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Effect of Rainfall Regime on Catchment Runoff Response in Tropical Urban Environments

Vladan Babovic and Ali Meshgi
National University of Singapore, Civil and Environmental Engineering, Singapore, Singapore (vladan@nus.edu.sg)

Increasing global urbanization has severely altered the hydrological cycle, resulting reduction of pervious areas, groundwater infiltration and the lateral sub-surface component during rainfall events, increasing peak discharges in urban drainage infrastructure. On the other hand, behaviour of rainfall-runoff processes in urban systems is highly non-linear and spatially heterogeneous. This call for a better understanding of rainfall-runoff processes in urbanized areas. Unfortunately, knowledge about rainfall-runoff processes in tropical urban environments is still limited. This study proposed genetic programming to establish a physically interpretable modular model consisting of two sub-models to simulate the hydrograph flow components (i.e. baseflow and direct runoff) for a tropical urban catchment in Singapore. Rainfall events were divided into clusters and sub-clusters based on rainfall regimes (i.e. total precipitation in the event, maximum 30-min intensity and duration) and antecedent catchment conditions using a hierarchical technique. Average runoff coefficients of each cluster/sub-cluster were then estimated from runoff module of the modular model to estimate the effect of various rainfall regimes on catchment runoff response in tropical urban systems. The results suggested that either a very large rainfall event (e.g. 10 year ARI) or a small rainfall event may cause runoff generation processes to be significantly different among different land-uses types. The results also showed rainfall regimes had the largest effect on the runoff coefficient of bush areas compared to other land use types. In addition, the runoff coefficients of all the land uses increased gradually from sub-cluster-1 (relatively un-saturated condition) to sub-cluster-3 (relatively saturated condition). The outcomes of this study can yield better insights in the rainfall-runoff processes and helps for better understanding of runoff generation mechanism in tropical urban environments.