Determination of the Peak Runoff in a Small River Basin.

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1. Introduction

In the design of water conveyance and storage systems, one of the main factors that determines the capacity is the expected probable maximum flow that the system may have to contain. For a given river basin, any rainstorm that is received within the vicinity of its catchment is expected to flow into the channel that drains it primarily as surface runoff with the rest going to waste. The expected peak flow from any likely rainfall can therefore be determined if the relationship between the two, rainfall and runoff is known. This is based on the assumption that flow is an empirical and deterministic quantity. Having a defined model will help in determining this unknown quantity, in this case peak flow, as a product of an expected rainfall.

2. Observation

In the search for a model for the determination of the peak flow, data obtained from the field was used in the investigations. This case study is from a watershed situated in the upper reaches of the Akashi River basin. The total watershed is about 1680*ha* with three points for flow measurements, two on the Akashi River and the third is on a tributary, the Komi River. Only data from observation point *A* that has a watershed area of about 365*ha* is presented here. Figure 1 is a schematic representation of the entire area showing the relative positions of the measuring points.

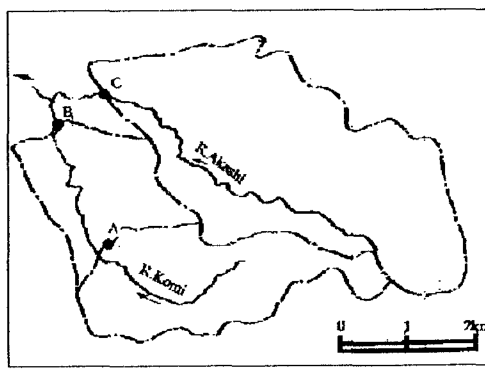


Figure 1. A schematic representation of the watershed

3. Model Description

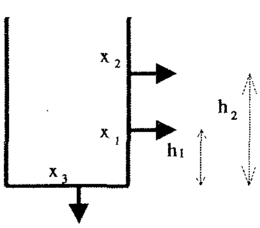


Fig. 2: The Tank Model

A Tank Model is set up as shown in Figure 2 to represent the rainfall-runoff system that is assumed to exist in this situation with h_1 and h_2 fixed at 5*mm* and 10*mm* respectively and the upper limits for the parameters x_1, x_2 and x_3 were set at 0.25. The set of parameters (x_1, x_2, x_3) that optimally describes the model is chosen for further investigations.

The Constrained Simplex, which is used in optimizing the flow, has twenty vertices. For each of selected events, a convergence limit of 0.01 was used for the mean square error of the objective function at the vertices.

The initial round of computations yielded a value of 0.027 for x_1. With this fixed value the computations were carried out again to determine values for the other two, x_2 and x_3, and to examine the behaviour of x_2 in relation to other quantities like objective function of the model, and the normalized centroid and skewness of the rainfall.

4. Analysis

The objective function *F*, is a measure of the error between the observed flow Q_o and the computed Q_c defined as $|Q_o - Q_c|/Q_o$. The normalized centroid, C, which is a measure of the mid-point of the rainfall distribution, is defined as $\left(\sum R_i \times M_i\right)/\left(T \times \sum R_i\right)$. Here, R_i is the hourly rainfall and M_i the moment arm - which is the time interval between each point in time and the point when cumulative rainfall first exceed the initial loss value of 5*mm*. T is the time interval between the initial excess rain and peak runoff.

5. Results

Figures 3a and 3b respectively show the combined hyetographs and hydrographs (both observed and computed) for two extreme cases - i) 90-09-19 and ii) 95-05-11, a good fitting and an unsatisfactory fitting. Table I shows values obtained for parameters x_2 and x_3, F, C and S (skewness). The relationships between these latter four terms and the parameter x_2 are shown in figures 4a, 4b, 4b and 4d.

