Rainfall-runoff simulations by using a distributed instantaneous unit hydrograph derived from DEMs

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1. Introduction

Unit hydrograph theory has been applied in estimating the relationship between rainfall and runoff for many years. However, manipulating the unit hydrograph to estimate the outflow hydrograph of the specific basin needs lots of hydrologic record to calibrate the model. Thus, for ungauged area and those basin where the hydrologic environment has been changed by human activity or urbanization, it is inadequate to adopt the model.

In this study, by combining DEM and Kinematic Wave routing method, discharge of the surface runoff of specific location inside the basin within given rainfall intensity has been calculated, and water depth and velocity also has been derived. By adopting the concept of IUH and through describing the runoff mechanism, the traveling time of water movement from any specific location of the basin to the outlet is examined; consequently, a distributed instantaneous unit hydrograph of the basin is derived.

2. Methodology

(1) Usage of DEM

By dividing the basin into several isochrones, the time-area histogram which denotes the relationship between travel time and area could be derived. Here, DEM is used efficiently to extract the geomorphic factor. By comparing the elevation of the central grid to its eight adjacent cells, the flow direction of the central grid could be determined. According to the flow direction, the flow path from the specific grid to the outlet of the basin and the drainage area (which indicates the number of cells which drains into this cell) f the grid could be retrieved; the distance of each grid inside the basin to the outlet is calculated according to the length of the flow path.

(2) Extraction of instantaneous unit hydrograph

The discharge of a specific cell could be expressed by its drainage area with given rainfall intensity, duration through kinematic wave equation. For a given rainfall intensity i_e, the equilibrium flow discharge Q_0 is equal to i_eA, where A is drainage area. With specified rainfall intensity to the grid, by retrieving the water depth of the grid, traveling time of the grid is solved by dividing distance by water movement velocity, and IUH capturing the effect of rainfall intensity is established, as shown in Fig. 1.

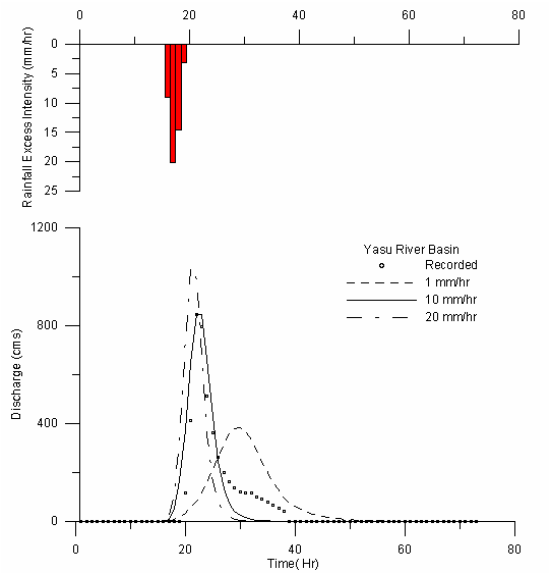

Fig. 1 Simulation result by using IUH derived from different rainfall intensity.

3. Conclusions

The land use, land cover and rainfall intensity are the most important features which control the rainfall-runoff mechanism. The method could reflect the topographic feature and rainfall intensity by combining hydrology and hydraulics. Comparing to traditional geomorphic hydrologic model, distributed IUH was acquired by the DEM; there is no need to acquire the geomorphic factors. Topographic feature and rainfall characteristic also reflect well in the model, which implies that the model is suitable for real time flood forecasting purpose or rainfall-runoff simulation over ungauged area.