Reply to Referee 1

We are grateful to the referee for the encouraging comments and careful revisions, which helped to improve the quality of our paper. In the following we quoted each review question in the square brackets and added our response after each paragraph.

[The paper can be improved with more in-depth discussion. In the introduction, the authors can write a more comprehensive literature review on the precipitation-aerosol relationship, such as, what are controversy issues, what are the research gaps and what are the possible underlying mechanisms for various processes. Then the review can lead to what the authors will address in this paper. The conclusions and abstract seem to have different emphasis. What do the authors really like to emphasize? Should the authors also discuss, in conclusion, the spatial correlation pattern between visibility and rainstorms and other issues emphasized in the abstract?]

Reply 1: Many thanks to the reviewer for the great suggestions. Following the suggestions, we have substantially improved the manuscript with more in-depth discussion with modifying the introduction about a more comprehensive literature review on the precipitation-aerosol relationship and highlighting our study results in both conclusions and abstract.

Please find the detailed revisions in the uploaded marked-up manuscript version with track changes.

[The presentation can be greatly improved. Please pay close attention on the presentation because poor presentation can hamper the readers from understanding the contents in the paper. There are numerous places requiring polishing on presentation and corrections for grammatical errors. Some examples are provided in Specific. The authors can take advantage of the editing service provided by the journal.]

Reply 2: We are grateful to the referee for encouraging comments. We have greatly improved the presentation with rewriting the sentences and correcting the grammatical errors in the revised manuscript. Please find the detailed revisions in the uploaded marked-up manuscript version with track changes.

[Figure 3 shows trends for different rain intensity. Have the authors looked into the total precipitation? What is the trend? What that trend tells us?]

Reply 3: Thanks for the suggestions. We have looked into the total precipitation averaged over Eastern China. The trend in the interannual variations of the total precipitation from 1961 to 2010 is insignificant, which indicates that the impact of aerosols on precipitation could be complicated by different rain intensity.

[Figure 10 can be improved in the presentation and discussion. How significant is the correlation at each level? The statement in line 204 "indicating they were negatively correlated at low boundary layer" is not supported by Figure 10a and 10b.]

Reply 4: Following the referee's suggestion, we have modify Fig. 10 and the corresponding text in the revised manuscript as follows:

To reveal the relationship between aerosols and atmospheric vertical thermal structure, the correlation between surface $PM_{2.5}$ concentration and atmospheric thermal structure in both polluted and clean areas in July, 2013 was investigated (Fig. 10). The stations of Changsha and Hongjia located in Hunan and Zhejiang provinces in EC respectively were selected to represent the less light rain region while those of Linzhi and Dingriin of Tibet were selected to represent the high-frequency light rain region. The correlation coefficient profiles between the observed surface daily $PM_{2.5}$ concentration and atmospheric temperature profiles derived from high-resolution L-band sounding were calculated. The correlations at Changsha and Hongjia stations (Figs.10a-b) show that the correlation between $PM_{2.5}$ and temperature profiles presented an "inverse phase" pattern, reflecting the high aerosol concentrations in a thermal stable structure similar to temperature inversion layers with "cold at low-layer and warm at upper-layer" in the eastern China. On the contrary, the correlations in Linzhi and Dingri stations in the Tibetan Plateau (Fig. 10c-d) indicate that an unstable atmospheric structure with "warm at low-layer and cold at upper-layer" for a favorable condition for the occurrence and development of convection and light rain events in the Tibetan region.

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[Line 33, delete "It is widely acknowledged that".]

Reply 5: it has been deleted in the revised manuscript.

[Line 46, give the full expression of CCN IN.]

Reply 6: The full expressions of CCN and IN have been given with "cloud condensation nuclei" and "ice nuclei" in the revised muanscript.

[Line 51, use "An earlier study showed" to replace "The study shows".]

Reply 7: It has been changed. .

[Line 75-82 Data, some descriptions on quality control would be helpful.]

Reply 8: The precipitation data are archived at the China Meteorological Administration （CMA） with the conventional quality control of global climate data.

