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Some results of application of flood routing models in the Kherlen River basin

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I Introduction

Recent years, the occurrence of floods globally has increased and due to urbanization and growth of population the vulnerability of communities is now greater. By 1990s, the frequency of flood events has increased nearly 6 times since 1960s. Consequently, economic losses and death toll due to flood events are increasing rapidly. Economic losses due to floods only in 2002, is estimated to be about 4.1 billion US dollar (WMO Bulletin, 2004).

Similar situation can be observed in Mongolian case. Some studies show that number of flood magnitude has increased and flood duration becomes shorter and more sudden. For example duration of single flood event in Tuul was about 15 days in mid 1940s, and then nowadays it is shortening for 2-3 days. (Davaa, 2002). Reason of such flow regime change of rivers is change of ground surface (vegetation and soil cover of the basin) due to human activities and climate change. Since establishment of monitoring activities (since mid of 1940s) for river regime in Mongolia, economic losses due to flood event is estimated about 56 billion tugrik and dead several hundreds of people.

Therefore flood forecasting becomes an essential research and practical applications in our hydrological studies. There are a large number of models available for use in flood forecasting and since early 90s several routing models such as Single linear reservoir, Muskingum routing model were applied for flood forecasting and flow simulation (Oyunbaatar and Davaa, 1994, 1999). Due to lack of adequate data on the basin and channel geomorphology, soil and climate, other dynamic and conceptual complex models could not find their application in our case.

This paper considers results of application of some flood routing models in the Kherlen River basin. Several gauging stations along the river and less lateral tributaries between stations of the Kherlen River are meet basic application requirement of such flood routing models.

II Brief description of study area

The Kherlen River takes its origin from southern slope of Khentei Mountain range at elevation about 1,750 m and drains into Dalai nuur in China. The river basin area in territory of Mongolia is 116,455 km^2 with length of 1,090 km (Fig. 1). Mean slope along the river is 0.0012. Width of river valley in upper reaches varies 0.7-0.9 km and while in lover steppe basin could reach up to 10-15 km. Generally, surface runoff in the river basin mainly forms from rainfall during the warm period and spring snow melt (56-76%). By the flow regime classification the Kherlen River belongs to a type with summer rainfall and spring snow melt floods.

The analysis shows that by passing from forest-steppe into steppe zone, the river runoff lost up to 40-50 percent (eds: Myagmarjav and Davaa, 2000). For instance, flood peak at Baganuur station decreases by 40 percent at Underkhaan station and by reaching lower Choibalsan station, runoff loss increases up to 60 percent of upper value (Oyunbaatar, 2003).

Highest flood event in Kherlen River basin were observed in 1933, 1954, 1959, 1967, 1973, 1984, 1988, 1990 and in 1954, at Baganuur station flood discharge reaches 1,320 m^3/sec.

III Results and analysis

1. Linear regression model (Method of related discharge or water stage)

The daily discharge data of the Baganuur, Underkhaan and Choibalsan stations are available for 20 years from 1980 to 2000. For calibrations of linear regression model have selected 6 years data which differ by high, mean and low annual flows. Equations, which give best results, were recommended for forecasting purpose (Table １).

Travel time between stations was estimated by concurrent flow series at three stations: Baganuur, Underkhaan and Choibalsan. Travel time between Baganuur-Underkhaan and Underkhaan-Choibalsan varies 3-8 and 6-15 days, respectively.

Fig. 1 Kherlen River basin.

Table 1 Derived regression equations for forecasting.

River-station	Forecasting equations	R
Kherlen-Baganuur-Underkhaan	**$Q_{UKH}=0.53\,Q_{BN}+13.83$** $Q_{UKH}=0.29\,Q_{BN}+47.4$	0.93 0.87
Kherlen-Underkhaan-Choibalsan	$Q_{Choi}=0.62\,Q_{UKH}+7.54$ **$Q_{Choi}=0.56\,Q_{UKH}+6.64$**	0.90 0.96

Flood peak attenuation analysis shows that flood peak at upper station-Baganuur decrease on average by 40 percent at Underkhaan and 60 percent at Choibalsan (Fig. 2).

