Hydrol. Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/hess-2018-522-AC2, 2019

Hydrology and Earth System Sciences
Discussions

Interactive comment on "Estimating changes of temperatures and precipitation extremes in India using the Generalized Extreme Value (GEV) distribution" *by* Kishore Pangaluru et al.

Kishore Pangaluru et al.

kishore1818@gmail.com

Received and published: 4 March 2019

Reviewer #2 replies Pangaluru et al. analyze the spatial distribution of extreme precipitation/ temperature return levels over India. To estimate return levels, they use a GEV distribution. The paper is well written and content fits HESS. My main concern is that the authors are using a non-stationary GEV model, but they do not even mention non-stationary. Research has not yet agreed if all parameters of GEV model should be considered non-stationary (Lee et al. 2017). The authors (without convincing the reader) just use non-stationary GEV model and consider that all parameters are non-stationary. Therefore, I recommend publishing the article once the authors address

Printer-friendly version

Discussion paper

the following: Reply: We appreciate your thoughtful review and appreciating the actual content of the manuscript by offering constructive suggestions and comments, which made us to improve the manuscript significantly. During revision, we tried our best to provide all the details for your views/suggestions and hope you will be satisfied with the revised manuscript. Details of the revision are given below: We agree with the reviewer's concern about the non-stationary GEV model. In the revised manuscript we discussed the stationary and non-stationary GEV statistical distributions and the importance of the non-stationary GEV model and we provided references for important sentences. Major concerns: Non-stationary: It seems that the authors are using a non-stationary GEV distribution while they do not even mention non-stationary. This is not acceptable. If you are using a non-stationary model, you have to convince the reader that this is the best option. Why are you using a non-stationary model? There is no literature review about non-stationary! Why did you consider all three parameters to be non-stationary? Studies have concluded that it is very hard to estimate a non-stationary shape parameters in GEV distribution (see Lee et al., 2017 and references cited there). It's not clear how the authors have dealt with this problem.

Reply: We sincerely appreciate the reviewer's suggestion in this regard. In the revised manuscript we clearly mentioned the non-stationary method and we added literature regarding the non-stationary GEV statistical distribution. Adoulni et al. (2007) also mentioned non-stationary GEV model is an efficient tool and it takes consideration the dependencies between extreme value random variables or the temporal evolution of the climate. However, the frequency of extremes is likely to change in response to changes in climate (IPCC, 2007). Coles and Dixon (1999) modify the likelihood function by introducing a penalty term to restrict the shape parameter values to the range for which the GEV distribution has finite mean. Kharin and Zwiers (2005) estimated the annual extreme temperature return values from a fitted GEV distribution with time-dependent location and scale parameters. They found that changes in temperature extremes are largely associated with changes in location parameter of the distribution of annual extremes without substantial changes in the shape parameter over most of

the globe. We also discussed the non-stationary GEV distribution method and importance of the non-stationary method in the revised manuscript.

Literature review: The literature review does not seem to be covering the entire content. More literature review on precipitation extremes is needed. Also, a significant portion of the introduction covers extremes in China while the study area is India. I suggest adding literature review of other regions such as U.S as well. A recent paper on the extremes of the U. S. is Zarekarizi et al. (2018).

Reply: We agree with the reviewer's concern in this regard. In the revised manuscript we included more literature on extreme precipitation studies and we reduced the text on extremes over China in the introduction. As per your suggestion, we discussed the extremes over the USA and we added the Zarekarizi et al. (2018) in the revised manuscript. Thanks for providing the recent work on extremes studies.

Model parameters: In the parameters are non-stationary, the readers need to see the variations in the parameters. I would like to see the parameters (all of them) in all datasets! (Historical, CRU, and all RCP's). Did you estimate the parameters for every dataset (Historical, CRU, and every RCPs)? Did you estimate the parameters once in the historical period and used it for the future? Please explain and show the estimate parameter maps in the revisions.

Reply: Thanks for your suggestion. We prepared for Historical, CRU, and all RCPs of CMIP5 datasets of GEV results. Totally, six plots of extreme temperatures and six plots for precipitation and it is not possible to add all in the manuscript. So, we showed one figure in the text and the remaining figures are attached at the bottom of the reviewer replies (see Figures: Pfit1-5).

