Review for “Future changes in the mean and variability of extreme rainfall indices over the Guinea Coast and role of the Atlantic equatorial mode” by Worou et al.

Overview

The present manuscript investigates the current and future characteristics of West African rainfall according to an ensemble of 24 CMIP6 GCM models and further relates them to the development of the Atlantic equatorial mode (AEM), which has been a driver of rainfall over the Guinea Coast region. The authors use 12 ETCCDI rainfall indices to compare the nature of present-day rainfall with gridded observation data, i.e., CHIRPS, as well as with the rainfall behaviour in three future periods (near-term, mid-term, long-term) under the strongest SSP5 scenario (SSP5-8.5). By regressing CHIRPS rainfall indices to the AEM index, a reference is created in order to assess and quantify changes in the relationship between future extreme rainfall and the variability of AEM over the Guinea coast. The main results indicate increasingly less frequent but more intense rainfall over a gradually shorter period in the future. Furthermore, the AEM is suggested to have a diminished influence on future extreme rainfall over the Guinea coast region due to a decrease of AEM variability.

An increased knowledge about climate extremes over West Africa, especially that of rainfall, is of high importance for the assessment of current and future risk and subsequent development of risk mitigation strategies, action plans and decision making. In that regard, this study has the potential to be of high relevance for this part of the scientific community. However, as will be pointed out in more detail in the comments below, my biggest concern is the usage of CHIRPS for a study revolving around rainfall extremes, which potentially require a major revision. Furthermore, the study becomes diluted by the high number of rainfall-related indices, some of which are not particularly necessary to include in my opinion. Therefore, the presentation of the results somewhat suffers from an overload of numbers and a lack of structure. Overall, the topic of the manuscript is within the scope of WCD. Being non-native in English, language appears fine to me with only minor corrections to perform.

General comments/questions

- As mentioned above, by biggest concern is related to CHIRPS being the reference in a study about extreme rainfall. While it excels at interannual timescales over Africa (e.g., Camberlin et al., 2019), it struggles with the representation of rainfall in the extreme spectrum by showing substantial underestimation tendencies at a daily timescale (e.g., Sanogo et al., 2021; Ageet et al., 2022). Therefore, I do not think that relying on CHIRPS alone is sufficient to address the research question of this manuscript. Based on the outcomes of recent validation studies, I suggest to include the exercise with either GPCC-FDD (Becker et al., 2013) or one of the GPM products GsMAP or IMERG (Kubota et al., 2007; Huffman et al., 2015). This will allow to make at least basic statements about the uncertainty that stems from the observational data themselves.

- How did the authors choose the study periods? I was wondering why the long-term future was selected such that it exhibits a 20-year gap to the mid-term future, while the latter directly follows up to the near-term future. Can the authors elaborate on that?

- The study somewhat suffers from the plethora of indices and/or the lack of a structured presentation of their results. For instance, is it necessary to include both the 95^{th} and 99^{th} percentile (same for R10mm and R20mm)? Is it worth to include PRCPTOT when SDII is basically the same but defined as a rate? Regarding the structure, with this many indices, it can become difficult for readers not familiar with these to keep track of the arguments being made and being confronted with too big panels. I understand that the current structure follows a logical build-up going from the current situation to the perspective in the future followed by the link to AEM. However, the authors may consider to form groups, e.g., extreme precipitation indices (R99p, R20mm, RX1day, …) and frequency (R99pf, CDD, CWD, …), and analyze their current and future characteristics in their own subsection. I believe that this will

particularly improve the readability of the tables, which currently mixes indices with different units together.

- The introduction is too long, which inhibits a sharper formulation of the research question. Looking at each paragraph, the following topics are addressed:

    1. Socio-economic impacts of extreme rainfall
    2. IPPC AR6
    3. Recent trends in AMJ daily rainfall in Guinea coast region
    4. Recent trends in JAS daily rainfall in Guinea coast region
    5. 3.) and 4.) for specific coastal areas
    6. CMIP6 models behaviour of current rainfall characteristics over Africa
    7. GCM behaviour of future rainfall characteristics over Africa
    8. RCM behaviour of future rainfall variability on daily and seasonal timescale
    9. MCSs, AEM, SST
    10. Historical and current relationship between AEM and Guinea coast rainfall
    11. Goal of study

    Some of the paragraphs, e.g., 3-5, can be easily merged and stripped-down to the fundamental information. I advise the authors to revise and shorten the introduction. Also, I believe that AEM should be introduced earlier to facilitate a better build-up to the research topic.

- The beginning of summary and conclusion section lacks a systematic and brief recapitulation of the motivation and research question of the study, the data and methods used and a point-by-point summary of the key results. Also, some discussion was integrated in the result section, which should rather be shifted to the this section (see specific comments). Overall, I am somewhat missing the link of the presented results with existing literature, i.e., a proper discussion, and how they integrate, complement, or disagree with them. As mentioned, a part of it can be just shifted from the result section.

