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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Seasonal and spatial variations in aerosol vertical distribution and optical properties over China from long-term satellite and groundbased remote sensing" *by* Pengfei Tian et al.

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Using long-term satellite and ground-based remote sensing observations, this study describes the climatology of aerosol vertical distribution and optical properties over China, particularly for several important regions. In principle, this paper is well written and the findings are interesting. Response: The authors are grateful for the positive comments on our work. All the comments and concerns raised by the referee have been considered and incorporated into the revised manuscript. The followings are my minor comments: (1) Page 2, line 20, I would suggest to add references Garrett

and Zhao 2006 and Zhao et al. 2015, which both show the strong warming climate effect of aerosols by serving as CCN and changing cloud properties. Garrett, T. J., C. Zhao, and P. C. Noel, 2010: Assessing the relative contributions of transport efficiency and scavenging to seasonal variability in Arctic aerosol. Tellus B, 62, 190-196. Zhao, C., and T. Garrett, 2015:ÂËŸ a- Effects of Arctic haze on surface cloud radiative forcing,ÂËŸaGeophys. Res. Lett.,Â ËŸa42, doi:10.1002/2014GL062015. Response: The recommended references have been added in the revised manuscript. (2) Page 3, line 4, I would also suggest to add one reference which is about the effects of IN scheme representation using dust aerosols to radiation balance in climate model of CAM5. 21.Xie, S., X. Liu, C. Zhao, and Y. Zhang, 2013: Sensitivity of CAM5 simulated Arctic clouds and radiation to ice nucleation parameterization, J. Climate, 26, 5981–5999. doi:ÂËŸahttp://dx.doi.org/10.1175/JCLI-D-12-00517.1. Response: The recommended reference has been added in the revised manuscript. (3) Page 3, line 16-18, is there any reference to support your claim that CALIOP AOD presents an underestimation because of the challenge of the thin layer detection. I am not sure if my understanding is right: if the thin layer clouds are missed, CALIOP AOD could be overestimated, not underestimated. Response: The AOD underestimation of CALIOP has been discussed in several previous studies (e.g., Winker et al., 2013; Liu et al., 2014; Papagiannopoulos et a., 2016), which have been discussed in the revised manuscript. The ambiguous description "thin layer detection" has been replaced by "thin aerosol layer detection". The misclassification of thin layer clouds as aerosols leads to higher aerosol loading in the upper troposphere sometimes (Winker et al., 2013). However, the data quality of the CALIOP level 2 data is good enough in estimating the regional aerosol climatology (Yu et al., 2010; Winker et al., 2013; Amiridis et al., 2015). Those points have been provided in the revised manuscript. (4) Page 3, line 21, I would suggest "slight underestimation" instead of "small underestimation". Response: Modified as recommended. (5) Page 4, line 2, do you mean "seasonal averaged vertical profiles"? Response: We have added "average" in the sentence. (6) Page 4, line 4-6, what do you mean 'evaluate' here: do Guo et al. 2016a use satellite observations to evalu-

ate the ground-based findings? The logic seems not right to me. Response: We have replaced the word “evaluated” with “estimated”. Guo et al. (2016a) didn’t use satellite observations to evaluate the ground-based findings. (7) Page 4, line 7, what do you mean for the “representative regions” here? Where are they? Response: The representative regions are the Taklimakan Desert, the Tibetan Plateau, the Loess Plateau, the Northeast China Plain, the Sichuan Basin, the North China Plain, the Yangtze River Delta, and the Pearl River Delta as defined in Section 2.1 and shown in Table 1 and Fig. 1. Each region represents one or more aerosol types such as dust, anthropogenic or mixed type aerosols. Those have been clarified in the revision.

(8) Page 5, line 3-4, I would suggest to add a reference Yang et al. 2016, which estimated the air pollution enhancement due to the aerosol-PBL feedback in Beijing. Yang, X., C. Zhao, J. Guo, and Y. Wang (2016), Intensification of aerosol pollution associated with its feedback with surface solar radiation and winds in Beijing, J. Geophys. Res. Atmos., 121, 4093–4099, doi:10.1002/2015JD024645. Response: The recommended reference has been added. (9) Page 5, line 11, use ‘between ... and ...’ or ‘ the ratio of 1064 nm to 532 nm backscatter’ Response: Changed as recommended. (10) Page 5, line 15-18, what are the major points or findings you want to use from this cited study? Response: The cited study was removed because of less relevance. (11) Page 6, line 1, ‘ have investigated’ ->’investigate’. Response: Modified as recommended. (12) Page 6, line 8, ‘in sections 4 and 5, respectively’. Response: Modified as recommended. (13) Page 6, line 16-17, are you sure that Northeast China Plain is one of the cleanest regions in China? I do not know if it is right but it seems that this region is often heavily polluted. Response: The Northeast China Plain is one of the cleanest regions in the selected eight representative regions in China from the perspective of AOD in our research and in the previous studies (Luo et al., 2014; Tao et al., 2015). Some big cities may be heavily polluted sometimes in this region, but it presents less natural dust and anthropogenic pollution relative to the other selected regions except the Tibetan Plateau. Those points have been clarified in the revision. (14) Page 8, line 1, ‘daytime solar background illumination’ -> ‘daytime background solar illumina-