[Line 76-77, some description on MODIS data would be helpful, for example, what is the resolution of the MODIS data? How are the data used in this study?]

Reply 9: because the MODIS aerosol products are not used in the result analysis of revised manuscript, we have deleted the sentence "annual average AOD data in 2001-2010 from Moderate Resolution Imaging Spectroradiometer (MODIS)" at the beginning of Section 2. Data. Therefore, we have not given any information on MODIS data in the revised manuscript..

[leave space between 200 and mm. Correct the same problem in the rest of the paper. For example, in Lines 78, 79, 94 and 95.]

Reply 10: Thank the referee for careful review. It has been corrected.

[Line 108, Xu et al. (2016) is missing in Reference]

Reply 11: we have added the following ACP-paper into References:

Xu, X., Zhao, T., Liu, F., Gong, S. L., Kristovich, D., Lu, C., Guo, Y., Cheng, X., Wang, Y.,

and Ding, G.: Climate modulation of the Tibetan Plateau on haze in China, Atmos. Chem. Phys., 16, 1365-1375, doi:10.5194/acp-16-1365-2016, 2016.

[Line 130, delete "trends" and "extreme".

Line 112, use "the differences in the trends between" to replace "the interannual variation trend differences for".

Line 117, use "rainstorm, especially large rainstorms, have presented a significant increase trend" to replace "rainstorm and especially large rainstorm extreme events presented significantly an increased trend".

Line 118, delete an extra comma.]

Reply 12: The careful reviews are greatly appreciated. All the errors have been corrected in the revised manuscript.

[Line 130, delete "trends" and "extreme".]

Reply 13: The have been deleted.

[Line 112, use "the differences in the trends between" to replace "the interannual variation trend differences for".]

Reply 14: It has been done in the revised manuscript.

[Line 117, use "rainstorm, especially large rainstorms, have presented a significant increase trend" to replace "rainstorm and especially large rainstorm extreme events presented significantly an increased trend".]

Reply 15: Following the referee's comments, it has been revised.

[Line 118, delete an extra comma.]

Reply 16: It has been deleted.

[Line 123-126, the sentence can be rephrased as "The areas with negative trends in light rain frequency almost matched with areas with positive trends in visibility and haze frequency

in EC (Fig. 4a,b and c), which are well consistent with the area of high aerosol concentrations and frequent haze events (Fig.2a,b). The light rain frequency reduction in China was closely associated with the enhancement of aerosol levels in the atmosphere (Qian et al., 2009)."]

Reply 17 : Following the suggestion, the lines 123-126 have be rephrased as "The areas with negative trends in light rain frequency almost matched with areas with positive trends in visibility and haze frequency in EC (Fig. 4a,b and c), which are well consistent with the area of high aerosol concentrations and frequent haze events (Fig.2a,b). The light rain frequency reduction in China was closely associated with the enhancement of aerosol levels in the atmosphere (Qian et al., 2009)." in the revised manuscript.

[Line 123-126, what is light rain frequency? Is it the number of days with light rain in a year? What are visibility and haze frequencies? Please define them clearly in the paper.]

Reply 18: It has been clarified with " The light rain frequency is the number of days with light rain in a year; and the visibility is in unit of km, haze frequency is the number of days with haze" in the revised manuscript.

[Line 127, The sentence can be rephrased as "The areas with negative trends in light rain almost covered eastern China and a large part of China".]

Reply 19: The sentence has been rephrased as "The areas with negative trends in light rain almost covered eastern China and a large part of China" following the referee's suggestion. .

[Line 142-143, change the phrase as "make the number of cloud droplets increase but the size of cloud droplets decrease".]

Reply 20: Thanks for the suggestion. Following the referee's suggestion, it has been changed.

[Line 159-160, change the phrase as "As shown in Fig. 6b (left), in the three periods".]

Reply 21: It has been changed.

[Line 171, use "significant increasing trends" instead.]

Reply 22: It has been done.

[Line 176, delete "could".]

