THE KOREAN JOURNAL OF QUATERNARY RESEARCH Vol. 22, No. 2, p. 16-18 (December. 2008)

Hydrological Modeling Of The Kharaa River Basin

Munkhtsetseg Zorigt[1], Adiyabadam Gelegpil[2]

[1]*National University of Mongolia*
[2]*Institute of Meteorology and Hydrology, Mongolia*

Introduction

Runoff computation is very important for hydrological analysis and water budget evaluation. There are many ways of runoff computation in hydrology, for instance computer models. Computer based hydrological models have been developed and applied at an ever increasing rate during the past few years in Mongolia.

This paper is focused to apply the hydrological model HBV and to parameterize it for the Kharaa river basin of Mongolia. The model output, such as the simulated runoff and the water balance, is then analyzed. Input data for the model are precipitation, air temperature, and surface runoff data with daily time steps. The model was used as a lumped version which means that the basin is not divided into sub basins. Goodness evaluation of computed and observed runoff was calculated by using the Nash & Sutcliff criterion.

Study area

The basin is situated at between 47°88′N-49°64′N of latitude and 105°33′E-107°39′E of longitude in Northern Mongolia. The total area of the Kharaa basin is 14534 km^2 (based on a topographical analysis carried out at CERS, University of Kassel) and elevation ranges from around 650 to about 2600 meters. The Kharaa River originates on the north-western slope of the Khentii mountain range and is located with in the Arctic Ocean Basin.

According to its topographic features, the Kharaa basin can be subdivided into incised mid and low mountain types which show typical elevation ranges of 1600-1700 m a.s.l (Annual report of Institute of Geography in Mongolia, 2007). Topographic contours of the study area are shown in Figure 1.

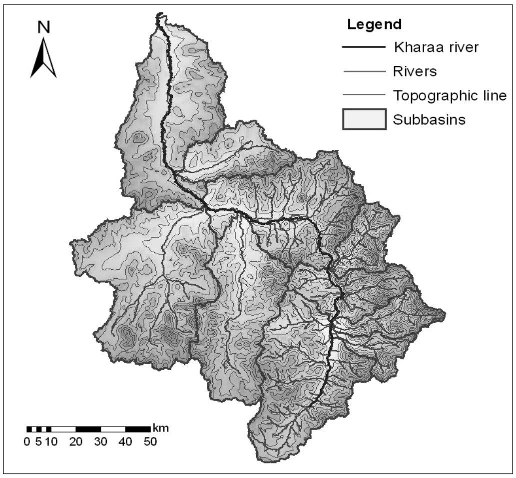

Figure 1: Topographic map and river network of the Kharaa river basin.

Furthermore, the Kharaa river basin includes flood plains, valleys with incised channels and rounded hills. Valleys with incised channels are present throughout the area, but valleys on the east side are shorter, steeper, and more incised than on the west side of the Kharaa river basin. Rounded hills are characteristic for the northern part of a long, north-south-trending ridge of the study area, but cliffs are more characteristic for this ridge in the southern part.

At Center for Environmental System Research of the University of Kassel in German, the basin has been divided into 10 distinct sub basins based on natural drainage patterns (Fig.1).

There are two main runoff peaks in the flow regime of the Kharaa river including spring snow melting and summer rainfall floods. In general, spring flood starts from mid April to end of May due to accumulated snow and ice melting.

The climate in the study area is semi-arid and cold (Climate and Water Resource Atlas of Mongolia, 1985). Mean annual precipitation is in the range of 300 mm and usually occurs as rainfall in the summer period between June and August. In winter time precipitation is generally low and appears as snow.

The maximum and minimum air temperature amplitude is high, whereas maximum temperature occurs in July and its counterpart in January. The minimum mean annual temperature varies between 0°C to -2°C. Mean annual actual evaporation is more than 250 mm per year. Climate is characterized by long and cold winters, dry and hot summers, low precipitation, high temperature fluctuations, and a relatively high number of sunny days (an average of 260) per year. Accordingly, there are not only four sharply distinct seasons, but also quite distinctive months within each of them. January is the coldest month, with average temperatures of –15°C to –35°C.

Methods

The HBV is named after the abbreviation of Swedish words Hydrologiska Byrrens Vattenbalansavdelning (Hydrological Bureau Water balance-section). It was the former section at SMHI where the model originally was developed (SMHI). In different model versions HBV has been applied in more than 40countries all over the world.

