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Interactive comment on "Comparison of the optical properties of pure and transported anthropogenic dusts measured by ground-based Lidar" *by* Zhijuan Zhang et al.

Zhijuan Zhang et al.

zhangzj2010@lzu.edu.cn

Anonymous Referee #3

General comments

The authors attempted to establish one or more threshold for distinguishing polluted dust from pure dust using their optical properties (i.e., total attenuated backscattering coefficient, depolarization ratio and color ratio) measured by a ground-based Lidar. They concluded that depolarization ratio threshold of 0.2 could be used to differentiate the polluted and pure dust. The authors presented a good literature review. However,

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the study does not give much new insight into the study topic. Generally, the manuscript was poorly written and exhibits some mistakes, which largely hampers its readability. Numerous adjoining sentences are repeated (see the specific comments). Moreover, I have some major concerns with the methods and explanations in the manuscript.

Thank you for your serious review. This manuscript was intended to further prove the detection method of anthropogenic dust first proposed by Huang et al. (2015). After your suggestions, we have rewrote the manuscript.

1. The 'anthropogenic dust' is defined in a confusing way. The definition of the anthropogenic dust in the literatures (Tegen and Fung, 1995; Huang et al., 2015) is clear, that is the dust produced by human activities on disturbed soils. I cannot understand why the authors proposed a new definition for it (Lines 94-95). It seems that the anthropogenic dust in the manuscript means the dust (taking no account of its source) mixed with pollutants. Why not simplify it to "polluted dust"?

Sorry for my confusing definition of 'anthropogenic dust' in this manuscript. Actually in this manuscript one of the dusts I focused is transported anthropogenic dust. It is a kind of dust that originates from dust source regions and mixes with anthropogenic polluted aerosols during transportation. We used this word 'anthropogenic dust' is mainly to strengthen the human influence and then to study the different optical properties of dust from natural source and influenced by human activities. So owing to the word 'anthropogenic dust' is not properly used, now we change it to 'polluted dust' after serious consideration.

2. Can the subtype of dust aerosols be identified using the surface weather record and boundary layer height? I doubt. Firstly, the PBL height derived from the Lidar may be in low accuracy during the dusty days owing to the impact of the dust layer. Seco ndly, the PBL height shown in Figs.3 and 5 doesn't have a diurnal variation, why? Thirdly, according to figure.6, the authors claimed that the dust aerosols detected at SACOL originate from the Mongolia (Lines 292-293). Noting that the air parcels passed through

Mongolia at an altitude of much more than 4500m, thus the dust is unlikely to originate from the Mongolia. Fourthly, still according to figure.6, the authors concluded that the dust is mixed with anthropogenic pollution when passing through Baotou and Yulin city. Again, the air parcels passed through Baotou and Yulin at an altitude of more than 4500m, the dust is unlikely to be mixed with anthropogenic pollution. Moreover, the dust may enter the atmosphere when the air parcels were in contact with the surface (starting at 00:00 UTC, 31 Mar 2010 in Fig.4, and 00:00 UTC, 30 Jul 2010 in Fig.6) or even prior to the start date of the back-trajectory simulations, doesn't it? The results will be more reliable if both the pathway and the altitude of the air parcels were considered. When was the first dust case detected? On 19 October 2009 (see line 253) or 31 March 2010 (see line 743)?

The detection method used in this manuscript refers to the literature of Huang et al. (2015). Pure dust and polluted dust can be distinguished by using a combination of ground-based L2S-SM-II dual-band polarization lidar data, surface weather station records, PBL heights and back trajectories. Firstly, we agree with you that the PBL height derived from lidar is in low accuracy during the dusty days. If there is dust storm, we didn't calculate the PBL and regarded all the detected dust as pure dust. This will be stated clearly in the manuscript. Secondly, the PBL, derived from soundings conducted three or four times daily in summer, tends to peak in the early afternoon, and the diurnal amplitude of PBL is higher in the northern and western subregions of China than other subregions. During a diurnal cycle, the PBL is typically shallow (a few hundred meters) at night due to the strong near-surface stability, and the PBL can be well developed and reach several kilometers in the afternoon (Guo J. et al., 2016). This is the typical diurnal variation. Guo et al. (2014) found a lack of diurnal variation, but a cycle of 4-7 days in the aerosol properties, indicating a reduced PBL diurnal trend during polluted periods. In figure 3 we didn't calculate the PBL, and in figure 5, it did not show the diurnal variation. That's because deriving PBL using lidar is better in daytime and relatively clean days. Daytime observations were used from CALIPSO to ensure that residual layers were not picked out in nighttime data (Liu et al., 2015). Another

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two cases were picked out as shown in figure 3 and 5. Third, we agree with you that the pathway and altitude should both be considered. Appropriate cases were shown in Figure 4 and Figure 6. Last, the time of first dust case is 19 March 2010. And we have corrected it in the manuscript.

