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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

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Discussion paper

Reviewer #3

General comments: The manuscript describes the results of comparing aerosol column value of particle linear backscatter depolarization ratio retrieved from AERONET sun-radiometer measurements, , and its direct measurements by lidar, , as well as detailed analysis of the relationship between the parameter and the characteristics of the aerosol dust fraction. The results of this work can be implemented in observations of Asian dust transport. Evaluation of aerosol depolarization ratio, , from AERONET measurements of direct and scattered solar radiation is the result of solving of “ill-posed” inverse problem. Correlation coefficients between and characterize the uncertainties of parameter . It is useful information to improve the algorithms for processing data of complex experiments with employment of sun-radiometers and lidars. I consider this paper to be a good and useful work and suggest to public it with some corrections.

Specific comments: 1. 1. The term "linear backscatter depolarization ratio" is used in the scientific literature to denote two similar but not identical parameters: the ratio of the backscatter perpendicular intensity to the parallel intensity, as well as the ratio perpendicular to the total backscattering intensity. The relationship between these quantities is nonlinear and for large depolarization the difference between parameters is significant. Therefore, at the beginning of this manuscript (in Abstract) it should be specified which parameters are used for characterization of radiometric and lidar data. : We used the same physical meaning (the backscatter perpendicular intensity to the parallel intensity) in the data retrieval. The depolarization ratio by lidar measurement is also calculated by a meaning of . The previous expression of is changed as in the revised manuscript.

2. The question of the causes of the differences in depolarization evaluations, made from the results of radiometric and lidar measurements, is of interest. What part of these differences is caused by instrumental measurement errors? : The lidar measured depolarization ratio is directly measured by backscatter signal. But, depolarization ratio retrieved by AERONET sun/sky radiometer measurement is the result of

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Discussion paper

solving of “ill-posed inverse problem” as reviewer commented. Although the lidar measured depolarization ratio has systematic errors, the value is closed to real value. But, AERONET sun/sky radiometer data has not been verified yet. In that reason, we try to verify the reliability of AERONET-derived depolarization ratio by comparing lidar data. AERONET-derived depolarization ratio at 1020 nm shows high correlation with lidar-derived depolarization ratio at 532 nm. But, AERONET-derived depolarization ratio at 440 nm shows low correlation. The explanation for the reason of these differences between AERONET-derived depolarization ratio at 440 nm and lidar –derived depolarization ratio at 532 nm has been newly added in the revised manuscript in line 325 - 388. “We tried to find the reason for the comparably low correlation at 440 nm. For that reason, we retrieved the at 532 nm by interpolating the value of at 532 nm on the basis of the four AERONET wavelengths. In the next step the differences between and at 532 nm ( ) were calculated by deducting (at 532 nm) from (at 532 nm) for all 580 cases for which we have at the four AERONET sites. The values of were varied from 0.14 to -0.09. In the following step the data were sorted according to the differences of . In the final step we divided these differences into intervals of 0.02, i.e. 1: >0.12, 2: 0.10 - 0.12, 3: 0.08 - 0.10, . . ., 11: -0.06 – (-0.08), 12: <(-0.08). Figure 5 shows the variation of the averaged at the five wavelengths and the values of at 532 nm divided by the differences of . The differences of between the wavelengths at 440 nm and 1020 nm are high. We find that decreasing of with increasing wavelength if the value of is low. The differences between at 440 nm and at 1020 nm become less for increasing interval number, i.e. for the interval number 7 (0 - 0.02); i.e. the yellow triangle pointing to the right . The value of at 532 nm shows lower values than at 1020 nm in those intervals. The differences between at 532 nm and at 1020 nm are reduced as the is decreased up to the interval number 7 (0-0.02). We find an increasing of with increasing wavelength from the interval number 8 (0-(-0.02)) . The value of at 532 nm is larger than the value of at 1020 nm in the interval number 8 (0-(-0.02)). Also, the differences between at 532 nm and at 1020 nm as the interval number increased.. If we assume that the value of at 532 nm is close to real value of , the results in Figure 5 indicate that

