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Runoff Analysis in a Catchment Area Covered by Tropical Forests Using a Robust Multiple Regression Model

2. Analysis and application

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Abstract
Actual rainfall runoff modeling involves two kinds of procedures: identification of the optimum parameters and selection of suitable data. Although many reports described automatic procedures to obtain the optimum parameters of models, few proposed a suitable procedure of data selection. In these papers a new multiple regression model which enables to identify the optimum parameters of linear runoff and select suitable data for the modeling of linear runoff is described. The method based on the robust statistical theory is referred to as RFMD (robust fixed maximum discharge) method developed in the past decade. In this paper, this method was tested by using the original data of the Muda and Pedu dams in Malaysia. Compared to the FMD method, the RFMD method can supply similar models for long-term analysis and improved models for short-term analysis which contains irregular data.

Discipline: Irrigation, drainage and reclamation
Additional key words: robust estimation, runoff analysis, tropical forests, multiple regression analysis

Introduction

In the former paper[1)] the authors introduced the robust multiple regression method into runoff analysis in relation to the FMD method. A robust estimation method can omit the biased effect of error distribution. In this paper, the model was applied to the rainfall runoff analysis of a catchment covered by tropical forests where the data may contain some unexpected errors.

The biweight method in the M estimation method was selected for analysis in the former paper. It is homologous to the FMD method from the view point of separation of the linear runoff component. This paper analyzed this robust multiple regression method in relation to the FMD method in which the rate of robustness strongly depends on the percentage of irregular data. In this paper a long-term analysis and a short-term analysis are presented.

Long-term analysis of a catchment covered by tropical forests

The following analysis was performed on the original data in a catchment covered by tropical forests. The object area was selected in the basin of two irrigation dams, the Pedu and Muda dams, in the Kedah province in Malaysia. The acreage is 1,551.1 km^2 and the basins of the two dams are connected by a tunnel for the passage of the runoff discharge. Therefore, the basins of the two dams can not be separated. They are treated as a connected basin. Fig. 1 shows the outline of the basin.

Inflow and rainfall data covering a 12 year period from 1971 to 1982 were used for the calculation.

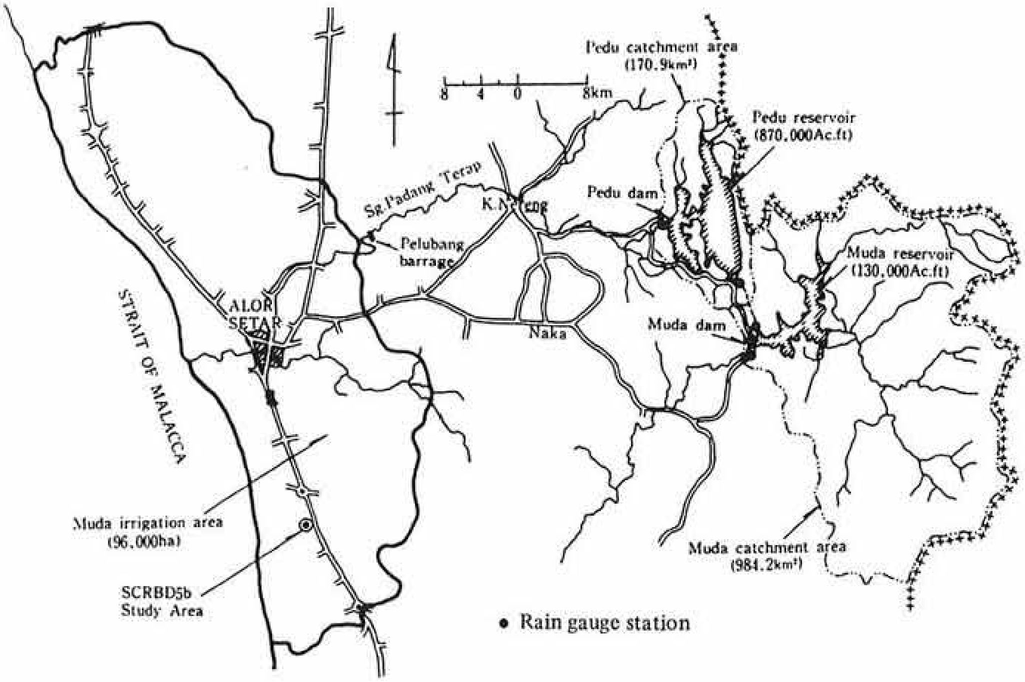

Fig. 1. Outline of the basin

Inflow discharge was converted from the record of daily water level of a dam lake. In a long dry spell, minus inflow is calculated by this method. The weather in this basin is characterized mainly by a dry season (from January to April), an intermediate season (from May to August) and a rainy season (from September to December). This paper analyzes the data collected in an intermediate season.

