Dear Editor and Referee#1,

Thank you very much for your attention and the referee's evaluation and comments on this work. Those comments are all valuable and very helpful for revising and improving our paper, as well as the important guiding significance to our research. 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.

Specific Comments:

(1) L1-2: The title could be clearer. Perhaps "Diurnal differences in the effect of aerosols on Sichuan-Basin lightning"

Reply: Thank you for your comment. We have changed the title of the manuscript to "Diurnal differences in the effect of aerosols on cloud-to-ground lightning in the Sichuan Basin". Since only cloud-to-ground lightning data were analyzed in this manuscript, we thought that using "cloud-to-ground lightning" might be more appropriate in the title. (Lines: 1-2)

(2) L60-61: The meaning of this sentence is unclear. Are you saying that aerosol radiative effects counter microphysical effects and make it difficult to confirm the modeling results using observations or something else?

Reply: Thank you for your comment. What we want to express is consistent with your comment. In some model studies, the concentration of aerosols is set very high. However, in reality, when aerosol concentration reaches such a high level, the radiation effect of aerosol often becomes very obvious and counters the microphysical effects. Therefore, it is difficult to verify these model results with observations. We have rewritten this sentence:" However, these model results are difficult to verify using observations, because the radiative effects of aerosols will offset the microphysical effects when the aerosol loading is excessively high." (Lines: 57-58)

(3) L90: Possible contamination by what? IC flashes? If yes, please say this.

Reply: Thank you for your comment. Yes, it is intracloud (IC) flashes. We have revised this in the manuscript. (Line: 90)

(4) L90: Since you only discuss CG flashes in this draft, you might replace all references to CG lightning with lightning – after stating once that lightning flash refers to CG lightning flash.

Reply: Thank you for your comment. We have revised this in the revised manuscript.

(5) L91: These 2 sentences are confusing. Is this what you mean?

Additionally, only the first stroke is retained if more than one stroke occurs in the next second within the first 10 km of the first stroke as two strokes that occur within 0.5 seconds are assumed to be from the same flash.

Reply: Thank you for your comment. What we want to express is consistent with this comment. We have rewritten these two sentences according to the comment to make them clear. The revised sentences are as follows:

"Only the first stroke is retained if more than one strokes occur in the next second with 10 km of the first stroke and two strokes that occur within 0.5 seconds are assumed to be from the same flashes (Cummins et al. 1998). In addition, it is a different flash if the polarity of the stroke is different." (Lines: 91-93)

(6) L105: You mention 5 factors but discuss 7.

Reply: We are sorry for this mistake. We have revised this in the revised manuscript. (Line: 110)

(7) L123-L128: It is unclear how you obtained 564 and later 11408 samples. In addition, the reference to section 3.4 is confusing. Please rephrase this paragraph giving information such as how many grid boxes are in the region of interest? What percent of these grid boxes were excluded by the flash criterion? Also, only mention the 10 flash threshold once in the revised paragraph.

Reply: Thank you for your comments. In the revised manuscript, we modified the sample processing method.

In the previous manuscript, the time of a sample includes 24 hours. It starts at 0600 BJT one day and ends at 0600 BJT the next day, as shown in Fig. 7-1.

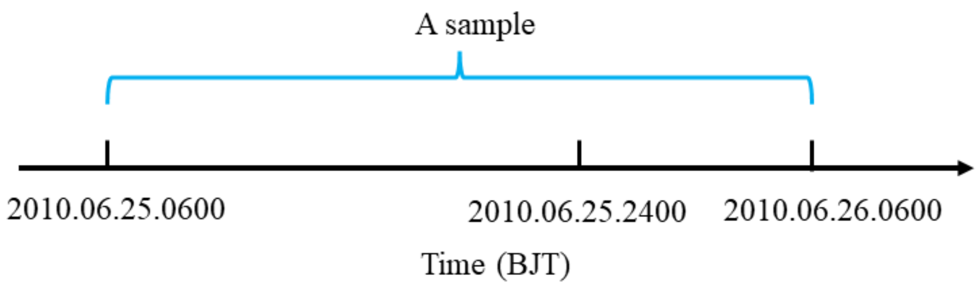

Figure 7-1. Schematic diagram of sample time selection.