Model choice: Authors need to prove that non-stationary GEV is the best-fit model. I am not convinced why the authors have used non-stationary GEV.

Reply: Thanks for your comment. Generally and commonly used statistical models

are stationary and non-stationary models. The stationary model, a linear trend in the location and linear trends in both location and scale parameters. For non-stationary models, the estimated return values are calculated at the center of the periods (Grigory et al. 2011). During the recent decades' concern on climate change, some key developments for extending the concepts of the return period with extreme events under non-stationary conditions have appeared in the statistical and climate change (e.g., Wigley 2009; Cooley 2009, 2013). Later Cheng et al. (2014) used stationary and non-stationary GEV model simulations using annual monthly maximum temperatures and they conclude that non-stationary simulations are better than the stationary simulations. So, after going through all the literature and we opted non-stationary GEV model is good for our analysis. I mentioned some of them only, you can find more on this in the Introduction section. All these literature we incorporated and discussed in the revised manuscript.

It's not clear why the authors chose GEV for extreme precipitation. You can add literature review if other studies have use GEV extreme precipitation as well.

Reply: Thanks for your suggestion. In the revised manuscript we have added more literature regarding extreme precipitation in the introduction section.

Authors are only using plots to show the goodness-of-fit. This is not enough. Please use 1-2 quantitative measure too (such as AIC, BIC, DIC, RMSE, NSE, etc.).

Reply: Thanks for your comment. From the literature, we found the best fitting model is the likelihood ratio test and this method is used for our analysis purpose. Simkova and Picek used estimation methods (L-, LQ-, TL-moment, and maximum likelihood) to estimate high quantiles of the Generalized extreme-value distribution (GEV) and Generalized Pareto distribution (GPD) considering various sample size, the shape parameter, and probability. The simulation study revealed that the L-moment and maximum likelihood methods provide the best high quantile estimates of the GPD and GEV distributions. The more description of the likelihood function has given in the revised

manuscript.

Downscaling (Line 112) Did you do any downscaling? If yes, explain. if not, explain the reason in the discussion section! Also, say exactly how many cells you have? For figures, have you used smoothing? If yes, what method?

Reply: Thanks for your comment. The output for both historic and different CMIP5 RCPs outputs are available on different spatial scales, which are spatially down-scaled to a common grid 1x1 (longitude-latitude). In the present study we have used bias correction and downscale method (BCSD) and clearly mentioned in the revised manuscript. All figures are generated using Interactive Data Language (IDL). We did not apply any smoothing technique while generating the figures. The total number of cells over India is 574. The cell locations are shown by gray color filled circles in Figure 2 in the revised manuscript.

Introduction: The introduction needs more literature review on precipitation extremes. Explain in more detail what are the goals of the study?

Reply: Thanks for your comment. We provided literature on extreme temperatures and precipitation in the revised manuscript. The details of the study are clearly mentioned in the revised manuscript.

Minor concerns: It's not clear what program the authors have used to estimate the parameters.

Reply: Thanks for your comment. We used the GEV package and it is available in the R programming exTremes (Guilleland and Katz, 2011). This sentence is incorporated in the revised manuscript.

Cite papers that have used GEV to model extreme precipitation.

Reply: Thanks fro your suggestion. We have added all the citations wherever it is necessary in the revised manuscript.

In case, a reader is interested to reproduce you research, where can they get the data? Please provide links. Also, I always encourage open source research. Please indicate if you are planning to share data and code? If yes, where can a reader find the data?

Reply: Thanks for your suggestion. For our analysis purpose we used precipitation, minimum and maximum surface temperatures of CRU (http://www.cru.uea.ac.uk/data), Historical, and different scenarios of CMIP5 models are available at http://cmip-pcmdi.llnl.gov/cmip5/. These datasets are available free for public. Generally, I am providing the code to everybody request via electronic mail.

Explain how you extracted cold extremes from the dataset.

