Reply to Reviewer 2

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:

General Comments

The manuscript describes a very interesting method to correct random and systematic errors from satellite infrared precipitation estimates based on gauge data and grid points from interpolated precipitation fields. The manuscript is well structured and present links to access all the data that is used in the work. However, I found that the analysis period (summer of 2016, JJA) is too short to make significant conclusions about this precipitation dataset. Also, the manuscript could have explored another ways to analyze and evaluate the dataset other than the very conventional use of statistical metrics, that are definitely needed, but the authors could have explored beyond that. Maybe using a case study or exploring the usefulness of the data for a particular hydrological application would be helpful. The dataset published with the manuscript is of good quality and is stored in a standard and easy to read format. I suggest that the authors make another English revision, especially regarding the use of articles and prepositions.

Answer:

Thank you for your advices on the analysis period, method, validation and the syntax modification.

The WHU-SGCC approach is a promise tool to monitor the summer precipitation over the Jinsha River Basin, considering the spatial correlation and historical precipitation characteristics.

However, in the previous experiment, the analysis period (summer of 2016, JJA) was too short to make significant conclusions. Therefore, 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.

What's more, the rain gauge stations and gridded points were used as the reference precipitation data in the previous experiment. Now, due to the gridded precipitation 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 (This data can be obtained from the China Meteorological Data Service). In hence, only the 30 rain gauge stations were used in the new WHU-SGCC experiments and the validation method was changed from "selecting 30% of the stations for validation" to leave-one-out cross validation for using all the rain gauge stations. Based on this, the WHU-SGCC was also modified for better precipitation correction.

It is quite a worthy advice that using a case study or exploring the usefulness of the data for a particular hydrological application. But the monitoring data for water level and velocity at the gauge stations are not available online, which limits the input data for hydrological model. Nevertheless, we are applying to hydro-graphic office. The applying on a particular hydrological case would be carried on further research.

In the new experiment, the applicability of the WHU-SGCC method over the complicated mountainous terrain with sparse rain gauge data could be confirmed by the multi-year statistical validation over the Jinsha River Basin.

Specific Comments

(1)- Line 18: It was evaluated not only by categorical indices.

Answer: Thanks. The performance of WHU-SGCC approach was evaluated by multiple error statistics and from different perspectives, such as overall accuracy, daily accuracy and performance on different rain events.

Change: So according to your advice, we changed "which is evaluated by categorical indices" to "which is evaluated by multiple error statistics and from different perspectives".

(2)- Line 28: The number of gauge stations is actually very limited, especially in regions with complex terrain and in the case of gauges that measure solid precipitation. Accuracy of this gauges is also not very good in the case of solid precipitation. It would be a good idea to state that the paper focus is on liquid precipitation (rainfall), and use this term throughout the text.

Answer: 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: We changed "In general, ground-based gauge networks include a substantial number of precipitation observations measured with high accuracy" to "In general, ground-based gauge networks include a substantial number of liquid precipitation observations measured with high accuracy"

Changed "As such, the aim of this article is to offer a novel approach for blending daily precipitation gauge data, gridded precipitation data and the Climate Hazards Group Infrared Precipitation (CHIRP) satellite-derived precipitation estimates developed by the UC Santa Barbara, over the Jinsha River Basin." to "As such, the aim of this article is to offer a novel approach for blending daily liquid precipitation gauge data and the Climate Hazards Group Infrared Precipitation (CHIRP) satellite-derived precipitation estimates developed by the UC Santa Barbara, over the Jinsha River Basin."

Added "Here, we will use precipitation to name liquid precipitation throughout the text."

(3)- Line 35: I found this line confusing in the way it is phrased. I think this sentence could be phrased this way: "Satellite estimates are susceptible to systematic biases that can influence hydrological modelling."

Answer: Thanks. Done.

Change: We changed "However, the retrieval algorithms for satellite-based precipitation estimates are susceptible to systematic biases in hydrologic modelling and are relatively insensitive to light rainfall events" to "However, satellite estimates are susceptible to systematic biases that can influence hydrological modelling and the retrieval algorithms are relatively insensitive to light rainfall events".

(4)- In the introduction, I think that a better description of what is available to estimate precipitation from satellites is missing. For example, GOES-R and GPM are missing in the description.

Answer: Thanks. Done. The description of GEOS-R and GPM has been added into introduction.

Change:

Added the description into introduction:

1) The Global Precipitation Measurement (GPM) satellite was launched after the success of the TRMM satellite by the cooperation of National Aeronautics and Space Administration (NASA) and Japan Aerospace Exploration Agency (JAXA) on February 27, 2014 (Mahmoud et al., 2018;Ning et al., 2016). The main core observatory satellite (GPM) cooperates with the ten other satellites (partners) to offer the high spatiotemporal resolution products (0.1° × 0.1°- half- hourly) of the global real-time precipitation estimates (Mahmoud et al., 2019).

2) The Geostationary Operational Environmental Satellite (GOES)-R Series is the geostationary weather satellites, which significantly improves the detection and observation of environmental phenomena. The Advanced Baseline Imager (ABI) onboard the GOES-R platform will provide images in 16 spectral bands, spatial resolution of 0.5 to 2 km (2 km in the infrared and 1–0.5 km in the visible), and full-disk scanning every 5 minutes over the continental United States. The GOES-R Series will offer the enhanced capabilities for satellite-based rainfall estimation and nowcasting (Behrangi et al., 2009;Schmit et al., 2005).

