Responses to Reveiwer 1

Comments: I would like to thank the authors for the effort they put to revise their manuscript. Though many issues still remain, thus, I would suggest a new revision of the manuscript according to the following suggestions/comments.

To facilitate the discussion, I've chosen to directly answer to the authors' responses. Thus, the initial numbering of the first review's comments is kept. Please, for each of the comments below, refer to my initial comment and your response.

Response: Thank you very much for your kind patience,constructive and insightful criticism and advice. We tied to addressed all the points as below.
We believe that we have made comprehensive and carefully changes according to your suggestions.We hope that the changes listed below are acceptable.
All the changes made were highlighted using "Track Changes" mode of Microsoft Word in the revised manuscript attached.

Major Comments:

- First major comment: The manuscript still lacks clarity in terms of scope of the work, presentation of methods and results (please see below). The language issues are additional to that. Even significant efforts have been done, both problems still remain. Please try to clarify the above and at the same time carefully correct the language issues..

Response: .We sincerely thank you for your kind comments and review. We tried our best to correct, revise and check the manuscript and addressed them point to point below.
Some more revision about the language issues are listed here
Line 8, "flood risk" was revised as "risk"
Line 10, the result was revised as "(1) continuous precipitation events of 36 hours contributed the most precipitation to the total but with lower frequency, which

would be key events for flood monitoring; (2) The intensity and the occasional probability of extreme precipitation will increase in spring in the future in stations like Yifeng, Zhangshu and Ningdu, which will in turn increase the risk of storm floods; (3) spatial distribution of extreme precipitation risk shows that the risk increases as elevation increases in the northern lowland and the Jitai Basin in the mid-stream region, while the risk in the southern mountainous region decreases with elevation increasing."

Line 49, climate was replaced by weather as "Wu et al. analyzed the changes of extreme weather events under the background of future warming and pointed out ……"

Line 81 was revised as "They found that RX5day, R95, R20mm and SDII have an inter-annual tendency rate of 0.17 mm a-1, 1.14 mm · a-1, 0.02 d-1 · a-1 and 0.01 mm·d-1·a-1 (d-1·or a-1 is the abbreviation of per day or per year)"

Line 186 was revised as "which can estimate parameters of a distribution based on samples."

- Second major comment: I agree with the choice to work with precipitation amounts as there are no higher resolution data available to calculate intensity, but this should be explicitly discussed as a shortcoming when floods are the focus. Moreover, the extreme events were defined from the 99th percentile of each station, so the extreme threshold value is specific to each station. Why you refer to values above 14mm/12h? Is there a fixed threshold used and how is this supported?

Response: Thanks for your kind comments. We checked the whole manuscript and did not find the numbers of "14mm or 14mm/12h". Is it in the table ? or something else?

For the definition of the extreme events, we use the events above the thresholds, which is 99th percentile of the precipitation in each station, which is fixed during the reference time (1959-2016) in the station but different from one station to another. Precipitation about this threshold were considered as the extreme events.

Specific Comments

Response: Below is our point-by-point modification to your suggestions.

3, Lines 15-16: How the results help in planning and management? This also affects the discussions and coclusions as well.

Response: Thanks. We revised this sentence as: “These findings will facilitate emergency preparedness, including risk management and disaster assistance in the study areas.”

7，My query was not about the word “quasi”, it was about the circulation systems that you mention and how they affect precipitation in the area. This is important for a reader who is not familiar with the weather patterns of this area.

Response: Thanks. Yes. The quasi-stationary front is a kind of a weather front or transition zone between two air masses (cold and warm). The near-stationary front usually remains in the same area for hours to days, which result in high precipitation from April to June.

We also revised the sentence in line 132 as “Due to the long existence (hours to days) of near-stationary fronts over the basin, over 70% of the annual precipitation occurs during the period from April to June.”