Reply: Thanks for your comment. Generally, cold extremes temperature purpose we utilized the minimum temperatures (Tmin) and we extracted the cold extremes similar to the maximum temperatures. The cold extreme plots are attached at the bottom of the reviewer's replies (see Figures: Pfit1 and Pfit2).

Figure captions are generally too short and need to address more details.

Reply: As per reviewer's suggestion, we provided more information for figure captions in the revised manuscript.

Line 32-34: Revise, grammatical issue.

Reply: We are sorry for the mistake. In the revised manuscript, we have taken utmost care in minimizing the grammatical mistakes.

Line 39: use the term "return period"

Reply: Thanks for your suggestion and we change in the revised manuscript.

Line 46: What is CRU? Spell out or just say observation.

Reply: Thanks for your suggestion, which is implemented in the revised manuscript.

Line 56: Grammatical issue

Reply: This sentence has been modified correctly in the revised manuscript.

Line 67: What was their conclusion?

Reply: We have mentioned their conclusion in the revised manuscript.

Line 81: Spell out GCM

Reply: Thanks for your suggestion, we have given the full name of the GCM in the revised manuscript.

Line 90: This is confusing. Please separate data and method. There is no transition from data to method.

Reply: In the revised manuscript, we have separated data (section 2) and method (sub section 2.1).

Line 94: is the length of CRU data up to 2005 or you choose this period.

Reply: Climate Research Unit (CRU) datasets are available globally over land areas for the period 1901 to 2017 with horizontal resolution of 0.5o x 0.5o on monthly basis. For our analysis purpose we have collected from 1901 to 2005. We have given all details and we have provided the link where we can download the CRU dataset in the revised manuscript.

Line 97: Is it not clear if the authors have done "quality checking procedures" themselves or it's available through data source?

Reply: Thanks for your comment. The CRU precipitation and temperatures datasets quality control checked by the University of East Anglia and they provided for the public. We modified the sentence in the revised manuscript.

Line 106-107: Explain in more detail

Reply: Thanks for your suggestion we have incorporated more details of the ensemble member 'r1i1p1' in the revised manuscript.

Line 114-116: Not clear. Revise please

Reply: We agree with the reviewer comment and we removed those lines because we already discussed about the Table 1 in previous paragraph.

Line 117: Add a section or subsection here

Reply: Thanks for your advice we have added the subsection in the revised manuscript.

Line 129: Please look at Lee et al., (2017) in GRL., too.

Reply: We thank to the reviewer for this suggestion and we added description and reference in the revised manuscript. As suggested by the reviewer, we have discussed of four types of GEVs with his reference in the revised version of the manuscript.

Line 151: what do you mean by "regression"

Reply: Sorry for the mistake, now we modified the sentence in the revised manuscript.

Line 151: Explain "delta" method.

Reply: Thanks for your suggestion we have explained the delta method in the revised manuscript.

Line 152: As you know, in GEV model, the realizations should be i.i.d. How can you convince the reader that a month is enough to make sure that data are dependent? You can cite previous papers that have used monthly maximum temperature and precipitation.

Reply: Thanks for your comment. The probability of values selected by this way converges asymptotically to the generalized extreme value distribution (GEV), under the assumptions that they are independent and identically distributed (iid). From the literature, Fernado et al. (2006) used annual maximum temperature. They used only one point per year for their analysis. They mentioned it is difficult for seasonal extremes. Some of the points are discussed in the revised manuscript.

Printer-friendly version

Discussion paper

Figure 1: Please indicate how many points you have and if you are ignoring any outliers?

Reply: Thanks for your comment. For Figure 1, we used the Historical maximum surface temperatures during the period from 1901-2005 at a particular longitude and latitude grid. The total number of points is 1260, in that we observed very few are outliers, but it varies location to location.

Line 156: Please add all the fitting information.

Reply: Thanks for your suggestion. We explained and discussed about the fitting and confidence level procedures in the revised manuscript.

Figure 1: What data are you using for these plots? Historical or CRU? Explain in the caption. It would be good to see this for other datasets too (if possible).

