Reply to Reviewer 1

Manuscript ID: essd-2018-150
Title: WHU-SGCC: A novel approach for blending daily satellite (CHIRP) and precipitation observations over Jinsha River Basin
Journal: Earth System Science Data
Type: Article

Dear Reviewer,

Thank you for your insight comments and suggestions. We have modified the manuscript accordingly. We trust that all of your comments have been addressed accordingly in the revised manuscript. If you have further suggestions for changes, please let us know. The detailed corrections are listed below point by point:

All changes in the manuscript are marked with red color.

Minor comments

(1)- Line 14: By mentioning the CHIRP database the University of Santa Barbara needs to be cited as developer. Thus, the sentence has to be changed in: the Climate Hazards Group InfraRed Precipitation (CHIRP, daily 0.05) satellite-derived precipitation developed by the UC Santa Barbara

Answer: Thanks. Done. The University of Santa has been cited when mentioning the CHIRP database.

Change: changed "the Climate Hazards Group Infrared Precipitation (CHIRP, daily, 0.05°) satellite-derived precipitation estimates" to "the Climate Hazards Group Infrared Precipitation (CHIRP, daily, 0.05°) satellite-derived precipitation developed by the UC Santa Barbara over the Jinsha River Basin for the period of June-July-August in 2016"

(2)- Line 52: When the CHIRPS dataset has been mentioned the developer (UC Santa Barbara et al.) has to cited as well.

Answer: Thanks. Done. The University of Santa has been cited when mentioning the CHIRP database.

Change: changed "the Climate Hazards Group Infrared Precipitation with Station data (CHIRPS)" to "the Climate Hazards Group Infrared Precipitation with Station data (CHIRPS) developed by the UC Santa Barbara"

(3)- Line 109: Section 2.2 can to be compacted in only 2 subsections for a better reading: 1) precipitation gauged observations and 2) gridded precipitation+CHIRPS

Answer: Thanks. Done. Because the gridded precipitation used here was from China

Meteorological Data Service, interpolated from 2472 rain gauge stations. The interpolated data with some errors was less accurate than the direct measurements from stations, for example, daily precipitation was more than 1000 mm at one interpolated grid point. So only the rain gauge observations were used to the new experiments.

Change: We have only used rain gauge stations to conduct the WHU-SGCC method over the Jinsha River Basin during the summer seasons from 1990 to 2014. So we delete the relative sections (2.2.2 Gridded precipitation observations; 3.1.3 Rule 2 of the WHU-SGCC method). And we changed the classifications of the target pixels from "1) Classify all regional pixels into five types: C1 (pixel including one gauged station in its area), C2 (pixel including one gridded point), C3 (pixel physically similar to C1C2), C4 (pixel physically similar to C3) and C5 (remaining pixels)." to "Classify all regional pixels into four types: C1 (pixel including one gauge station in its area), C2 (pixel statistically similar to C1), C3 (pixel statistically similar to C2) and C4 (remaining pixels). "

(4)- Line 159: what's "SICR approach"?

Answer: Sorry. Thanks. The "SICR" approach must be clerical error.

Change: This sentence has been changed "On this basis, the WHU-SGCC method identifies the geographical locations and topographical features of each pixel and applies the classification principles of the SICR approach, including five classification and blending rules." to "On this basis, the WHU-SGCC method identifies the geographical locations and topographical features of each pixel and applies the four classification and blending rules."

(5)- Line 162 "C3 (pixel physically similar to C1C2)". What does it mean "physically"?

Answer: Thanks. Some studies indicate that pixels have similar precipitation features in certain spatial scope. And the size of spatial range can be determined by similar geographical location, elevation and other terrain information with the method of fuzzy c-means (FCM) clustering in this study. Because we deleted the gridded precipitation observations and changed the pixels classifications to "Classify all regional pixels into four types: C1 (pixel including one gauge station in its area), C2 (pixel statistically similar to C1), C3 (pixel statistically similar to C2) and C4 (remaining pixels)." So in the new experiments, we can assume that **the C2 pixels have similar precipitation features (e.g. rainfall distribution) with C1 pixels in the same cluster**, which may be better called **statistically simila**r rather than physically similar.

Change: We changed "C3 (pixel physically similar to C1C2), C4 (pixel physically similar to C3)" to "C2 (pixel statistically similar to C1), C3 (pixel statistically similar to C2)"

(6)- Line 180 ": : :satellite precipitation estimations deviated from observed data : : :". Really satellite precipitation even though retrieved are always measured data. Thus, it is better replacing the above sentence with: "satellite precipitation estimations deviated from ground-based measurements"

Answer: Thanks. Done.

Change: changed "satellite precipitation estimations deviated from observed data" to "satellite precipitation estimations deviated from ground-based measurements".

(7)- Section 4 – This section is too much subdivided getting quite difficult the reading. Please, let you group the discussion.

Answer: Thanks. Done.

Change: Because of the modification of the WHU-SGCC approach, the section 4 was adjusted accordingly.

Now the section 4 was divided into 4 parts: 4.1 Spatial Clustering from the FCM method, 4.2 Model performance based on overall accuracy evaluations, 4.3 Model performance based on the spatial distributions and 4.4 Model performance for rain events., which may be simpler for reading.

(8)- Table 6: What's "wet precipitation?" You mean, probably liquid precipitation, right?

Answer: Yes. Thanks. It is a good idea to state that the paper focus is on liquid precipitation (rainfall) and this term would be used throughout.

Change: changed "wet precipitation" to "liquid precipitation".

