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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Bias correction of gauge-based gridded product to improve extreme precipitation analysis in the Yarlung Tsangpo-Brahmaputra River Basin" *by* Xian Luo et al.

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1. I have carefully read the article: "Bias correction of gauge-based gridded product to improve extreme precipitation analysis in the Yarlung Tsangpo-Brahmaputra River Basin." By Luo et al. While I find that the results of the authors are interesting, I don't quite see how they amount to novel and publishable results as they stand. I should stress that my field of research, in the strictest sense, is bias correction of hydrological data from regional climate models for use in impact model forecasts. So, although I am well informed in matters concerning bias correction of observations, there may be

something in the significance of this article that I am not quite understanding. The authors are using two sources of non-gridded observational data (NMIC and GHCN) to bias correct APHRODITE which is a gridded observational dataset. They use 4 well established Bias Correction (BC) methods. The first two are essentially multiplicative correction factors. They differ in that the second uses a wet-day correction. The third is a variational method, fitted to correct mean and variance, and the last is a parametric Quantile Mapping BC. All these methods are well established, their pros and cons are well studied. As far as I can see, the authors use all the available non-gridded data to correct the APHRODITE data-set, and then examine the effects of the different BC methods against the very same non-gridded data-set that was used for BCing. This implies that all the comparative results (section: "Evaluation of APHRODITE estimates") are only demonstrative of the mathematical construction of the BC methods and not of any increase in the skill of the corrected APHRODITE data. In simple words, if you bias correct a model to an observation, then, trivially, it looks like that observation. In climate forecasting, one uses past observations and hindcasts to calibrate the BC method and, subsequently, applies the results to bias correct future climate simulations. To validate the BC method one divides the observations into two periods and uses one for correction and one for validation. The studies I have reviewed where observations are bias-corrected, usually divide their observations into two groups as well, one for correction and one for validation, alternatively they sometimes use a leave one-out cross-validation method. Again, unless I missed something, the comparisons of extreme events indexes between corrected and raw APHRODITE, while insightful, doesn't tell us anything about which one is better since we do not have observations of extreme event statistics from the non-gridded data. In conclusion, I suggest that the authors extend their work to validate the bias-corrected APHRODITE against observations that were not used in the calibration process and then resubmit their work. Below are line-by-line comments the authors may find useful.

Response: Thank you for your comments concerning our manuscript entitled "Bias correction of gauge-based gridded product to improve extreme precipitation analysis in

the Yarlung Tsangpo-Brahmaputra River Basin". Those comments are all valuable and very helpful for revising and improving our paper, as well as the important guiding significance to our researches. We have studied comments carefully and have extended our work and made corrections. As you pointed out, the observations are usually divided into two periods to validate the bias correction, and one is used for correction and the other for validation. This study used non-gridded observational data (NMIC and GHCN) to correct APHRODITE. However, many records collected from GHCN are usually short and incomplete. It is difficult to divide short records into two groups. Alternatively, a leave one-out cross-validation method could be also used to validate bias correction. To improve our manuscript, we have used this method to compare extreme events indexes between corrected and raw APHRODITE. The observations in each one of the rainfall stations was leaved and used to calculate extreme precipitation indices alternately for validation. The observations in all other rainfall stations were used for bias correction and extreme precipitation analysis, and extreme event statistics in the rainfall station for validation were obtained from interpolation and compared with the results calculated from observations. A new figure named "Mean error of extreme precipitation indices for leave one-out cross-validation in the YBRB" was added. By using leave one-out cross-validation, the comparisons of extreme events indexes among raw APHRODITE and different corrected APHRODITE could be more reliable, and QM was proved to be better than the other 3 methods.

2. Line 30 to 32: I do not think the authors have proven this statement: "Bias correction [. . .] greatly improves the performance of extreme precipitation analysis".

Response: After using leave one-out cross-validation, it could be found that bias correction greatly improves the performance of extreme precipitation analysis.

3. Line 36 to 38: I do not see how the results, since they are not cross-validated, help select a bias correction method. Moreover, there are many more bias correction methods available in the literature than those mentioned in this article. See Teutschbein and Seibert 2012 or Cannon et al. 2015 Cannon, A, et al. Bias Correction of GCM Pre-

cipitation by Quantile Mapping: How Well Do Methods Preserve Changes in Quantiles and Extremes?, Alex J. Cannon*, Stephen R. Sobie, and Trevor Q. Murdock, Pacific Climate Impacts Consortium, University of Victoria, Victoria, British Columbia, Canada. https://doi.org/10.1175/JCLI-D-14-00754.1

Response: The results has been further cross-validated, which could help select a bias correction method. There are more bias correction methods available than those mentioned in this article. We have added some statements about these methods in the paper.

4. Line 90: As explained above, I do not think the authors "evaluated" as much as "described" their performance.

Response: We have further evaluated the performances of bias corrections using leave one-out cross-validation method.

5. Line 125: The sentence: "The ratios of rainfall observations. . . " and the sentence after are unclear.

Response: We have modified the sentence. The rainfall observations that had undergone quality control were gathered, and the ratios of rainfall observations to the world climatology were calculated and then interpolated for each month.

