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Scale-Invariant Hyetograph Model for Urban Drainage Design

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Hyetographs are essential to many hydrological designs. Many studies have shown that hyetographs are specific to storm types and durations. Recent work presented evidence that dimensionless hyetographs are scale invariant. We show that the simple scaling property of rainfall guarantees that the normalized rainfall rates of different storm durations are identically distributed and propose a nonstationary Gauss-Markov model based on the annual maximum events that arise from the dominant storm type. The proposed model allows translating hyetographs between storms of different durations. We also compare and evaluate four hyetograph models (the alternating block model, the average rank model, the triangular hyetograph model, and the scale-invariant Gauss-Markov model), with regards to peak rainfalls and peak flows, using annual maximum storms. In general, the scale-invariant Gauss-Markov model is most favorable for the study area. The alternating block and the average rank models are almost equally competitive in terms of peak rainfall estimation; however, the alternating block model performs slightly better in peak runoff estimation. The triangular hyetograph is not a good approximation for hyetographs of long-duration cyclonic storms, and underestimates the peak rainfall intensity in almost all events. We also propose a method for regionalization of design hyetographs. By combining the K-means cluster analysis technique and an indicator-variable-based probabilistic algorithm, we demonstrated that a map of regionalized hyetographs could be developed and used to determine the design hyetograph of any ungauged site in the study area.