:

line 50: …at which these…

Response: It will be changed in line 50 of revised manuscript.

line 51: give the height used to separate between high and low altitude levels

Response: It will be changed as "at high altitude levels (< 3 km) until arrival over Gwangju, and (case II) the Asian dust layers were transported near the surface and the lower troposphere (> 3 km) over industrialized areas before they arrived over Gwangju." in revised manuscript.

line 53: …within the lower…

Response: It will be changed in line 53 of revised manuscript.

line 58: …for case I…

Response: It will be changed in line 58 of revised manuscript.

line 59: …lower linear particle depolarization ratios… The numbers presented in the following sentence could be included in this statement.

Response: The statement will be changed as
"In contrast, plumes transported at lower altitudes (case II) showed low depolarization ratios (0.13±0.04 at 532 nm), and higher lidar ratio (63±9 sr at 355 nm and 62±8 sr at 532 nm) and Ångström exponents (0.98±0.51)." in line 59 of revised manuscript.

Line 113:omit last sentence of paragraph, the information has been given before

Response: You are correct. The sentence "We also categorize the optical properties of these pollution plumes according to their transport pathway and their vertical distribution." will be removed.

Line 126 and 150:add respectively to end of statement

Response: The word will be added up in line 125 and line 149 of revised manuscript.

Line170:is this the proper reference?

Response: Yes, I refer "Bohren, C. F., and Huffman, D. R.: Absorption and scattering by a sphere, Absorption and Scattering of Light by Small Particles, 82-129, 1983"
(2008) was new edition version of this book.
In order to avoid any misleading, I changed the year which was published for the first time and the added the reference above in the reference section in the revised manuscript.

Line 179: I guess you are referring to another paper of Tesche et al. published that year. Please clarify if you mean: Tesch, M., Ansmann, D. Muller, D. Athausen, R. Engelman, V. Freudenthaler, and S. Groβ (2009), Vertically resolved separation of dust and smoke

over Cape Verde by using multiwavelength Raman and polarization lidars during Saharan Mineral Dust Experiment, J. Geophys. Res., 114, 2009JD11862.

Response: You are correct. The reference "Tesche, M., Ansmann, A., Müller, D., Althausen, D., Engelmann, R., Freudenthaler, V., and Groß, S.: Vertically resolved separation of dust and smoke over Cape Verde using multiwavelength Raman and polarization lidars during Saharan Mineral Dust Experiment 2008, Journal of Geophysical Research: Atmospheres (1984–2012), 114, doi:10.1029/2009JD011862, 2009." has been in the reference section in revised manuscript.

Line180: there should be earlier papers that describe this fact

Response: The reference will be replaced with "Murayama et al., 2003"

and the reference "Murayama, T., Masonis, S. J., Redemann, J., Anderson, T. L., Schmid, B., Livingston, J. M., Russell, P. B., Huebert, B., Howell, S. G., and McNaughton, C. S.: An intercomparison of lidar-derived aerosol optical properties with airborne measurements near Tokyo during ACE-Asia, Journal of Geophysical Research: Atmospheres (1984–2012), 108, doi: 10.1029/2002JD003259, 2003." will be added in revised manuscript.

Line 183: is this the proper reference? It seems unnecessary.

Response: The reference (Somekawa et al., 2008) will be removed in revised manuscript.

Line 199: omit and bandwidth. It's the interference filter that count here

Response: The word has been removed as "The term δ_m is the linear depolarization ratio of air molecules at the wavelength of the emitted laser wavelength." at line198 of revised

manuscript.

Line 205: omit Tesch et al. (2009) and

Response: It has been removed in revised manuscript.

Line 216: do Burton et al. (2013) present observations of Asian dust

Response: Burton et al., don't measured the optical properties in Asia, They summarized the values of optical properties of Asian dust for the comparison the values of optical properties of dust measured over the U.S. I realized that the reference regarding Burton et al doesn't match in this sentence. It will be removed at line 215 in revised manuscript.

Line 305: give the dates also in the text

Response: The sentence "Figure 4 shows the distribution of aerosol optical depth (AOD) at 550 nm for dust and anthropogenic pollution on 10 April 2010 and 8 March 2013." will be added up in line303 the revised manuscript.

Line 460: It is confusing to refer to a figure without discussing it right away. I suggest replacing this sentence with: We also investigated the optical properties of Asian dust with respect to transport time at different height levels.

Response: The statement you suggested "We also investigated the optical properties of Asian dust with respect to transport time at different height level." will be added up at line453 in the revised manuscript.

Line 552: add …downwind of the source regions. To the end of the sentence

Response: The sentence will be replaced as "In this study we presented the differences of optical properties of mixed Asian dust layers in dependence of their vertical position over China during transport from the Chinese dust source regions to Korea, downwind region of

the source regions.” in line522 of the revised manuscript.