Then, we only retain grids with CG flashes larger than ten during the period of a sample (the blue region shown in Fig. 7-2) to make sure there are relatively strong thunderstorms in those grids (hereinafter referred to as useful grids). Only samples with useful grids will be retained. Based on this rule, we finally got 564 samples during the whole study period.

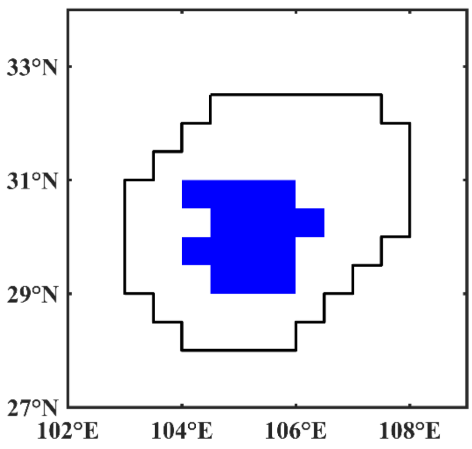

Figure 7-2. Black lines frame the study region. The blue region is grids with CG flashes larger than ten during the period of a sample. The spatial resolution of these grids is 0.5°×0.5°.

The AOD in a sample was calculated from the hourly averaged AOD of these grids as follows:

$$AOD_{Sample} = \frac{\sum_{k=1}^{24} AOD_{Grid,k}}{24 \times n_{Grid}}$$

The AOD_{Sample} is the AOD value of a sample. The $AOD_{Grid,k}$ is the AOD value in k hour of a useful grid. The n_{Grid} is the number of useful grids in a sample.

This method has some drawbacks. It did not take into account the wet deposition of aerosols by precipitation during thunderstorms. Therefore, the definition of clean and polluted subsets, as well as the analysis related to the value of AOD in the previous manuscript were not rigorous. In addition, we set a lightning threshold of ten to filter out many relatively weak lightning activities. However, these weak lightning activities should also be considered in the analysis. In the revised manuscript, we have improved the sample processing method in view of these drawbacks.

In the revised manuscript, a sample starts at 1200 BJT one day and ends at 1200 BJT the next day, as shown in Fig. 7-3 (b). In the study region, most thunderstorms from in the afternoon, at night, and the next morning (Fig. 7-3 (a)). The thunderstorms in the morning may be associated with intense thunderstorms at night. Therefore, noon is a relatively appropriate cut-off point for the sample period. The thunderstorm is weakest at noon, and the impact of precipitation on aerosols is relatively weak. Therefore, we selected the averaged AOD of the useful grids on the first hour (between 1200 BJT and 1300 BJT) of a sample period to represent the AOD_{Sample}. In addition, we limited the number of grids with CG lightning flashes to less than 10% of the total grids (7 grids) in each of the six hours before the start of a sample. This is to ensure that thunderstorm has been weak for a period of time before the start of a sample to reduce the possible impact of thunderstorm precipitation on aerosol loading.

(a)

(b)