8. Thank you for the clarification. Though, I strongly recommend reconsidering the use of the word “runs” for the 12-hour intervals of precipitation observations. “Runs” has no particular meaning and confuses the reader. In addition, you have added it in the abstract, without any explanation.

Response: You are welcome. Your kind and detailed comments improve our manuscript a lot.

“Run” refers as a consecutive period, a series, or a round, We find it was used to refer to precipitation series, which are dependent from run to run but with continuous rainfall in literatures below:

Llamas, J. and M. M. Siddiqui (1969). Runs of precipitation series, Colorado State University. Libraries.

Peel, M. C., T. A. McMahon, et al. (2005). "Global analysis of runs of annual precipitation and runoff equal to or below the median: run magnitude and severity." International Journal of Climatology: A Journal of the Royal Meteorological Society 25(5): 549-568.

We can sorry to say that we can not to find other suitable words to replace it at present. Could we keep it in the manuscript?

But We further revised it to avoid confusing in the abstract as “continuous precipitation events of 36 hours contributed the most precipitation to the total but with lower frequency, which would be key events for flood monitoring”

We also revised the definition in Section 2.1 as “Runs are defined as consecutive precipitation series in this paper.”

I understand that by “sliced” you mean that you selected a sub-set from the entire dataseries. If this is the case, then “sliced” is not appropriate. Please rephrase..

Response: Yes. “Sliced” means “selected” here. We revised it in line 146 as “Twelve-hours (12-H) precipitation was defined as precipitation records from 8:00 to 20:00 during days or precipitation from 20:00 to 08:00 the following day during nights and the data were selected from the original data between 1959-1-1 and 2016-12-31 with the purpose of keeping the data consistency.”

10, A reference or a link is missing regarding the recorded floods in China. This number of events happens where? In entire China or in the examined region?

Response: Thanks. It is the examined region. We did not find the data to show how many flood disasters in the study area. This number is estimated by the experts in our team.

We revised this sentence as “According to this threshold, 0-4 extreme precipitation events can be found in a year, which is very close to the number of flood disasters that the study area experienced”

11. Again, the question is not answered. What is meant by “information science problem”?

Response: Thanks. We revised it as “needs deterministic information with sufficient skill How to accurately estimate the return period of extreme precipitation needs deterministic information with sufficient skill (El Adlouni and Ouarda, 2010)”, which is more specific according to the manuscript.

14. As mentioned above, precipitation extremes cannot be connected per se to flood risk. In order to provide flood risk, the vulnerability and the exposure of the examined area must be also assessed. The spatial distribution of the extreme precipitation gives the hazard component of the risk. In my understanding, the other components have not been assessed or if they have been assessed, this is not presented in the paper. If this is the case, then, the maps in Figure 6 are not risk maps. In addition, the variable of the colorbar should be given in the caption. If it is the total number of events for the entire examined period, then it should be divided by the number of years to get the number per year which is more meaningful.

Please note that I strongly suggest removing “flood risk” from the title and the scope of the paper as it not assessed.

Response: Thank you for your kind and professional explanation of the flood risk. According to your suggestion, we revised the concept as below:

1) We removed flood risk or flood such as in line 7-8, “Climate warming increases the intensity of extreme precipitation. Studying extreme precipitation patterns and changes is vital to reducing disaster risk.”

In line 69-70, “The choice of extreme definition depends on the intended use in terms of reducing disaster loss.”

In line 109, “Time distribution patterns and return levels of extreme precipitation should be analyzed in risk research locally (Wu et al., 2018).”

In line 119, “(3) to explore the risk caused by extreme precipitation with different time scales and return periods in a case study.”

In line 233-236, “The extreme precipitation thresholds of different probabilities are used to evaluate the risk. The number of events above the thresholds are calculated at each meteorological station. The inverse distance weighted method (IDW) is then used to interpolate and zone the number after validation with observations, with the purpose to show the spatial characteristics of the extreme precipitation risk.”

