Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2020-1162-AC2, 2021

Atmospheric Chemistry and Physics Discussions
Open Access

ACPD

Interactive comment

Interactive comment on "Study on variations in lidar ratios for Shanghai based on Raman lidar" *by* Tongqiang Liu et al.

Tongqiang Liu et al.

oxeye75@163.com

Received and published: 16 February 2021

Anonymous Referee #2 Interactive comment on "Study on variations in lidar ratios for Shanghai based on Raman lidar" by Tongqiang Liu et al.

Aerosol lidar ratio (LR) is a key parameter for retrieving aerosols optical properties from elastic lidar measurements, and better evaluating its climatic effects. The article presents an investigation of lidar ratio (355 nm) variation of atmospheric aerosols in Shanghai from long-term Raman/polarization lidar measurements. Moreover, relation between LR at 355 nm and other factors are discussed in detail. The topic is of sufficient interest to the communities of study of laser remote sensing and atmospheric aerosol. In general, I find this manuscript to be of interest for publication and appropriate for Atmospheric Chemistry and Physics. There are several suggestions for improvement listed below that should be considered by the authors and the editors before publication.

Reply: We are very grateful for referee's encouraging comments and recommendation for publication. We have tried our best to improve this paper according to referee's very helpful suggestions. The following are our point-by-point responses to referee's comments.

1. The title of the manuscript is inappropriate. In my opinion, it is preferred to use "Long term variation of aerosols lidar ratio in Shanghai based on Raman lidar measurement".

Reply: The title of the manuscript has been revised according to referee's suggestions.

2. This study discuss distribution of lidar ratio at 355 nm, it is suggested that the authors have to clearly specify it throughout the manuscript, especially mark "lidar ratio (355 nm)" in all figures.

Reply: We appreciate the referee's suggestions, and have specified in section 2.1.1 that the LR in our study was at 355 nm.

Therefore, the LR obtained and discussed in this study is at 355nm.

We've also marked "355 nm Lidar Ratio" in Fig. 2, 3, 4(a), 6(a), 7(b), 7(c) and 8 according to the referee's suggestions.

3. Honestly speaking, this study cannot provide enough valuable LR information for improvement of the CALIPSO lidar retrieval. Because CALIPSO algorithm need LR at 532nm for seven aerosols types, not that at 355nm. However, LR at 355nm in this study would be very useful for the EARTHcare lidar in the future. Please rewrite sentences in Line 64-66.

Reply: We agree with referee's concerns and have rewritten it.

On the one hand, the range-resolved LR obtained from the ground-based Raman lidar

Printer-friendly version

Discussion paper

can not only be used to compare with 355nm LR obtained from ATLID (Atmospheric LIDar) on the EarthCARE (Earth Clouds and Radiation Explorer) planned to be launched by ESA (European Space Agency) (Liu et al., 2020; Nicolae et al., 2018), but also can provides a reliable basis for the inversion hypothesis of elastic lidar in Shanghai and surrounding areas, and improves the products reliability from elastic lidar network such as the Asian dust and aerosol lidar observation network.

4. Line 60-61: combine citations to “Noh et al., 2007 and 2008”. Similar to citations in line 118. Please check such problem throughout the manuscript.

Reply: We appreciate referee’s reminding and have checked and revised the inappropriate citations throughout the manuscript.

In South Korea and Japan, some researches have also been carried out on the LR of the Asian dust and biomass burning aerosols based on Raman lidar (Murayama et al., 2004; Noh et al., 2007 and 2008).

Because Section 2.2 was compressed, the citations in line 118 were deleted.

5. Section 2: retrieved method of aerosol optical properties from Raman lidar is widely used and almost common knowledge among lidar community. The authors do not modify or improve the method in this study at all. So, it is suggested that section 2.2 could be compressed. More important information (such as lidar data correction) should be briefly introduce in section 2. For example, overlap correction is very important before retrieving LR from Raman lidar observation. Improper overlap correction would lead to large uncertainty.

Reply: The referee’s comments are very valuable. We’ve compressed section 2.2 and added a brief introduction of lidar data pre-processing. Because signals in the incomplete overlap area were not used for retrieval, the overlap correction was not introduced in section 2.2.