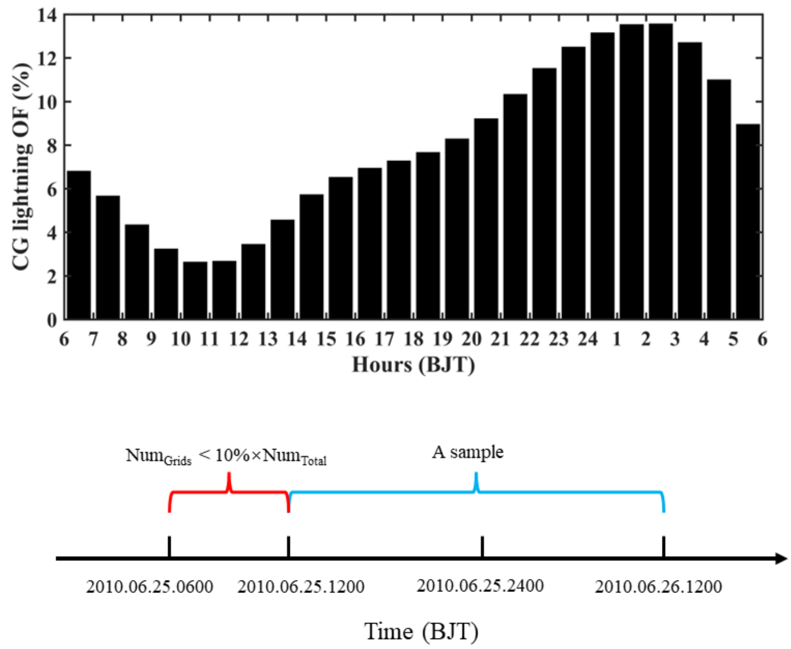

Figure 7-3. (a) The diurnal variation of CG lightning flashes during the study period. Num_{Grids}: number of grids with CG lightning flashes in each hour. Num_{Total}: number of grids (70) in the entire study region. (b) Schematic diagram of sample time selection.

It should be noted that the definition of useful grids has been changed to those grids with at least one CG lightning flash during a sample period. This change allowed some grids with relatively weak thunderstorms to include in the analysis. Finally, the AOD in a sample is calculated as follows:

$$\mathrm{AOD_{Sample}} = \frac{\sum_{\mathrm{k}=1}^{n_{Grid}} \mathrm{AOD_k}}{\mathrm{n_{Grid}}}$$

The $\mathrm{AOD_{Sample}}$ is the AOD value of a sample. The $\mathrm{AOD_k}$ is the AOD value in the first hour of a useful grid. The $\mathrm{n_{Grid}}$ is the number of useful grids in a sample. The samples with AOD larger than 0.8 were removed. Finally, we got 532 samples. The definition of the clean and polluted subsets is the same as the method used in the previous manuscript. All samples are sorted according to $\mathrm{AOD_{Sample}}$ and divided into three equal sample subsets where the top third of the AOD range is labelled as polluted, and the bottom third is labelled as clean. The distribution of samples' AOD and the AOD range of clean and polluted are shown in Fig. 7-4.

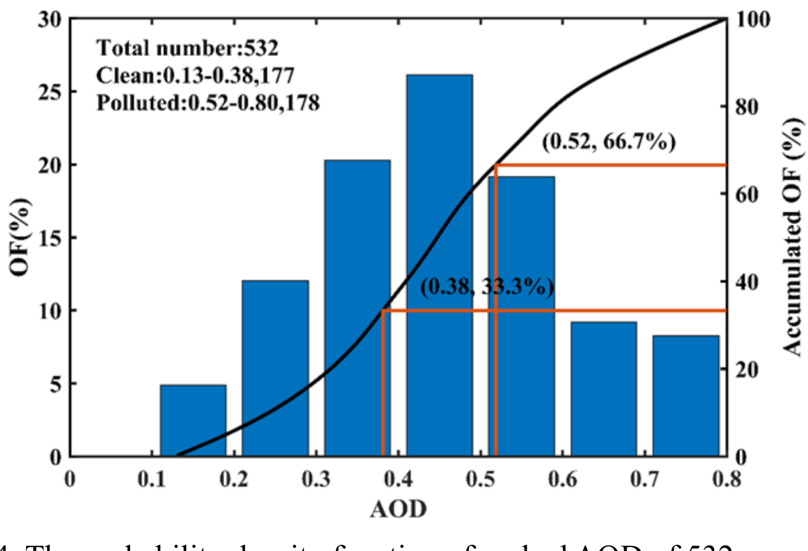

Figure 7-4. The probability density function of ranked AOD of 532 samples. Black solid lines denote accumulated occurrence frequencies for the AOD. Red lines show the top and bottom terciles.

In section 3.4 (in raw manuscript), we aim to discuss the joint effects of aerosols and dynamics-thermodynamics factors. The analysis method we used needs enough samples. Therefore, we take each useful grid in a sample as a new sample, thus obtaining 11408 new samples. However, this method is not rigorous, so we abandoned it in the revised manuscript. We adjust the content in section 3.4 and the analysis in section 3.4 is still based on the 532 samples used in the above content. (Lines: 138-155)

(8) L130: The rectangular study region shown in Figure 1a doesn't match any of the other study regions shown in the paper. Perhaps remove.

