# Response to Reviewers

Dear Editors and Reviewers:

Thanks for giving us an opportunity to revise our manuscript and the reviewers' comments concerning our manuscript. Those comments are valuable and very helpful for revising and improving our paper, as well as the important guiding significance to our researches.

After receiving the comments, we attached great importance to them and carefully discussed the issues mentioned in the manuscript. Though this period of thinking, we thoroughly revised the manuscript and improved every point, which we hoped meet with approval. Revised portion are marked in the paper. The main corrections in the paper and the responds to the reviewer's comments are as flowing.

We highly appreciate your time and consideration to allow us resubmit a revised copy of the manuscript. Please let us know if there is anything need to discuss during the review process.

Authors,

Sincerely.

**Response:**

Reviewer 1

Raindrop size distribution and the number of raindrops is an important parameter to describe the microstructure of precipitation. Numerous studies have been carried out the statistical characteristics of DSD in different regions. Qilian mountains are the vitally important ecological protection barrier and important water source in northwest arid areas of China. In this paper, the authors select 6 sites with different backgrounds representing the southern slopes, northern slopes and inside of Qilian mountains. This study reveals the microphysical variability of precipitation in the complex topography of the arid and semi-arid regions of Northwest China, which is of great significance to solving the shortage of water resources in the arid and semi-arid regions. The manuscript is of high quality and innovative. The data are full and reliable. I suggest that it be accepted after minor revisions.

Issue 1: The English and grammar of the article need to be carefully revised.

Revision: Thank for the advice. The language of the manuscript has been revised as well as formatting and punctuation.

Issue 2: How to determine the observation instruments are at the same accuracy standard in the 6 sites?

Revision: Thank for the comments. The instruments are used the same type, including the same particle size classification and velocity classification as well as the sensor of observation instruments. Besides, it is also used the same data processing and quality control, which insure the same accuracy at time and particle size.

Issue 3: In Fig 1, the size of sites is small and unclear. Add the photos of observation station or equipment.

Revision: Thank you for reminding us the description. As suggested we have redrawn the diagram (Fig 1) to express the geographical overview of the Qian Mountains and the sites, with clearer google satellite map and more rational selection of drawing areas. Also, we added the photo of equipment placed at one of the observation sites.

Issue 4: The research needs to further highlight the reasons for the differences between sites in the discussion and conclusion. And how is the precipitation different from other areas?

Revision: Thank you for your comments. According to the characteristics of raindrop size distribution (DSD) in Qilian Mountains, we find there are some similarities in different sites, while different from other areas. This is mainly due to melting of tiny, compact graupel, and rimed ice particles (relative to large, low-density snowflakes). Besides, there are also some similarities such as the basic law of stratiform and convective rainfall reflecting in the raindrop size distribution. However, it still exists some differences in Qilian Mountains, especially the DSD parameters, because they have different altitudes and geographical environments. Based on the suggestion and above description, we have supplemented the discussion section on . In order to better illustrate the precipitation difference between Qilian Mountains and other areas, we will choose representative site in Qilian Mountains to compare with other areas.

Issue 5: Extended discussion: Whether the change of DSD is related to other meteorological factors, such as local wind speed?

Revision: Thank for the tips. DSD can reflect the microstructure of precipitation. But it involves a series of microphysical and physical processes from rain generation to falling. There will be more research to explore the possible factors about the change of DSD. And we will continue to think about the contribution of local wind speed on the change.

Reviewer 2

The authors investigate the characteristics of the raindrop size distribution (DSD) over the complex mountainous terrain Qilian Mountains which are sensitive to climate change in recent decades. Such a study is very helpful to increase the knowledge of the precipitation regimes over the arid and semi-arid region. Overall, the study is written well in terms of science and techniques, and can be accepted and published after minor revision. More comments are as follows:

Issue 1: On line 18, the “which” had better to be replaced with “while”.

Revision: Thank for your advice. We have revised the conjunction

Issue 2: The period on line 32 should be updated with English style.

Revision: Thanks for your advice. We have revised the parentheses with English style.

Issue 3: The period before (SR) should be removed on line 50.

Revision: Thanks for your advice. We have deleted the period.

Issue 4: “in southeast” should be updated as “in the southeast”.

Revision: Thanks for your advice. We have updated this statement in the whole manuscript.