Original signals need to be pre-processed before retrieval, including background sub-

Printer-friendly version

Discussion paper

traction, photon counting signal dead-time correction, gluing, and overlap correction (D'Amico et al., 2016). The calculation of the glue coefficients used the method proposed by Newsom et al. (2009). In order to reduce the influence of incompletely overlapping detection areas of lidar on retrieved results, only signals in the complete overlap area were used for retrieval. In addition, affected by the location altitude of Raman lidar and the least square method used in the retrieval process, the lowest height of LR obtained by Raman method is 569.5m (ASL). Since Raman Lidar used in this study can detect the Raman scattering signal of 387nm nitrogen and signal-to-noise ratios of Raman signals in daytime are much lower than that in night time, the 355nm LR at night can be obtained through retrieval. The retrieval results of raw signals were counted by hour, and the hours with more than 15 minutes of retrieval results were regarded as effective observation hours. The retrieval results within the effective observation hours were averaged to obtain hourly average data. During observation period, data of 667 effective observation hours was obtained through retrieval and statistics. The monthly distribution is shown in Fig. 1.

6. LR is a really complicated parameter which not only depends on aerosol types. It is hard to identify aerosol type from LR only, without additional independent information. The authors claimed that dust aerosol is usually distributed around 1-2 km, according to range of LR variation. This conclusion is inconsistent with statement in line 193-194. It should be noted that depolarization ratio can identify dust from other aerosol reasonably, rather than LR. Please rewrite the sentences.

Reply: We agree with referee's concerns. It is not accurate to identify aerosol types only by LR and we've deleted Table 1 and the analysis on aerosol type determined by LR in section 3.1.1.

The average LR from 0.5 km to 1km was 68.2±19.5 sr, which was in good agreement with the 355nm LR observed by Ferrare et al. (2001) in Oklahom, America. The mean value of LR was between 40 sr and 50 sr in the altitude range of 1 km–2 km, and the mean values of LR were usually less than 40 sr above 2km, which was related to low aerosol concentration and low absorption efficiency of aerosols (Hänel et al., 2012; Hee et al., 2016).

Figure. 3 shows the frequency distribution of LR in the different altitude range. Overall, LR were widely distributed in the altitude range of 0.5 km–5 km. In most cases (about 90%) LR ranged from 10 sr to 80 sr with the highest frequency of 17.3% between 40 sr and 50 sr. It should be noted that the number of observations trailed off at larger LR and the frequency of abnormally large LR (> 90 sr) was about 4%. LR also had a wide distribution range within 0.5 km–2 km, and the frequency of 40 sr–50 sr was the highest (24.6%), which was similar to the range of 0.5 km–5 km. Large LR (> 60 sr) were mainly distributed in the range of 0.5 km–2.0 km, suggesting that the aerosol in this height range had strongly absorbing ability. Although there were a few large LR (> 60 sr) above 2 km, LR was mainly distributed between 0 sr–40 sr with the highest frequency of 34% between 10 sr and 20 sr.

7. Page 9 line 247: I guess “an effort” should be “order”.

Reply: We appreciate the referee’s suggestions and have revised it. In order to further research the influences of wind directions on LR and its vertical distribution, cluster analysis of back trajectories was used to study the transport of atmospheric aerosols.

8. Page 12 line 343: change “667-hours” to ‘667-hour’.

Reply: We have revised it according to referee’s suggestions. The aerosol LR at 355nm were retrieved, and the variations of LR and their influencing factors were analyzed in detail based on 667-hour data.

9. Figure 5: x-axis of this figure should be marked by date (not hour), so that readers easily understand seasonal variation of LR in Shanghai.

Reply: The x-axis of Figure 5 has been marked by date (Day/Month/Year) according to referee’s suggestions.

10. Figure 6: it is well known that dust aerosols usually show large depolarization

ratio (DR). As descried by the authors, LR of dust is 40-60 sr. However, LR which corresponds to large DR are in range of 100-120 sr. Please explain the reason.

Reply: The referee's comments are very valuable. We have added some analysis to explain why LR which responses to large DR are in range of 100-120 sr in our manuscript.