Reply: Thank you for your comment. We have removed this subgraph and redrawn this figure. (Line: 546)

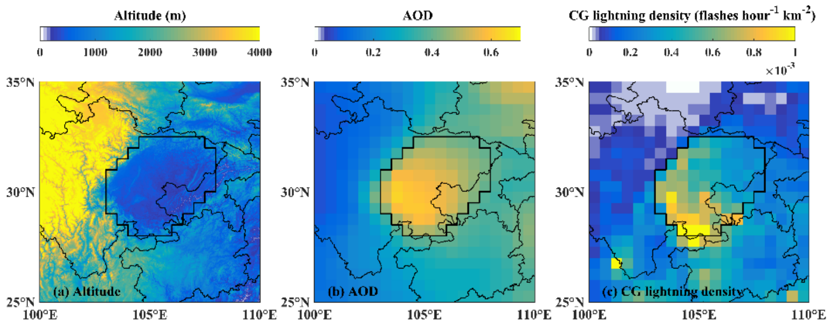

Figure 8-1. (a) The terrain of the study region is on a 0.02°×0.02° grid. Spatial distributions of (b) aerosol optical depth (AOD) and (c) CG lightning density (flashes hour^{-1} km^{-2}) at a spatial resolution of 0.5°×0.5° for the period 2010–2018 including the summer months (June, July, and August). The black lines in (a–c) outline the specific area investigated in this study.

(9) L143: Figure 3 does not show the wind field.

Reply: We are sorry for this mistake. We did not draw the wind field in this figure. We have revised the incorrect content in the manuscript.

(10) L181: Why do we care about hourly variations in the percentage of positive CG flashes?

Reply: Thank you for your comment. The space charge distribution of thunderstorms plays a crucial role in determining the polarity of lightning (Zhao et al., 2015). The space charge distribution of a thunderstorm is tightly correlated with the ice particle distribution (size, number) of the thunderstorm. By acting as CCN and IN, aerosols can affect ice particle size and number and thus affect the lightning flash polarity. Therefore, changing aerosols loading in a thunderstorm may affect its PPCG.

Some observational studies have investigated the relationship between aerosols and PPCG (Murray et al. 2000; Lang et al. 2006; Naccarato et al. 2003; Kar et al. 2014; Tan et al, 2016). Both positive and negative relationships between aerosol loading and PPCG were reported. However, the effect of aerosols on PPCG is still far from understand and related observational researches are few. Therefore, in the previous manuscript, we also analyzed the diurnal variation of the relationship between aerosol loading and PPCG.

After we change the method of processing samples (as described in the reply to comment 7), the results are not obvious (as shown in Fig. 10-1). Therefore, in the revised manuscript, we removed this part of the analysis and focused on the impact of aerosols on the lightning quantity in the Sichuan Basin. However, we believe this is an interesting subject worthy of further study. In future research, we will adopt more appropriate methods to conduct a more comprehensive study about this

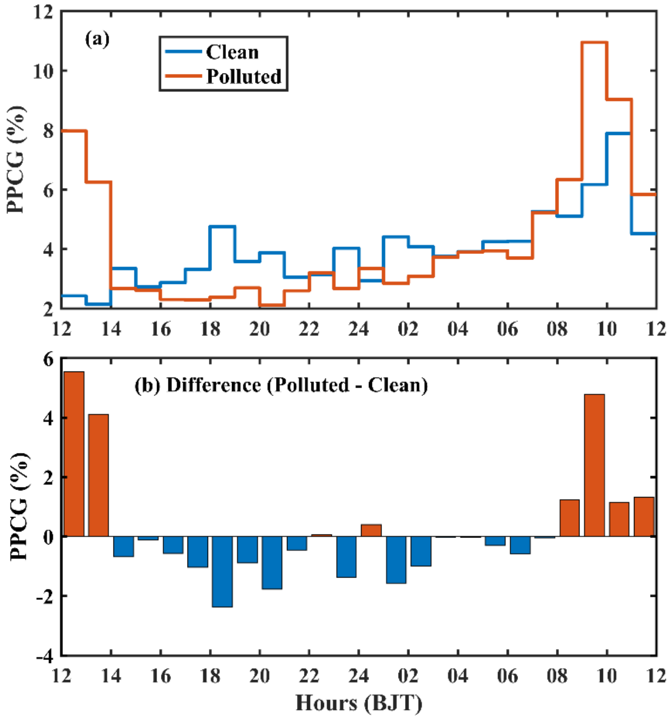

Figure 10-1. (a) The diurnal variation of the percentage of positive polarity CG lightning flashes (PPCG) in clean and polluted subsets. (b) The difference in the PPCG between polluted and clean subsets.

