

Dear editor and referee#1,

Thank you very much for your time and attentions on this work. The constructive comments and suggestions are very useful to improve our manuscript. Following are point-by-point responses to referee #1's comments. All the line numbers mentioned in responses are referred to the manuscript with changes marked.

(1) From a general point of view, I would suggest the authors to maybe underline more efficiently the novelty of the study and its interest. Maybe that authors need, to do so, to modify the section of introduction. For instance, authors need to revise the aims of the study based on the results and conclusions. At least, it is necessary to highlight the different aerosol effects on CG lightning between in the plateau and basin regions of Sichuan, Southwest China.

Reply: We have revised the introduction and highlighted the aim of the study. "There are significant geographical and environmental differences between the western Sichuan plateau and the eastern Sichuan basin. The thermal conditions of the western Sichuan Plateau are obviously weaker than those of the Sichuan Basin (Qie et al., 2003), and the aerosol concentration in the plateau is also significantly lower than that in the basin (Ning et al., 2018a). Previous studies (Yuan et al., 2011; Wang et al., 2011; Yang et al., 2013; Yang and Li, 2014; Fan et al., 2015) have suggested that aerosol effects on lightning activity differ significantly due to differences in topography and aerosol. The purpose of this study is to investigate any similarities and differences in the effects of aerosols on lightning activity in the context of different topography and aerosol concentrations between the Western Sichuan Plateau and Sichuan Basin." The details can be seen L136-145 of the revised manuscript.

(2) Both Lines 120-126 in the introduction section and Lines 138-143 in the Data and methodology section describe the complex topography around Sichuan province. Thus, I suggest that the authors move the contents of Lines 138-143 to the introduction section and rewrite the parts related to the complex topography around Sichuan Basin.

Reply: We have moved this sentence to the introduction section and rewrote the

parts related to the complex topography around Sichuan Basin. The details can be seen L125-130 of the revised manuscript.

(3) Lines 128-132: “Previous studies have suggested that” belongs to future research plane and not to the research goal of this study, which is not suitable to appear in the section of introduction. These sentences should be moved to the discussion or conclusion section to indicate the limitations of this article that need to be solved in future research.

Reply: We have moved this sentence to the conclusion section to indicate the limitation of current study and the potential of the future study. The details can be seen L703-708 of the revised manuscript.

(4) Lines 275-279: the correlation between aerosol loading and lightning is negative in the basin region but is positive correlation in the plateau region. According to the above correlation coefficients, the authors concluded that aerosols stimulate lightning in the plateau region, but suppress lightning in the basin region. I think this conclusion is unconvincing. I thus suggest that the authors need to provide more sufficient evidence.

Reply: To further verify the stimulation and inhibition of aerosols on lightning activity and eliminate the interference of seasonality on the effects of aerosols on lightning, Pearson correlation coefficients between anomalies of total AOD and CG lightning and anomalies of sulfate AOD and CG lightning were implemented. As can be seen from the comparison between Fig. 3 and Fig. 4, the correlation coefficients between anomalies of AOD and lightning are significantly lower than those between AOD and lightning. While in an overall view, there is still a positive correlation between aerosols and lightning in the plateau region, and a negative correlation between aerosols and lightning in the basin region, especially for sulfate aerosols. This further verifies that aerosols have the potential to stimulate lightning activity in the plateau region and inhibit lightning activity in the basin region. The specific physical relationship will be further discussed below. The above discussion and the following figure as Figure 4 have been added to the revised manuscript. The details can be seen L344-364 of the revised

manuscript.

