Representation of Urbanized Terrain and Its Use in a Morpho-Climatic Instantaneous Unit Hydrograph

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Abstract. Urbanization can modify landscapes in a variety of ways that significantly affect their hydrologic behavior. Imperviousness can increase runoff production, and the addition of pipes, streets, and artificial channels can modify the accumulation of flow. In many storm-water models, large pipes and channels are simulated with sophisticated hydraulic methods, but the subcatchments that feed these elements are modeled with hydrologic methods that neglect the presence of smaller pipes, streets, and artificial channels. In particular, the subcatchment characteristics that are embedded in these hydrologic methods are often derived from digital elevation models (DEMs) that do not resolve such features. In this research, a model called the U-McIUH (Urban Morpho-climatic Instantaneous Unit Hydrograph) is developed, which considers the IUH as the probability density function of the travel time from a random location in the urban terrain to the subcatchment outlet. Flow paths are extracted from a specially processed DEM that incorporates streets, pipes, and channels by reducing the elevation of the surface to match the known elevations of these elements. Each grid cell is then classified as a hillslope, street, pipe, or channel, and travel times are computed using kinematic wave theory. The travel time expressions depend on the upstream contribution of flow and the excess rainfall intensity, which implies that the basin response depends nonlinearly on the excess rainfall intensity (in contrast to typical unit hydrograph methods). Each rainfall pulse is convoluted with its respective IUH and the results are superimposed to generate the response to a given storm event. The application of the model to real catchments shows that the U-McIUH provides relatively good reproductions of observed hydrographs. The results also suggest that the inclusion of artificial elements and the nonlinear dependence on excess rainfall intensity both play major roles in determining the hydrologic response of urban watersheds.

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