The results are discussed in terms of linear percentage runoff, unit hydrograph and discharge hydrograph.

Fig. 2 shows the variance of the linear percentage runoff. The variance of the linear percentage runoff calculated by the RFMD method was smaller than that calculated by the FMD method when the FMD or RFMD values were small. The variance of intercepts was large in both methods. Relatively the variance by the RFMD method was smaller than that by the FMD method. When the RFMD or FMD values were large, the intercepts were negative because the inflow discharge data contained negative values.

Unit hydrographs were compared at 5 mm/d of FMD/RFMD where the linear percentage runoff in

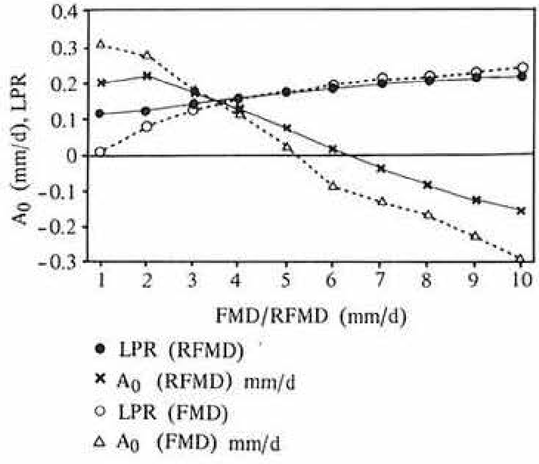

Fig. 2. Linear percentage runoff and intercepts

both methods is the same. Fig. 3 shows the shapes of the unit hydrographs. The shapes of the two unit hydrographs were similar and the difference between the two methods was not significant.

Fig. 4 shows the discharge hydrographs obtained by the RFMD method. Estimated discharge shown in Fig. 4 coincided well with the observed discharge.

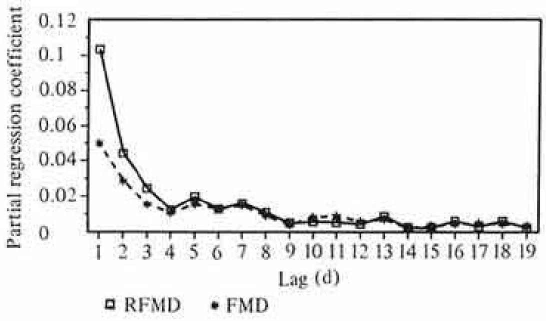

Fig. 3. Statistical unit hydrographs

Fig. 5 shows that the adjustive weight was small when the inflow discharge was negative. Especially, the abruptly changing part of minus data, which contains some measuring errors, was neglected by using adjustive weights. However the difference between the FMD and RFMD methods was small because the percentage of neglected data to the whole data was low.

Short-term analysis in tropical rainfall area

The long-term analysis described above showed few differences between the RFMD and FMD methods because the percentage of irregular data was low. Therefore, when the percentage of irregular data is high short-term analysis should be applied. The targeted area was the same as that above. The period of analysis was limited to 1974, during which the longest dry spell in 12 years was recorded. For testing the robustness of the method, the authors assumed that the right characteristics of rainfall were similar to the characteristics obtained by long-term analysis because the effect of irregular data was less appreciable in the long-term analysis than in the short-term analysis. In other words, the target of this short-term analysis was to obtain the average characteristics of rainfall runoff from the data of the longest dry spell. Table 1 shows the analytical conditions.

In Fig. 6, the shapes of unit hydrographs are compared. In case 1, the partial coefficient of the day (lag 2) was smaller than that of the day before (lag 3). Case 2 did not display this unnatural trend. In the lag from 4 to 6, both cases 1 and 2 showed this unnatural trend. Compared to cases 3 and 4, case