Reply: Thanks for your suggestion. Figure 1 corresponds to the Historical maximum temperature (Tmax, Units = degrees K) during the period from 1901 to 2005 and we mentioned clearly in Figure 1 caption also in the revised manuscript. As per your suggestion, we have generated some more figures and attached at the bottom of the replies document. The plot names are (Figures: Tfit1, Tfit2, Tfit3, Pfit4, and Pfit5).

Line 161: Please use the term "return period"

Reply: Thanks for your suggestion and we corrected in the revised manuscript.

Line 165: Please explain this in the caption, too

Reply: Thanks for your suggestion and we added in the Figure 2 caption in the revised manuscript.

Line 168: "(Figure not shown)". It is important to show this figure (if not limited in the number of figures. In that case, you can add it in the responses to this review).

Reply: Thanks for your comment. As per reviewer's suggestion, we have added the two

more figures and related discussion on precipitation. So, we don't have room to add some more figures. Here are the CRU GEV maximum and minimum extreme results (see Figure 1).

Line 209: Revise the title of sub-section. This section is more of analyzing the spatial distribution, not changes.

Reply: Changes are made as suggested by the reviewer in the revised manuscript. We changed the sub-section title as "Spatial distribution of CMIP5 future climate extremes" in the revised manuscript.

Line 247: standard deviation of what? Estimated return levels?

Reply: Thanks for your comment. The estimated return level standard deviations for CMIP5 for all scenarios (RCP2.6, RCP4.5, RCP6.0, and RCP8.5). These sentences are incorporated in the revised version of the manuscript.

Line 271: I could not find Lee et al. (2014) in the list of references. Please make sure all the cited papers are included in the references.

Reply: Sorry for the mistake. We provided the details of the Lee et al. (2014) in references list. We checked thoroughly all cited references are given in the reference list.

Line 283: You did not analyze trend. Please revise this term.

Reply: Thanks for your suggestion and we revised in the manuscript.

Line 313: Issue with citing style.

Reply: Sorry for the mistake and we corrected in the revised manuscript.

Tables: Table 1: Please highlight the rows to indicate the models that you have used in the study. Also, make it clear in the caption too.

Reply: Thanks for your comment. We keep what we used in this study only in Table 1

and remaining are deleted from Table 1.

Table 1: The quality (of both tables) is low. Explain in the caption what "stem" is.

Reply: We have modified the Table 1 and Table 2 with best resolution. We explained the "stem" and "Pr" in the revised manuscript.

Figures: I suggest the map in figure 1 from the rest of the figure. They are representing different ideas.

Reply: Thanks for your suggestion. We separated the map in figure 1 and renamed as Figure 2 in the revised manuscript.

What are they gray dots in the map in figure 1?

Reply: Actually the gray dots are grid of the data. We separated from the Figure 1 and in the revised manuscript we named as Figure 2.

Figure 1, lower right panel: add legend

Reply: As suggested by the reviewer, we have added the legend for lower right panel and replaced the new Figure 1 in the revised manuscript.

Expand the figure 1 caption and add more detail especially about the dataset.

Reply: Thanks for your suggestion. We added the dataset details for the Figure 1 caption in the revised manuscript.

Figure 2: Explain in the caption that what the numbers above each panel is? This applies to all figures.

Reply: Thanks for your suggestion. We modified the figure caption in the revised manuscript.

Figure 3: Revise the title of the colorbar to make sure the reader understands that this is difference and not absolute values.

Reply: As per reviewer's suggestion, we have modified the title of the colorbar in the revised manuscript.

Is this difference between return periods? or absolute values. Make it clear in the figure.

Reply: Thanks for your comment. The difference between return periods and mentioned clearly in the text and caption of the Figure 4.

Figure 4: You could change the colorbar so that the spatial distribution of the data is clearer.

Reply: Thanks for your suggestion. We redraw the figure 4 with new colorbar (now Figure 5 in the revised manuscript) and changed the numeration of the figure.

References: Lee, B. S., Haran, M. Keller, K., 2017. Multidecadal scale detection time for potentially increasing Atlantic storm surges in a warming climate. Geophys. Res. Lett. https://doi.org/10.1002/2017GL074606. Zarekarizi, M., Rana, A., Moradkhani, H., 2018. Precipitation extremes and their relation to climate indices in the Pacific Northwest USA. Clim. Dyn. https://doi.org/10.1007/s00382-017-3888-2.