Major comments to Authors

The proposed manuscript tries to improve the performance of the CHIRP/S datasets by statistically adjusting the original data over complex terrain. The general statistics described in table 5 reveals very light improvements even though WHU-SGCC performs better and CHIRPS dataset seems to be worse also respect to raw data (CHIRP). Skipping to the performance evaluation for rain categories, how do you justify the inversion of BIAS tendency from the category (5,10) to > 40 (see table 6)? The accuracy of WHU-SGCC method seems to be limited to low precipitation (<10, not >20) where the model tends to overestimate. For precipitation greater than 10 the WHU-SGCC starts to underestimate. Please, let u clarify this! Really, the validation of the WHU-SGCC method is only limited to the Jinsha River Basin in summertime 2016 thus new and more accurate validation campaigns have to be done. On that, the challenging efforts to apply and validate a new method over orographically complex terrain have to be supported by new application on similar morphology where the rain-gauges are typically sparse. Furthermore, since during the monsoon season precipitation is typically higher than 20 mm, how the WHU-SGCC will perform? Of course, this question needs to be exhaustively answered by a new validation using the same methodology described in the manuscript.

Answer: The CHIRPS was derived from blending in-suit precipitation observations and the CHIRP data, with a modified inverse-distance weighting algorithm at a quasi-global area (land only, 50° S-50° N). The blended data (CHIRPS) has an effective performance on a large scale region according to existing studies, such as at the national scale, but there are still large discrepancies with ground observations at the sub-regional level, especially at the river basin scale. The performance and applicability of CHIRPS at the sub-regional level still need to be validated. What's more, the interpolation performance from the limited and sparse rain gauge stations will be affected by more errors which was evaluated with rain gauge stations shown in Table 5.

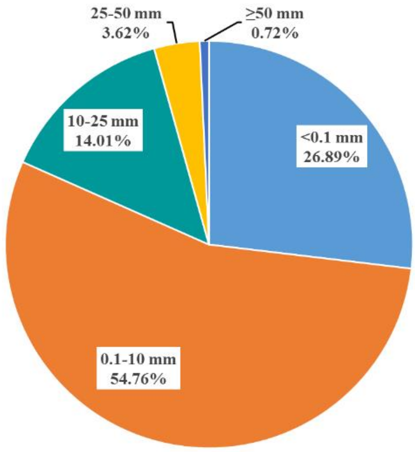
As such, due to the poor performance of CHIRPS data at the sub-regional scale and the shortcomings of the modified inverse-distance weighting algorithm, the aim of this article is to offer a novel blending approach to improve the precipitation estimated accuracy at the river basin scale.

The Jinsha River Basin is a typically study area, with the complex and varied terrains that the range of elevation is from 263 to 6575 m above sea level, which results in significant temporal and spatial weather variation within the basin. What's more, the multi-year (1990-2014) average annual precipitation increases from north to south and the spatial distribution of precipitation is uneven, with an average annual precipitation ranging from less than 250 mm to more than 600 mm during the summer seasons over the Jinsha River Basin. However, the number of rain gauges stations is limited inside the river basin which cause precipitation estimations bias a lot.

In the previous experiment, the rain gauge stations and gridded points were used as the reference precipitation data. From that data, the training samples represented 70% of total gauged stations and gridded points, and the remaining data were used to verify the model performance. And the WHU-SGCC approach was evaluated for the Jinsha River Basin for JJA 2016.

However, the gridded precipitation used here was from China Meteorological Data Service, interpolated from 2472 rain gauge stations, which was less accurate than the rain gauge stations observations, for example, daily precipitation was more than 1000 mm at one interpolated grid point. So only the 30 rain gauge stations were used in the new WHU-SGCC experiments. In the new experiment, selecting 30% of the stations for validation was not an appropriate validation method, while the leave-one-out cross validation step was a better instead for using all the stations in WHU-SGCC correction algorithm. What's more, in order to evaluate the model performance more reasonably, the study period was changed from summer of 2016, JJA to a longer study period during June-July-August from 1990 to 2014.

In the results, the days of each class of rain events at the validation gauge station during JJA from 1990 to 2014 were shown in Table 6 in the paper and the following figure. The major rain events inside the Jinsha River Basin were light rain (0.1-10 mm), accounting for 54.76% of the total days (the average percentage of rain event days in its total days at each gauge station), while the days with daily precipitation over the 50 mm was least, only accounting for 0.72%. And the percentage of the daily precipitation of <0.1, 10-25, and 25-50 mm were 26.89%, 14.01% and 3.62% respectively. The result indicated that the average daily precipitation was less than 10 mm, though in the summer seasons during the multi-year. As well as, the spatial distribution of precipitation was also uneven, with an increase from north to south. In terms of performance with respect to different daily rain events, the WHU-SGCC approach had the lowest error, as indicated by RMSE, MAE and BIAS for events with total rainfall less than 10 mm which can represents the mainly precipitation conditions over the Jinsha River basin.



The WHU-SGCC approach blended daily precipitation gauge data and the CHIRP satellite-derived precipitation, considering the spatial correlation and the historical precipitation characteristics. Therefore, the applicability of the WHU-SGCC method over the complicated mountainous terrain with sparse rain gauge data could be confirmed by the multi-year validation.

It is quite a worthy advice that applying and validating the WHU-SGCC method over the other similar terrain area where the sparse rain-gauges layout. But due to only one month for revising the paper, our major work was on the study period extension and the method modification, the validation on the other area would be carried on further research.