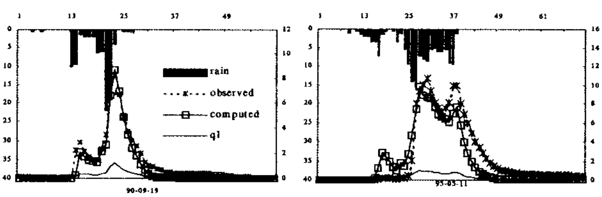
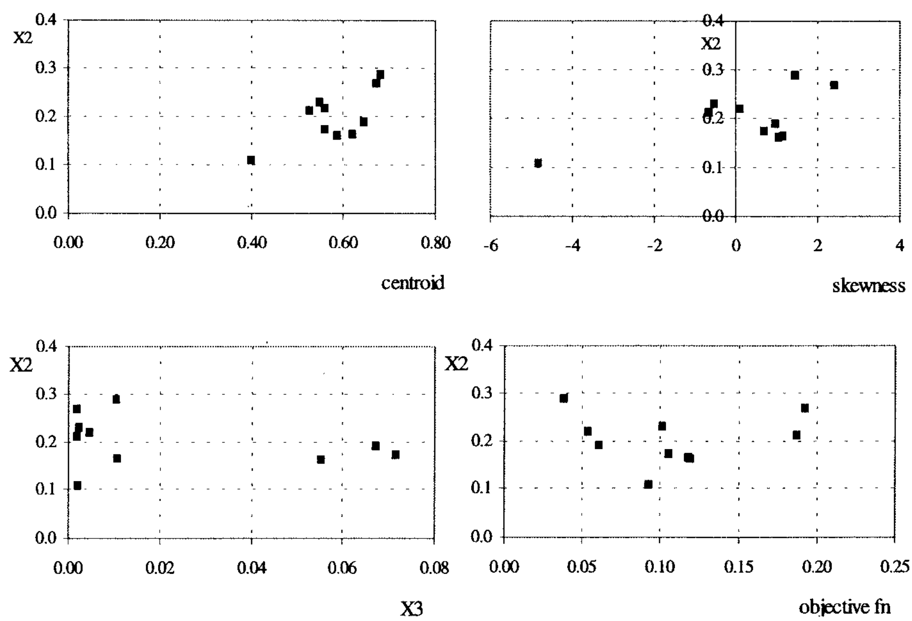


Figure 3a & b: Hyetographs, combined and computed hydrographs for 90-09-19 and 95-05-11

Table 1 . Values of F, S, C, x_3, and x_2

	centroid	skewness	X3	F	X2
09/02/89	0.6212	1.133	0.0106	0.1180	0.1650
09/18/89	0.3987	-4.8411	0.0020	0.0925	0.1090
09/19/90	0.6445	0.9514	0.0672	0.0608	0.1900
10/08/90	0.5257	-0.6681	0.0018	0.1870	0.2120
11/30/90	0.5871	1.0263	0.0551	0.1190	0.1620
04/07/91	0.5473	-0.5489	0.0023	0.1010	0.2300
09/29/93	0.6818	1.4247	0.0103	0.0381	0.2880
05/11/95	0.672	2.3932	0.0018	0.1920	0.2680
06/13/96	0.5597	0.6661	0.0715	0.1050	0.1740
10/14/96	0.5591	0.0852	0.0045	0.0533	0.2190



Figures 4 (a-d). x_2 against normalized centroid, objective function, skewness and x_3

6. Conclusion

Of these four variables that where compared with x_2, with the exception of x_3, the remaining three namely skewness, centroid and objective functions showed an amount of being positively related to x_2. This trend though not very distinct gives the indication that those rainfall distributions that have a higher centroid and are positively skewed have a tendency of yielding higher values of x_2. This type of rainfall pattern that is concentrated in the latter periods gives an indication of higher x_2 values and more pronounced peaks. x_3, on the other hand were of values less than 0.01 except in three instances which however do not appears to follow and direct trend. For x_3, therefore the results were inconclusive on its relationship with x_2. For the centroid and skewness their respective relationship with x_2, needs further investigation to help determine the pattern involved.