

Response to Reviewer 1 – Professor Chuck Kroll

Second round of review

Reviewer's general comments

Re-Review of Non-stationary low-flow frequency analysis with mixed Weibull components and Copula-based dependence framework (<https://doi.org/10.5194/egusphere-2026-1820>) submitted to HESS.

Reviewer: Chuck Kroll, SUNY ESF, Syracuse, NY USA

The authors have done an excellent job addressing my minor concerns with the original manuscript. I do have a few minor suggestions for the final manuscript.

Response to Reviewer's general comments

Dear Professor Chuck Kroll,

Thank you very much for your positive assessment of our revisions and for these additional suggestions. Please find below our point-by-point response, where we refer to each comment in italics, followed by our response and the corresponding suggested revisions. In the revised text, additions and modifications are shown in blue, while deletions are shown in ~~red-strikethrough~~.

Sincerely yours,

Farhana Sweeta Fitriana, Svenja Fischer, Gabriele Weigelhofer, Johannes Laimighofer and Gregor Laaha

Reviewer's specific comments

(1) Line 93. Do any of the ROBIN sites you are employing contain intermittent flows, i.e. zeros? If so, how does this impact your analysis?

a) While I would consider any site with any flows recorded as zero as intermittent, I'm not bothered if your use this stricter definition.

b) In the end, do you remove the 3.2% of intermittent sites, or do you keep them in your analysis? Assuming you keep them, is there any problems keeping them in your analysis (i.e. censored flows reported as zeros)? It also seems that you can't have a non-stationary lower bound if you have zeros throughout the record.

Response to the additional on comment 1:

Thank you for these helpful clarifications. We recognised that any recorded zero flow can indicate intermittency, whereas our reported percentage follows the stricter classification previously described. The catchments classified as intermittent were retained and analysed using the same procedure as the other catchments, without specific treatment of zeros or censoring. The fitted seasonal minimum 7-day flow samples were not separately screened for zeros, and their influence on the estimates was not separately assessed. We also appreciate your point about the lower bound. We have expanded the existing discussion to clarify the inclusion of these catchments and the interpretation of zero-flow records.

We have now added this clarification to the revised manuscript in (Lines 397-403) Finally, intermittent-flow conditions relevant to the applicability of the WEI3-based framework were identified by comparing the ROBIN catchments used in this study with the intermittent-flow classifications of Tramblay et al. (2021). There are 3.2,% of catchments that were classified as intermittent

and were retained in the analysis. Because the WEI3 distribution is continuous and cannot explicitly represent a probability mass at zero, catchments with repeated zero-flow occurrences would require a modelling framework that accounts for zero flows, for example by treating zeros as censored observations within a mixed discrete-continuous L-moment framework (Laaha, 2023a, b; Bhatti et al., 2019). However, explicitly accounting for these data conditions is beyond the scope of the current study.

(10) Line 251. It would be helpful to either include the likelihood function or provide a reference to where this could be obtained. Are you assuming your observations are independent?

Even if the series are stationary, this expression depends on independence of the observations to decompose the likelihood function. As such, I would include here on the last line ". . . over time, and assuming the observations are independent, the log-likelihood function is given by". Even for the non-stationary case, I think you still need the assumption of independence, so I'd probably include it there too.

Response to the additional on comment 10:

Thank you for this suggestion. We have added the independence assumption directly in the sentence at Line 250-252 and removed the separate sentence referring to Appendix A at Line 259. The revisions are shown below:

(Line 250-252) . . . over time, and assuming the observations are independent, the likelihood functions for the stationary and non-stationary WEI3 models are provided in Appendix A.

~~(Line 259) The likelihood functions for the stationary and non-stationary WEI3 models are provided in Appendix A.~~

(14) Line 300. What about precipitation patterns? It appears that southern Europe is experiencing decreasing precipitation. Zeder D. and Fischer, E.M. (2020), Observed extreme precipitation trends and scaling in Central Europe, Weather and Climate Extremes, doi:10.1016/j.wace.2020.100266.

It might read better if the period is replaced by a comma, and this is written as 1 sentence.

Response to the additional on comment 14:

Thank you for this suggestion. We have replaced the period with a comma and combined the text into a single sentence, as suggested. The revised text reads:

(Lines 322-324) These patterns suggest that summer low flows are shaped by the combined effects of warming, enhanced evapotranspiration, drought intensification, and regional precipitation deficits, particularly in central Europe (Zeder and Fischer, 2020), whereas winter low flows reflect a more mixed response linked to snow processes and cold-season hydrological dynamics.

(22) Line 362. Is "strongly correlated" the correct term? Is this an increased seasonal dependence?

I would remove the word "more" before "increased seasonal dependence"

Response to the additional on comment 22:

Thank you for this suggestion. We removed "more" before "increased seasonal dependence." The revised text now reads:

(Line 425-427) In this respect, this behaviour is consistent with Laaha (2023a, b) showing that under moderate seasonal dependence, the copula-based correction has only a limited influence, whereas larger differences would be expected for ~~more~~ increased seasonal dependence between summer and winter low-flow components.

References

- Bhatti, S. J., Kroll, C. N., and Vogel, R. M.: Revisiting the probability distribution of low streamflow series in the United States, *Journal of hydrologic engineering*, 24, 04019 043, 2019.
- Laaha, G.: A mixed distribution approach for low-flow frequency analysis–Part 1: Concept, performance, and effect of seasonality, *Hydrology and Earth System Sciences*, 27, 689–701, 2023a.
- Laaha, G.: A mixed distribution approach for low-flow frequency analysis–Part 2: Comparative assessment of a mixed probability vs. copula-based dependence framework, *Hydrology and Earth System Sciences*, 27, 2019–2034, 2023b.
- Tramblay, Y., Rutkowska, A., Sauquet, E., Sefton, C., Laaha, G., Osuch, M., Albuquerque, T., Alves, M. H., Banasik, K., Beaufort, A., et al.: Trends in flow intermittence for European rivers, *Hydrological Sciences Journal*, 66, 37–49, 2021.
- Zeder, J. and Fischer, E. M.: Observed extreme precipitation trends and scaling in Central Europe, *Weather and Climate Extremes*, 29, 100 266, 2020.