In line 269, “Therefore, 1-10 runs were selected as experimental data for estimating the risk in the follow-up analysis.”

In line 334, “which will be used for risk analysis later in the following section. ”

In line 335, “4.3.2 Extreme events”

In line 369, “It is reasonable that the predicted extreme precipitation events are bigger than or equal to flood events in the risk assessment.”

In line 378, “If time intervals of precipitation are too long, this flood event will be missed because of the high threshold. Run 1（12-H precipitation） will be the best time interval for predicting extreme events in disaster management, which will avoid such missed cases.”

In line 379, “4.3.3 Spatial distribution of extreme precipitation risk”

In 382, “The paper further analyzed the spatial distribution of extreme precipitation risk in the study area”

In line 443,”We further spatially mapped the risk across the entire study area ”

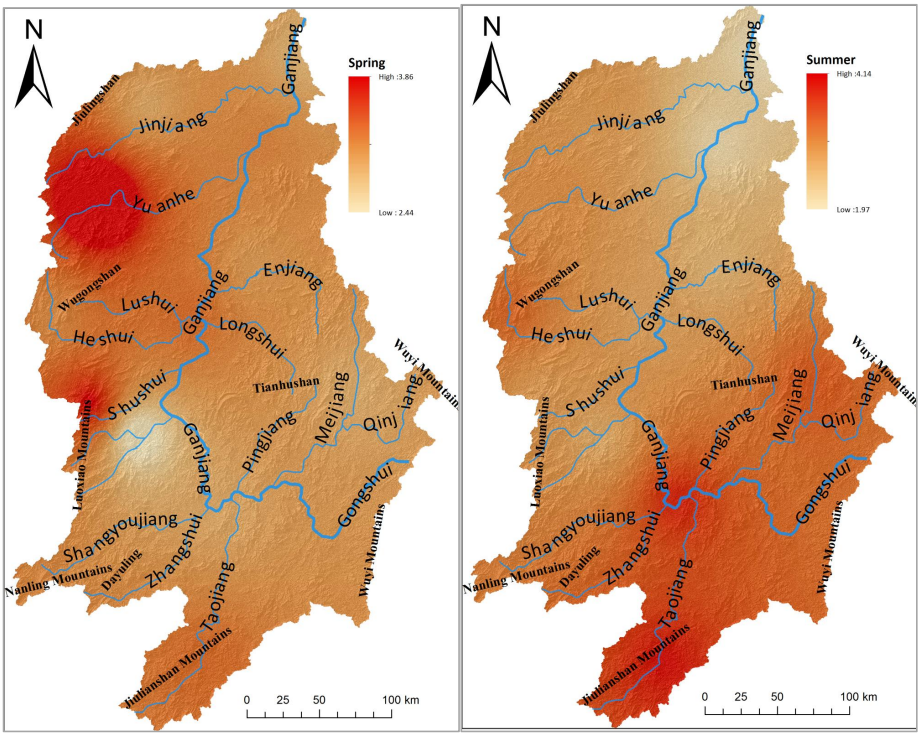
2) We removed risk such as in line 99, “However, events with scales shorter or longer than one day also cause floods.”

In line 103, “ Another example is that a precipitation event below the extreme precipitation threshold posed floods because it began on one day and ended the next and the total amount was high but not recorded.”

3) We replaced flood risk with extreme precipitation risk, such as in line 392-393 “Maps of extreme precipitation risk in spring, summer, autumn and summer with the methods above are followed in Figure 6 to show spatial distribution of extreme precipitation risk.”

In line 467, “Extreme precipitation risk shows increasing as elevation increases in the northern river-lake plain area and the Jitai Basin in the midstream area.”

Figure 6 were revised with the yearly average number of the events and we added an explanation to the variable of the colorbar in the caption.



