An analytical approach to obtain the cumulative distribution function for maximum discharges and total volumes in Urban Watersheds

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Abstract One of the most common ways to model and characterize watershed response is through a hydrologic analysis based on existing records of discharge and volume. Typically a statistical analysis of these data can be performed to develop a model. Unfortunately, this approach is not useful in most urban watersheds. Not only the lack of information is important, especially in locations where urban hydrology is a recent research topic, but also the data collection is very difficult and watershed characteristics change continuously, altering the statistical model as well. Therefore these models are neither feasible nor useful tools.

On the other hand, rainfall-runoff models have been proven to be a very good tool for predicting hydrologic response in cases where there is a lack of hydrologic data. These models allow the user to represent a watershed through a series of different parameters and simulate the hydrologic processes taking place within a watershed, which are represented through different equations. Finally, a discharge series can be obtained by solving these equations numerically using these parameters and continuous records of precipitation. Continuous simulation helps illustrate the strong relationship between the return period for the discharges and for the rain events.

One of the problems related to these numerical models is the difficulty in understanding the relative weight that different physical variables have in influencing the hydrologic behavior of the system. Considering this, it would be more useful to have an analytic model to estimate the probability distribution for the most important hydrologic variables, such as the storm's characteristics, the maximum discharges and the final volumes.

Guo and Adams (1998a, b) presented a methodology to estimate the cumulative distribution function for maximum discharges and total volumes of urban floods based on the rainfall-runoff transformation and the rainfall volume and duration, modeled as independent variables exponentially distributed. This approach may fail at estimating these distributions since in some locations the dependence between the rainfall magnitude and its duration is important, being typically related short durations to small magnitudes, therefore this approach. In this work a new analytical model -originally developed for Santiago, Chile- based on a different characterization of the storms is presented. In order to represent the dependence between rain volume and duration, the average intensity and duration are modeled as independent variables exponentially distributed. The present methodology includes the theoretical probability distributions for the storm events magnitude, the mathematical functions used in the developing of the analytical model, and the probability distribution for runoff volumes and peak discharges, which are developed by means of probability distribution theory. Good results are obtained in comparison with those from continuous SWMM simulations, and actually it is interesting to analyze the performance of this methodology for cases where rainfall volumes and durations are not statistically dependent. Modifications of the typical watershed parameters and the respective effects and results using the model proposed by Guo and Adams, are also presented.