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Logarithmic transformation and peak-discharge power-law analysis

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Peak-discharge and drainage area power-law relation Q=αA$\hat{\theta}$ has been widely used in regional flood frequency analysis since the nineteenth century. The coefficients α and θ can be obtained by the notional least squares linear regression of the logarithmic form or the least squares nonlinear regression. To illustrate the deficiencies of applying log-transformation in peak-discharge power-law analyses, we studied 114 peak-discharge events observed in the Iowa River Basin, the United States from 1991 to 2017. The basin drainage areas range from 7 to 33,000 square kilometers. The results show that: (1) the estimated scaling exponents (θ) by these two methods are statistically different with a p value of 0.007; (2) for about 80% chances, the power-law relationships obtained by log-log linear regression produce larger modeling errors (mean absolute error, MAE) of peak discharge in the arithmetic scale than that predicted by nonlinear regression; and (3) logarithmic transformation result retains the order of untransformed data but alters the relative distance between adjacent data points. Also, the transformation may fail to stabilize residuals in the arithmetic domain, it assigns higher leverages to data points representing smaller peak discharges and drainage areas, and it alters the visual appearance of the scatter in the data. While log-transformation provides a simple approach to estimating peak-discharge scaling parameters, it fundamentally changes the nature of the variables of peak discharge and drainage area, creating problems in interpreting the fitted power functions. A remedial action to peak-discharge scaling analysis is avoiding log-transformation and applying nonlinear regression on the arithmetic scale for estimating the scaling parameters.