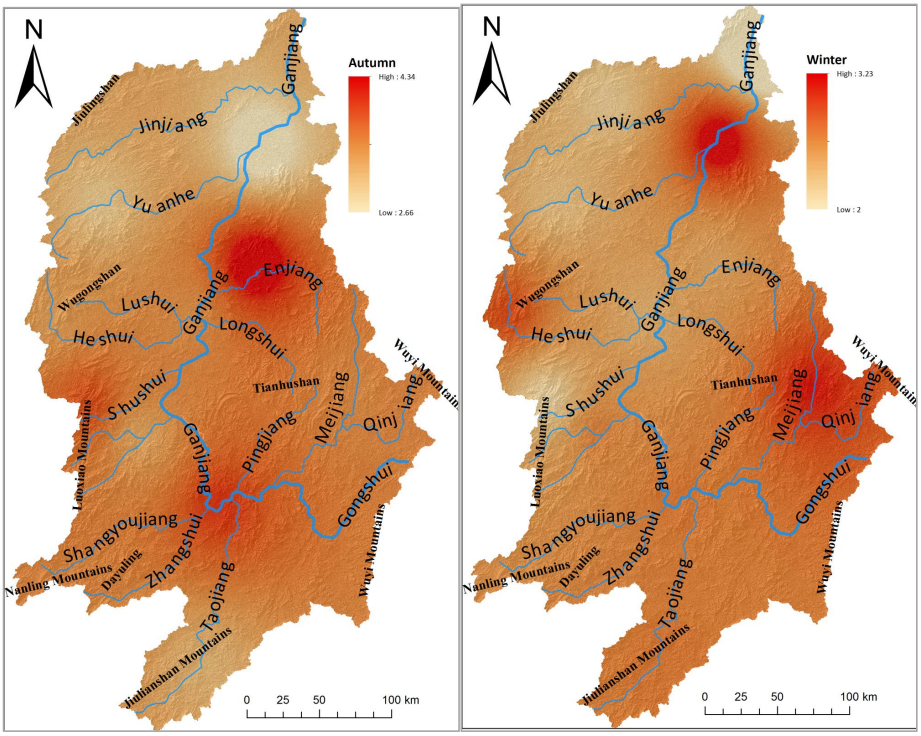


Figure 6 Extreme precipitation risk under Scenario 2 in spring, summer, autumn and winter in the Ganjiang River basin. The colors range from light orange to red, indicating the increasing risk from low to high. The numbers are annual averages of estimated extreme precipitation events.

16. The question still remains. Why is this conclusion important for flood risk analysis?

Response: We get the conclusion from Figure 2 below, which shows the frequency (orange bars) and contribution of the total precipitation (blue bars). Runs here means the Continuous precipitation. From the figure, we find 3-run precipitation events contributed the most precipitation to the total, but with lower frequency than that of Run 1 and Run 2. That means a higher rainfall per events than others, that is, they are high-intensity precipitation in a short time, which often cause floods. That is the reasons we think it is important for flood risk analysis.