Specific comments/questions

L28: "…the exposure to river flooding events is expected to increase 4.6, 8, and 8.6 times more than without climate change". Are these numbers related to the 1.5°C, 2.4°C and 3.5°C scenarios further down the sentence? It didn't get quite clear from the structure of the sentence.

L32: "…for the safety of young people". Maybe better "future generations"?

L49: "… which represents up to 4% of the seasonal daily mean rainfall". Do the authors mean that the JAS mean daily rainfall has decreased by 4%?

L67: "Regional Climate Models (RCMs) forced with CMIP5 GCMs outputs…". Are they related to CORDEX Africa?

L107: "a mode characterized by anomalous warming and cooling in the eastern equatorial Atlantic basin". It should be additionally mentioned that the phenomenon refers to an interannual variability.

L141-143: See general comment on the choice of the periods.

L150-151: "Only one realization of each simulation is considered for each GCM". Based on what criterion did the authors decide on the ensemble member per GCM?

Table 1: The meaning of the metadata IDs (r, i, p, f) should be explained in the caption or in the text. Why do the historical members differ from SSP5-8.5 members for some models?

L153: See general comment on CHIRPS.

L161-162: "This study is focused on the July-September season (JAS), when the Guinea Coast rainfall covariability with the AEM is at its maximum in the current climate models". I believe that this covariability in JAS was not mentioned in the introduction!? For the Guinea coast region, JAS largely falls within the little dry season over the Guinea coast region, thus outside of the two rainy seasons. Have the authors also investigated April-June (AMJ) and/or September-November (SON) when MCSs are more prevalent in the coastal region?

If so, I think it would be worth a few sentences (e.g., in the conclusion) on how future extreme rainfall develops in these seasons.

L162-165: This text snippet looks like it could also be shifted to the introduction.

L167: Have the authors tested the sensitivity of R10mm and R20mm on the choice of the resolution? I would think that different resolutions lead to different outcomes with indices where the threshold is an absolute value (e.g., 1mm for a wet day).

L175: What remapping procedure (bilinear, bicubic, …) is used?

Table 2: Mention again in the caption that the indices are based on ETCCDI. Is PR95/PR99 calculated from wet days only or from all timesteps?

L222: I think the TSS deserves a bit more explanation here about which combination of measures it attempts to create a skill score with (i.e., correlation coefficient and standard deviation). It is worth noting that these components can be weighted differently. For instance, deviations in the standard deviation can be penalized harsher than the correlation coefficient. I believe however that the standard formulation of the Taylor skill score is used here.

L250: "… and 250 the percentage of bias reaches 0.98%, against −1.28% for RX1day". This is not much, is it?

L251-252: "Alongside, the wet days and extremely wet days (R95p and R99p) statistics over the entire Guinea Coast show positive biases that represent 14.66% and 24.10% of the observations". This potentially falls back again to the issues of CHIRPS and the question, whether this could rather be due to the deficiencies of CHIRPS to resolve extremes.

Table 3: How robust are these numbers? How much variance do they exhibit across the members? The authors may consider expressing these numbers rather in a box-whisker plot to account for the uncertainty of the ensemble.

L281-282: "The spatial distribution of the mean changes in R95p, R10mm and R20mm in our study are different from the patterns obtained in the RCM-CMIP5 projections (Akinsanola and Zhou, 2019)". In what way? Please elaborate on that in more detail.

Figure 3: "… diagonal bars…". Better use "hatching".

L290: "The changes in the near-term period relative to the present-day conditions are not clear for the majority of the indices". How is this seen from Fig. 4?

L291: "The mid-term and long-term changes indicate a clear increase in mean and standard deviation…". Again the question from the general comments about how much of an impact on the increase the 20-year jump has from the mid-term to long-term future period!?

Figure 4: Which significance test was used?

L320: "… there is overall a good spatial distribution of the SDII and PRCPTOT anomalies over West Africa". Do the authors mean a "good agreement"?

Figure 5: While the structures of the indices pretty much look alike for EnsMean, the spatial variability for CHIRPS is visibly higher in Fig. A2. Can the authors elaborate on the sources of these differences?

Table 4: This is again a comparison with CHIRPS, correct? Then it should be mentioned in the caption as such.

L363-375: This belongs in the conclusion section in my view.

Figure 7: Please explain in more detail in the text on what you computed here with respect to one standard deviation of the AEM. You varied AEM by one standard deviation and quantified the difference?

L439: One "a" too many.

Table 5: "… of the proportion of the variance explained by the AEM". What exactly does that mean? Are the median values of the indices potentially calculated from different sample sizes?

Summary: See also general comment on the summary and conclusion section. It does not get clear what the source of the rainfall indices are, which SSP scenario was taken, that the link of extreme rainfall to AEM in current and future period is investigated, etc. This should be more carefully and meticulously summarized right in the beginning.

References

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