Reply 23: Thank the referee for the kind suggestions. It has been done.

[Line 197, use "PM2.5" instead.]

Reply 24: It has been done.

[Lines 198, 219, 225, 226, add "s" after "concentration".]

Reply 25: It has been done.

[Lines 220, 225, 226, delete "s" after "droplet".]

Reply 26: It has been done.

[Line 224, use "These aircraft observations showed" instead.]

Reply 27: It has been changed in the revised manuscript.

[Line 229, use "and the effects depend" to replace "depending".]

Reply 28: It has been done in the revised manuscript.

[Line 235, delete "trend".]

Reply 29: The "trend " has been deleted in the revised manuscript.

[Line 236, delete extra space between occurrence and more. Add a space between "with" and "an"]

Reply 30: It has been done in the revised manuscript.

[Line 237, add "the" before "1960"]

Reply 31: It has been changed in the revised manuscript.

[Line 234, delete "of precipitation events" before "and".]

Reply 32: It has been deleted in the revised manuscript.

[There are various problems in the figures, their captions and annotations. The following are some examples for the authors to take into consideration.

1. Be consistent with the figure format;

2. Use the consistent fonts and font size;

3. Use correct term to label x-axis and y-axis.

4. Use capitalized words to label x-axis and y-axis;

5. Label sub-plots using letters (usually at the top, top-left, or top-right of a sub-plot);

6. Use superscripts and subscripts when necessary;

7. Provide the unit for the variable displayed if no unit, indicate with dimensionless or "(-)";

8. Indicate the unit for the color bar.

9. Remove zeros for the most insignificant digit after a decimal.

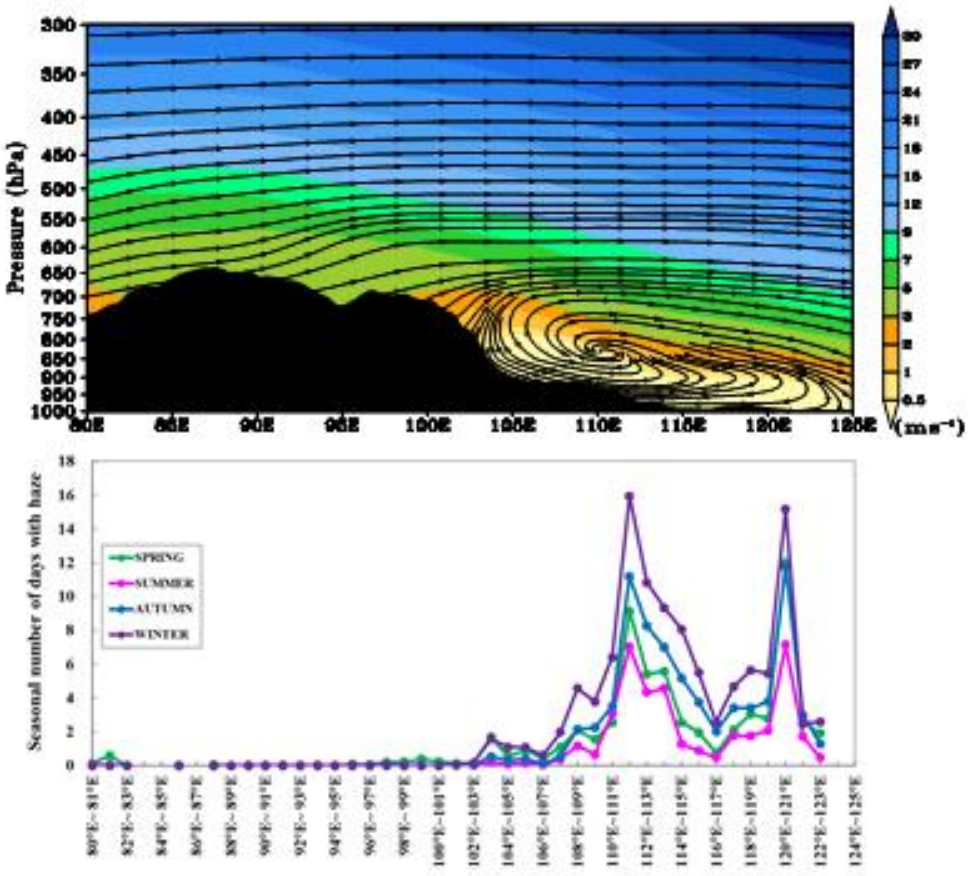
10. Add significant level (p value) on trends.