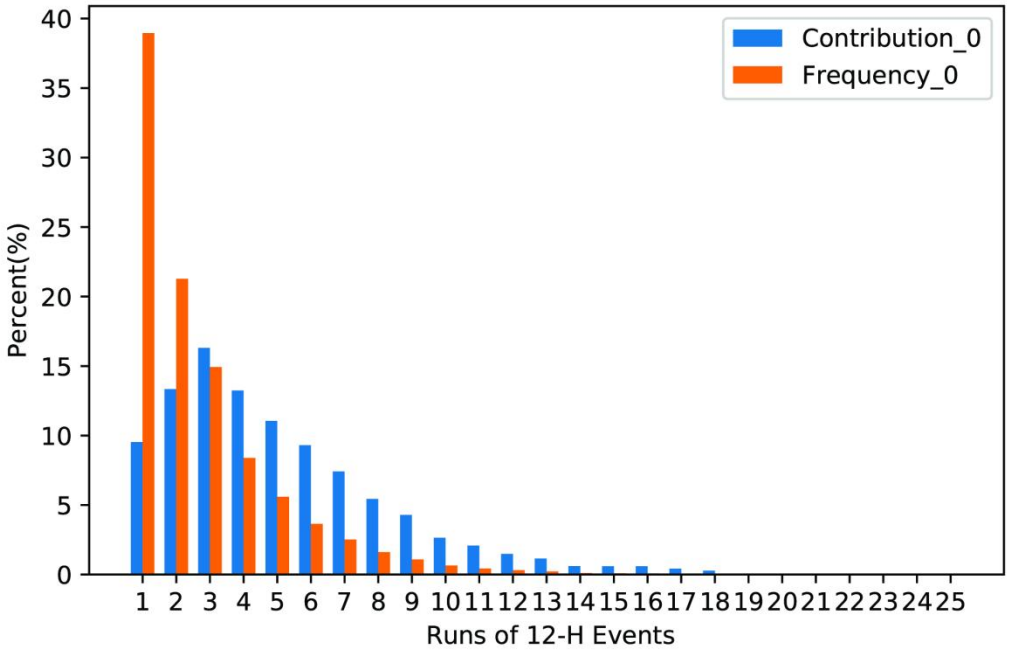


Figure 2 Frequency and contribution of runs of 12-H events

21. The question was about the significance of the differences. Are these differences statistically significant and, thus, important to be discussed?

Response: Yes. The 99% percentile of the observed data just shows the situation in the past. Their gamma distribution could give us more information about the overall trend. We explained the reasons in Section 2.3 as

"In this study, there are 58 years of rainfall records, which forces us to use limited samples to estimate events with a chance of 1 in 100 years or even more, i.e., exceedance probabilities of one percent or more. The addressed problem is solved in practice by estimating probability distributions, which can estimate parameters of a distribution based on samples. Such distributions involving precipitation research mainly includes: Gamma, Generalized Extreme Value and Pearson type 3 distributions."

22. I am afraid I do not agree with the explanation. Risk management can benefit from the calculation of the risk or any changes in the risk. Please explain which is the relevance of a lower threshold for extreme precipitation with management.

Response: Thanks. We added “estimated” before risk in line 316 to make it more specific as “A slightly lower threshold for extreme precipitation will increase the estimated risk,”.

This sentence can be discussed. We think that a slight lower threshold could help to find more extreme events, which means more hazards in risk evaluation. Thus lower threshold will increase estimated risk. The increased risk can make managers aware of more dangers and then take measures to down the lost risk.

25. So, the only available recorded flood events are in these five years of Halinqiao? And again, why you compare Halinqiao with Gx?

Response: Thanks. We want to make the comparison to find out what kinds of precipitation extreme events would cause floods in the study area. But we only find the five-year hydrologic record data (which can used to find the recorded flood events) at Halinqiao. Gx is the nearest weather station to Halinqiao.

The data limit us to do more comparison. Sorry about it.

26. Precipitation obviously happened before the flood event. You should take under consideration all consecutive 12-hour intervals before and on the event. If there are intermittent 12-hour intervals, then it should be discussed as well. And this is not a matter of forecasting, but rather of providing an insight into how much rain is needed to lead to a flood (even if intensity is not considered).

Most importantly, as you mention and I do agree, the paper focuses on the analysis of extreme precipitation and not in flood risk. Thus, I once again suggest removing “risk” from the title.

Response: Thanks for the suggestion. We checked the precipitation data in Gx and add the discussion below in Section 3.3.2 “ The precipitation records at Gx were selected with the flood occurrence date. There are 9 precipitation events found on the same day when the floods happened, with the highest precipitation of 72.2mm in 12 hours and 118.1mm in 24 hours.There was no precipitation recorded with the same date of the rest three floods, but precipitations were found on the previous day, which the highest precipitation of 73.3 mm in 12 hours before the date and 83 mm in 24 hours before the date. Two floods were found with a 6-run precipitation event in the

early stage, four floods with a 4-run precipitation event, two floods with a 3-run precipitation event, one flood with a 2-run precipitation event, and three floods with a 1-run precipitation event."

