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New approaches to extremes: Multivariate line-mesh distributions and transformed annual maxima

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Two alternative approaches to exceedance estimation are considered, for the respective cases of univariate and multivariate hydrological data. For the univariate case, the point is made that situations may arise when asymptotic extreme value theory is inapplicable, even though good data fits are achieved. For example, if a distribution of independent rainfall magnitudes is approximated by a heavy-tailed Weibull distribution, then the annual rainfall maxima give the illusion of a Type 2 extreme value distribution. However, the true (unachievable) asymptotic distribution of annual maxima is the Type 1 (Gumbel) distribution. Similarly, maxima from a half-normal distribution can give the illusion of EV3 distributions, when the EV1 is the true limit distribution. The alternative approach uses implicit transformation of the sampled distributions, possibly yielding faster convergence to the true limit extreme value distributions.
For multivariate extremes, we introduce a “line-mesh distribution” as a set of lines in N-space, with a univariate distribution defined along each line. Joint exceedance probabilities are obtained by integrating the univariate distributions within the exceedance region concerned. Line-mesh distributions are simpler to apply than copulas and can be paramaterised to preserve the Pearson correlation coefficients and marginal means and variances, relative to the original multivariate data.