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Atmospheric Chemistry and Physics
Discussions

Interactive comment on "Depolarization Ratios Retrieved by AERONET Sun/Sky Radiometer Data and Comparison to Depolarization Ratios Measured With Lidar" *by* Youngmin Noh et al.

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We responded to all the comments by the reviewer. The criticism and suggestions by the reviewer were appropriate and improved the quality of our manuscript. We appreciate such efforts.

Authors' response to reviewers' comments

Paper No.: acp-2016-1181 Title: Depolarization Ratios Retrieved by AERONET Sun/Sky Radiometer Data and Comparison to Depolarization Ratios Measured With Lidar

Revision of the paper

Reviewer #2 General comments This article addresses a problem of dust particles detection in the atmosphere, which is of high interest of scientific community. A new method for quantitative estimation of dust presence based on particle depolarization ratio retrieved from AERONET inversion is suggested. Authors made significant efforts to evaluate the AERONET retrieved particles depolarization ratio by comparing them with ones measured with lidar. To do so a vertical profile of particle depolarization ratio retrieved from lidar measurements is column-integrated using a weighting function. To my knowledge this work shows one of the few positive results of such comparison. I would recommend this paper for publication, given that authors will address the issues listed below.

Specific comments 1. The general idea of evaluating depolarization ratio retrieved from AERONET by comparison with lidar retrieved values implies that lidar retrievals are well evaluated. I think that such implication is not properly supported in the paper. : As reviewer suggested, description of the depolarization ratio calibration has been included in the revised manuscript in the line from 218 - 234. "In order to obtain reliable depolarization ratios, the data of the lidar measurements must be calibrated before physical quantities such as the linear volume depolarization ratio can be retrieved. It is important to calibrate the signal intensities of the and first, before the linear volume depolarization ratio is calculated. Thet calibration method of the lidar system is explained in detail by Shimizu et al. (2017) and Nishizawa et al. (2017). The difference of the sensitivity between two PMTs that are used by the lidar system to detect these components is checked regularly by the following method. A sheet polarizer whose polarizing direction is set at 45° to the polarizing plane of the emitted light is inserted in front of the beam splitter cube, and the backscatter signal from the sky is recorded as a reference signal. In this reference record, the light intensities of the two channels are equal after the sheet polarizer, so the calibration constant can be obtained by comparing the recorded values of and . In the next step, the sheet polarizer is rotated by 90° which sets the polarizing angle at −45°, and another reference signal is recorded. Then relative calibration of and channels using signals measured for the polarizing angles at

± 45°. This pair of reference signals reduces any error caused by a poor positioning of the sheet polarizer (Freudenthaler et al., 2009; 2016). The reference signals are usually recorded once per year for each lidar (Shimizu et al., 2017)."

2. The depolarization ratio defined from AERONET retrievals by eq. 1 has a meaning of . Justification needed why this parameter is compared with one retrieved from lidar (eq. 4), which is not the same physical value. : The depolarization ratio by lidar measurements can also calculated according to . The previous expression of is changed to .

3. Page 11. Line 217. Molecular depolarization ratio is system dependent it is not clear if the value 0.0044 provided by Behrendt and Nakamura suits the lidar system used. : The molecular depolarization ratio of 0.0044 can be used to the optical filters with very small bandwidth and measure almost only central Cabannes line of Rayleigh scattering. It is for that reason that the value of 0.0044 is not the correct value. We checked the related thing and the value of 0.014 was applied in the research. We applied 0.014 in the calculation of depolarization ratio, but it is our mistake to have 0.0044 in the manuscript. It has been corrected.

4. Page 11. Formula 7. From the description it is not clear how aerosol backscatter coefficient is "measured". Was Raman or Klett technique used? If Klett, which lidar ratio was assumed? If Raman, which angstrom was used? Do these values suit dust particles? Also it is not clear how their selection influences the column-integrated depolarization ratio estimated from lidar, if any of the methods was applied. : The backscatter coefficient was calculated by Fernald's method. And the lidar ratio of 50 sr is applied in the calculation. The value of the lidar ratio is important to calculate the exact value of the aerosol backscatter and extinction coefficients. However, the aerosol backscatter coefficient was used to obtain the ratio of the vertical distribution of aerosols in this research. The related explanation was added in the manuscript in line 261-272. "The aerosol backscatter coefficient is derived by the backward version of Fernald's method (Fernald, 1984). The data observed at 9 km height are used as