(11) L203-204: Warm (cold) colours in the figure mean more (less) … subset. Consider moving this sentence to the caption for Figure 5.

Reply: Thank you for your comment. We have moved this sentence to the caption for Figure 6 in the revised manuscript.

(12) L200-216: Discussion of Figure 5: Could you calculate and show the percent of 0.1 x 0.1 degree grid boxes where the change is positive and also give the mean change (amount and percent) for each of the 8 regions.

Reply: Thank you for your comment. We have redrawn this figure and added this information to it (Fig. 12-1). Related discussion is also added in the manuscript.

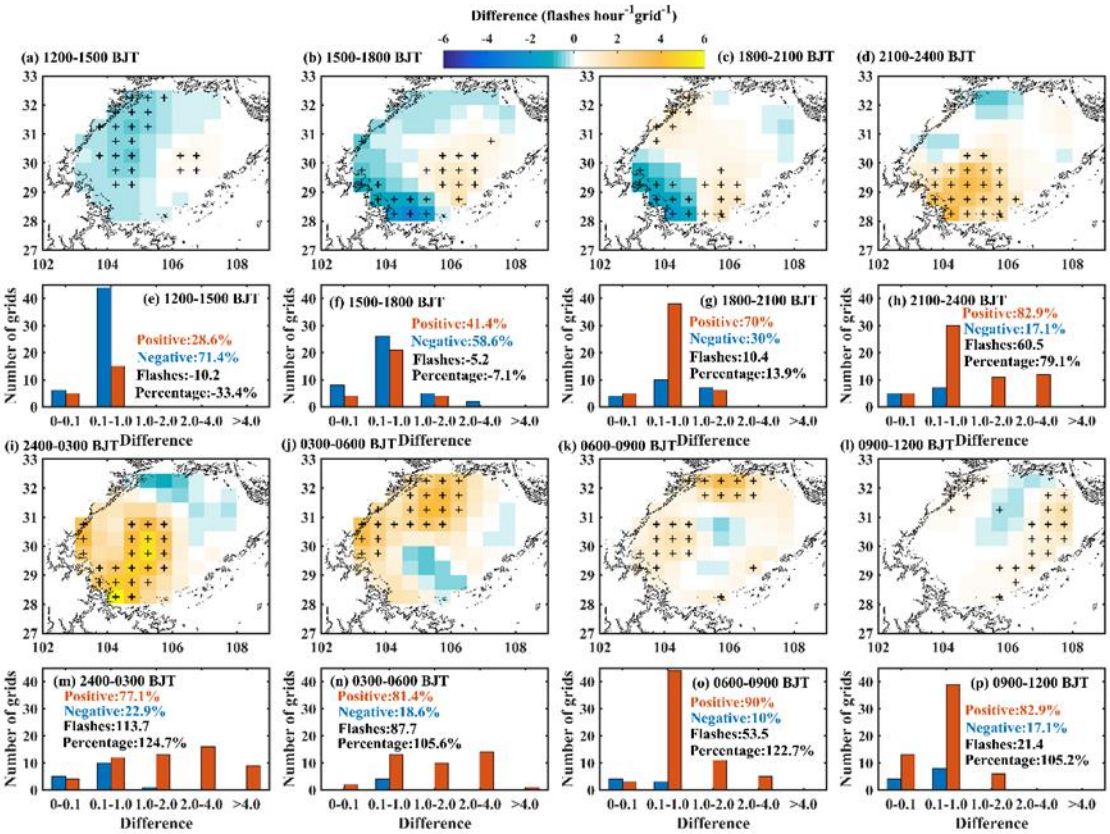

Figure 12-1. (a-d, i-l) Diurnal changes of total CG lightning flash differences (unit: flashes hour^{-1}) between polluted and clean subset (polluted−clean) during the study period with an interval of 3 hours (BJT). Black lines represent the 1500m contour lines. The spatial resolution is 0.5°×0.5°. Warm (cold) colours in the figure mean more (less) total CG lightning flashes in the polluted subset. Plus signs denote those grids with relatively large lightning flashes difference (the absolute value of lightning flashes difference ranks in the top third). (e-h, m-p) Histograms of the differences (red: positive, blue: negative) between lightning flashes in the polluted and clean subsets. The percentages of grids with the positive (negative) difference in the total grids, the total change of lightning flashes, and its percentage are also given.

(13) L219: You repeatedly refer to Period1 and Period2 over the next several pages. It might be better to replace these terms with morning and middle-of-the-night or something meaningful.

Reply: Thank you for your comment. We use “afternoon” and “night” to represent these two periods in the revised manuscript.

(14) L233-234: It is unclear what you mean by this sentence. Are you saying that you see a 0.3 threshold during the day in this study consistent with other studies? If yes, state this more clearly.

Reply: Thank you for your comment. We have rewritten the relevant content in the revised manuscript and stated it more clearly.

(15) L253-255: Are there any scientific studies of convection in the Sichuan Basin that support this inference? If yes, please reference them.

Reply: Thank you for your comment. We are sorry that we have not found relevant studies that directly point out this difference in convective activities in Sichuan Basin. We revised the relevant speculation in the article. It is not rigorous for that inference.

(16) L256: TCL is negatively ï Be clear as to whether you mean TCLW or TCIW.

Reply: We are sorry for this mistake. We have revised it in the revised manuscript.