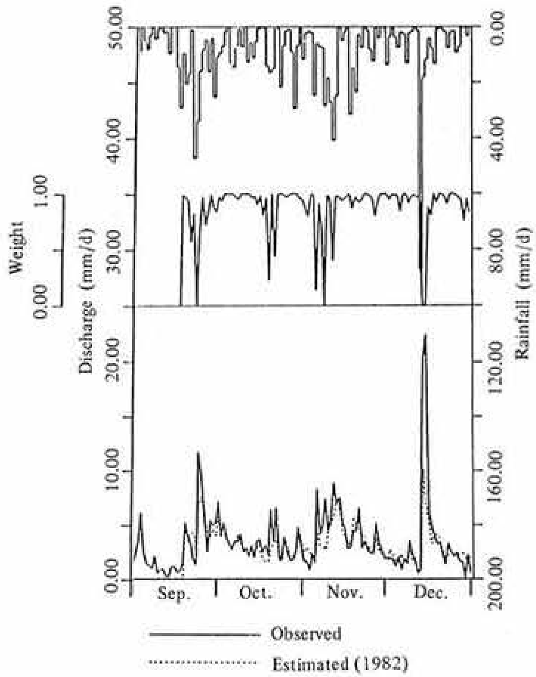

Fig. 4. Sample of discharge hydrographs

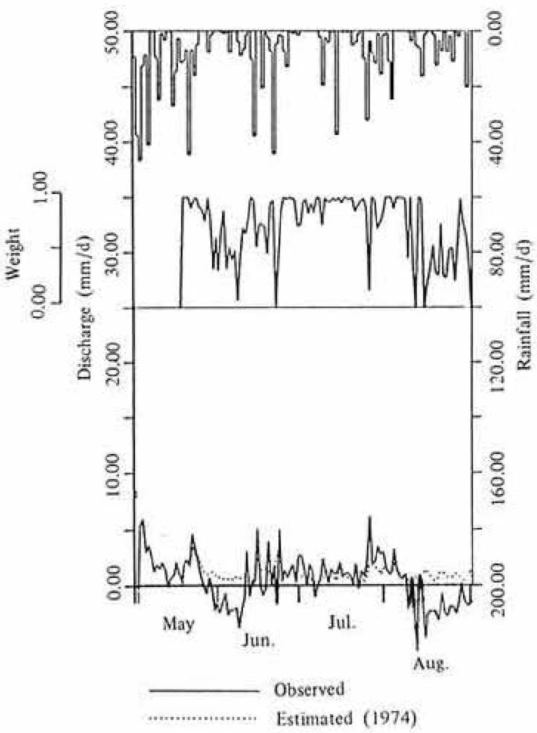

Fig. 5. Sample of discharge hydrographs

Table 1. Analytical conditions

Case	Year	Period	Method	lag (d)	RFMD/FMD (mm/d)
1	1974	20 May - 20 August	FMD	6	6
2	1974	20 May - 20 August	RFMD	6	6
3	1971-1982	1 May - 31 August	FMD	6	6
4	1971-1982	1 May - 31 August	RFMD	6	6

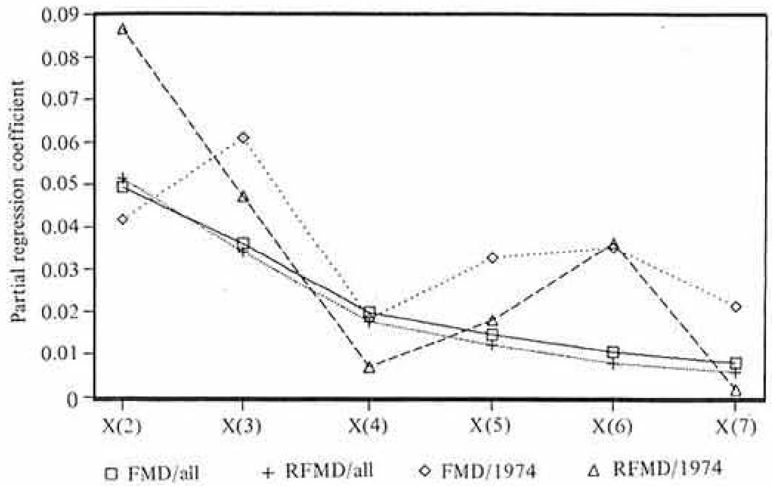

Fig. 6. Comparison of unit hydrographs

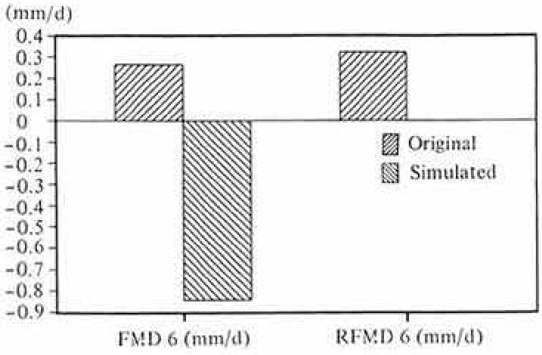

Fig. 7. Intercept

2 showed a more similar trend than case 1. Fig. 7 shows intercepts of cases 1 and 2, which represent the difference from the base inflow and evapotranspiration. The intercepts of long-term analysis show values from 2 to 3 mm/d in cases 3 and 4. The intercept of case 1 gave a negative value of -0.8 mm/d, and that of case 2 a value of 0 mm/d. For the value of the intercepts, the RFMD method was more accurate than the FMD method.