We removed the risk in the title as "Variations of extreme precipitation events with sub-daily data: a case study in the Ganjiang river basin"

27. The phrase "low estimated" is wrong. And, in addition, the question is not answered: what is underestimated; the number of events or the precipitation amount?

Response: Sorry for the wrong words. That is the number of the events. We revised it as "Scenarios 3, 4 and 5 (probabilities at 0.1, 0.05 and 0.02) have high thresholds which will underestimate the number of the flood events"

30. Thank you for providing the steps on how the number of events is calculated and spatially distributed. Though, the question was on how the risk has been calculated. Please see comment 14.

Response: Thanks and we revised the concept here and in other parts of the manuscript according to Comment 14.

31. See again comment 14 and 30. In addition, please explain how Zhang et al. (2001) support the findings.

Response: Thanks. We revised them according to comment 14. Reference (Shan et al., 2001) just explained the main weather systems that cause extreme precipitation in the study area. We want use these weather systems to explain the reasons of the spatial disctribution of the high-risk centers in the four seasons, that is the result of weather system and the topography, such as the monsoons result in the high centers in the west and south mountain regions in spring and summer; the fronts of the winter monsoons and warm air currents cause the high-risk centers in the eastern and southern parts in winter and autumn.

32. No, the problem is not the language. It is that mostly other works are discussed and they are poorly linked to the findings of this study.

Response: We want to thank you for your constructive and insightful criticism and advice. About the discussion, we use the first one with the purpose to outstand the importance of the finding "3-run precipitation events contributed the most precipitation but with lower frequency" and the hazard in the future. Reference of Cheng (Cheng and Aghakouchak, 2014) and Hosseinzadehtalaei et al ((Hosseinzadehtalaei et al., 2020)) show the climate change will change the short duration precipitation more. Ren et al. find the same case. These changes might be hazardous.

The second discussion was used to talked about the key extreme precipitation data for flood Flood monitoring and risk analysis., Reference of Merino support the idea that short-duration data in extreme event analysis could avoid underestimation of potentially dramatic consequences (Merino, Fernández‐González et al. 2018). Reference of Müller (Müller and Kaspar, 2014) gives us another idea to solve the issue of the lace of short-time data.

To focus on the topic, we also revised the manuscript below:

we readjusted the sections into 4 as Introduction, Data and methods, Results and discussion and Conclusion .

we revised the result in the abstract as "continuous precipitation events of 36 hours contributed the most precipitation to the total but with lower frequency, which would be key events for flood monitoring; (2) The intensity and the occasional probability of extreme precipitation will increase in spring in the future in stations like Yifeng, Zhangshu and Ningdu, which will in turn increase the risk of storm floods; (3) spatial distribution of extreme precipitation risk shows that the risk increases as elevation increases in the northern lowland and the Jitai Basin in the mid-stream region, while the risk in the southern mountainous region decreases with elevation increasing.".The first finding is from the analysis of frequency and contributions of precipitation events. The second finding is from Estimated distribution of precipitation events and the third finding is from risk of extreme precipitation.

We hope this revision will make each part of the manuscript more focused .

Responses to Reveiwer 2

Comments:

The manuscript includes a statistical analysis of extreme precipitation in a sub-region of China. The state of the art, the methodology and the results are properly analyzed and presented. The discussion is confined mainly in the statistical features of precipitation, without including for example extensive comments about the connection between them and large-scale atmospheric circulation factors. However, the findings are useful and they are properly and analytically presented, leading to a manuscript of high scientific level. I recommend the publication of the manuscript, provided that the authors will take into account the following minor comments:

Response: We sincerely thank you for your kind encouragement and recognition. We revised the manuscript according to your comments point by point. We hope that the changes listed below are acceptable.
All the changes made were highlighted using "Track Changes" mode of Microsoft Word in the revised manuscript attached.

