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Estimation of Flood Hydrographs in Ungauged Qareh-Sou Watershed with Gamma Synthetic Unit Hydrograph Model

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1-Introduction

As one of the most common natural disasters, floods have affected communities worldwide. Hydrological and hydraulic investigation to estimate the maximum volume and flow rate of floodwater is one of the most important problems in the water structures design (Adib et al., 2010). Due to the lack of sufficient information to measure rainfall and runoff and the shortage of measuring stations in developing countries, synthetic unit hydrograph models to estimate the characteristics of river floods in basins without statistics are of interest to researchers. Based on the rapid development of computing technologies in the past few decades and the increasing need for flood forecasting in this field, various models have been proposed in flood estimation. Meanwhile, the Gamma model is more accurate than other models and has been less used and evaluated. This is especially noticeable in small basins. Due to the high cost of setting up measuring stations and their maintenance, these basins face the problem of lack of information and flood data. Many investigations have been performed in flood estimation using unit hydrograph models and synthetic unit hydrographs (Adib et al., 2011). A unit hydrograph model was developed to calculate the flood hydrograph resulting from the Effective Rainfall Hyetograph (ERH) of the watershed, widely used in applied hydrology (Eidipour et al., 2016). Based on the studies and the need for the country to use simple and appropriate hydrological models for flood prediction, it is necessary to independently select and apply the method of losses and base flow extraction and study its simultaneous effect on the shape of the flood hydrograph; the peak flows, the flood volume, the time to reach the peak flows, the flood flow, of flood and the time of the beginning of the flood and its end (Vartalska et al., 2002). A comparative study of these methods can lead to a preliminary result that has not yet been considered in the country. Therefore, considering the importance of the issue in this field, this study aims to introduce the Gamma synthetic unit and evaluate this model accuracy in estimating flood hydrographs in a basin without statistics in the west of the country.

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2-Materials and methods

2-1 Estimation of base flow and excess rainfall

2-1-1- Straight line method

The straight line is the simplest method for extracting base flow (Chow, 1988). Here, in a river hydrograph, a straight line is drawn from the flood starting point to the point where the flood ends. The part of the hydrograph above this line is called the direct runoff hydrograph. Fig. 2 shows a schematic of the used method.

2-1-2-Ø Method

The index of Ø was used to determine the excess rainfall height in this study. In this method, the direct runoff height is defined as RD. The following Equation was used to estimate Ø (Chow, 1988). By selecting a time interval of ΔT, estimating the number of M intervals of rainfall that joins the direct runoff, and subtracting the term of ØΔT from the measured rainfall at each interval time, the direct runoff was obtained.

In this equation:

$RD = \sum(RM - \O\Delta T)$ RM: Largest precipitation pulse (mm), RD: Direct runoff (mm) , Ø: Fi index (mm/h), M: number of pulses in excess precipitation

2-2-Gamma Method

Calculating the Gamma synthetic unit hydrograph is easier and more accurate than other available methods. This model represents the empirical relationships to estimate the overall form required for the IUH by providing an accurate approximation.

2-2-1-Gamma distribution

The shapes of hydrographs often match closely with a two-parameter Gamma function, given by the following Equation $F(x) = \frac{x^{\alpha} e^{-\frac{x}{\beta}}}{\beta^{\alpha+1}\Gamma(\alpha+1)}$

Where 0<x<∞ .The parameter α is a dimensionless shape factor (which must be greater than -1), and β is a positive scale factor having the same units as x controlling the base length in the products of α and β which in turn gives the value x, corresponding with the apex or maximum value of f(x). For α>1, the distribution has a single apex and several plots similar in shape of hydrograph (Croley, 1980). By determining α and β, the hydrograph peak value can be obtained from Equation.

3-Results and Discussion

According to the error criterion in estimating the peak flow, the Gamma synthetic unit hydrograph model has led to underestimating peak flows of the flood hydrograph in some events and overestimating peak flows of the flood hydrograph in other events so that both are relatively equal. According to the numbers provided for this criterion (as shown in Table 2), the error value in this field is quite limited. Evaluation of the criterion of error in estimating flood volume also shows that the behavior of the Gamma synthetic unit hydrograph model in overestimating and underestimating flood volume in the studied events is relatively balanced. However, it should be noted that the values provided for this criterion in modeling the basins without statistics are completely acceptable. According to the mean absolute error criterion, on average, there is a very limited error in estimating the values corresponding to the flood hydrograph observed by the Gamma synthetic unit hydrograph model in the studied events in this study. The mean bias error also shows that in five of the ten studied events, the observed hydrograph flows values are slightly higher than the corresponding computational values and slightly lower in the other five events. It shows the balanced behavior of the Gamma synthetic unit hydrograph model in this study. Kling-Gupta criteria and coefficient of explanation show the flood accuracy. These criteria in different events show the complete and appropriate accuracy of the Gamma synthetic unit hydrograph model for estimating flood hydrograph in the studied events in the Qareh-sou watershed.

4-Conclusions

The Gamma model has a high potential for estimating flood runoff in basins without statistics as a widely used model. With attention to the previous studies, there is only one method in most research to estimate the excess rainfall or the extraction of the base flow, and significant attention has not been paid to this method. The developed models feature for basins without statistics is that it can be used to estimate flood hydrograph using limited data and without considering the simultaneously recorded rainfall-runoff data. In the present study, flood modeling in the Qareh-sou watershed in Kermanshah province was investigated, and ten rainfall-runoff events were used to evaluate this model efficiency. Criteria such as peak flow error, flow volume error, mean absolute error value, mean bias error, explanation coefficient, and Kling-Gupta efficiency were used in this study to evaluate the simulation results.

Keywords: Gamma Model, Simulation, Flood Estimation, Qareh-Sou Watershed

5-References

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