Issue 5: “results from” had better be replaced with “measurement in” on line 56.

Revision: Thanks for your advice. We have replaced the expression.

Issue 6: Insert a blank space between the number and unit on line 57.

Revision: Thanks for your advice. We have inserted a blank between the number and unit in the whole manuscript.

Issue 7: “vary from location” had better be replaced with “vary with”, or “vary from location to location”.

Revision: Thanks for your advice. We have revised as “vary from location to location”

Issue 8: The equation on line 139 shows up suddenly and suffers from discontinuity in the context. Similar case can be seen for Eq. (7) on line 169.

Revision: Thanks for your advice. We have added some contexts (line 161 and 205) before the both equations to improve the continuity.

Issue 9: “with” or “by” should be added after the word “calculated” on line 149.

Revision: Thanks for your advice. We have added the word “by” after the word “calculated” and checked the similar problems.

Issue 10: Refine the sentence on 167-168.

Revision: Thanks for your advice. We have refined as “And it has better fitting capability than M-P distribution on the broader variation of DSD fluctuations, including the middle rain drops, especially on small and large rain scale”.

Issue 11: Replace “to be well fitted” with “to well fit” on line 167.

Revision: It shown as the above response.

Issue 12: Refine the sentence on line 174-175.

Revision: Thanks for your advice. We have refined as “Although, the gamma distribution is commonly accepted, the normalized gamma distribution has also been widely adopted with its independent parameters and clear physical meaning as follows”.

Issue 13: Add legends for different color points, and add descriptions for the rectangles in grey line in the subfigures in Fig.7.

Revision: Thanks for your advice. We have updated the legends and descriptions in Fig 7.

Issue 14: “with the rain rate class rising” can be refined as “as the rainfall rate increases”.

Revision: Thanks for your advice. We have refined it and checked in the whole manuscript.

Issue 15: Refine sentence on line 478-479.

Revision: Thanks for your advice. We have refined as “Above all, the proposed classification of stratiform and convective rainfall is suitable for Qilian Mountains, which is applicable to the precipitation in the arid and semi-arid regions.”. And we also rewrote this part.

Issue 16: “Fig 1” needs to be considered for better presenting sites information.

Revision: Thanks for your advice. We have changed Fig 1 with bigger size of sites and smaller areas in the map, which better presents the sites information.

Issue 17: The differences from different sites can be described more clearly in the Conclusion section.

Revision: Thanks for your advice. We have revised Conclusion section, which described the differences from four aspects including different rainfall rates and types, as well Z-R relationship.

Issue 18: Some key raindrop parameters can be reported in the Analysis section, such as 3.4 Section reflecting the differences in different rain types.

Revision: Thanks for your advice. We have considered some key raindrop parameters to analyze and compare such as $\log_{10}N_w$ and $D_m$. But there are six sites showing the values, which makes it hard to choose site or the average values of sites. We will add the key parameters of typical site to report the differences in different rain types. And we also prepare another manuscript chosen one site to indicate the differences with other areas. We think it will be more clearly reported with some key raindrop parameters' values.

Issue 19: Line 320: "based on the classification ideas of Chen and Saurabh", Saurabh is not shown in the part of classification method. Please check this sentence.

Revision: Thanks for your comment. "based on the classification ideas of Chen and Saurabh" should be revised as" "based on the classification ideas of Chen et al. (2013) and Das et al. (2018)"

Issue 20: Check the accuracy of the subscripts in the manuscript.

Revision: Thanks for your comment. We have revised the subscripts in the whole manuscript.

Reviewer 3

**General comment**

The English is not up to the standard of a journal like EGU-HESS. The manuscript absolutely needs to be checked and improved on this aspect as for some instances, the reader would be confused and can only guess what the authors wish to say. In addition to this, the manuscript has a high frequency of occurrence of typo on units, punctuation and itemization. It thus needs a careful proofreading either by the authors or an external reviewer. I find it hard to concentrate on the content of the paper, and thus would suggest that the authors improve that aspect first, and then

submit a revised version that could be reviewed for assessing the content. I thus suggest a major revision based on this comment only.

Thanks for your comment and the opportunity. We have revised the language of whole manuscript as well as some long or confused sentences, which will be easier to understand. Besides, we checked all the subscripts, units and format in the manuscript and revised them. So, we sincerely hope that the manuscript can move forward in the journal.

