APPLICATION OF SURFACE RUNOFF MODELS TO THE PROBLEM OF QUANTIFYING HYDROLOGIC INFLUENCE OF WATERSHED CHARACTERISTICS

by

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ABSTRACT

A necessary part of hydrologic simulation is the assessment of the relation between physiographic features and simulation results. How are the physiographic features incorporated into mathematical models relating rainfall and runoff? If these features are distorted in simplifications necessary in model formulation, what are the hydrologic consequences? These questions are addressed by examining three specific rainfall-runoff models: a lumped linear model, a lumped nonlinear model, and a distributed nonlinear model.

The three models considered lead to different relationships between watershed characteristics and model parameters. One of the most common techniques is to relate geomorphic parameters of the drainage basins under consideration to model parameters, usually by least-squares fitting. A second technique is to formulate the model so its characteristics correspond to characteristics of the watershed determined from topographic maps. The advantages of the second method are obvious, yet of necessity, most simulation studies involve a combination of the two procedures.

The linear Nash model (Nash, 1957) is a lumped model with parameters N and K related to watershed characteristics by least squares. The CONV model (Singh, 1974) is a lumped nonlinear model with two geometric parameters estimated from topographic data and a roughness-slope parameter related to watershed characteristics by least squares. The distributed nonlinear model (Kibler and Woolhiser, 1970) generally called a kinematic cascade model, has watershed geometry represented by a series of planes and channels with water cascading over planes to a channel and with the possibility of channels combining to form a higher order channel. Roughness parameters for this nonlinear-distributed model are estimated either from tabular data based on experiments or via optimization. Least squares relations between roughness parameters and watershed characteristics are yet to be developed for this model. However, there are geometric goodness-of-fit statistics indicating how well the model preserves watershed geometry (Lane, 1975). Therefore, the price for more geometric correspondence between watershed and model is an increase both in the number of parameters and in the amount of topographic data required.

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Results of the analyses of data from a variety of small watersheds support the hypothesis that the models incorporating more watershed characteristics are relatively more powerful in assessing the influences of watershed characteristics and management changes on runoff simulation and that these models permit more systematic parameter estimation techniques.

While the three specific models considered cannot represent all models, they do in fact represent a range of techniques and results sufficient to suggest appropriate experimental design procedures for simulating surface runoff. The experimental design can be planned to correspond to the general model features: lumped-distributed, linear-nonlinear, and degree of model-watershed correspondence with respect to physiographic features. Certainly no specific model can be said to be better under all conditions yet different models suggest different experimental design criteria. Conversely, given an experimental design, insights gained from this study make it possible to more confidently choose from available models.

REFERENCES CITED


KEYWORDS: Hydrology; Runoff; Mathematical Models; Unsteady Flow; Kinematic Wave Theory; Basin Characteristics.