Evaluating the performance of a max-stable process for estimating intensity-duration-frequency curves

Our goal: Calculate how much the estimation of IDF curves is affected by including the dependence between the maxima of different durations.

How?: Comparing the performance of two methods to estimate IDF curves: d-GEV model (Koutsoyiannis 1998)[1] (assuming independence) and a max-stable process[2], which explicitly models dependence[3]

Why?: Recent studies[3] have shown the possibility of using max-stable processes to estimate IDF curves. But is this estimation better than the commonly used d-GEV model?

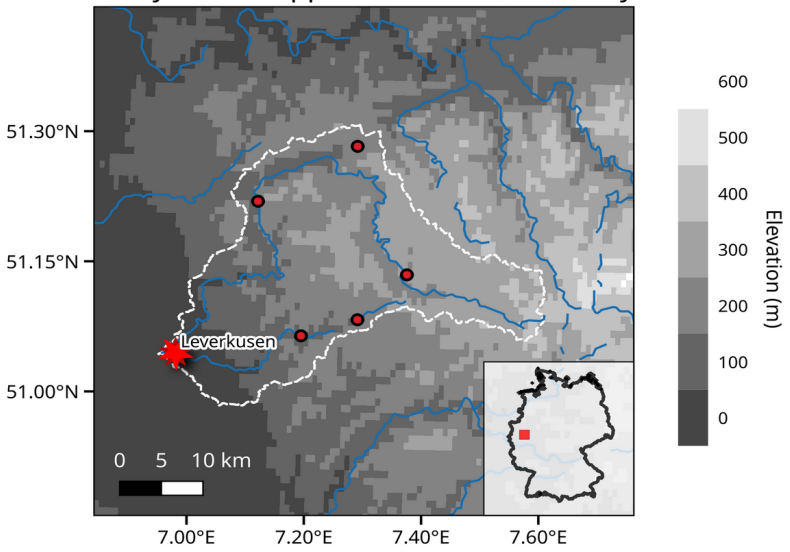
Oscar E. Jurado* *jurado@zedat.fu-berlin.de*
Jana Ulrich*
Henning W. Rust*
Marc Scheibel – *Wupperverband*
**Institut für Meteorologie, Freie Universität Berlin*

Freie Universität Berlin

Natural Hazards and Risks in a Changing World

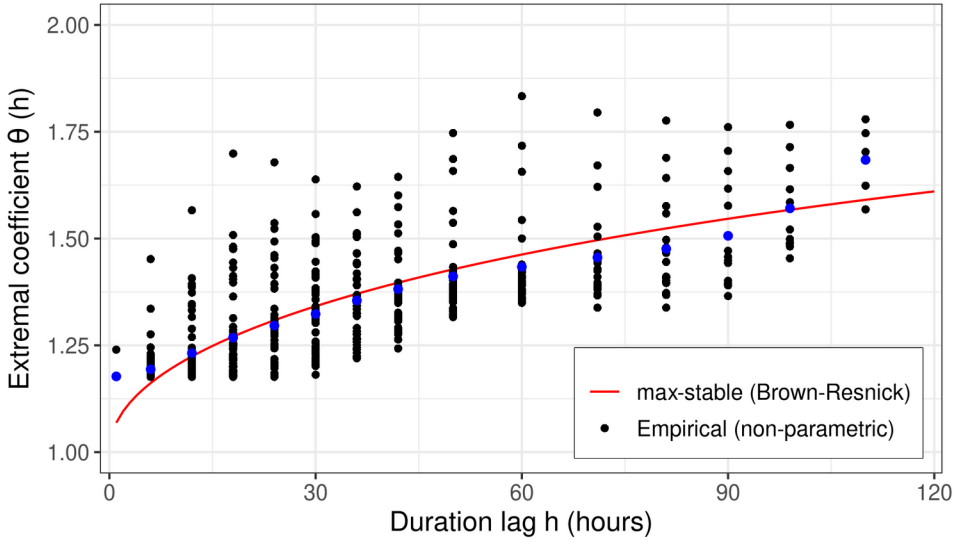
Method

Study area: Wupper catchment, Germany



We used data from 6 stations, each with 38 years of hourly precipitation values (mm).
In these slides we show only the results for the highlighted station (Leverkusen).

Dependence modeled by a max-stable process and its empirical estimate



Following Tyralis and Langousis (2019)[3], we estimated the IDF curves using a spatial max-stable process via the use of a **Brown-Resnick model**, where instead of geographical space we used a one-dimensional *duration* space.

Model performance is compared using the Quantile Skill Score (QSS)[4]:

$$QSS = 1 - \frac{QS_{mod}}{QS_{ref}}$$

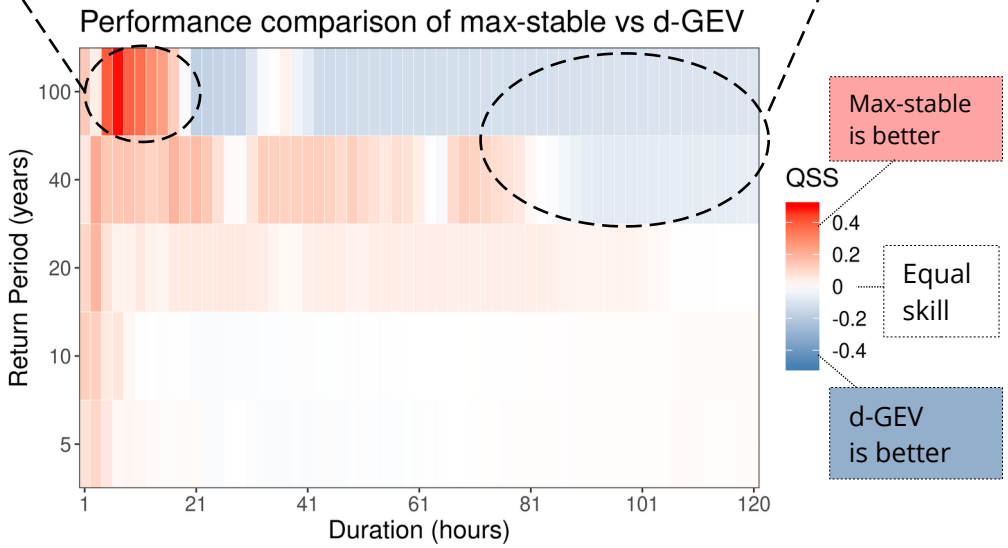
QS_{mod}: Quantile Score of the Brown-Resnick max-stable process

QS_{ref}: Quantile Score of the d-GEV model

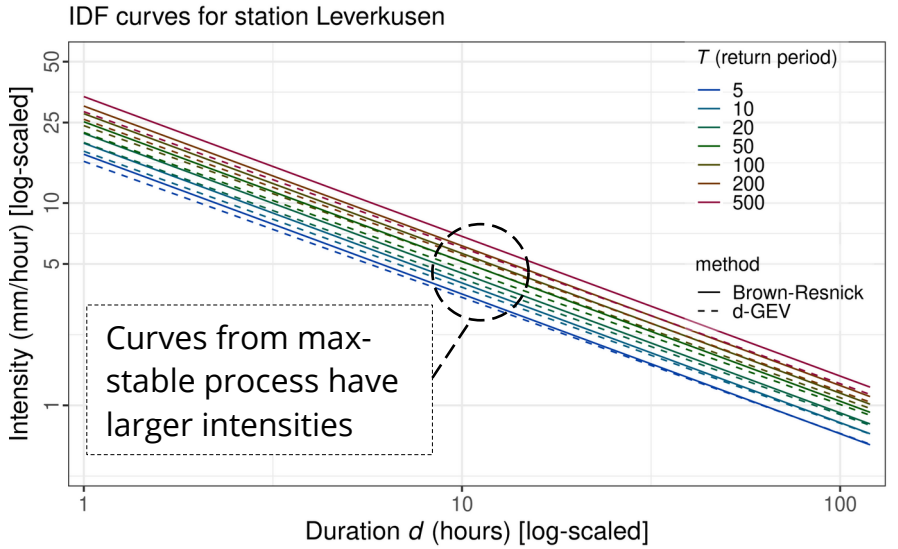
Results and insights

Better performance of max-stable for the shorter durations...

...but worse performance for the longer durations



Overall, the QSS shows that the performance of the max-stable process is either better or just as good as the d-GEV model, except for the long durations (d>24h)



The resulting IDF curves for this station show that the max-stable process (continuous line) results consistently in larger intensity values than the d-GEV (dashed line).

What have we learned?

- Taking the dependence between durations into account when estimating IDF curves **improves** the performance of the estimation for short durations.
- We are now looking into how different levels of dependence could also affect the performance.

References

[1] Koutsoyiannis, D., Kozonis, D., & Manetas, A. (1998). A mathematical framework for studying rainfall intensity-duration-frequency relationships. Journal of Hydrology, 206, 118–135.
[2] Ribatet, M. (2013). Spatial extremes: Max-stable processes at work. Journal de La Société Française de Statistique & Revue de Statistique Appliquée, 154(2), 156–177.
[3] Tyralis, H., & Langousis, A. (2019). Estimation of intensity–duration–frequency curves using max-stable processes. Stochastic Environmental Research and Risk Assessment, 33(1), 239–252.
[4] Bentzien, S., & Friederichs, P. (2014). Decomposition and graphical portrayal of the quantile score. Quarterly Journal of the Royal Meteorological Society, 140(683), 1924–1934. https://doi.org/10.1002/qj.2284

Acknowledgements

We would like to thank the Wupperverband for providing the precipitation time series.
The first author thanks both the Mexican Science Council for Science and Technology (CONACyT) and the German Academic Exchange Service (DAAD) for their financial support.

Curious about the d-GEV and how to extend it to include spatial information?
Check out our other EGU display! [Session HS7.2]
https://doi.org/10.5194/egusphere-egu2020-18724

Appendix

IDF curves

IDF curves model a relationship between **intensities** of extreme rainfall events and their **frequencies** (i.e. the return levels) as a function of **duration** of the event.

We focus on **two** ways to estimate this relationship: The d-GEV model and the max-stable process. We are interested in the different way they handle the **dependence** between events of different duration. For example, the 1 and 2 hour events are likely to be highly dependent, but the 1 and 72 hour events should be independent.

Duration-dependent GEV model (d-GEV)

d-GEV conceives the GEV as a function of duration. Maxima from several durations are used simultaneously to estimate the parameters of the distribution.

It considers the maxima of different durations to be *asymptotically independent* from each other.

For comparison fairness, we used a reduced model of the d-GEV, where the theta parameter was set to zero.

Max-stable process

Max-stable processes are an extension to infinite dimensions of finite-dimensional extreme value theory models. They are commonly used to model extreme events in settings with many dimensions, such as spatial extremes.

For IDF relations, they explicitly model the dependence between maxima of different durations.