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Modeling seasonal variations of extreme rainfall on different timescales in Germany

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Supplement

S1: Model diagnosis for station Bever-Talsperre

The distribution of monthly maxima for a range of durations is modeled using the d-GEV distribution. We visually inspect, whether the d-GEV distribution is a reasonable approximation for the distribution of monthly maxima at the considered stations using quantile-quantile (q-q) plots. As an example, we present the q-q plots for the station Bever-Talsperre with respect to each month in Fig. S1. The different aggregation times are indicated by different colors. We find that the d-GEV distribution describes the monthly maxima sufficiently well for each month. There are few outliers that correspond to the limits of the duration range, i.e. very short or very long durations.

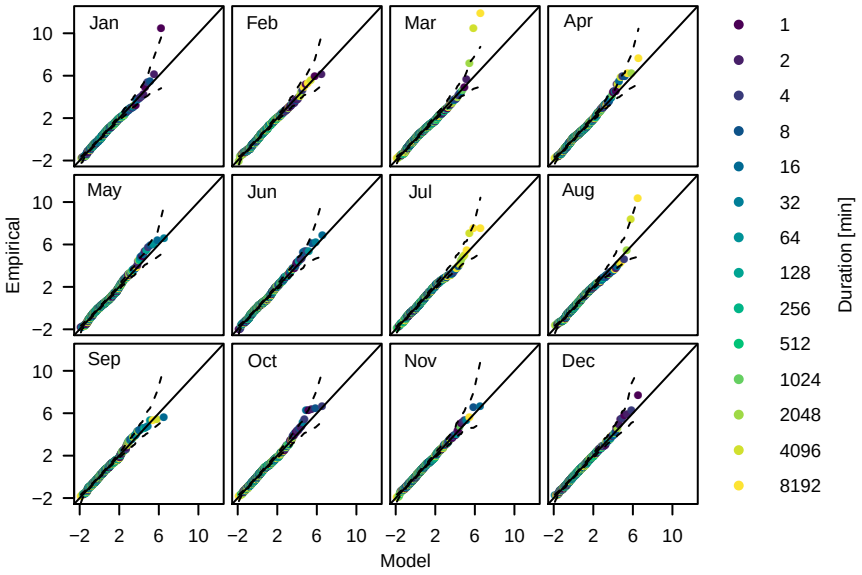

Figure S1: Diagnostic q-q plots of the d-GEV model for each month at station Bever-Talsperre. The observations and the modeled quantiles are transformed to standard Gumbel $G(\mu = 0, \sigma = 1, \xi = 0)$ to remove the duration dependency. Dashed lines represent 95% confidence intervals.

S2: Annual maxima station Bever-Talsperre

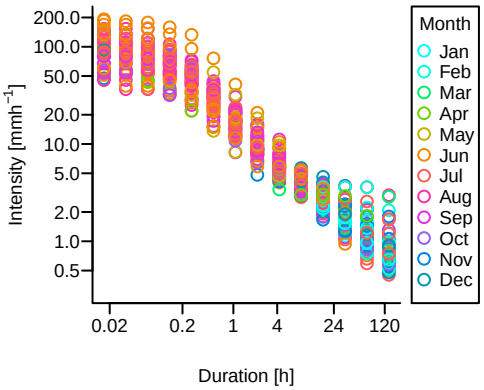

Figure S2: Annual intensity maxima for different durations at station Bever-Talsperre. The months in which the respective maxima occurred are represented by colors.

The annual maxima of different durations for the station Bever-Talsperre are presented in Fig. S2. The colors indicate the month in which the respective maxima occurred. It is evident that at this station the maxima of short durations occur mostly in summer, while from $d \gtrsim 8\,\mathrm{h}$ the maxima originate from different seasons, especially autumn and winter. This is in agreement with the results presented in Fig. 4 (top left). In addition, we find that the span of the data exhibits a minimum at $d \approx 8\,\mathrm{h}$. This is consistent with the minimum value of the shape parameter ξ at this duration observed in Fig. 7 (c).

S3: Phase difference in seasonal variations of location and scale parameter

From the parameter estimates of $\tilde{\mu}$ in Fig. 2, it can not be clearly determined whether modeling variations of $\tilde{\mu}$ throughout the year is a reasonable choice. Since the modified location parameter is defined as $\tilde{\mu} = \mu(d)/\sigma(d)$, setting $\tilde{\mu}(\mathrm{doy}) = \mathrm{const.}$ would result in not allowing a phase difference in the annual cycle of the location parameter μ and the scale parameter σ for any fixed duration d. Maraun et al. (2009) investigated this relationship for daily precipitation sums in the UK and found that this assumption is not justified, because the annual cycles of these two parameters are slightly out of phase. We investigate this in an exploratory analysis by modeling the individual durations. For this purpose, we model the monthly maxima of each duration separately using a GEV distribution with monthly covariates. Fig. S3 shows the resultig parameter estimates μ and σ for some durations at station Bever-Talsperre in the first two columns as lines. For comparison, the estimates resulting from separately modeling the maxima of each duration and month with a GEV distribution are shown as dots. The right column presents the resulting estimates for μ/σ for each duration. Since μ/σ shows a clear variation for each duration, we conclude that assuming no phase shift in the annual cycle of μ and σ for each duration may restrict the model too much.

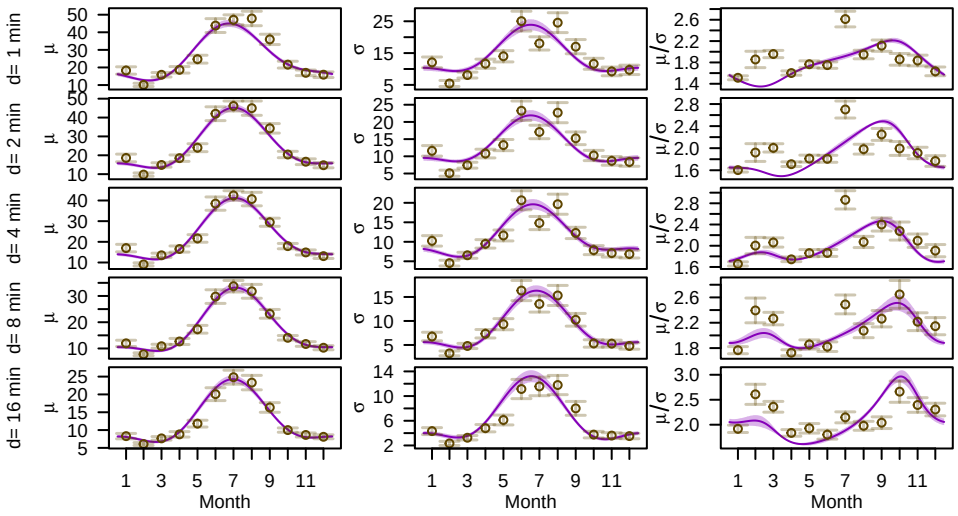

Figure S3: Parameter estimates for fixed durations modeling monthly maxima using (1) a GEV with monthly covariates (purple lines) and (2) a separate GEV model for each month (dots). The error bars and shaded areas show the 95% confidence intervals obtained via the estimated Fisher information matrix.