It is worth noting that LR which responses to large depolarization ratio are in range of 100 sr–120 sr. Generally, the LR of dust aerosol with large depolarization ratio was between 40 sr and 60 sr (Murayama et al., 2004; Noh et al., 2007). Hee et al. (2016) found that 355nm LR of aged forest fire aerosols was relatively large, ranging from 80sr to120sr. And previous studies have found that some aged forest fire aerosols also show large depolarization ratios (Hu et al., 2019; Murayama et al., 2004). There might be two reasons for this phenomenon. One is that dust aerosols on the surface are lifted into the biomass burning plume (Müller et al., 2007), and the other is nonsphericity of particles due to coagulation of smoke particles during aging process (Reid et al., 1998). Therefore, the LR in the range of 100 sr–120 sr corresponds to large DR may be caused by aged forest fire aerosols.

11. Figure 9: Please mark the location of lidar site in all panels.

Reply: The location of lidar site has been marked by blue star in all panels in Figure 9 according to referee's suggestions.

12. The English of manuscript should be further improved before publication.

Reply: We appreciated the referee's suggestions. We reviewed the manuscript carefully and have tried our best to corrected grammatical errors and improve the English of the paper.

References

D'Amico, G., Amodeo, A., Mattis, I., Freudenthaler, V., Pappalardo, G., 2016. EARLINET Single Calculus Chain – technical – Part 1: Pre-processing of raw lidar data.

Atmospheric Measurement Techniques 9, 491-507.

Ferrare, R.A., Turner, D.D., Brasseur, L.H., Feltz, W.F., Dubovik, O., Tooman, T.P., 2001. Raman lidar measurements of the aerosol extinction-to-backscatter ratio over the Southern Great Plains. Journal of Geophysical Research: Atmospheres 106, 20333-20347.

Hänel, A., Baars, H., Althausen, D., Ansmann, A., Engelmann, R., Sun, J.Y., 2012. One-year aerosol profiling with EUCAARI Raman lidar at Shangdianzi GAW station: Beijing plume and seasonal variations. Journal of Geophysical Research: Atmospheres 117, n/a-n/a.

Hee, W.S., Lim, H.S., Jafri, M.Z.M., Lolli, S., Ying, K.W., 2016. Vertical Profiling of Aerosol Types Observed across Monsoon Seasons with a Raman Lidar in Penang Island, Malaysia. Aerosol and Air Quality Research 16, 2843-2854.

Hu, Q., Goloub, P., Veselovskii, I., Bravo-Aranda, J.-A., Popovici, I.E., Podvin, T., Haeffelin, M., Lopatin, A., Dubovik, O., Pietras, C., Huang, X., Torres, B., Chen, C., 2019. Long-range-transported Canadian smoke plumes in the lower stratosphere over northern France. Atmos Chem Phys 19, 1173-1193.

Jacobson, M.Z., 1998. Studying the effects of aerosols on vertical photolysis rate coefficient and temperature profiles over an urban airshed. Journal of Geophysical Research: Atmospheres 103, 10593-10604.

Jacobson, M.Z., Kaufman, Y.J., 2006. Wind reduction by aerosol particles. Geophysical Research Letters 33.

Liu, B.M., Ma, Y.Y., Gong, W., Zhang, M., 2017. Observations of aerosol color ratio and depolarization ratio over Wuhan. Atmospheric Pollution Research 8, 1113-1122.

Liu, D., Kanitz, T., Ciapponi, A., Mondello, A., D'Ottavi, A., Mateo, A.B., Straume, A.-G., Voland, C., Bon, D., Checa, E., Alvarez, E., Bellucci, I., Do Carmo, J.P., Brewster, J., Marshall, J., Schillinger, M., Hannington, M., Rennie, M., Reitebuch, O., Lecrenier, O., Bravetti, P., Sacchieri, V., De Sanctis, V., Lefebvre, A., Parrinello, T., Wernham, D., Wang, Y., Wu, Y., Gross, B., Moshary, F., 2020. ESA's Lidar Missions Aeolus and EarthCARE. EPJ Web of Conferences 237.

Luo, B., Minnett, P.J., Szczodrak, M., Nalli, N.R., Morris, V.R., 2020. Accuracy Assessment of MERRA-2 and ERA-Interim Sea Surface Temperature, Air Temperature, and Humidity Profiles over the Atlantic Ocean Using AEROSE Measurements. J Climate 33, 6889-6909.

