TIME-VARYING IUH DERIVED USING TEMPORAL RAINFALL INTENSITY

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The nature of streamflow in a region is related to the rainfall characteristics and watershed geomorphology. The rainfall characteristics are the time and spatial distribution of the rainfall quantity. The geomorphic characteristics are the channel network and surrounding landscape which translate the rainfall input into an output hydrograph at the outlet of the watershed. Time-varying instantaneous unit hydrograph (IUH) has been shown promising to be applied for rainfall-runoff simulations. The geomorphologic IUH (GIUH) proposed by Rodriguez-Iturbe and Valdes (1979) is one of the physical based models that can produce the time-varying IUH.

Instead of adopting an empirical equation for travel time estimation in the GIUH model, Lee and Yen (1997) estimated the time of concentration based on kinematic-wave approximation to obtain a kinematic wave based GIUH model (KW-GIUH); therefore, the resultant IUH has been explicitly shown as a function of the rainfall intensity. In performing the KW-GIUH model, temporal rainfall intensity was used to generate the time-varying IUH, and then the rainfall depth multiplied the IUH to obtain a component hydrograph for later superposition. Recently, we found that although the KW-GIUH model usually obtained good simulation results in most storm events, it nevertheless resulted in overestimated peak discharge especially for concentrated rainstorm cases.

From hydraulic viewpoints, the surface flow observed at the outlet of a watershed at time t should result from the rainfall excess occurred not only at time t but also before time t in a short period. It is because a short period is required to transport the rainfall excess to the watershed outlet. In this study, the watershed time of concentration, T_c, was recognized as the short period required for the rainfall excess to be transported to the watershed outlet. The quantity of the temporal rainfall intensity used as an input to generate the time-varying IUH at time t is the averaged value of the rainfall intensity between time t and t-T_c, which can be expressed as.

$$\overline{i_e}(t) = \frac{1}{n}\left[i_e(t) + (t - \Delta t) + (t - 2\Delta t)\Lambda \ + (t - n\Delta t)\right] \tag{1}$$

where $\overline{i_e}(t)$ is the averaged rainfall intensity between t and t-T_c; Δt is the time interval of the measured rainfall record, and $n = T_c/\Delta t$. Schematic description of Eq. 1 can be shown in Fig. 1.

Hydrologic records from two example watersheds were used to compare the results generated by using the original and revised method for hydrograph simulations. As shown in Fig. 2(a), if the original method is applied in WT watershed, the maximum rainfall temporally resulted in IUH with very high peak discharges and consequently overestimated runoff peaks. Nevertheless, if we adopt the revised method, the high intensity rainfall is replaced by adopting the averaged rainfall in a period of the time of concentration. The simulated hydrographs are then close to the measured ones even for the concentrated rainstorms shown in Fig. 2(a). It can, of course, be expected that the reducing of the simulated hydrograph peak can be completed by adjusting the roughness coefficient value. As shown in Fig. 2(b), while the value of the overland roughness coefficient increases from 4.0 to 10.0 in WT watershed, we can obtain good simulation results even for the concentrated rainstorms. The results show that the revised method can produce a lower IUH in concentrated rainstorm cases, and then the condition for the overestimated in peak discharge is then relaxed.

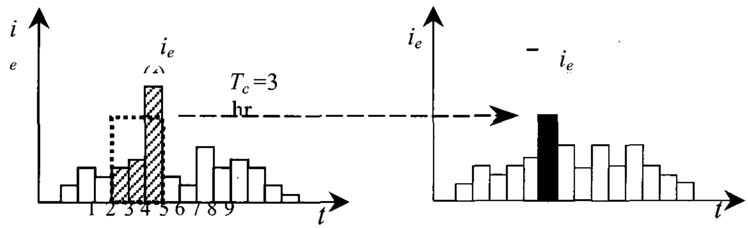

Fig. 1 Rainfall intensity input in the revised KW-GIUH model

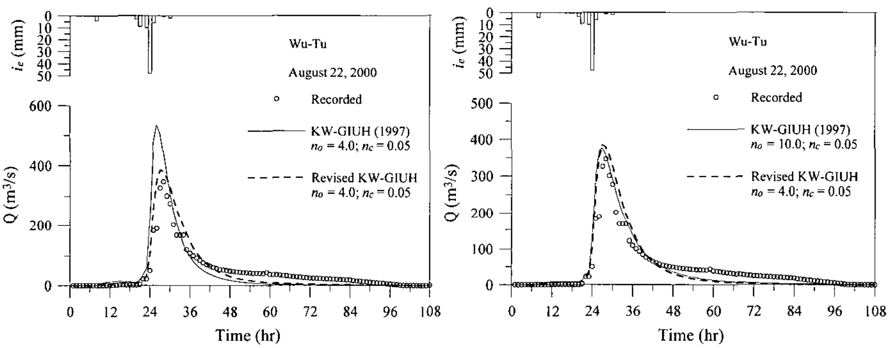

Fig. 2 Hydrograph simulations in Wu-Tu (WT) Watershed

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