Added the relevant references:

Behrangi, A., Hsu, K. L., Imam, B., Sorooshian, S., Huffman, G. J., and Kuligowski, R. J.: PERSIANN-MSA: A Precipitation Estimation Method from Satellite-Based Multispectral Analysis, J. Hydrometeorol., 10, 1414-1429, 10.1175/2009jhm1139.1, 2009.

Mahmoud, M. T., Al-Zahrani, M. A., and Sharif, H. O.: Assessment of global precipitation measurement satellite products over Saudi Arabia, Journal of Hydrology, 559, 1-12, 10.1016/j.jhydrol.2018.02.015, 2018.

Mahmoud, M. T., Hamouda, M. A., and Mohamed, M. M.: Spatiotemporal evaluation

of the GPM satellite precipitation products over the United Arab Emirates, Atmospheric Research, 219, 200-212, 10.1016/j.atmosres.2018.12.029, 2019.
Ning, S., Wang, J., Jin, J., and Ishidaira, H.: Assessment of the Latest GPM-Era High-Resolution Satellite Precipitation Products by Comparison with Observation Gauge Data over the Chinese Mainland, Water, 8, 481-497, doi:10.3390/w8110481,2016.
Schmit, T. J., Gunshor, M. M., Menzel, W. P., Gurka, J. J., Li, J., and Bachmeier, A. S.: Introducing the next-generation Advanced Baseline Imager on goes-R, Bulletin of the American Meteorological Society, 86, 1079-+, 10.1175/bams-86-8-1079, 2005.

(5)- Line 62: That are other sources of uncertainty in the monitoring of rainfall in complex terrain (e.g., orographic enhancement).

Answer: Thanks. Done. In existing studies, they found that topography, seasonality, and climate impacted on the satellite-based precipitation estimations performance.

Change: We changed "estimations over mountainous areas with complex topography often have large uncertainties and systematic errors due to the sparseness of rain gauges (Zambrano-Bigiarini et al., 2017)" to "estimations over mountainous areas with complex topography often have large uncertainties and systematic errors due to the topography, seasonality, climate impact and sparseness of rain gauges (Derin et al., 2016;Maggioni and Massari, 2018;Zambrano-Bigiarini et al., 2017)" and we added the relative references.

(6)- Line 94: I was not able to understand the average precipitation over the Yangtze River Basin. You could be more specific about what statistic you are presenting here. Usually what is presented is the spatially averaged annual accumulation of precipitation as an indication of precipitation climatology for the region.

Answer: Thanks. Done. We have used the spatially averaged annual accumulation of precipitation as an indication of precipitation climatology for the study region.

Change:

1)We changed "The river's catchment proximately covers an area of ~180 × 10^4 km^2.In 2016, the average precipitation in the Yangtze River Basin was 12053 mm and the total precipitation was 21478.7195 billion m3, which is 10.9% higher than the annual average total precipitation" to "The river's catchment proximately covers an area of approximately ~180 × 10^4 km^2 and the average annual precipitation is approximately 1100 mm (Zhang et al., 2019)."

2)We changed "Average annual precipitation in the Jinsha River Basin is approximately 3433.45 mm, the total annual precipitation north of Shigu is 937.25 mm, while south of Shigu annual precipitation is 2496.20 mm." to "The average annual precipitation of the Jinsha River Basin is approximately 710 mm, the average annual precipitation of the lower reaches is approximately 900-1300 mm, while the average annual precipitation of the middle and upper reaches is approximately 600-800 mm (Yuan et al., 2018)."

(7)- Line 98: I was not able to comprehend the units for the area of the basin. It should be presented as km2.

Answer: Thanks. The units for watershed area (the area of the basin) are km^2.

Change: We changed "covering a watershed area of 460 × 103 km^2" to "covering a watershed area of 460×10^3 km^2".

(8)- Line 102: Topography would not exert a temporal variation in climate, since this is not a very dynamic feature of the Earth's surface. It could exert a temporal variation in weather though.

Answer: Thanks. It is indeed that complex and varied terrains would not exert a temporal variation in climate due to relatively stable feature of Earth's surface. However, a temporal variation in weather would be susceptible to topography.

Change: We changed "which results in significant temporal and spatial climate variation within the basin" to "which results in significant temporal and spatial weather variation within the basin"

(9)- Lines 102 and 103: Please try be consistent with the statistics you are using here.

Answer: Thanks. Done. We have been consistent with the statistics and used the spatially averaged annual accumulation of precipitation as an indication of precipitation climatology for the study region.

Change:

We changed "Average annual precipitation in the Jinsha River Basin is approximately 3433.45 mm, the total annual precipitation north of Shigu is 937.25 mm, while south of Shigu annual precipitation is 2496.20 mm." to "The average annual precipitation of the Jinsha River Basin is approximately 710 mm, the average annual precipitation of the lower reaches is approximately 900-1300 mm, while the average annual precipitation of the middle and upper reaches is approximately 600-800 mm (Yuan et al., 2018)."

(10)- Line 134: Maybe explain better what is the CHPClim product.

Answer: Thanks. Done. The reference (Funk, C., Verdin, A., Michaelsen, J., Peterson, P., Pedreros, D., and Husak, G.: A global satellite-assisted precipitation climatology, Earth Syst. Sci. Data, 7, 275-287, 10.5194/essd-7-275-2015, 2015) can better explain the CHpClim product. We have added the reference to the sentence (monthly precipitation from CHPClim) and make some changes.

