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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  $\beta$  estimated by Maximum Likelihood (ML). The large-sample variance of the ML estimate  $\hat{\beta}_{MR}$  is compared with the variance of the trend  $\beta_{LR}$  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  $\beta$ ; the power of the MK test was always least, for all values of  $\beta$ .

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

[Final Revised Paper](#) (PDF, 608 KB)

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