reference height for the analysis of data taken under cloud-free conditions. The reference height is lowered if the signal-to-noise ratio at 9 km is not sufficient which may be the case of high aerosol concentration. Molecular density profiles are taken from the COSPAR international reference atmosphere (CIRA-86) for computing the Rayleigh scattering component. A constant lidar ratio of 50 sr is applied in the calculation of the aerosol backscatter coefficients (Shimizu et al., 2017). Since the lidar ratio differs for different aerosol types, the selection of the lidar ratio is important to obtain exact values of extinction and backscatter coefficients. However, we only use the ratio of the backscatter coefficient in the calculation of W(z) in our study. For that reason, the value of the lidar ratio does not affect the calculation of W(z)."

Technical issues

Page 2. Line 42-43. "Decreases with increasing" and "In contrast … increases with decreasing" describe the same situation. Should be "increases with increasing", I presume. : As reviewer suggested, the sentence " increases with decreasing" has been changed as " increases with increasing" in the revised manuscript.

Page 3. Line 67. "global atmosphere", I think simple "atmosphere" would be enough. : "global" has been removed in the revised manuscript.

Page 4. Line 76. "desert dust and other anthropogenic …". Usage of "other" implies that dust I s also anthropogenic, consider removing it. : "other" has been removed in the revised manuscript.

Page 4. Line 78 & 80. "typical radius" instead of "typically". : It has been changed as reviewer suggested.

Page 4. Line 83. "we'll" instead of "we" for conditional clause. : It has been changed as reviewer suggested.

Page 4. Line 90. Space is missing in "lidar.The" : It has been corrected.

Page 14. Lines 296–299. "Values of …from both instruments". It is not clear that authors are discussing results of Muller et al 2012. : It has been changed as below in the revised manuscript in line 416 - 421. "Müller et al. (2010; 2012) compared those data with data derived from collocated AERONET Sun/sky radiometer observations. Values of from both instruments agree at 1064-nm wavelength (Müller et al., 2010; 2012). If the Sun/sky radiometer results are extrapolated to the lidar wavelength of 355 nm, the value of obtained from the Sun/sky radiometer is 20 % lower than the value obtained from the lidar observations, see Figure 3 in Müller et al. (2010) and Figure 7 in Müller et al. (2012)."

Page 17. Description of figure 7. Figure 7 shows AERONET results and it is not indicated neither in the figure description in the text neither in the figure caption. : The text "derived from the AERONET sun/sky radiometer measurements" has been added in the revised figure 7 caption.

Page 18. Line 368-369. Whole sentence "Dust particles are. . ." has no logical connection with the main paragraph describing optical properties of desert dust, consider removing. : It has been removed in the revised manuscript.

Page 18. Line 382-383. "Except for SSA at 440 nm . . ." and "at each wavelength" in the same sentence are in logical contradiction. Consider reformulating or deleting "each wavelength". : " at each wavelength" has been removed in the revised manuscript.

Page 20. Line 427. Description of the table containing abbreviations, and some of them (CMF) are not referenced earlier in the text. Please, indicate the meanings of symbols. : It has been corrected.

Page 21. Line 447. "and/or a higher" change to "and/or by a higher" : It has been corrected.

Page 22. Line 474. ". . .by the mixing of pollution . . .", maybe ". . . by the presence of pollution . . ." instead. : It has been corrected.

Page 27. Line 576. "The average .. decreases as .. increases ". This phrase is too

general. It is true for the values of Rvs and particle type discussed in the text, but generally the dependence is not monotonous. Consider reformulating. :The relationship between volume median radius and retrieval has been newly discussed in section 3.1. in the revised manuscript. We can know through the discussion that volume median radius of fine-mode is strongly influencing at 440 nm. But, the volume median radius of coarse-mode is less affected than the fine-mode median radius. For that reason, we removed the sentence "The average Rvc decreases as increases." in the revised manuscript.

Figure 3. AERONET does provide AOD at 500nm, but it is not "measured", it is "estimated" (or "retrieved") from measurements at 440, 670, 870 and 1020nm. : Figure 3 caption has been changed.

Figure 6. Is it possible to make plots bigger? And since the plots are referenced by the number of the group, maybe, it'll be more logical to name plots 1a, 1b, 1c. . . 6a, 6b, 6c rather than a1, a2, a3, ... f1, f2, f3. : It has been changed as reviewer suggested.