6. Line 146: I find the indexing not to be exhaustively clear. Is Pobs a station data value? Has the corresponding PAPH been interpolated or vice versa?

Response: We have modified the statement about the variables. Pobs is the observation at rainfall station, while PAPH is APHRODITE estimate at corresponding grid.

7. Line 153: I know what a wet day correction is but I doubt anyone who does not would understand this sentence.

Response: We have modified the statement. Firstly, an adjusted precipitation threshold is determined so that the number of days exceeding this threshold for APHRODITE

estimates matches the number of observed days with rainfall larger than 0 mm.

8. Line 172: Why show the Gamma density if you are fitting the CDF? Indeed, why write a generic functional form at all? What do the authors mean by “matched”? Is it “fitted”?

Response: We have added the formula and explanation of cumulative distribution function besides density function. In this study, generic functional form of Gamma distribution is used. Besides, we have modified statement about quantile–quantile mapping. The cumulative density function (CDF) of the APHRODITE estimates is corrected to agree with that of the observation, and the daily precipitation for APHRODITE estimates is corrected depending on its quantile.

9. Section 2.3.2: I do not see the need for 5 different error measurements.

Response: We have deleted 4 statistical metrics (Pearson correlation coefficient (r), Percentage bias (PB), Mean absolute error (MAE), and Root mean squared error (RMSE)). Mean error (ME) was used in the evaluation of original and corrected APHRODITE estimates.

10. Line 203 to 204: IDW has serious effects on extreme value distributions. The authors should compare what the distributions look like before and after interpolation.

Response: We selected IDW to interpolate extreme precipitation indices due to its deterministic feature. Interpolation methods can be divided into exact interpolation and approximate interpolation. When exact interpolation (such as IDW) is used, interpolation surface moves exactly through each of the points, while the surface of approximate interpolation dose not. In the Yarlung Tsangpo-Brahmaputra River Basin, influenced by complex topography, extreme precipitation vary greatly. The application of IDW could ensure that the interpolated results equal to the values in these grids so that extreme precipitation indices would be more reliable. In addition, the results of leave one-out cross-validation also showed that IDW could be used in the interpolation.

11. Section Results: As explained above, results in section 3.1 are unsurprising, while section 3.2 are not clearly useful to APHRODITE data users.

Response: The results of leave one-out cross-validation were put into section 3.1 to better compare the performance of different bias correction methods. To make the results more useful to APHRODITE data users, some characteristics of APHRODITE estimates were summarized in section 3.2, and the advantage of different bias correction methods were also further analyzed.

12. Line 250 to 251: I do not see how the authors can say this.

Response: We have deleted this sentence.

13. Section Conclusions: The authors draw three conclusions and, in the strictest sense, I agree with all of them. This is because the first conclusion is unsurprising while the last two are couched as possibilities instead of results. I refer to language such as: “. . . is expected to perform better in extreme precipitation analysis” and “extreme precipitation may be greatly improved”. While I absolutely agree with these two statements, they are not novel.

Response: The statement of the section of conclusions were modified, and the features of APHRODITE estimates and the advantage of bias correction on extreme precipitation analysis were further summarized. Thanks for all of your suggestions.

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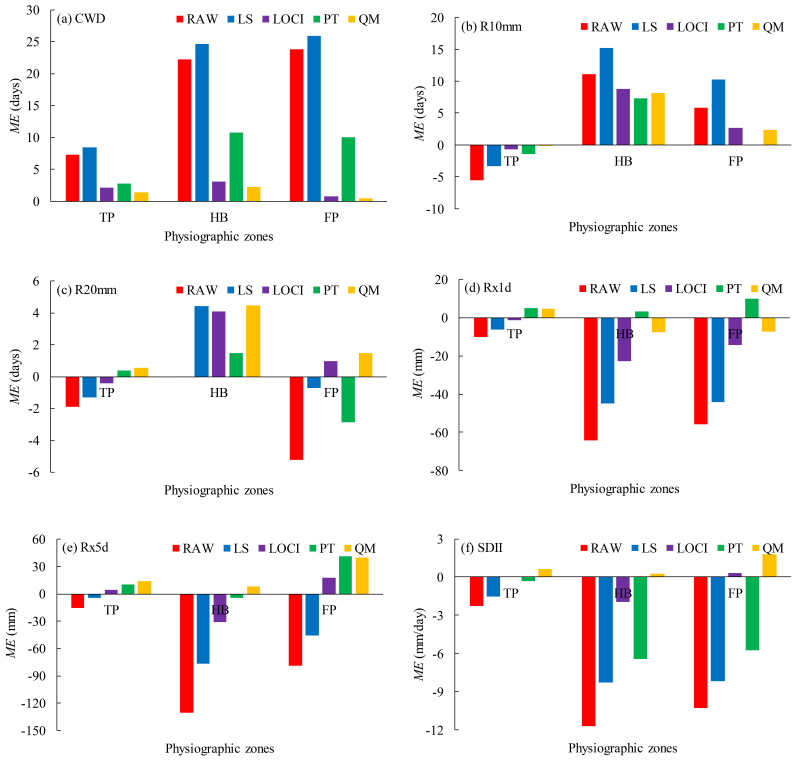

Fig. 1. Mean error of extreme precipitation indices for leave one-out cross-validation in the YBRB