Müller, D., 2003. Saharan dust over a central European EARLINET-AERONET site: Combined observations with Raman lidar and Sun photometer. Journal of Geophysical Research 108.

Müller, D., Ansmann, A., Mattis, I., Tesche, M., Wandinger, U., Althausen, D., Pisani, G., 2007. Aerosol-type-dependent lidar ratios observed with Raman lidar. Journal of Geophysical Research 112.

Murayama, T., Müller, D., Wada, K., Shimizu, A., Sekiguchi, M., Tsukamoto, T., 2004. Characterization of Asian dust and Siberian smoke with multi-wavelength Raman lidar over Tokyo, Japan in spring 2003. Geophysical Research Letters 31.

Newsom, R.K., Turner, D.D., Mielke, B., Clayton, M., Ferrare, R., Sivaraman, C., 2009. Simultaneous analog and photon counting detection for Raman lidar. Appl Opt 48, 3903-3914.

Nicolae, D., Donovan, D., Zadelhoff, G.-J.v., Daou, D., Wandinger, U., Makoto, A., Vassilis, A., Balis, D., Behrendt, A., Comeron, A., Gibert, F., Landulfo, E., McCormick, M.P., Senff, C., Veselovskii, I., Wandinger, U., 2018. Earthcare atlid extinction and backscatter retrieval algorithms. EPJ Web of Conferences 176.

Noh, Y.M., Kim, Y.J., Choi, B.C., Murayama, T., 2007. Aerosol lidar ratio characteristics measured by a multi-wavelength Raman lidar system at Anmyeon Island, Korea. Atmospheric Research 86, 76-87. Reid, J.S., Hobbs, P.V., Ferek, R.J., Blake, D.R., Martins, J.V., Dunlap, M.R., Liousse, C., 1998. Physical, chemical, and optical properties of regional hazes dominated by smoke in Brazil. Journal of Geophysical Research: Atmospheres 103, 32059-32080.

Sajadi, M.M., Habibzadeh, P., Vintzileos, A., Shokouhi, S., Miralles-Wilhelm, F., Amoroso, A., 2020. Temperature, Humidity, and Latitude Analysis to Estimate Potential Spread and Seasonality of Coronavirus Disease 2019 (COVID-19). JAMA Netw Open 3, e2011834.

Song, H.-J., Kim, S., Lee, H., Kim, K.-H., 2020. Climatology of Tropospheric Relative Humidity over the Korean Peninsula from Radiosonde and ECMWF Reanalysis. Atmosphere 11.

Tian, Y., Pan, X., Nishizawa, T., Kobayashi, H., Uno, I., Wang, X., Shimizu, A., Wang, Z., 2018. Variability of depolarization of aerosol particles in the megacity of Beijing: implications for the interaction between anthropogenic pollutants and mineral dust particles. Atmos Chem Phys 18, 18203-18217.

Tzanis, C.G., Koutsogiannis, I., Philippopoulos, K., Deligiorgi, D., 2019. Recent climate trends over Greece. Atmospheric Research 230.

Wang, L., Lyu, B., Bai, Y., 2020. Aerosol vertical profile variations with seasons, air mass movements and local PM2.5 levels in three large China cities. Atmospheric Environment 224.

Xiao, M., Yu, Z., Kong, D., Gu, X., Mammarella, I., Montagnani, L., Arain, M.A., Merbold, L., Magliulo, V., Lohila, A., Buchmann, N., Wolf, S., Gharun, M., Hörtnagl, L., Beringer, J., Gioli, B., 2020. Stomatal response to decreased relative humidity constrains the acceleration of terrestrial evapotranspiration. Environmental Research Letters 15.

Xu, J., Wang, Q., Deng, C., McNeill, V.F., Fankhauser, A., Wang, F., Zheng, X., Shen, J., Huang, K., Zhuang, G., 2018. Insights into the characteristics and sources of primary and secondary organic carbon: High time resolution observation in urban Shanghai. Environ Pollut 233, 1177-1187.

Zhang, L., Qiao, L., Lan, J., Yan, Y., Wang, L., 2020. Three-years monitoring of PM2.5 and scattering coefficients in Shanghai, China. Chemosphere 253, 126613.

Interactive comment on Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2020-1162, 2020.

Printer-friendly version

Discussion paper