11. It is better to indicate latitude/longitude in the China maps in Figures 4 and 5.]

Reply 33: We are very grateful to the referee for the encouraging comments and careful revisions. All the mentioned problems in the figures, their captions and annotations have been corrected in the revised manuscript. All the figures have been redrawn following the referee's suggetsions..

[Figure 2. Labelling sub-plots (a) and (b). Capitalize "pressure" for the label for the y-axis in Figure 2a. It should be " Pressure (hPa)" so to leave a space between "pressure" and its unit. In the caption, wind speed should have a unit of m s-1. Please use correct superscripts.]

Reply 34: Following the referee's suggestion, Figure 2 has been modified as follows:



[Figure 3. Use the same font and font size to label sub-plots. No need for zeros after a decimal point in y-axis. Label "Precipitation" or "Rain" for the y-axis in Figure 3a. Use "Year" to label x-axis (not "date"). Add significant level (p-value).]

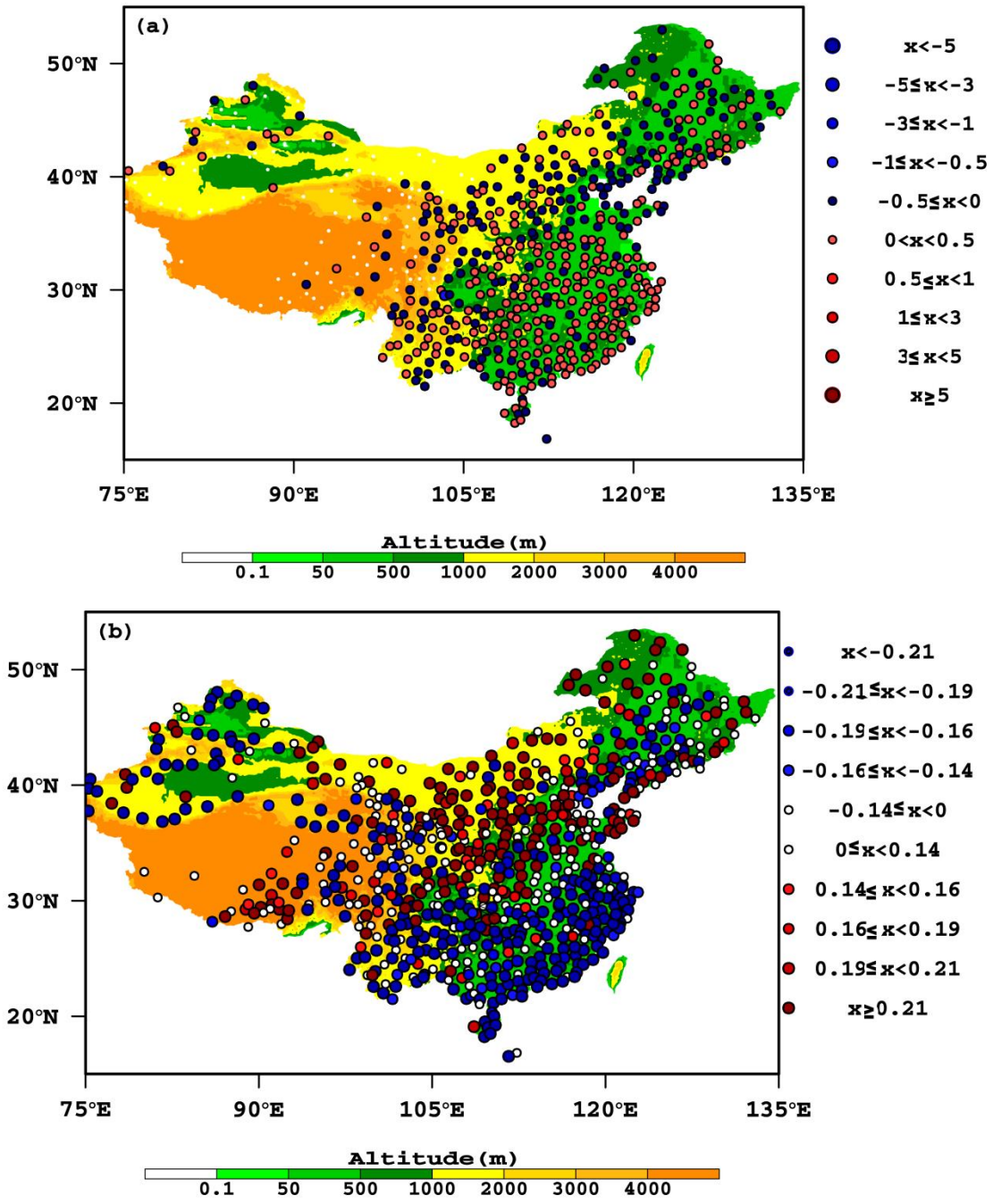
Reply 35: Following the suggestion, has Fig. 3 suggested been modified in the revised manuscript.