Change: We have changed "monthly precipitation from CHPClim" to "monthly precipitation from CHPClim v.1.0 (Climate Hazards Group's Precipitation Climatology version 1) derived from the combination of the satellite fields, gridded physiographic indicators, and in situ climate normal with the geospatial modelling approach based on moving window regressions and inverse distance weighting interpolation (Funk et al., 2015 b)"

(11)- Line 146: Which CHIRPS data? The data from its stations? Or the blended product? Please make this clear here.

Answer: Thanks. It was stated from section 2.2.2 that CHIRPS data is a blended product interpolating from CHIRP data and in situ precipitation observations obtained from a variety of sources including national and regional meteorological services (Funk et al., 2014).

Change: We changed a more accurate explain for CHIRPS data used for comparisons of precipitation accuracy. Changed "and the corresponding daily CHIRPS data was used for comparisons of precipitation accuracy" to "and the corresponding daily CHIRPS blended data was used for comparisons of precipitation accuracy"

(12)- Line 162: What do you mean about physically similar? Is this means that these pixels are related to others based on its physical attributes (lat, long, elevation, slope, aspect, and curvature)? Or this means that is similar is terms of rainfall distribution? If is in terms of rainfall, I think a better world would be statistically similar rather than physically similar, since this is based on a cluster analysis.

Answer: Thanks. We assumed 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 similar 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)"

(13)- Line 170: Please explain why you chose 30% of the stations/grid points for validation. Since the stations and grid points are of limited number, it would not be better to do a Bootstrap validation instead? Then you are able to use all the stations/grid points in your correction algorithm.

Answer: Thanks. The number of rain gauge stations over the Jinsha River Basin is limited. And because 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 to the new 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. And the analysis period was changed from (summer of 2016, JJA) to "during JJA from 1990 to 2014".

Change: We changed the validation method from "The proposed approach was evaluated for the Jinsha River Basin for JJA 2016. 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." to "The proposed approach was evaluated over the Jinsha River Basin based on 30 gauge stations and CHIRP satellite-based precipitation estimations during JJA from 1990 to 2014. The leave-one-out cross validation step was applied to computing the out-of-sample adjusted error with gauge stations.”

(14)- Lines 224 and 225: Since your method relies heavily on the cluster algorithm, it would not be better to use some sort of statistical metric to define the number of clusters?

Answer: Thanks. Done. The optimum number of clusters was determined by L(c) which was derived from the inter-distance and inner-distance of samples in the following equation. It is ensured that the distance between the same samples is smaller, while the distance between the different samples is larger.

$$L(c)=\frac{\sum_{i=1}^{c}\sum_{j=1}^{n}w_{ij}^{m}\|c_i-\bar{x}\|^2/(c-1)}{\sum_{i=1}^{c}\sum_{j=1}^{n}w_{ij}^{m}\|x_j-c_i\|^2/(n-c)}$$

In that equation, the denominator is inner-distance and the molecular is inter-distance. The initial value of c is 1 and the maximum value of c is the number of gauge stations in this study area. The optimum number of clusters was optimized to maximize the L(c). For this reason, c value is conducted in the range from 1 to the number of gauge stations with an incremental interval value of 1 in this study.

Change: We added the L(c) metric to determine the optimum number of clusters and the Fig. 4 (The optimum number of clusters determined by the maximum L(c) with the iterative process) was given. Based on this, the optimum number of clusters was set 22 in this study.

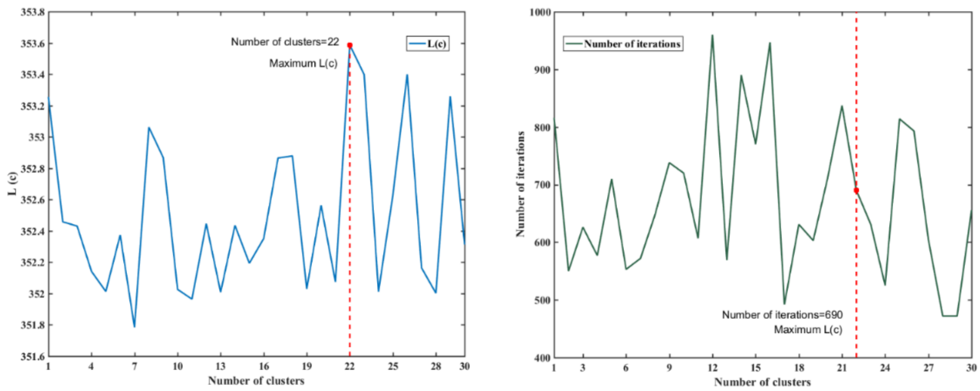


Figure The optimum number of clusters determined by the maximum $L(c)$ with the iterative process.

(15)- Line 234: Pixels should also be similar regarding precipitation characteristics, is that right?

Answer: Thanks. Some studies indicate that pixels have similar precipitation futures 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. Therefore, in each cluster, pixels both have the similar terrain features and precipitation characteristics.

Change: We changed "Pixels in each cluster have similar terrain features" to "Pixels in each cluster have similar terrain features and precipitation characteristics".

(16)- Line 244: I think you should use the word relationship or correlation instead of confidence in this line.

Answer: Thanks. Done.

Change: We changed "confidence is not only determined by the value of the correlation coefficient but also from the correlation test's *p* value" to "correlation is not only determined by the value of the correlation coefficient but also from the correlation test's *p*-value".

(17) Line 259: Why the number of decision trees was set to 500?

Answer: Thanks. Done. The number of decision trees was set to 500, which was determined by out-of-bag (OOB) error (Figure S1). The OOB error reached the minimum value when the number of decision trees was less than 500.