tion’. Response: Modified as recommended. (15) Page 8, line 19, National Institute for Environmental Studies (NIES). Response: Modified as recommended. (16) Page 10, line 6, ‘ is set as a threshold value to define weakly ...’ Response: Modified as recommended. (17) Page 11, line 3, how is the inconsistency, larger or smaller? Response: Smaller. The dusty conditions always show heavy aerosol load, so excluding profiles under such conditions decreases the values of the average extinction profiles from the CE370-2 lidar. We have modified the sentence in the revised manuscript. (18) Page 12, lines 7-8, this sentences have been repeated two times, you may just keep one time description. Response: We have removed the redundant sentence. (19) Page 16, line 5-9, for these findings or descriptions, may you please give the likely reasons? Response: We have modified our descriptions and provided the reasons in the revised manuscript. Strong winds transport boundary layer dust aerosols to higher altitudes in spring (Ge et al., 2016). Very low boundary layer height in the Taklimakan Desert region (Guo et al., 2016b) traps more aerosols near the surface. (20) Page 17, line 14, ‘ is also correspond to ..’ ->’corresponds to’ Response: Modified as recommended. (21) Page 18, line 9, as suggested earlier, please add one reference by Yang et al. 2016. Response: The recommended reference has been added. (22) Page 18, line 12-13, is the claim generally right or just right for studied cases? Response: The claim is right in the representative regions over China, because this claim is based on climatological results from almost 10 years’ CALIOP observations. We have attributed this phenomenon to the interactions between absorbing aerosols and the atmospheric boundary layer in the polluted regions. References Amiridis, V., Marinou, E., Tsekeri, A., Wandinger, U., Schwarz, A., Giannakaki, E., Mamouri, R., Kokkalis, P., Binietoglou, I., Solomos, S., Herekakis, T., Kazadzis, S., Gerasopoulos, E., Proestakis, E., Kottas, M., Balis, D., Papayannis, A., Kontoes, C., Kourtidis, K., Papagiannopoulos, N., Mona, L., Pappalardo, G., Le Rille, O., and Ansmann, A.: LIVAS: a 3-D multi-wavelength aerosol/cloud database based on CALIPSO and EARLINET, Atmos. Chem. Phys., 15, 7127-7153, doi:10.5194/acp-15-7127-2015, 2015. Liu, C., Shen X., Gao W., Liu P., and Sun Z.: Evaluation of CALIPSO aerosol

optical depth using AERONET and MODIS data over China, In SPIE Optical Engineering Applications 2014 Oct 2 (pp. 92210F-92210F), International Society for Optics and Photonics, doi:10.1117/12.2058929, 2014. Luo, Y.X., Zheng, X.B., Zhao, T.L., and Chen, J.: A climatology of aerosol optical depth over China from recent 10 years of MODIS remote sensing data, Int. J. Climatol. 34, 863-870, doi:10.1002/joc.3728, 2014. Papagiannopoulos, N., Mona, L., Alados-Arboledas, L., Amiridis, V., Baars, H., Binietoglou, I., Bortoli, D., D'Amico, G., Giunta, A., Guerrero-Rascado, J.L., Schwarz, A., Pereira, S., Spinelli, N., Wandinger, U., Wang, X., and Pappalardo, G.: CALIPSO climatological products: evaluation and suggestions from EARLINET, Atmos. Chem. Phys., 16, 2341-2357, 2016, doi:10.5194/acp-16-2341-2016, 2016. Tao, M., Chen, L., Wang, Z., Tao, J., Che, H., Wang, X., and Wang, Y.: Comparison and evaluation of the MODIS Collection 6 aerosol data in China, J. Geophys. Res., 120, 6992-7005, doi:10.1002/2015JD023360, 2015. Winker, D.M., Tackett, J.L., Getzewich, B.J., Liu, Z., Vaughan, M.A., and Rogers, R.R.: The global 3-D distribution of tropospheric aerosols as characterized by CALIOP, Atmos. Chem. Phys., 13, 3345-3361, doi:10.5194/acp-13-3345-2013, 2013. Yu, H., Chin, M., Winker, D.M., Omar, A.H., Liu, Z., Kittaka, C., and Diehl, T.: Global view of aerosol vertical distributions from CALIPSO lidar measurements and GOCART simulations: Regional and seasonal variations, J. Geophys. Res., 115, D00H30, doi:10.1029/2009JD013364, 2010.

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