Thanks for giving the references, which helped while revising the manuscript.

We have take care of most of the major concerns in the revised manuscript. We once again thank the reviewer for going through the manuscript carefully and offering potential solutions to improve the manuscript further.

Please also note the supplement to this comment:
https://www.hydrol-earth-syst-sci-discuss.net/hess-2018-522/hess-2018-522-AC2-supplement.pdf

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2018-522, 2018.

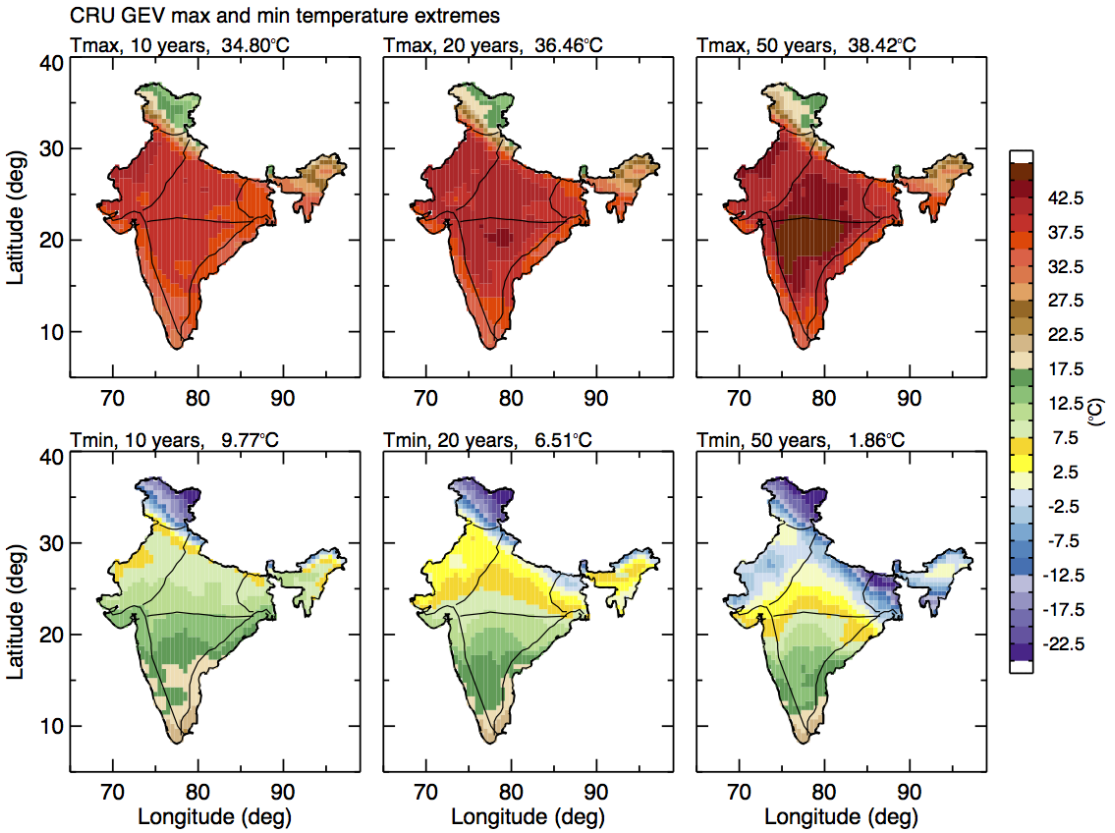

Fig. 1. Spatial variations of CRU maximum temperature (Tmax: top panel), and minimum temperature (Tmin: bottom panel) extremes for 10-year (left), 20-year (middle), and 50-year (right) return periods during 1