Change: We calculated the OOB-error of Random forest regression with the increase of the number of decision trees from 1 to 500 at each rain gauge station and the Fig. S1 is shown the change of out-of-bag (OOB) error with the number of decision trees increase in appendix.

(18)- Line 264: Do C1 and C2 pixels included in the R pixel category?

Answer: No. Thanks. In the previous experiment, C1 and C2 pixels were not included in the R pixels. Now, in the new experiment, we changed the classification of C2, C3 and C4 pixels. 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. So only the rain gauge observations were used to the new experiments. 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). "

Change: So with the new experiment, we changed "pixels in each cluster represent potential C3 pixels, with exception of the C1 and C2 pixels and are called R pixels" to "With exception of the C1 pixels, the remaining pixels in each cluster represent potential C2 pixels called R pixels"

(19)- Lines 267 and 280: Are you also considering only SCC values with p-value lower than 0.05 here?

Answer: Yes. Thanks. The correlation coefficient value higher than 0.5 and the p-value lower than 0.05 were considered for C2 pixels selection.

In the new experiment, we changed the statistical metric of SCC to Pearson's correlation coefficient (PCC) because PCC measures the linear correlation between two series better than SCC to evaluate the adjusted precipitation accuracy.

Change: Changed "both the data with a maximum SCC of at least 0.5 and the corresponding index of C1 and C2 pixels" to "both the data with a maximum PCC of at least 0.5 and a p-value lower than 0.05 (Zhang and Chen, 2016)"

(20)- Line 287: Why did you choose the 10 mm value? Could you please explain the meaning of this constant better?

Answer: Thanks. In Eq.(11), the relationship between C2 pixels and the corresponding CGURP grid cells is expressed by the ratio:

$$w_i = \frac{C2_{as_i} + \lambda}{Y_{s_i} + \lambda} \quad i=1, \dots, n \tag{11}$$

where λ is a positive constant to avoid the denominator value being 0 when CHIRP grid cell value was 0. (Sokol, 2003) tested various λ values indicated that the selected value was not too closely related to the calibration set.

In Rule 3, the values of C3 pixels are derived from Eq. (12):

$$C3_{as} = \max(w \times (Y_s + \lambda) - \lambda, 0) \tag{12}$$

In this equation, the λ set to 10 mm made the calculating simpler, and other values are also available.

(21)- Line 298: Please use the actual percentage here.

Answer: Thanks. In the previous experiment, each C5 pixel value is set to be the same as the CHIRP grid cell value at the corresponding position, because of the few number of the C5 pixels. However, in the new experiment, we abandoned the gridded precipitation observations and only the 30 rain gauge stations with four rules were used to conduct the WHU-SGCC approach. The C5 pixels were changed to C4 pixels for Rule 4 and the percentage of C4 pixels is around 60% of the total number of pixels over the study area. (Due to the leave-one-out cross validation step, the different training samples will have the different number of C2, C3 and C4 pixels respectively inside the Jinsha River Basin). So that, the Inverse Distance Weighted (IDW) method was used to obtain the C4 pixels values.

Change: We added the Table 4 (The number of each class pixels adjusted by each rule using the WHU-SGCC method inside the Jinsha River Basin.) which lists the clearer number and percentage of each class pixels. And the Fig.4 in the previous paper was deleted.

Table 4 The number of each class pixels adjusted by each rule using the WHU-SGCC method inside the Jinsha River Basin.

Validation gauge station	C1 Pixels (%)	C2 Pixels (%)	C3 Pixels (%)	C4 Pixels (%)
52908	29 (0.16%)	3066 (16.59%)	4224 (22.85%)	11163 (60.40%)

56004	29 (0.16%)	2882 (15.59%)	4111 (22.24%)	11460 (62.01%)
56021	29 (0.16%)	3311 (17.91%)	4510 (24.40%)	10632 (57.53%)
56029	29 (0.16%)	3338 (18.06%)	4447 (24.06%)	10668 (57.72%)
56034	29 (0.16%)	3300 (17.86%)	4427 (23.95%)	10726 (58.03%)
56038	29 (0.16%)	3209 (17.36%)	4014 (21.72%)	11230 (60.76%)
56144	29 (0.16%)	3347 (18.11%)	4442 (24.03%)	10664 (57.70%)
56146	29 (0.16%)	3183 (17.22%)	4480 (24.24%)	10790 (58.38%)
56152	29 (0.16%)	3173 (17.17%)	4176 (22.59%)	11104 (60.08%)
56167	29 (0.16%)	3362 (18.19%)	4346 (23.51%)	10745 (58.14%)
56247	29 (0.16%)	3385 (18.32%)	4416 (23.89%)	10652 (57.63%)
56251	29 (0.16%)	3301 (17.86%)	4348 (23.53%)	10804 (58.46%)
56257	29 (0.16%)	3313 (17.93%)	4043 (21.88%)	11097 (60.04%)
56357	29 (0.16%)	3352 (18.14%)	4390 (23.75%)	10711 (57.95%)
56374	29 (0.16%)	3341 (18.08%)	4294 (23.23%)	10818 (58.53%)
56459	29 (0.16%)	3345 (18.10%)	4334 (23.45%)	10774 (58.29%)
56462	29 (0.16%)	3380 (18.29%)	4377 (23.68%)	10696 (57.87%)
56475	29 (0.16%)	3345 (18.10%)	4344 (23.50%)	10764 (58.24%)
56479	29 (0.16%)	3305 (17.88%)	4212 (22.79%)	10936 (59.17%)
56485	29 (0.16%)	3393 (18.36%)	4419 (23.91%)	10641 (57.57%)
56543	29 (0.16%)	3373 (18.25%)	4384 (23.72%)	10696 (57.87%)
56565	29 (0.16%)	3241 (17.54%)	4450 (24.08%)	10762 (58.23%)
56571	29 (0.16%)	3306 (17.89%)	4263 (23.07%)	10884 (58.89%)
56586	29 (0.16%)	3387 (18.33%)	4434 (23.99%)	10632 (57.53%)
56651	29 (0.16%)	3340 (18.07%)	4432 (23.98%)	10681 (57.79%)
56664	29 (0.16%)	3368 (18.22%)	4262 (23.06%)	10823 (58.56%)
56666	29 (0.16%)	3323 (17.98%)	4431 (23.97%)	10699 (57.89%)
56671	29 (0.16%)	3356 (18.16%)	4367 (23.63%)	10730 (58.06%)