3. According to the manuscript, there were two types of pure dust: a) dust layer within the PBL and recorded by the weather stations; b) dust layer above the PBL and not recorded by the weather stations. It seems that the later one is more likely to be "pure dust", is there any different between their optical properties?

Sorry for the unreasonable detection method that we originally used. After analyzing every lidar picture, we found that quite a few dust aerosols can reach 3 km above the ground or even higher and the optical properties of those dusts is close. So we can't use PBL to clarify them as pure dust and polluted dust. In our new detection method, we used back trajectories to help us clarify the aerosol type.

4. With regard to Figs. 1 and 2, the discussions in the main text did not match the plots. Actually, the Fig.2 rather than Fig.1 shows the structure of the Lidar. The Fig. 1 was not discussed in the main text.

Thank you for your kind reminding. As you said, in this manuscript Fig.2 shows the structure of the Lidar. The Fig.1 was not discussed in the main text and now we add this part in the manuscript.

5. Color ratio is an indicator for particle size. A large value represents big particle and a small value represents small particle. Generally speaking, anthropogenic aerosols are mainly composed of fine mode particles, why it has a large color ratio (see line 219)?

Sorry for the confusion that caused by my poor expression. The transported anthropogenic dust in this manuscript is actually polluted dust. It is a mixture of pure dust from remote dust source regions and anthropogenic polluted aerosols. So it is larger than the dust from remote dust source regions that did not mix with polluted aerosols. There

are two kinds of pure dust in this manuscript, one is form remote dust source regions and one is from dusty days. Compared with the pure dust from remote dust source regions, the color ratio of polluted dust (anthropogenic aerosols, as you mentioned in the above question) is larger.

Specific comments

1. Check the order of the subtitle of Fig 9. The right panel should be the results of pure dust.

Thank you for your kind reminding. We have corrected in the corresponding position.

2. Mistake in lines 309-310: 'From the results above we can see the depolarization of pure dust is larger than that of anthropogenic dust which means the pure dust is more sphere.' 'the pure dust is more sphere' should be 'the anthropogenic dust is more sphere'

Sorry for the mistake that we have made. We have corrected it in the manuscript.

3. Mistake in lines 426-427: 'The mean value of pure dust is larger than that of anthropogenic dust, which means that the pure dust is more a spherical' 'the pure dust is more a spherical' should be 'the anthropogenic dust'. Sorry for the mistake that we have made. We have corrected it in the manuscript.

4. Lines 103-104: remove 'mixed with the anthropogenic dust'.

Sorry for the mistake that we have made. We have corrected it in the manuscript.

5. Lines 143-147: there is no essential difference between 'the environment of the mountain top is almost natural, and is rarely affected by human activity' and 'building at the top of the mountain, the influence of houses and human activity is escaped', delete the later one.

Sorry for the mistake that we have made. We have corrected it in the manuscript.

6. Line 359, change 'found' to 'used'.

Sorry for the mistake that we have made. We have corrected it in the manuscript.

7. Line 474-477, duplicate sentence. Remove 'Results showed that the backscattering depolarization ratio was smaller for all particle sizes in polluted dust.

Sorry for the mistake that we have made. We have corrected it in the manuscript.

Reference

[1] Liu, J., Huang, J., Chen, B., Zhou, T., Yan, H., Jin, H., Huang, Z. and Zhang, B.: Comparisons of PBL heights derived from CALIPSO and ECMWF reanalysis data over China, Journal of Quantitative Spectroscopy and Radiative Transfer, J Quant Spectrosc Ra, 153, 102-112, 2015.

[2] Guo J, Miao Y, Zhang Y, et al. The climatology of planetary boundary layer height in China derived from radiosonde and reanalysis data[J]. Atmospheric Chemistry and Physics, 2016, 16(20): 13309.

[3] Guo, S., Hu, M., Zamora, M. L., Peng, J., Shang, D., Zheng, J., Du, Z.,Wu, Z., Shao, M., and Zeng, L.: Elucidating severe urban haze formation in China, P. Natl. Acad. Sci. USA, 111, 17373–17378, 2014.