Printer-friendly version

Discussion paper

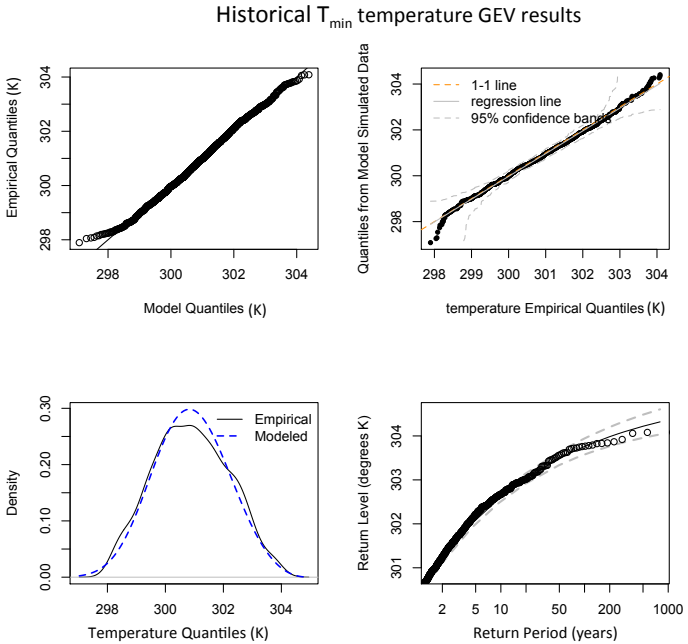

Fig. 2. Tfit1: The Generalized Extreme Value (GEV) statistical distribution return period values, empirical and modeled fits with 95% confidence level using Historical ensemble simulations of minimum temper

Printer-friendly version

Discussion paper

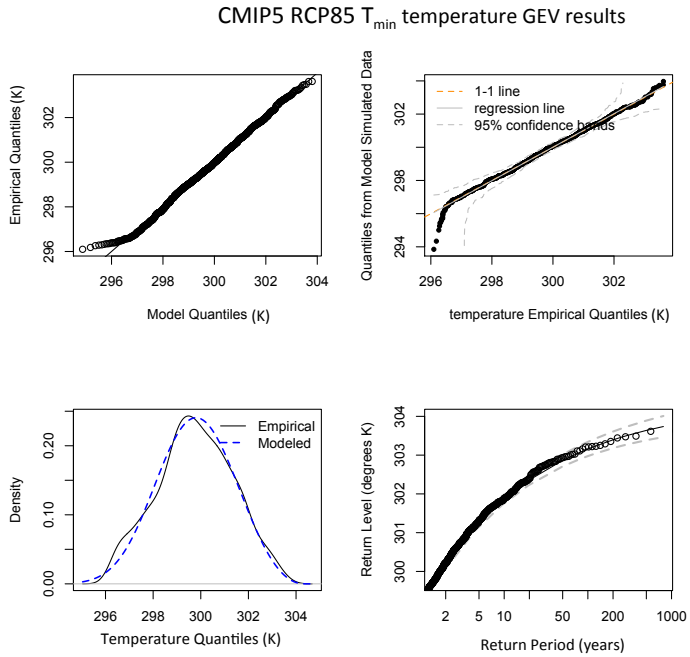

Fig. 3. Tfit2: The Generalized Extreme Value (GEV) statistical distribution return period values, empirical and modeled fits with 95% confidence level using CMIP5 RCP8.5 ensemble simulations of minimum temp