(22)Line 326: You should be clearer on what the numbers of pixels are here. Is this the number of pixels inside the basin multiplied by the number of days? It would be a good idea to describe the exact number of pixels for each class along with its actual percentage in the text.

Answer: Thanks. Done.

Change: We added the Table 4 (The number of each class pixels adjusted by each rule using the WHU-SGCC method inside the Jinsha River Basin.) with the exact number of pixels for each class along with its actual percentage. And the Fig.4 in the previous paper was deleted.

The sentence was added into the paper to describe the number and the percentage of each class pixels inside the basin "The number of C1 pixels was the number of training gauge stations accounting 0.16% of the total pixels (18482) inside the basin. Due to the leave-one-out cross validation step, the different training samples will have the different number of C2, C3 and C4 pixels respectively inside the Jinsha River Basin. The number of C4 pixels was approximately 10822 with the percentage around 60%, the number of

C3 pixels was approximately 4331 with the percentage ranging from 21.72% to 24.40%, and the number of C2 pixels was approximately 3300 with the percentage ranging from 15.59% to 18.36%."

(23)- Line 341: It would be better to use the same x axis scale in both plots. It seems that the gridded data observation has similar biases as CHIRP and thus their CDFs are more similar, providing less improvement in the adjusted dataset.
Answer: Thanks. According to the new experiment, we changed the Rule 1for the C1 pixels without Adj-QM, so the CDFs were not needed.
Change: We changed the Rule 1 from Adj-QM to establishing the regression relationships between each gauge historical observations and the corresponding CHIRP grid cell value by means of Random Forest Regression. And we deleted the relative sections 4.1 and 4.2 in the previous paper. So the section 4: Results and Discussion only include 4.1 Spatial Clustering of Rule 3 2 results, 4.2 Model performance based on overall accuracy evaluations, 4.3 Model performance based on daily accuracy evaluations, and 4.4 Model performance for rain events.

(24)- Line 355: It would be a good idea to explore and discuss more the statistics presented in Figure 7.
Answer: Because of the multi-year period studied in the new experiment, we modified the WHU-SGCC method. In the new experiment, due to the leave-one-out cross validation step using all the stations, the performance of WHU-SGCC method would be evaluated on the overall accuracy, not on a certain class of pixels. So we didn't evaluate the C3 pixels separately.
Change: The evaluation of C3 pixels and Figure 7 were deleted.

(25)- Line 373: NSE values have increased, but still not very good (i.e., still negative).
Answer: Thanks. The NSE (Nash and Sutcliffe, 1970) determines the relative magnitude of the variance of the residuals compared to the variance of the observations, bounded by minus infinity to 1.
Change: In the new experiment, the NSE of WHU-SGCC method was -0.0137 with an increase of 93.33% and 98.32% to CHIRP and CHIRPS, respectively.
Although the NSE of WHU-SGCC was far less than 1, it was improved to be 0 that indicates the adjusted results were close to the average level of the rain gauge observations, while the NSEs of CHIRP and CHIRPS were much worse.

(26)- Line 376: Is not intuitive that the evaluation metrics are better for CHIRP than CHIRPS, since CHIRPS adds stations data to their dataset. Could you please clarify this? I am seeing here that magnitude evaluation metrics have not changed considerably, probably because the improvement is seem in the low magnitude events. SCC has a considerable increase, but still cannot explain much of the variability of rainfall in the region. POD values are good.
Comments 1): Is not intuitive that the evaluation metrics are better for CHIRP than CHIRPS, since CHIRPS adds stations data to their dataset. Could you please clarify

this?

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, 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.

Change: We changed the sentence from "As such, the aim of this article is to offer a novel approach for blending daily precipitation gauge data, gridded precipitation data and the Climate Hazards Group Infrared Precipitation (CHIRP) satellite-derived precipitation estimates over Jinsha River Basin." to "As such, due to the poor performance of CHIRPS data at the sub-regional scale and the shortcomings of the existing blending algorithms, the aim of this article is to offer a novel approach for blending daily liquid precipitation gauge data, gridded precipitation data and the Climate Hazards Group Infrared Precipitation (CHIRP) satellite-derived precipitation estimates developed by the UC Santa Barbara, over the Jinsha River Basin." for better explanation.

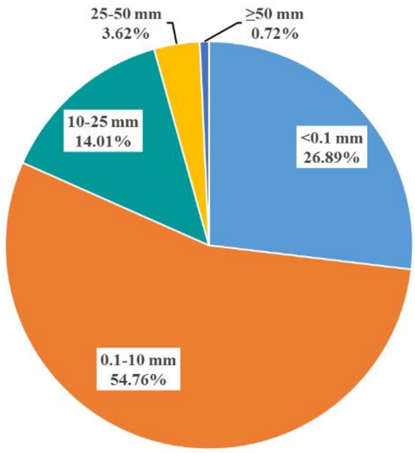
Comments 2): I am seeing here that magnitude evaluation metrics have not changed considerably, probably because the improvement is seem in the low magnitude events. SCC has a considerable increase, but still cannot explain much of the variability of rainfall in the region. POD values are good.

