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Fitting and testing the significance of linear trends in Gumbel-distributed data

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Abstract. The widely-used hydrological procedures for calculating events with *T*-year return periods from data that follow a Gumbel distribution assume that the data sequence from which the Gumbel distribution is fitted remains stationary in time. If non-stationarity is suspected, whether as a consequence of changes in land-use practices or climate, it is common practice to test the significance of trend by either of two methods: linear regression, which assumes that data in the record have a Normal distribution with mean value that possibly varies with time; or a non-parametric test such as that of Mann-Kendall, which makes no assumption about the distribution of the data. Thus, the hypothesis that the data are Gumbel-distributed is temporarily abandoned while testing for trend, but is re-adopted if the trend proves to be not significant, when events with *T*-year return periods are then calculated. This is illogical. The paper describes an alternative model in which the Gumbel distribution has a (possibly) time-variant mean, the time-trend in mean value being determined, for the present purpose, by a single parameter β estimated by Maximum Likelihood (ML). The large-sample variance of the ML estimate $\hat{\beta}_{MR}$ is compared with the variance of the trend β_{LR} calculated by linear regression; the latter is found to be 64% greater. Simulated samples from a standard Gumbel distribution were given superimposed linear trends of different magnitudes, and the power of each of three trend-testing procedures (Maximum Likelihood, Linear Regression, and the non-parametric Mann-Kendall test) were compared. The ML test was always more powerful than either the Linear Regression or Mann-Kendall test, whatever the (positive) value of the trend β; the power of the MK test was always least, for all values of β.

Keywords: Extreme value probability distribution, Gumbel distribution, statistical stationarity, trend-testing procedures

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