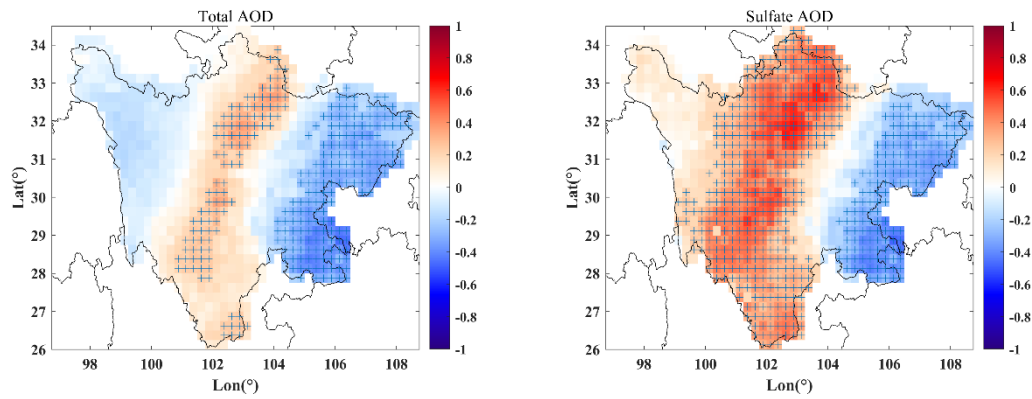


Figure 4. Pearson correlation coefficients between anomalies of total AOD and CG lightning (left panel) and anomalies of sulfate AOD and CG lightning (right panel) based on monthly data from 2005 to 2017. Crosses in the figure indicate grid boxes that have passed the 90% significance test.

(5) Lines 288-289: ‘Since sulfate AOD accounts for more than 80% of the total AOD in Sichuan, ...’, while as shown in Figure 2, sulfate AOD accounts for about 60-80% of the total AOD over the basin region and 40-55% of the total AOD over the plateau region. Please check it.

Reply: It has been revised.

(6) I suggest that the authors need to perform a significance test on the curve fitting results in Figure 4.

Reply: We have carried out significance test on the curve fitting results by using F-test method, and the P value of both curves is less than 0.001, indicating that the curve fitting results are significant. We have redrawn Figure 4 as Figure 5, marked the P value in the figure, and made modifications in the revised manuscript. The details can be seen L384-387 of the revised manuscript.

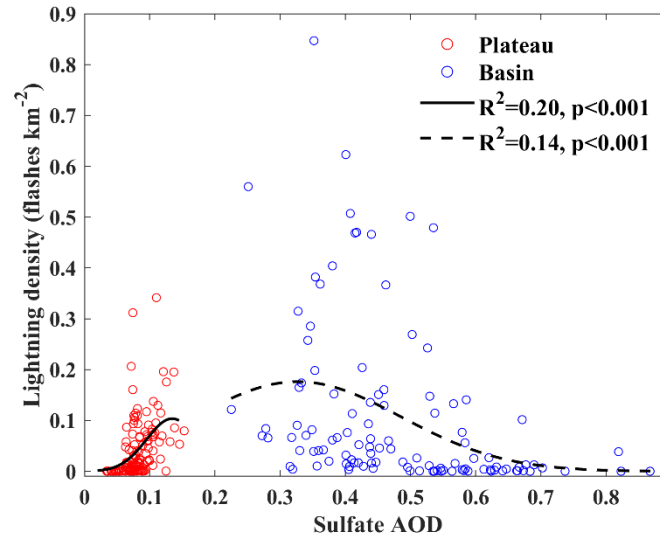


Figure 5. CG lightning density as a function of sulfate AOD over the basin (blue circles) and plateau (red circles) regions. Exponential-fit curves are shown, and coefficients of determination (R^2) and p values are given.

(7) Lines 442-445: “From the joint ..., an increase in CAPE inhibits the vertical wind shear in the lower to middle troposphere...” Why does an increase in CAPE inhibits the vertical wind shear?

Reply: CAPE is directly related to the upward movement, and CAPE can even be used to estimate the maximum updraft velocity (Molinari et al., 2012). Strong upward motion is not conducive to the development of vertical wind shear. previous studies (Li et al., 2013; Sherburn et al., 2016) on the complex of strong convection and mesoscale convection also found that the environmental vertical wind shear was smaller when CAPE was larger. Relevant references have been added to the revised manuscript. The details can be seen L524 of the revised manuscript.

(8) In the sections 3.5, the multiple linear regressions of CG lighting have been developed in the plateau region (as shown in EQ.6) and in the basin region (as shown in EQ.7), respectively. However, the positive or negative values of the regression coefficients in front of each regression factor (such AOD, RH, CBH, TCIW, and TCLW) are inconsistent with the Pearson correlation coefficients between these factors and CG

lightning in Figure 3 and Figure 5. For instance, the Pearson correlation coefficients between sulfate AOD and CG lightning are opposite between in the plateau region and the basin region; while the values of the regression coefficients associated with AOD are both positive in EQ.6 and EQ.7. I suggest authors to check the above results based on the multiple linear regression and give reasonable explanations. In addition, the similar situations are also observed in EQ.9.