Discharge hydrographs of cases 1 and 2 are shown in Figs. 8 and 9. For the expression of the peak and low discharge, the RFMD method was more accurate than the FMD method.

Conclusion

The authors introduced a new robust method of a rainfall runoff model (RFMD method) which enables to identify the model based on some irregular data. This method which is an improved method of the Shiraishi's FMD method was applied to a dam basin in Malaysia. For long-term analysis, the RFMD method gave similar results to those of the FMD method. For short-term analysis, which contained some irregular values, the RFMD method gave a better model than the FMD method.

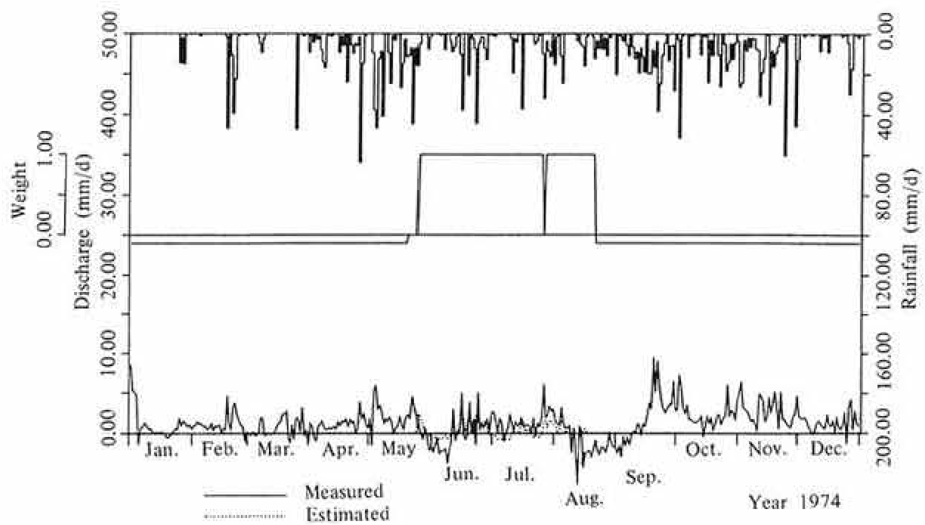

Fig. 8. Estimated discharge by FMD method

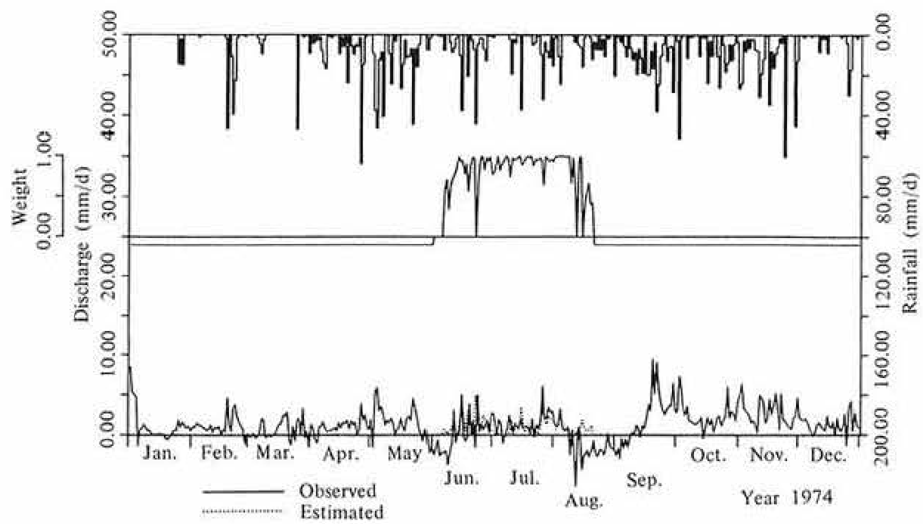

Fig. 9. Estimated discharge by RFMD method

Reference

1) Tanji, H. & Kitamura, Y. (1992): Runoff analysis in a catchment area covered by tropical forests using a robust multiple regression model. 1. Basic theory. *JARQ*, **26**, 187-191.

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