(17) L272-276: Check the captions in Figure 9 and make sure TCLW and TCIW are used appropriately. They probably all should be labeled TCLW.

Reply: Thank you for your comment. We have redrawn this figure and revised these mistakes in it.

(18) L296: Rather than stating that more CG flashes are found it would be more interesting if you could give a percent increase range by dividing values from a subset of the bins.

Reply: Thank you for your comment. Due to the modification of the data processing method of the article, we have made some adjustments to the content of this section. This content was removed.

(19) L305: Rather than "more marked" cite a percent change. This should be done throughout L296-305.

Reply: Thank you for your comment. We have rewritten this part of the content in the revised manuscript.

(20) L357: Hopefully, you can support this inference by other studies.

Reply: Thank you for your comment. We have revised the relevant speculation in the article. It is not rigorous for that inference.

(21) L591-595: Figure 4 caption does not match Figure 4.

Reply: We are sorry for this mistake. We have revised it in the revised manuscript.

(22) Figure 5: Be sure to use BJT consistently as opposed to BJ.

Reply: Thank you for your comment. We have revised these mistakes in the revised manuscript.

(23) L604: Here and elsewhere consider replacing "the error was calculated" with "the uncertainty was calculated".

Reply: Thank you for your comment. We have revised this in all relevant figure captions.

(24) Figures 10 and 11: It might make more sense to show the flash counts with the numbers rather than the number of samples in the cell. This would emphasize your main points and give the reader more interesting numbers to play with.

Reply: Thank you for your comment. In section 3.4 (in raw manuscript), we aim to discuss the joint effects of aerosols and dynamics-thermodynamics factors. The analysis method we used needs enough samples. Therefore, we take each useful grid in a sample as a new sample, thus obtaining 11408 new samples. However, this method is not rigorous, so we abandoned it in the revised manuscript. We adjust the content in section 3.4 and the analysis in section 3.4 is still based on the 532 samples processed by the improved method (as described in the reply to comment

7). However, this suggestion is very meaningful, and we will pay attention to it in similar drawings in the future work.

Technical Corrections:

Reply: Thank you for your technical corrections. We have revised all these errors in the revised manuscript.

References:

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Tan, Y., Peng, L.K., Shi, Z., and Haiqin, C.: Lightning flash density in relation to aerosol over Nanjing (China), Atmos. Res., 174, 1–8, https://doi.org/10.1016/J.ATMOSRES.2016.01.009, 2016.