Reply: In this study, we used multiple linear regression methods to fit the lightning density in Sichuan, and the regression factors included CAPE, RH, SHEAR, CBH, TCLW, TCIW, and AOD. In order to further analyze the most prominent factor contributing to the lightning density, we use the stepwise regression method to fit the lightning density. Because different factors contributed different proportions to the lightning density, there was a discrepancy between the positive and negative values of the regression factors and the positive and negative values of the Pearson correlation coefficient. Previous study (Wang et al., 2018) also had a similar situation.

Minor comments

(1) It is better to give a table of acronym because there are many abbreviations in the manuscript.

Reply: The acronym table has been added in the revised manuscript. The details can be seen in L274-276 in revised manuscript.

(2) Line 123: ‘diffusion’ -> ‘dispersion’

Reply: It has been revised.

(3) Lines 122-124: “The Sichuan basin is an area with high aerosol loading and with terrain ... (X. Zhang et al., 2012; L. Sun et al., 2016; Wei et al., 2019a, b)” is suggested to be changed to “The Sichuan basin is an area with high aerosol loading and with complex terrain ... (Zhang et al., 2012; Sun et al., 2016; Wei et al., 2019a, b; Ning et al., 2017, 2019)” .

Reply: It has been revised.

(4) Line 127: ‘influence’ -> ‘influences’

Reply: It has been revised.

(5) Line 176:“E. Sun et al. (2018, 2019) employed ...” ->“Sun et al. (2018, 2019) employed ...”

Reply: It has been revised.

(6) Line 192:“S. Lee et al. (2018) compared the ...” ->“Lee et al. (2018) compared the ...”

Reply: It has been revised.

(7) Line 270: ‘influenced’-> ‘affected’

Reply: It has been revised.

(8) Line 395: ‘over 1000’ -> ‘greater 1000’

Reply: It has been revised.

(9) Line 567: ‘influence’ -> ‘influences’

Reply: It has been revised.

(10) Line 577:‘diffusion’ -> ‘dispersion’

Reply: It has been revised.

Reference:

Fan, J., Rosenfeld, D., Yang, Y., Zhao, C., Leung, L. R. and Li, Z.: Substantial contribution of anthropogenic air pollution to catastrophic floods in Southwest China. *Geophys. Res. Lett.*, 42(14), 6066-6075, <https://doi.org/10.1002/2015GL064479>, 2015.

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Molinari, J., Romps, D.M., Vollaro, D. and Nguyen, L.: CAPE in tropical cyclones, *J. Atmos. Sci.*, 69 (8): 2452–2463. <https://doi.org/10.1175/JAS-D-11-0254.1>, 2012.

Ning, G., Wang, S., Ma, M., Ni, C., Shang, Z., Wang, J. and Li, J.: Characteristics of air pollution in different zones of Sichuan Basin, China. *Sci. Total Environ.*, 612, 975–984, <https://doi.org/10.1016/j.scitotenv.2017.08.205>, 2018a.

Qie, X., Toumi, R., Zhou, Y. J.: Lightning activity on the central Tibetan Plateau and its response to convective available potential energy, *Chinese Science Bulletin*,

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Yang, X., Yao, Z., Li, Z. and Fan, T.: Heavy air pollution suppresses summer thunderstorms in central China. *J. Atmos. Sol.-Terr. Phys.*, 95, <https://doi.org/10.1016/j.jastp.2012.12.023>, 28–40, 2013.

Yang, X., and Li, Z.: Increases in thunderstorm activity and relationships with air pollution in southeast China, *J. Geophys. Res. Atmos.*, 119, 1835–1844, <https://doi.org/10.1002/2013JD021224>, 2014.

Yuan, T., Remer, L. A., Pickering, K. E., Yun, H.: Observational evidence of aerosol enhancement of lightning activity and convective invigoration, *Geophys. Res. Lett.*, 38, L04701, <https://doi.org/10.1029/2010GL046052>, 2011.