The HBV model can be classified as a conceptual, semi-distributed model; with sub basins as primary units and within these an area-elevation distribution and a classification of land use can be made (Bergstrom, 2002).

Input data of the HBV model are daily observed data of precipitation and air temperature. The time step of the simulations within HBV is usually one day, but it is possible to use shorter time steps. In this study, the daily time step was applied. Air temperature data is used for calculations of potential evaporation, snow accumulation and melt.

Result

The HBV model was run for the Kharaa river basin in the lumped version which was not divided into sub basins. Figure2 shows output elements of the model in 1997. The difference between observed and simulated runoff was evaluated mainly by the Nash & Sutcliffe criterion (Figure 3).

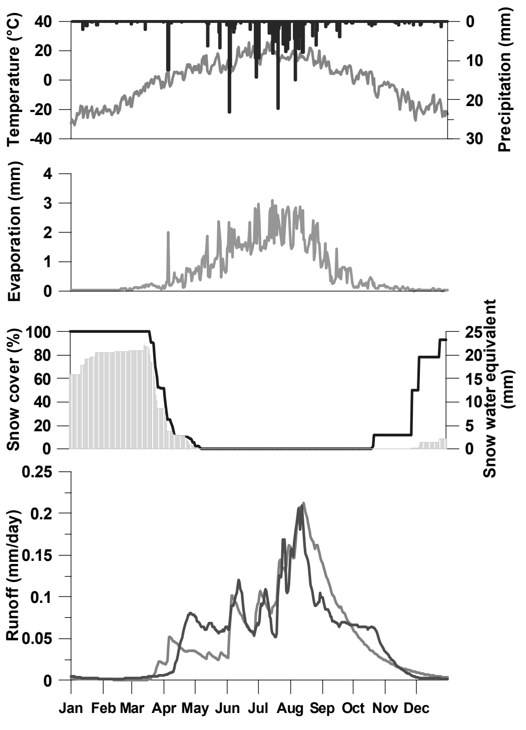

Figure 2 : Output of climatic and hydrological elements of the HBV model calibration in 1997 for the Kharaa basin.

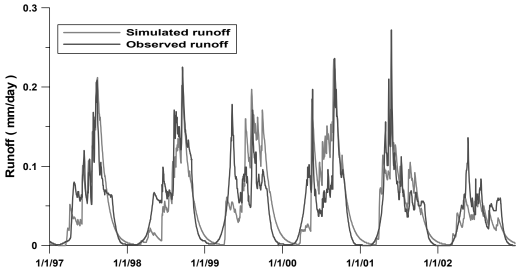

Figure 3 : Lumped version of simulated and observed runoff of the Kharaa river in 1997-2002.

The Nash & Sutcliffe efficiency criterion R^2, theoretically ranging from minus infinity to 1, was calculated for each sub basin (a value of 1 represents perfect performance). It shows the good agreement between the observed and simulated runoff (Table 1). The results of the calibration period showed that the R^2 was ranging from 0.46 to 0.79.

Table 1 : Different performance criterions for 1997 to 2002. R2 is the Nash-Sutcliff criterion

Criterion	1997	1998	1999	2000	2001	2002
F^2	0.19	0.24	0.57	0.48	0.21	0.12
R^2	0.76	0.79	0.17	0.46	0.76	0.60
R^2 log	0.70	0.75	0.42	0.56	0.68	0.70

Conclusions

1. The hydrology of the Kharaa river basin in Northern Mongolia was studied and the computer model HBV was applied.
2. The results of the HBV model were compared to observed runoff. It was shown that the model performed much better in lumped version than the distributed version of the HBV model.
3. This model can be used to estimate the runoff of Mongolian rivers, but it is necessary to improve the runoff data quality and quantity to elaborate this model in the future.

References

1. Arheimer, B. HBV modeling in several European countries. SMHI, SE-601 76 Norkwping, Sweden.
2. Batima,P., Dagvadorj,D.(2000). Climate change and its impact in Mongolia.
3. Bergstrom S, Sandberg G.(1983). Simulation of groundwater response by conceptual models—Three case studies. Nordic Hydrology 14: 71–84.
4. Bergstrom, S. (1992). The HBV model-its structure and applications. SMHI reports hydrology.
5. Oyunbaatar, D. (2004). Floods in Mongolia. Hydrology section, Institute of Hydrology and Meteorology.
6. Saelthun,N.R., (1996).The Nordic HBV model.
7. Seibert, J. (1997) . Estimation of Parameter Uncertainty in the HBV model. Nordic Hydrology, p. 247-262