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Investigation of extreme flows in Cyprus: empirical formulas and regionalization approaches for peak flow estimation

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The island of Cyprus has a typical Mediterranean, semi-arid climate, characterized, among others, by relatively short yet intense storm events causing flash floods. Current practices for the design of flood-protection works as well as flood risk assessment are based on regional approaches, which require a number of parameters that derive from the river basin characteristics. The main target of this work is to evaluate the existing empirical formulas for estimating those watershed parameters, emphasizing on the runoff coefficient and the time of concentration, which are typical inputs for most of the aforementioned tools, such as the rational and the unit hydrograph methods. For this purpose, we analyzed a large amount of hydrological and geographical data, provided by the Water Development Department and the Meteorological Service of Cyprus. This includes annual discharge maxima at 130 flow gauges and the corresponding rainfall data, intensity-duration-frequency (ombrian) curves for different regions of the island, and geographical information for 70 river basins (DEM, hydrographic network, land uses, geology and permeability). A preliminary statistical analysis of annual maxima data indicated that the empirical distribution functions of the flood discharges are much sharper than those of the corresponding rainfall depths, which denotes strongly nonlinearity of the rainfall-runoff mechanisms. In addition, we found that the existing peak runoff estimation methods fail to reproduce this kind of nonlinearity, thus leading to severe underestimation of flood risk. To handle this inconsistency it was necessary to revise the erroneous hypothesis that both the runoff coefficient and the time of concentration are constant properties of the basin. In reality, they depend not only to the constant geomorphological characteristics of the basin but also to the rainfall-runoff event itself. However, an analytical estimation of their actual values is impossible, since they are related to complex hydrological and hydraulic processes. For this reason, we examine the simple yet realistic assumption that the two variables are functions not to the event magnitude but to its return period. Using appropriate historical data, we attempt to establish improved empirical relationships for Cyprus, by fitting the simulated peak flow values to the observed ones.