Forecasting by the derived equations provide quite good results for the selected Kherlen River system with forecasting efficiency of about 70 percent on average (Fig. 3).

2. Muskingum linear routing model

For calibration of Muskingum routing models have been selected 15 years daily discharge along the Kherlen River and several tenths of single flood events. The analysis of several flood hydrographs show that routing interval between Baganuur and Underkhaan is estimated to be 72 hours or 3 days. Parameters of Muskingum models are estimated by graphic and Donnel's optimization methods. Several trials for several flood hydrographs give following parameters values for Kherlen-Baganuur-Underkhaan reach: k = 8 – 10 days, x = 0.1 – 02. Coefficients of routing equation of the Muskingum model estimated based on mentioned parameters are presented in the Table 2.

Fig. 2 Flood peak attenuation coefficients along the Kherlen River.

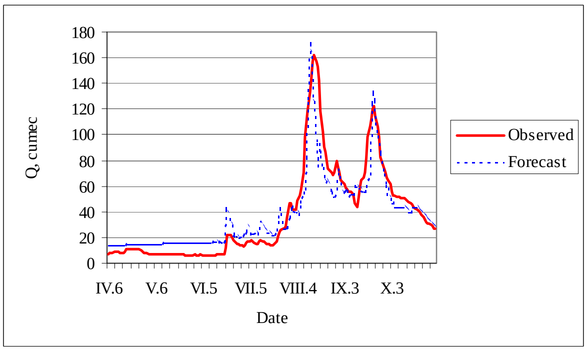

Fig. 3 Forecasted and observed hydrograph, Kherlen-Baganuur-Underkhaan.

The Muskingum model output also provides good results and from the Fig. 4, you could see good matching between simulated and observed hydrograph of Kherlen River system.

3. Muskingum-Cunge model

In this paper, we presented single case of simulation results by the Muskingim-Cunge model. There're some difficulties in estimation of parameters of the model due to lack of measured data along the river. Any way, with some assumption we estimated the parameters of model and run the hydrograph simulation for the Kherlen River system. Application of the Muskingum-Cunge model certainly is needs further improvement with availability of data and some additional measurement. Error of the model was too high (30-40%) which is unacceptable. However this single analysis will serve as pilot information for further analysis and application.

IV Conclusions

-The application of the models was limited to a very inadequately gaged river system due to long distances between stations.

Table 2 Muskingum model coefficients.

River-stations	C_1	C_2	C_3	Error, %
Kherlen-Baganuur-Underkhaan	0.23	0.053	0.716	17.3
Kherlen-Underkhaan-Choibalsan	0.027	0.41	0.616	17.2

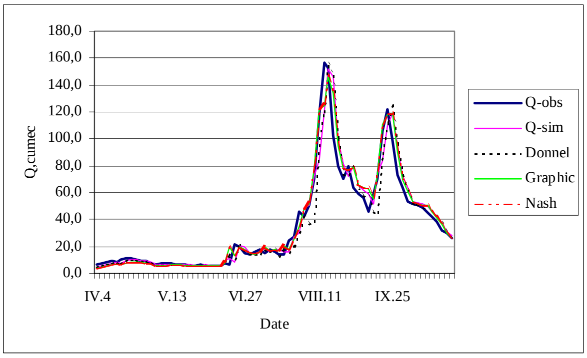

Fig. 4 Simulated hydrograph along the Kherlen River.

-The results obtained seem to encouraging, but need to be verified.

-Linear regression model is recommended to use for forecasting by updating the derived equations by the new inflow.

-Advantages of such simplified routing model are: channel geometry does not need to be defined in details, programming for computer solution is simple, ready integrated with other hydrological models.

-Disadvantages: cannot allow velocity changes and backwater, a large amount of measured inflow and outflow data is required to calibrate the parameters and such models sensitive to the time and distance between *etc*.

-According to the Table 3, the Muskingum model provides the best simulation results.

Table 3 Model accuracy comparison.

Models	R	Error, %
Linear regression model	0.87- 0.93	24.0-30.0
Muskingum flood routing	0.92-0.95	10.3-15.5
Muskingum-Cunge	0.89	32.5-42.4

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