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the at 440 nm has been retrieved to be higher value than the at 532 nm in the interval number from 1 (>0.12) to 7 (0-0.02) when the at 532 nm showed low values (less than 0.08). Conversely, when the high at 532 nm was measured, the at 440 nm showed a lower value than the at 532 nm. Figure 6 shows the average of volume particle size distributions of each interval data as separated in Figure 5. We see that the volume size distributions change from fine-mode dominated size distributions to coarse-mode dominated size distributions when the interval number moves from 1 (>0.12) to 12 (<(-0.08)). The important point of Figure 6 is the variation of the volume median radius (Rv). The volume median radius of the coarse (Rvc) and the fine (Rvf) mode shows a maximum value at the interval number 1 (>0.12). Rvf clearly and progressively decreases as the interval number moves from 1 (>0.12) to 12 (<(-0.08)). The Rvf of the interval number 1 (>0.12) is two time larger than the interval number of 12 (<(-0.08)) as 0.28 ± 0.03 μm and 0.13 ± 0.01 μm, respectively. Rvc also shows a pattern of decreasing values with decreasing values of . But it does not show as progressively as Rvf. Figures 5 and 6 show that the value of at 440 nm tends to be retrieved high for conditions where there is no dust at all or the dust concentration is low. Such conditions are usually dominated by a significant fine-mode of the particle size distribution. When dust particles contribute the main share to the particle concentration, i.e. high values of at 532 nm, the contribution of fine-mode particles is small. When particles in the fine-mode are the main contribution of the particle size distribution, i.e. low values of at 532 nm, the size of the particles in the fine-mode fraction are considered to have a large influence on the retrieval of the values of . This effect is considered to be more significant at 440 nm, i.e. at short wavelengths. Mamouri and Ansmann (2017) found that the value of is maximum at 532 nm and lower at 355 and 1064 nm because of the competing influence the fine-mode and coarse-mode dust fraction have on the overall values (fine + coarse) of at the three wavelengths. Haarig et al. (2017) found that on average the values of for aged Saharan dust were 0.25 at 355 nm, 0.31 at 532 nm, and 0.225 at 1064 nm. Müller et al. (2010; 2012) and Freudenthaler et al. (2009) also found spectral slope of the depolarization ratio with the maximum at 532 nm and lower values at 355 and 1064 nm during the Saharan Mineral Dust Experiment (SAMUM) 2006. The results clearly show a different pattern of the spectral variations of measured by lidar and retrieved from Sun/sky radiometer observations of dust. It is a striking result that at 1020 nm, unlike at 440 nm, is very similar to the values of at 532 nm. Though we cannot identify the reason for this similarity and even if the wavelengths (lidar at 532 nm and AERONET Sun/sky radiometer at 1020 nm) are different we may use the values of at 1020 nm as a qualitative indicator of the presence of mineral dust particles in the atmosphere. It remains open if we can use this parameter also as a qualitative measure of the mixing ratio of mineral dust and anthropogenic pollution particles compared to the more robust parameter (at 532 nm)."

3. Line 217: "The molecular depolarization ratio is assumed to be 0.0044". It means that all lidar systems have optical filters with very small bandwidth and measure almost only central Cabannes line of Rayleigh scattering (PC-SCI-201, CALIOP Algorithm Theoretical Basis Document Calibration and Level 1 Data Products). : The same interference filters were used to each lidar system. And molecular depolarization ratio was not 0.0044 but 0.014. The related sentences have been added in the revised manuscript.

4. Lines 41-44 in Abstract (the same, in Summary) should be compared to lines 362 -363. : The long word "decreasing" has been corrected as "increase" in Abstract and summary in the revised manuscript.

Interactive comment on Atmos. Chem. Phys. Discuss., doi:10.5194/acp-2016-1181, 2017.