Answer: In the previous experiment, the training samples represented 70% of total gauged stations and gridded points, and the remaining data were used to test model performance. This validation was not able to use all the rain gauge stations and the same validation set may not fully explain the performance on the Jinsha River Basin. As such, in the presented experiment, the leave-one-out cross validation step was a better instead for using all the stations in WHU-SGCC correction algorithm.

What's more, the analysis period (summer of 2016, JJA) is too short to make significant conclusions about this precipitation dataset, so we changed the period during June-July-August from 1990 to 2014, 92 days per year for 25 years totally.

Change: We use the leave-one-out cross validation to instead the fixed training and testing sets. And we also changed a longer study period during June-July-August from 1990 to 2014, to evaluate the model performance on different rainfall events.

In the results, the days of each class of rain events at the validation gauge station during the 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 precipitation conditions over the Jinsha River basin.



(27)- Line 383: Could this means that because the daily precipitation in the lowland region of the basin is higher, the RMSE values are also higher?

Answer:

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 lower than and 2025 mm, but WHU-SGCC performance for total rainfall higher than 25mm did not improve compared to CHIRP and CHIRPS (Table 6), though it was better than that of CHIRPS. This negative performance on the total rainfall higher than 25 mm was probably caused by the precipitation conditions inside the Jinsha River Basin (Table 5). The average daily precipitation was less than 10 mm inside the basin, during the multi-year summer seasons, which provided a large amount of rain gauge stations data with the values lower than 10 mm, that caused a significantly impact on the statistical relationships establishment for WHU-SGCC. In hence, the approach of WHU-SGCC is applicable for the detection of rainfall events over the Jinsha River Basin, with the precipitation less than 10 mm, or even than 25mm. Due to the 4.34% of summer days with the daily precipitation over the 25 mm, the performance of WHU-SGCC on these rain events was poorer than the results of CHIRP and CHRPS.

(28)- Line 388: The fact that your method performs well in complex terrain is a very positive point in your manuscript, but you will need a longer study period to confirm

this finding.
Answer: Thanks. Done.
Change: we changed the study period from summer of 2016, JJA to a longer study period during June-July-August from 1990 to 2014, to evaluate the model performance more reasonably.

(29)- Line 402: The boxplots do not show that the higher reduction is seen in the Bias metric.
Answer: 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. So the daily evaluation was changed to the performance on the overall evaluation and spatial distributions
Change: Deleted the boxplot.

(30)- Line 417: I am still confused about which rainfall value is presented is this figure. It does not seem realistic that the average daily rainfall would be ~ 200 mm. Please be more specific about which rainfall statistic you are using in this figure.
Answer: Thanks. This may the error in gridded precipitation observations.
Because the gridded precipitation used in pervious experiment 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.
Change: We have only used 30 rain gauge stations to conduct the WHU-SGCC method over the Jinsha River Basin during the summer seasons from 1990 to 2014.

(31)- Line 430: The evaluation metrics for the threshold values are quite similar among the three precipitation products. Just because the values for WHU-SGCC become slightly worse for precipitation higher than 20 mm/day does not mean they are significantly different from the other products. Since the values are very similar, I would suggest to test their differences statistically before making the assumption that WHU-SGCC works better for low magnitude events. This might also be caused by the limitation of the short study period. There is a tendency to use the word scale for a temporal dimension, better to use period instead. I think it would be interesting to add a map with the accumulated precipitation for the study period. The analysis period of 92 days is too short to make conclusive assumptions about the dataset usefulness in the region, which are made several times throughout the text. I understand why the authors want to focus on the summer months to avoid the higher biases introduced by solid precipitation, but I did not understand why they only performed the evaluation for one summer season. Is there a particular reason for that? I still think that is hard to make the conclusions you made based on 92 days, if you add more seasons to the analysis this can become a very interesting manuscript and dataset.

Answer: Thanks. In the previous experiment, the analysis period (summer of 2016, JJA) is too short to comment about this precipitation dataset.

Changed:

1) We added more summer seasons from 1990 to 2014, 92 days per year for 25 years totally to make a more reasonable conclusive.

2) And we added a map with the multi-year (1990-2014) average annual precipitation (Fig. 2). The multi-year 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.

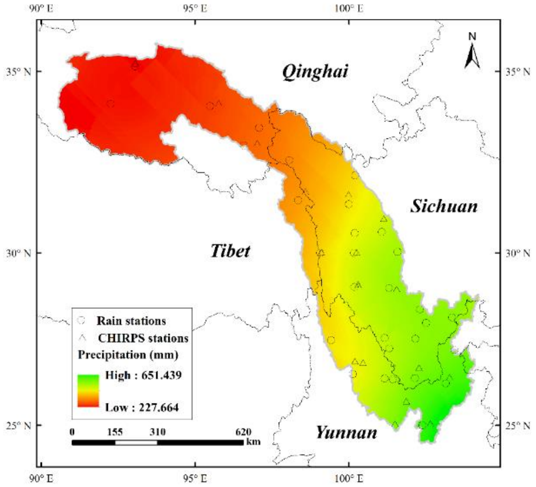


Figure 2 The multi-year (1990-2014) average annual precipitation during JJA over the Jinsha River Basin. 30 rain stations were provided by the China Meteorological Administration stations, the other 18 CHIRPS fusion stations were provided by the Climate Hazards Group UC Santa Barbara online at ftp://ftp.chg.ucsb.edu/pub/org/chg/products/CHIRPS-2.0/diagnostics/global_monthly_station_density/tifs/p05/ (last access: 10 December, 2018).

