REVIEW of « The ability of a stochastic regional weather generator to reproduce heavy precipitation events across scales », by X Guan et al.

This paper presents the application of two statistical methods to evaluate how a recently updated « non stationary Regional Weather Generator » (nsRWG) produces heavy rain events over Germany. The manuscript well explains the main features of the nsRWG and describes exhaustively the statistical methods used for the evaluation. I recommend publication in NHESS once the minor comments below have been solved.

GENERAL COMMENT

It would be highly beneficial for non-expert readers to give more references useful for the physical interpretation of values of WEI and xWEI, i.e., examples of how the values of WEI and xWEI link to extreme event extension and duration. This can be added/extended in the Methods and Results and Discussion Section (although in section 4.2 an example is already mentioned).

Reply: Thank you for the valuable suggestion. In the revised manuscript, we expanded the interpretation of Figure 2 to provide more clarity on the relationship between WEI, xWEI, and extreme event characteristics. Specifically, we explain how the extent and duration relate to the extremity pattern of the HPE event illustrated in Figure 2:

"For the exemplary HPE event, the analysis highlights that the daily extremity (in terms of 1-day rainfall intensity) occurred on the 4th day, with the highest EtA curve among the 7 days (Figure 2d). Comparing extremity across durations, the HPE was most extreme for a 1-day duration, affecting an area of over 10,000 km² (WEI-area). For longer durations (≥3 days), the HPE consistently influenced approximately the same area, showing a stabilization in spatial extent for these durations."

We believe this explanation offers a clearer physical interpretation of WEI and xWEI values and how they link to the extension and duration of extreme events.

TECHNICAL COMMENTS

Lines 53-55: Merge or connect sentences – it is not evident that they are discussing the same issue.

Reply: we follow reviewer's suggestion.

Lines 119-120: Specify that « SANDRA » is used to classify / cluster the circulation patterns.

Reply: thanks, "circulation pattern classification" is explicitly specified in SANDRA method description.

Lines 129-130: Specify that WEI is computed for each HPE

Reply: The sentence is rephrased as "The computation of WEI for individual HPE is illustrated in Figure 2."

Lines 133-134: Clarify that E_tA is computed once for every value of A. Moreover, the dependency of A on n should be expressed in Equation 1.

Reply: Thank you for pointing this out. The dependency of E_{tA} on A has been explicitly clarified in the description of the E_{tA} computation. Additionally, the equation in Line 156 has been revised to specify $A = \text{grid size} \times n$, ensuring clarity regarding the dependency of A on n.

Lines 165-170: In my opinion this paragraph, explaining why sub-daily precipitation is not considered, can be easily compressed as a note of a couple of lines, since it is a limitation, and not relevant for the discussion of your results.

Reply: Thank you for your comment. We have revised the paragraph to streamline the explanation and focus on the rationale for selecting durations from 1 to 7 days. The updated version emphasizes that these durations are sufficient to capture the events responsible for disastrous flood damage in Germany and briefly mentions the limitations of sub-daily precipitation observations. This modification addresses your suggestion by making the paragraph more concise while retaining the necessary context for understanding the analysis.

Lines 185-187: The last two sentences are not coherent with each other. Please adjust.

Reply: The two sentences have been merged to improve coherence as requested.

Lines 197-198: observed WEI is underestimated also for duration > 4 days and return periods between 10 and 20 years.

Reply: we merged the two sentences "For return periods between 2 and about 10 years and short durations, nsRWG slightly underestimates the observed WEI" is modified to "For short durations and return periods between 2 and about 10 years, as well as for durations longer than 4 days with return periods between 10 and 20 years, the nsRWG slightly underestimates the observed WEI."

Line 200: Is it worth mentioning here that the return period increases with duration, when considering fixed WEI values?

Reply: It is generally correct that for HPEs with the same WEI value, the return period increases with duration. This indicates that the occurrence probability of an HPE with the same extremity (in terms of WEI magnitude) becomes less frequent as the duration increases. This relationship reflects the rarity of longer-duration extreme events with comparable intensity.

Lines 219-222: How are the synthetic events in the comparison selected? Is there a way of selecting these based on the highest similarity in the WEI surface profile (i.e., sampling similar events in terms of extent and duration)?

Reply: The selection of synthetic events with similar xWEI values to the 2021 event was conducted as follows: we first extracted HPEs with annual maximum xWEI from the 100 precipitation realizations generated by nsRWG. These synthetic events were then compared to the 2021 event based on their xWEI values. We acknowledge that only a few synthetic HPEs exhibited extremities close to the 2021 event. The three selected synthetic HPEs were chosen based on their xWEI surface characteristics and extremity across various durations. While quantifiable indicators, such as mean squared error (MSE), could provide an explicit measure of similarity in xWEI surface profiles, we decided not to include this detail in the manuscript as it does not significantly impact the core analysis.

Line 248: Doesn't it underestimate the frequency, since the return periods for the same WEI value are higher in the synthetic data?

Reply: Thank you for your comment. We believe there may be a misunderstanding. The statement in the conclusion "However, it tends to overestimate the frequency of events with short durations and relatively small spatial extents," refers to results shown in Figure 4, which depicts the distribution of WEI-area across areas and durations. Specifically, the nsRWG underestimates the frequency of events with short durations (1 day) and small spatial extents (<10,000 km²). In contrast, the statement about return periods for the same WEI value being higher in synthetic data reflects an inference from Figure 5. These address different aspects, and we therefore propose to keep the sentence unchanged.

Line 257: Explain briefly what spatial counterfactuals are.

Reply: Thank you for your comment. In the updated manuscript, we have included a general explanation of counterfactuals in the context of climate extremes: "Counterfactuals are scenarios that describe alternative ways an event could have unfolded (Woo, 2019; Montanari et al., 2024). These scenarios may involve altering or removing specific factors, such as anthropogenic climate change, natural climate variability, or other boundary conditions (Gauch et al., 2020)." Additionally, the manuscript already includes a description of spatial counterfactuals: "Using spatial counterfactual scenarios, we can investigate the impact of HPEs in the hypothetical case that they had happened elsewhere." This provides the necessary context for understanding both counterfactuals and their spatial applications.

References:

Gauch, M. and Klotz, D. and Kratzert, F. and Nearing, S. and Hochreiter, S. and Lin, J. A Machine Learner's Guide to Streamflow Prediction. Workshop on AI for Earth Sciences 34th Conference on Neural Information Processing Systems (NeurIPS 2020) Vancouver, Canada, 2020.

Montanari, A., Merz, B., & Blöschl, G. (2024). HESS Opinions: The sword of Damocles of the impossible flood. *Hydrology and Earth System Sciences*, *28*(12), 2603–2615. https://doi.org/10.5194/hess-28-2603-2024

Woo, G. (2019). Downward Counterfactual Search for Extreme Events. *Frontiers in Earth Science*, *7*, 340. https://doi.org/10.3389/feart.2019.00340