Figure 7. Please, mention in caption that SSA and SD are from AERONET. : The figure caption has been corrected as "Average value of the SSA and the volume particle size distributions derived from the AERONET Sun/sky radiometer measurements for each of the 6 groups considered in this study: group 1 (black), group 2 (red), group 3 (blue), group 4 (pink), group 5 (gray), and group 6 (orange)."

Figure 9&11 Why only these figures have error bars? They are not discussed or mentioned in the text, are they necessary? : The error bars have been removed in the revised manuscript.

Figure 12. Please, put legend "case 1" and "case 2" on the plots. : It has been added.

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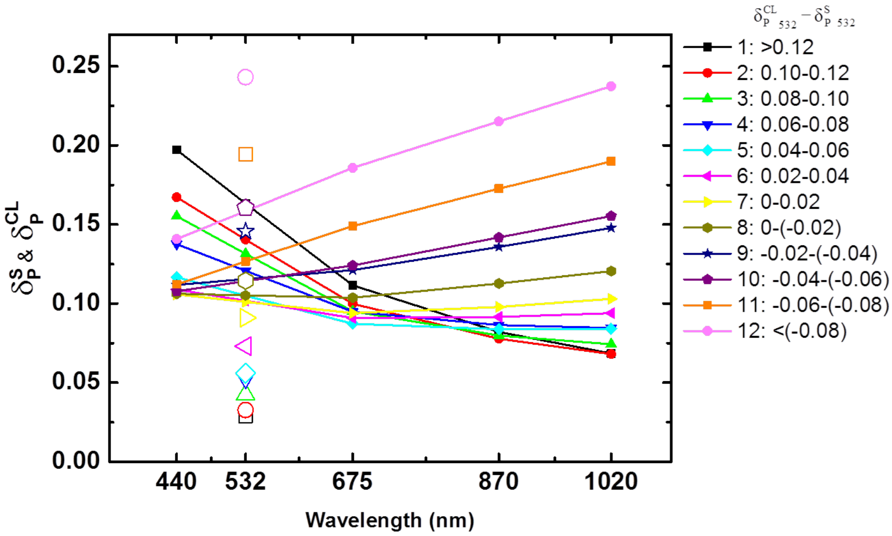
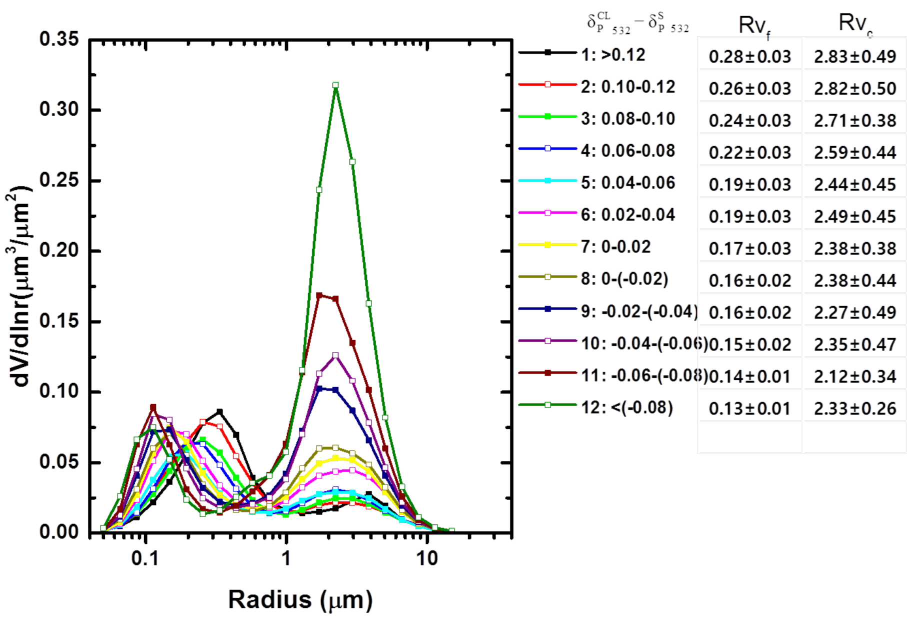


0.25
0.20
0.15
0.10
0.05
0.00
440
532
675
870
1020
Wavelength (nm)
1: >0.12
2: 0.10-0.12
3: 0.08-0.10
4: 0.06-0.08
5: 0.04-0.06
6: 0.02-0.04
7: 0-0.02
8: 0-(-0.02)
9: -0.02-(-0.04)
10: -0.04-(-0.06)
11: -0.06-(-0.08)
12: <(-0.08)

Fig. 1.