3) 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 25 mm which can represents the precipitation conditions over the Jinsha River basin.

According to the comparison, the WHU-SGCC approach achieves error reductions for the RMSE, MAE and BIAS statistics for rain events less than 25 mm. Specifically, compared with CHIRP, the RMSE value was reduced by approximately by 5.92%-39.44%, the MAE value by 4.28%-12.41%, and the absolute BIAS value by 9.15%-44.43%; compared with CHIRPS, the RMSE and MAE values were reduced by 11.04%-56.61%, and the absolute BIAS value by 23.77% -59.58%.

Table 7 Accuracy assessment on liquid precipitation events during the JJA from 1990 to 2014

	RMSE			MAE			BIAS		
Rain Event	WHU-SGCC	CHIRP	CHIRPS	WHU-SGCC	CHIRP	CHIRPS	WHU-SGCC	CHIRP	CHIRPS
<0.1	4.7253	5.0802	7.1643	2.5927	2.9562	2.9145	/	/	/
[0.1,10)	4.1661	6.8684	9.6022	3.9885	4.5534	6.2462	0.8021	1.4435	1.9842
[10,25)	10.4281	11.0848	13.4427	9.2722	9.6866	11.5909	-0.5762	0.6342	0.7559
[25,50)	25.7494	24.5600	25.4975	24.8386	23.0967	23.4927	-0.7784	0.7250	0.7388
≥50	56.6072	54.5037	52.7875	54.4168	52.1557	49.4318	-0.8861	0.8297	0.7852

(32)- The dataset seems to be of good quality. A few comments about it are the following. For a spatial extent of this magnitude I think it would be better to use a geographic coordinate system, rather than a Mercator projection. There is also some artifacts (0 precipitation values) that appear at the same location at multiple days. I was wondering if this is a limitation from the negative values of Rule 4. Is there any way to correct this? This dataset could be very useful if its period is extended to multiple years.
Answer: Thanks. The average annual precipitation of the Jinsha River Basin is less 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. So there are also possible no rain in some locations at multiple days over the north of Jinasha River Basin. The negative values derived from Rule 3 (in the new experiment, the Rule 4 was changed to the Rule 3) were not too closely related to the zero precipitation values appearing at the same location at multiple days.
Change: The results images of the WHU-SGCC method were changed from "Mercator projection" to "geographic coordinate system: WGS_84"

Technical Corrections

(1) Line 2: Change "over Jinsha" for "over the Jinsha".
Answer: Thanks. Done.
Change: We changed "over Jinsha" to "over the Jinsha".

(2) Line 31: Change "distributed" for "spatial distribution".
Answer: Thanks. Done.
Change: We changed "their uneven distributed" to "their uneven spatial distribution".

(3) Line 37: "without adjustment" is mentioned twice.
Answer: Thanks. Deleted one "without adjustment".
Change: We changed "Without adjustments, inaccurate satellite-based precipitation estimates without adjustment will lead to unreliable assessments of risk and reliability" to "Without adjustments, inaccurate satellite-based precipitation estimates will lead to unreliable assessments of risk and reliability"

(4) Line 68: In table 1, it should be written "PERSIANN-CDR" instead of "PRESSIANN-CDR".

Answer: Thanks. Done.

Change: We changed "PRESSIANN-CDR" to "PERSIANN-CDR"

(5) Line 84: Change "in summer 2016" for "in the summer of 2016".

Answer: Thanks. Done.

Change: We added the seasons in analysis period, so we changed "in summer 2016" to "over the Jinsha River Basin during the summer seasons from 1990 to 2014"

(6) Line 93: Change "proximately covers an area" for "covers an area of approximately".

Answer: Thanks. Done.

Change: We changed "The river's catchment proximately covers an area of ~180 × 10^4 km^2" to "The river's catchment covers an area of approximately ~180 × 10^4 km^2"

(7) Line 95: Change "sub-regions" for "sub-basins".

Answer: Thanks. Done.

Change: We changed "sub-regions" to "sub-basins"

(8) Line 136: Change "precipitation observations" for "surface based precipitation observations".

Answer: Thanks. Done.

Change: We changed "precipitation observations" to "surface based precipitation observations".

(9) Line 157: Change "other pixels" for "the remaining pixels".

Answer: Thanks. Done.

Change: We changed "other pixels" to "the remaining pixels".

(10) Line 159: The acronym "SIRC" meaning was not mentioned before.

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 five classification and blending rules."

(11) Line 169: The first sentence could be placed before the item 1.

Answer: Thanks. Done.

Change: We changed this sentence into the first phase in section 3.1, as the reference to the overview of items 1-4. And we changed the validation method from "The proposed approach was evaluated for the Jinsha River Basin for JJA 2016. 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.” to “The proposed approach was evaluated for over the Jinsha River Basin based on 30 gauge stations and CHIRP satellite-based precipitation estimations during the JJA from 1990 to 2014. The leave-one-out cross validation step was applied to computing the out-of-sample adjusted error with gauge stations.”

(12) Line 171: Is the same phrase that is shown in line 163.

Answer: Thanks. Line 171 and line 163 are repeated.