The study is based on the HSC-OTT Parsivel2: the authors refer to the OTT and HSC manufacturers of the instrument. It is unclear if this is the exact same instrument as the OTT Parsivel2 found extensively in the DSD literature, or if it is a slightly different version. It would be good if the author can provide more information on this.

Thanks for your advice. The DSG4 disdrometer is produced and sold by Huatron (China), including the sensor is mainly created from OTT Messtechnik (Germany). Essentially, there is not much difference between them (the core components are made by OTT Messtechnik). And after data quality control, the available data have accounted for a high percentage of total number of samples

It would be important to make the DSD data available on a repository. This is predominantly the norm now in the new DSD studies and would help advance science. This is not mandatory as part of the HESS policy (I suppose), but it should be encouraged nevertheless.

Thanks for your affirmation and recognition. We will try our best to improve the manuscript.

**Specific comments**

Issue 1: Line 126 units upper script

Revision: Thanks for your comment. We have revised as “m s-1” and checked the whole manuscript.

Issue 2: Line 131 starting with (1) is inappropriate here.

Revision: Thanks for your comment. We replaced the period before (1) with a colon, and then continued (2), (3), (4), (5) with a semicolon.

Issue 3: Line 131 to 142 you could cite Jaffrain et al. (2011) and Guyot et al. (2019) here:

Jaffrain, J. and Berne, A.: Experimental quantification of the sampling uncertainty associated with measurements from PARSIVEL disdrometers, J. Hydrometeorol., 12, 352–370, https://doi.org/10.1175/2010JHM1244.1, 2011.

Guyot, A., Pudashine, J., Protat, A., Uijlenhoet, R., Pauwels, V. R. N., Seed, A., and Walker, J. P.: Effect of disdrometer type on rain drop size distribution characterisation: a new dataset for south-eastern Australia, Hydrol. Earth Syst. Sci., 23, 4737–4761, https://doi.org/10.5194/hess-23-4737-2019, 2019.

Revision: Thanks for your advice. We have read the two articles and cited them in this part.

Issue 4: Line 138 do no use “can’t” in abbreviated form

Revision: Thanks for your advice. We have revised the expression form

Issue 5: Line 157 following equations

Revision: Thanks for your advice. We have revised as “equations”.

Issue 6: Line 174 add references on the parameterization of the DSD

Revision: Thanks for your advice. We have added the article from Zhang et al. (2019).

Issue 7: Figure 1 is not up to the standards in terms of resolution

Revision: Thanks for your advice. We have revised Figure 1 and chosen bigger the size of sites, including the clearer google satellite map and more rational selection of drawing areas

Issue 8: Section 3.1 could you provide a summary of the data of each site in terms of the number of samples before and after quality control, and DSD stats (see for example in Angulo-Martinez et al. 2015 or Guyot et al. 2019).

Revision: Thanks for your advice. We have added the number of samples before and after quality control in different sites.

Angulo-MartiÌnez, M., and A. Barros, 2015: Measurement uncertainty in rainfall kinetic energy and intensity relationships for soil erosion studies: An evaluation using PARSIVEL disdrometers in the Southern Appalachian Mountains. Geomorphology, 228, 28-40.

Issue 9: Line 127 spacing between value and units

Revision: Thanks for your comment. We have added the space and checked the whole manuscript.

Issue 10: Figure 3 space between Z and (dBZ); missing “.” at the end of the figure caption

Revision: Thanks for your advice. We have added the space and corrected the wrong figure caption in the words.

Issue 11: Figure 11: it would be good to add results from the literature as well on this graph so we can compare the value of the coefficients found in that paper with data from elsewhere (mountainous region, DSD from China in particular).

Revision: Thanks for your advice. In this article, we compared with some common relationships which are widely used in numerical model. There are six sites in this study and it is hard to choose more appropriate site to compare with elsewhere. And other researches also use one site to analyze the characteristics of local area. So we are preparing another manuscript chosen one typical site in Qilian Mountains to indicate the differences with other areas. It would be more clearly reported with some key raindrop parameters’ values, as well the Z-R relationship.

Issue 12: Line 516 Bringi et al.: which year?

Revision: Thanks for your comments. We have added the year. It is Bringi et al. (2003).