[Figure 4. Label (a), (b), (c) for the subplots. Provide the unit for haze frequency, visibility, and light rain frequency. Indicate what the dots and the background stand for. Indicate the unit for the color bar.]

Reply 36: We have changed Figure 4. Label (a), (b), (c) for the subplots. In the revised caption of Fig. 4, we have added "haze frequency (day), visibility (km), and light rain frequency (day). The dots stand for observation sites with shading by the variation trends, the background presents the terrain height in mainland China".

[Figure 5. Label (a) and (b) for the subplots. Provide the unit for the trend of the rainstorm frequency. Indicate what the dots and the background stand for. Indicate the unit for the color bar.]

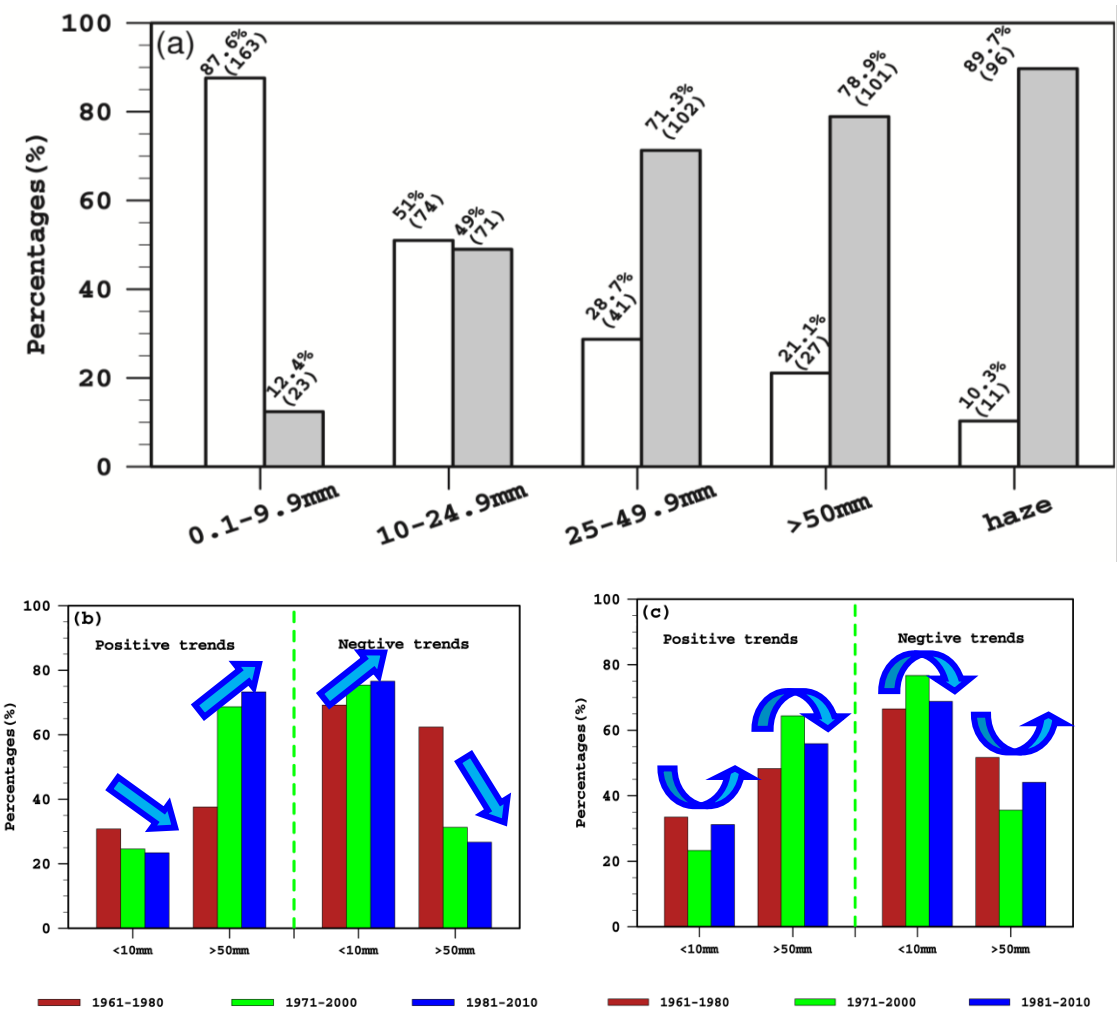
Reply 37: We have redrawn Fig. 4 as follows and revised the caption as "the trend (day per year) of the rainstorm frequency and the background (shaded colors) stands for the terrain height (m) in mainland China