Change: We deleted the repeated phrase in line 163.

(13) Line 172: The flowchart: CHIRP resolution should be 0.05 x 0.05. In the first box of rule 3, change “and gauged” for “with gauged”. In the last box of rule 3, change “can derive” for “can be derived”. In rule 4, change “ration” for “ratio” (this happens twice here).

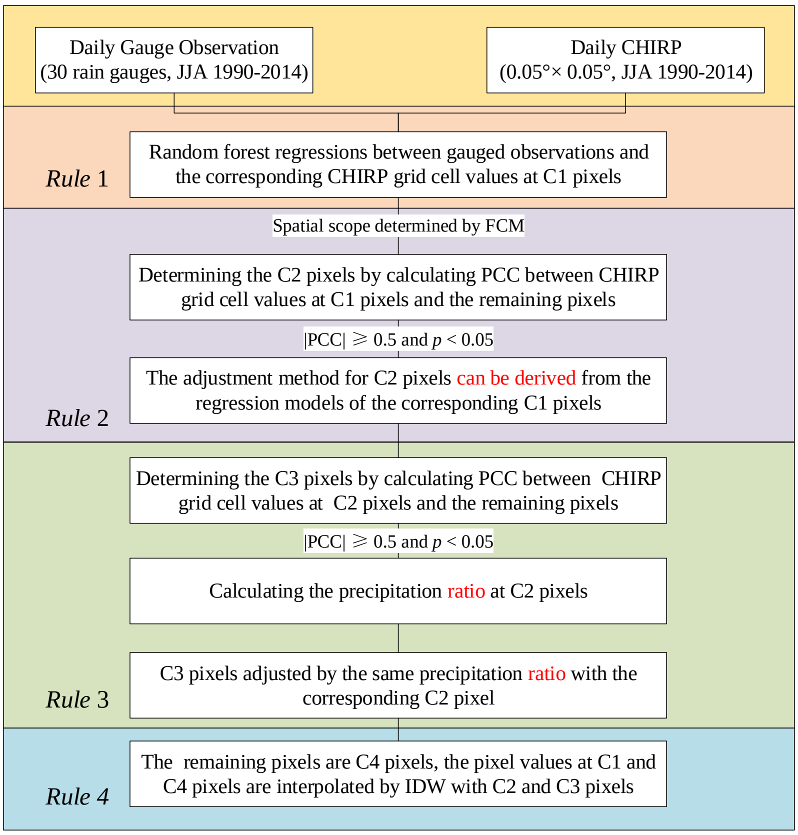
Answer: Thanks. Done. Because we changed the rules of WHU-SGCC, the flowchart was redrawn.

Change: In the flowchart, we changed the CHIRP resolution from “0.5° × 0.5°” into “0.05° × 0.05°”

changed “can derive” to “can be derived”

changed “ration” to “ratio” (two modifications)

The modified flowchart is as follows:



(14) Line 189: Change "as" for "in".
Answer: Thanks. Done.
Change: We changed the "as Eq. (2)" to "in Eq. (2)".

(15) Line 246: Change "p" for "p-value".
Answer: Thanks. Done.
Change: We changed the "*p* value" to "p-value".

(16) Line 283: The word "method" is repeated twice.
Answer: Thanks. Done.
Change: We deleted the repeated word "method". Changed "a method for merging method the CHIRP grid cell values" to "a method for merging the CHIRP grid cell values"

(17) Line 300: Change "for summer (JJA) 2016" for "for the summer (JJA) of 2016".
Answer: Thanks. Done.
Change: We changed the "for summer (JJA) 2016" to "for the summer (JJA) of 2016".

(18) Line 315: Change "as" for "in".
Answer: Thanks. Done.
Change: We changed the "All of the accuracy assessment indices are shown as Table 3" to "All of the accuracy assessment indices are shown in Table 3".

(19) Line 326: Change "to be adjusted" for "adjusted".
Answer: Thanks. Done.
Change: We changed the "There were 18482 daily pixels to be adjusted" to "There were 18482 daily pixels adjusted".

(20) Line 340: Change "study" for "studies".
Answer: Thanks. Done.
Change: We changed the "supports further study" to "supports further studies".

(21) Line 400: Change "with especially greatly decreases compared to CHIRPS" for "with greater decreases when compared to CHIRPS".
Answer: Thanks. Done.
Change: We changed the "with especially greatly decreases compared to CHIRPS" to "with greater decreases when compared to CHIRPS".

(22) Line 451: Change "in summer 2016" for "in the summer of 2016".
Answer: Thanks. Done.
Change: We changed the "in summer 2016" to "in the summer from 1990 to 2014".

(23) Line 456: Change "over region has" for "over a region that has".

Answer: Thanks. Done.
Change: We changed the “over region has” to “over a region that has”.

(24) Line 465: Change “of the precipitation region” for “of precipitation events in the region”.
Answer: Thanks. Done.
Change: We changed the “of the precipitation region” to “of precipitation events in the region”.

(25) Line 466: Change “short” for “short duration”.
Answer: Thanks. Done.
Change: We changed the “during short rainstorms” to “during short duration rainstorms”.

(26) Line 468: Change “complicated mountainous” for “complex terrain”.
Answer: Thanks. Done.
Change: We changed the “complicated mountainous region” to “complex terrain region”.

(27) Line 480: Change “topographic and long time series climatic factors” for “topographic factors and longer time series”.
Answer: Thanks. Done.
Change: We changed the “topographic and long time series climatic factors” to “topographic factors and longer time series climatic factors”.