0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
dV/dlnr(μm³/μm²)
0.1
1
10
Radius (μm)
Rv_f
Rv_c
1: >0.12 0.28±0.03 2.83±0.49
2: 0.10-0.12 0.26±0.03 2.82±0.50
3: 0.08-0.10 0.24±0.03 2.71±0.38
4: 0.06-0.08 0.22±0.03 2.59±0.44
5: 0.04-0.06 0.19±0.03 2.44±0.45
6: 0.02-0.04 0.19±0.03 2.49±0.45
7: 0-0.02 0.17±0.03 2.38±0.38
8: 0-(-0.02) 0.16±0.02 2.38±0.44
9: -0.02-(-0.04) 0.16±0.02 2.27±0.49
10: -0.04-(-0.06) 0.15±0.02 2.35±0.47
11: -0.06-(-0.08) 0.14±0.01 2.12±0.34
12: <(-0.08) 0.13±0.01 2.33±0.26

Fig. 2.

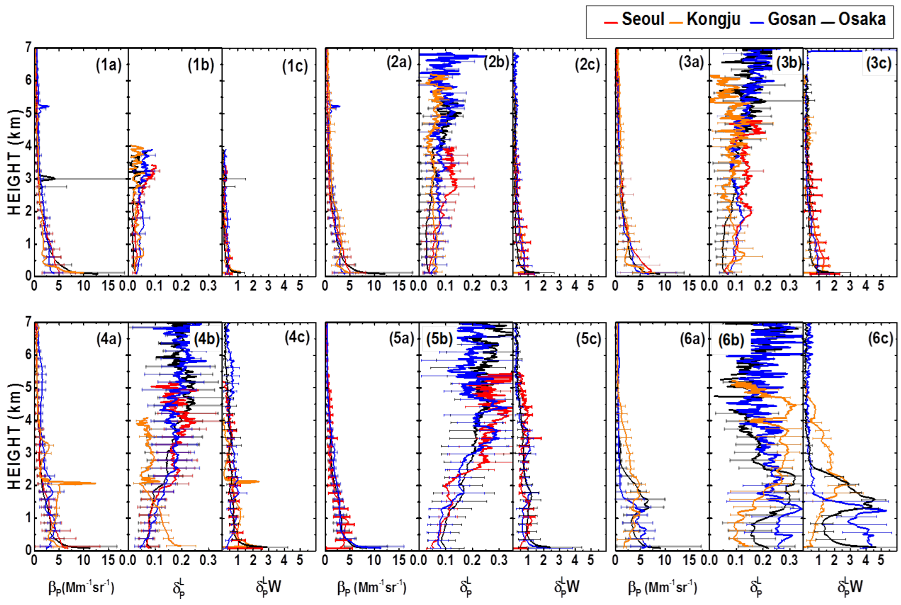

Seoul
Kongju
Gosan
Osaka
HEIGHT (km)
(1a)
(1b)
(1c)
(2a)
(2b)
(2c)
(3a)
(3b)
(3c)
(4a)
(4b)
(4c)
(5a)
(5b)
(5c)
(6a)
(6b)
(6c)
β_P(Mm^{-1}sr^{-1})
δ_P^L
δ_P^LW

Fig. 3.

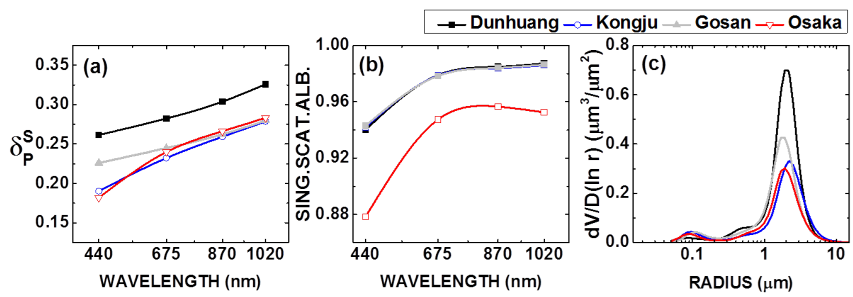

Dunhuang
Kongju
Gosan
Osaka
(a)
(b)
(c)
δ_P^S
WAVELENGTH (nm)
SING.SCAT.ALB.
dV/D(ln r) (μm^3/μm^2)
RADIUS (μm)

Fig. 4.