[Figure 6. Label (a), (b) and (c) for the subplots. In Figure 6a, no color is needed as this will cause confusion with Figure 6b and 6c. Good titles for each figure will help readers to

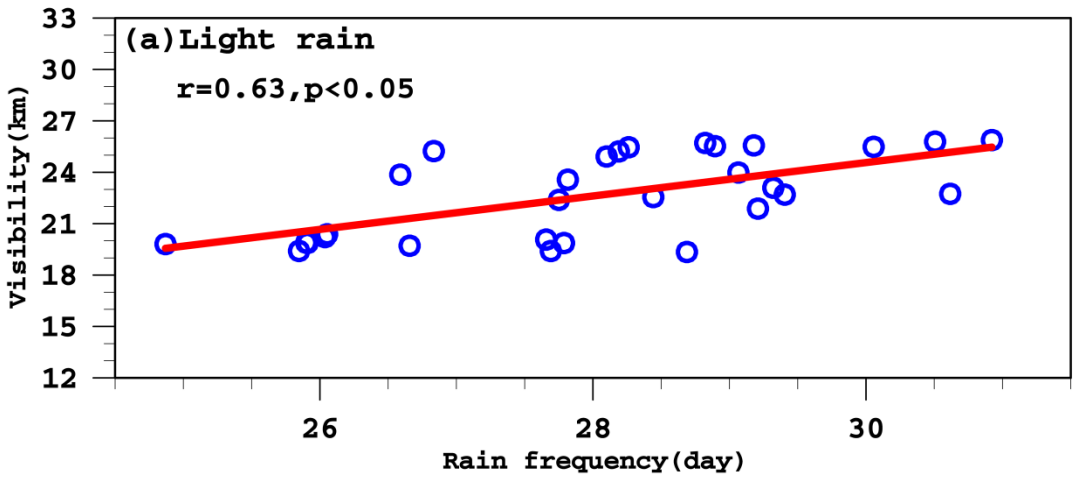
understand the differences between Figure 6a and Figure 6b and 6c. Otherwise, the figure can be quite confusion. In the caption, it is better to use "the positive (negative) trend" than "the positive (negative) variability".]