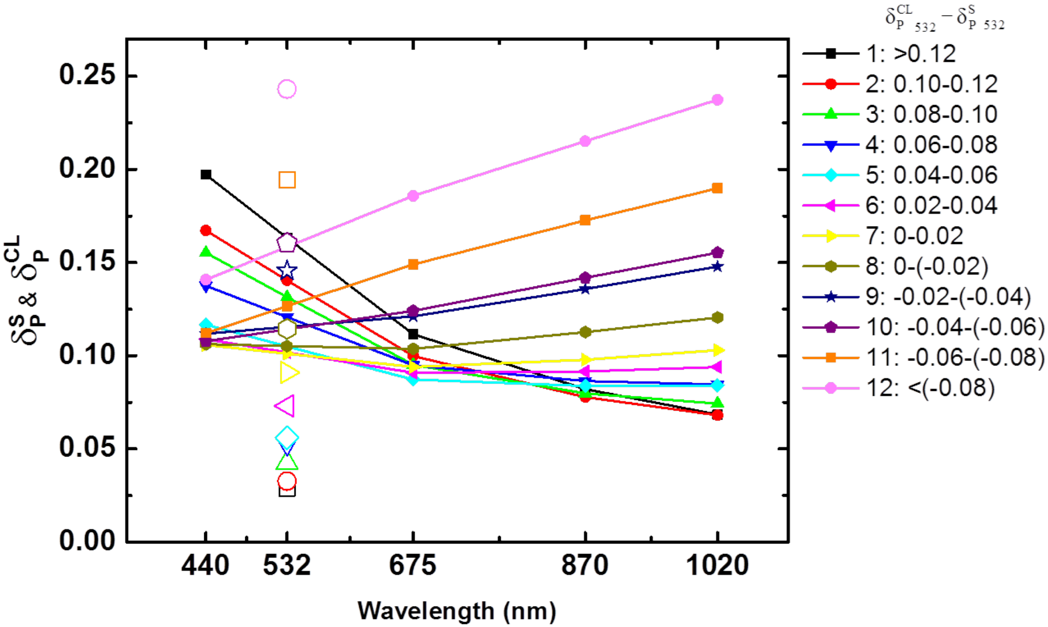

Fig. 1.

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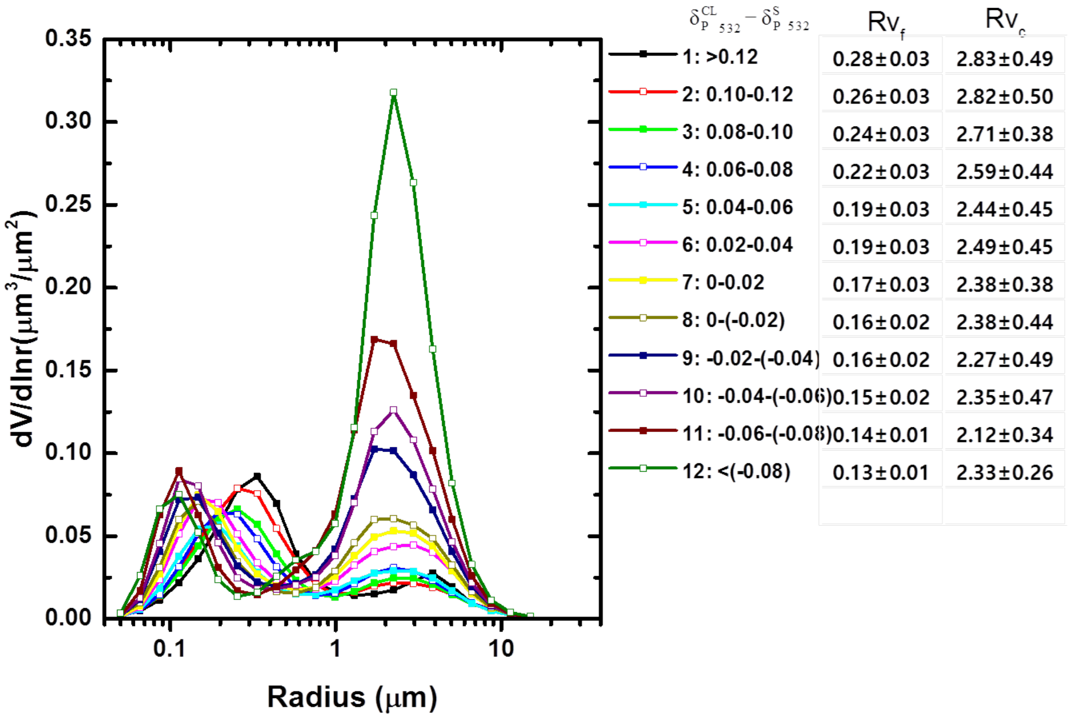

$\delta^{CL}_{P\ 532} - \delta^{S}_{P\ 532}$	Rv_f	Rv_c
1: >0.12	0.28±0.03	2.83±0.49
2: 0.10-0.12	0.26±0.03	2.82±0.50
3: 0.08-0.10	0.24±0.03	2.71±0.38
4: 0.06-0.08	0.22±0.03	2.59±0.44
5: 0.04-0.06	0.19±0.03	2.44±0.45
6: 0.02-0.04	0.19±0.03	2.49±0.45
7: 0-0.02	0.17±0.03	2.38±0.38
8: 0-(-0.02)	0.16±0.02	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.

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