1. Abstract, lines 10-11: Please do not use the term "runs" in the abstract, because it is not easily understood (the term is defined in the main part of the manuscript).

Response: Thanks for your kind suggestion. We revised it as "events of 36 hours" . The sentence was revised as "Results show that (1) continuous precipitation events of 36 hours contributed the most precipitation to the total but with lower frequency, which would be key events for flood monitoring".

2. Introduction, line 49: Please replace the term "extreme climate events" with "extreme weather events".

Response: Thanks. We revised it as "Wu et al. analyzed the changes of extreme weather events under the background of future warming and pointed out that compared with 1986-2005"

3. Introduction, line 81: Please explain what the unit "a" is.

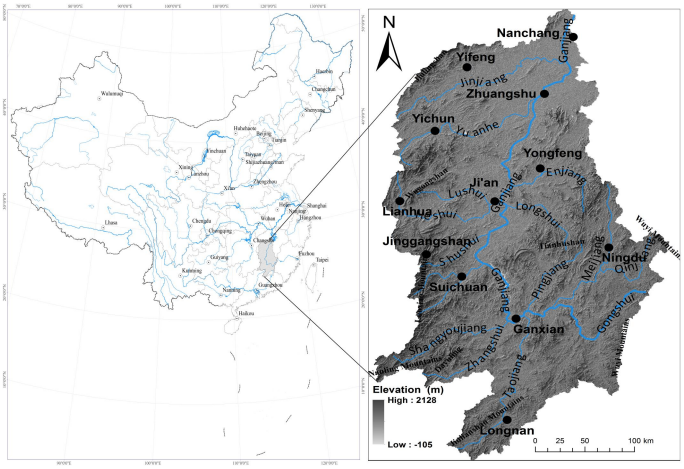
Response: Sorry for the problem. $d^{-1}\cdot$or a^{-1} is the abbreviation of per day or per year. We also corrected an error (it is 0.02 $d^{-1}\cdot a^{-1}$,not 0.02 $d\cdot a^{-1}$). The sentence was revised as "They found that RX5day, R95, R20mm and SDII have an inter-annual tendency rate of 0.17 mm a^{-1}, 1.14 mm$\cdot a^{-1}$, 0.02 $d^{-1}\cdot a^{-1}$ and 0.01 mm$\cdot d^{-1}\cdot a^{-1}$ ($d^{-1}\cdot$or a^{-1} is the abbreviation of per day or per year), respectively."

4. Study area: The section "Study area" could be the first sub-section of the "Data and methods" section.

Response: Thanks for the suggestion. We revised it in the manuscript. The sections were revised into four: introduction, data and methods, Results and discussion and conclusion.

5. Figure 1: Please add a map of China (Figure 1a) showing the exact location of the study area (Figure 1b). It would be useful for readers who are not familiar with the geographical characteristics of China.

Response: Thanks for the suggestion. We added a map of China and revised Figure 1 as below.



6. Table 2: The observation period of the stations shown in Table 1 is not common. The starting year is between 1951 and 1959. It is not clarified if the seasonal and annual means presented in Table 2 are based on different periods or on the common period 1959-2016. The selection of a common period is the most appropriate.

Response: Sorry for the missing information. We added an explanation in the caption of Figure 2 as “Seasonal and annual mean precipitation in stations (mm). The data are based on the selected period 1959-2016.”

6. Tables 3-5: Please draw vertical lines to separate the results of the four seasons in the tables. It will help the reader.

Response: Thanks for your kind suggestion. We added the vertical lines to separate the four seasons, which make the result more clearly.

Thank you again for your kind review and professional suggestions, which make the manuscript more clearly and readable.