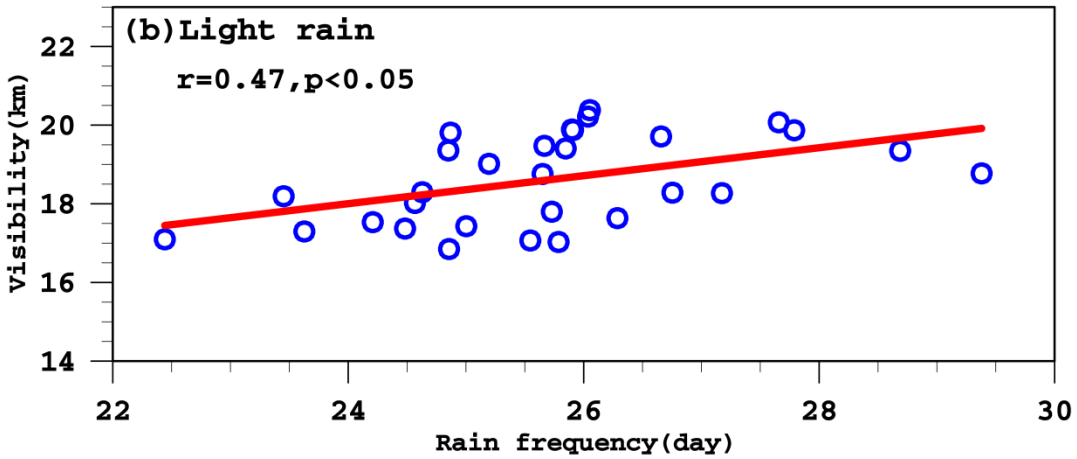
Reply 38: We have redrawn Fig. 5 as follows, and following the suggestiuon, the caption has been revised.