Printer-friendly version

Discussion paper

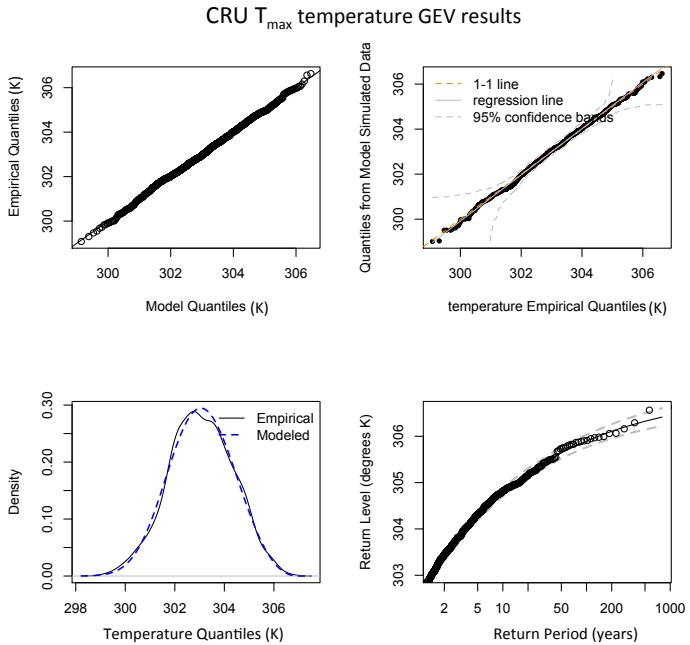

Fig. 4. Tfit3: The Generalized Extreme Value (GEV) statistical distribution return period values, empirical and modeled fits with 95% confidence level using CRU maximum temperatures (Tmax, units = degrees K

Printer-friendly version

Discussion paper

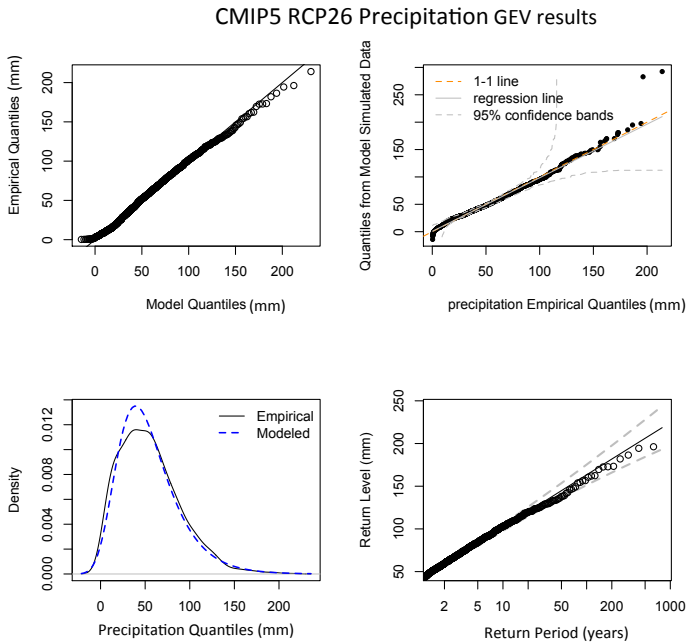

Fig. 5. Tfit4: The Generalized Extreme Value (GEV) statistical distribution return period values, empirical and modeled fits with 95% confidence level using CMIP5 RCP2.6 precipitation (P, units = mm) during

Printer-friendly version

Discussion paper

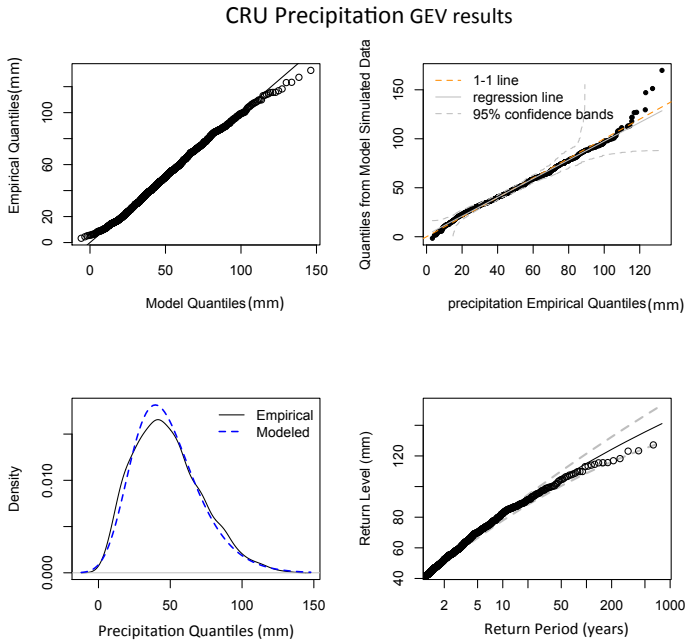

Fig. 6. Tfit5: The Generalized Extreme Value (GEV) statistical distribution return period values, empirical and modeled fits with 95% confidence level using CRU precipitation (P, units = mm) during 1901-200

Printer-friendly version

Discussion paper