Simple scaling based local and regional estimation of intensity-duration-frequency curves : Application to the central region of northern Algeria

Abstract

Intensity-duration-frequency (IDF) curves are one of the most common rainfall statistical models used in hydrologic design and risk analysis projects. The uncertainties related to the elaboration of these IDF curves have nevertheless seldom been evaluated in the past. These uncertainties may be large, especially in the regions of the world where reliable recorded pluviographic series are still limited in number and often short. An appropriate selection of the IDF formulation as well as of the statistical inference methods may reduce significantly these uncertainties as will be illustrated herein. This work will recall the existing link between the IDF formulation and some properties of the rainfall series that are often observed such as simple scaling and multifractal structure. A simple formulation for the IDF curves can be derived if these properties are assumed to be valid: the IDF formulation is then the product of a dimensionless probability distribution function for the annual maximum rainfall intensities/depths and a duration-dependent scaling factor. Its parameters can be evaluated in an integrated way (i.e. based on a unique pooled sample of rainfall annual maximum depths/intensities over a range of durations: from 15 minutes to 24 hours). The use of likelihood-based Bayesian Markov Chain Monte-Carlo (MCMC) statistical inference methods for this evaluation provides consistent uncertainties for all the parameters of the IDF relation and for the corresponding rainfall quantiles. This methodology has been tested on a large dataset of 48 rain-gauge records, spread over the North Central part of Algeria (25000 km^2), under various climatic regimes. The integrated approach is undoubtedly consistent with estimates from annual maximum rainfall fitted to single durations. Furthermore, credibility intervals are significantly reduced. Also, this integrated approach appears to be robust: unlike the traditional method based single durations, it generally provides reasonable quantile estimates, even when short observed series (10 years) are available. This is a significant advantage for engineering applications. In a second step, the robust integrated Bayesian estimation of IDF curves proposed herein is extended to regional extreme rainfall return level estimation. This latter approach combines local and regional merging and analysis methods for rainfall annual maximum series. Then, the impact of the proposed procedure on the uncertainties of spatially interpolated rainfall quantiles based on kriging is evaluated. Upper bounds of the 70% credibility intervals for various rain-rate quantiles are mapped, merging local estimation and spatial interpolation uncertainties. Due to lower point rainfall estimation uncertainties and higher spatial consistency of the estimated values, the proposed approach appears to significantly outperform the traditional approach also if implemented to provide estimates at ungauged sites.