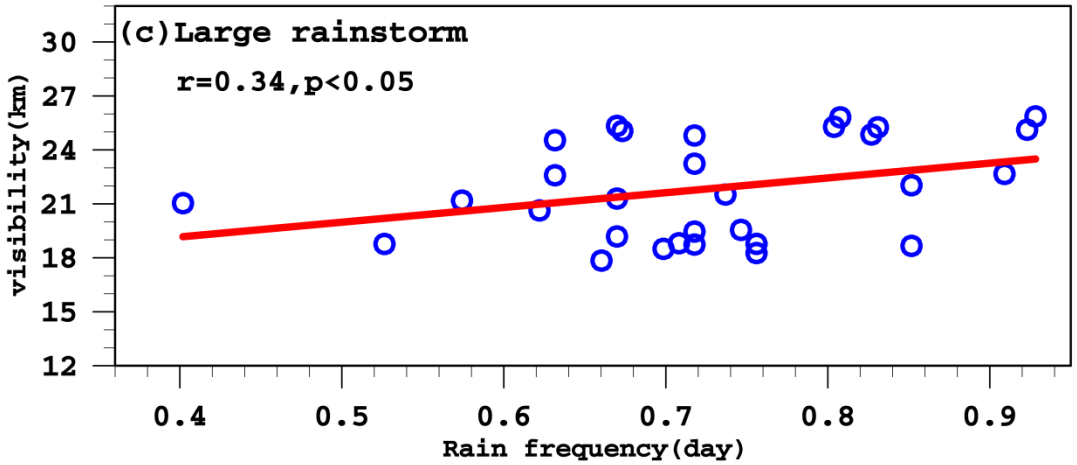


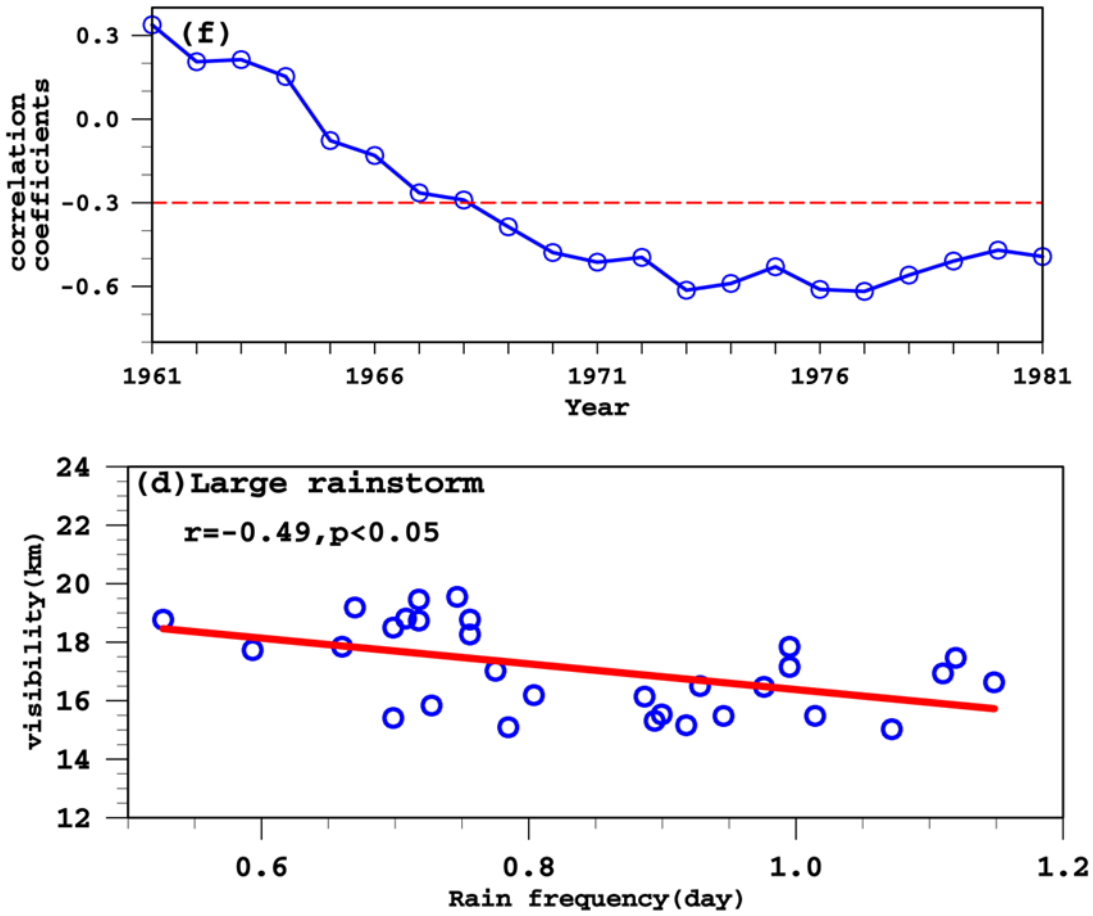
[Figure 7. Label sub-plots at the top, top-left, or top-right. Remove zeros for the most insignificant digit after a decimal. Keep sub-plots (a) –(d) the same size.]

Reply 39: Following the referee's suggestion, in the revised manuscript, Figs. 7a -7f have been redrawn as follows:


(a)Light rain
r=0.63,p<0.05
Visibility(km)
33
30
27
24
21
18
15
12
26
28
30
Rain frequency(day)


(b)Light rain
r=0.47,p<0.05
Visibility(km)
22
20
18
16
14
22
24
26
28
30
Rain frequency(day)


(c)Large rainstorm
r=0.34,p<0.05
visibility(km)
30
27
24
21
18
15
12
0.4
0.5
0.6
0.7
0.8
0.9
Rain frequency(day)



[Figure 9. Provide the unit for the dots.]

Reply 40: The revised caption of Figure 9 has provided the unit of day for the dots.

[Figure 10. For the label for the c-axis, remove "index".]

Reply 41: It has been removed in the revised manuscript.

[Figure 11. What are the different marks in Figure 11a?]

Reply 42: In the revised caption of Figure 11a, we have added "the different marks represent the different flights" T.