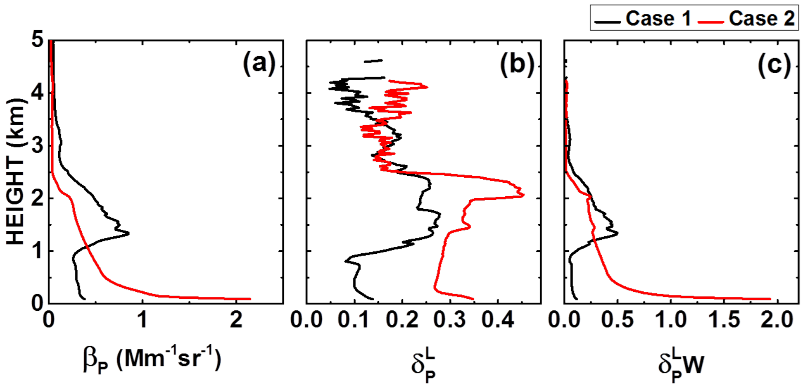

Case 1
Case 2
(a)
(b)
(c)
HEIGHT (km)
β_P (Mm^{-1}sr^{-1})
δ_P^L
$\delta_P^L W$

Fig. 5.

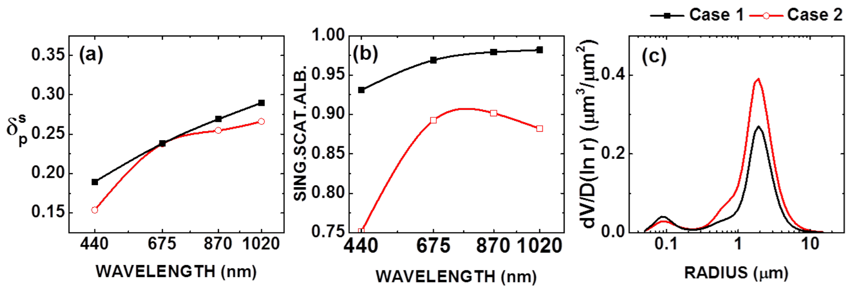

Case 1
Case 2
(a)
(b)
(c)
δ_p^s
WAVELENGTH (nm)
SING.SCAT.ALB.
WAVELENGTH (nm)
dV/D(ln r) (μm^3/μm^2)
RADIUS (μm)

Fig. 6.

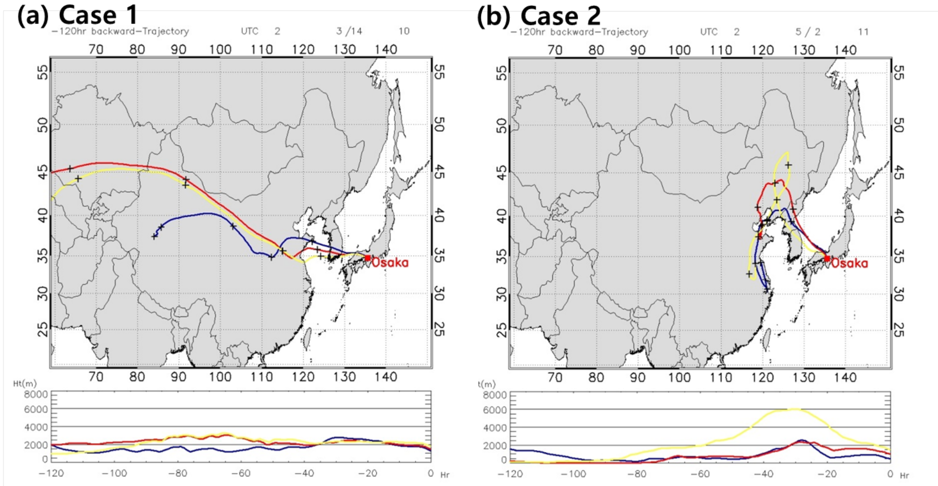

(a) Case 1
−120hr backward−Trajectory UTC 2 3 /14 10
Osaka
Ht(m)
Hr
(b) Case 2
−120hr backward−Trajectory UTC 2 5 / 2 11
Osaka
t(m)
Hr

Fig. 7.