新安江模型에 의한 洪水豫報

Application of Xinanjiang Model in Flood Forecasting

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요 지

본 논문에서는 三水源新安江模型으로 한국 위천유역에 대하여 홍수예보를 모의하였다. 결과 新安江模型은 위천유역의 홍수를 비교적 정확하게 모의하였고 평균 모형 효율성 계수는 0.93이나 되었으므로 홍수예보를 적용하는데 적합하다. 新安江模型은 습윤 반습윤지구의 蓄滿流出의 모형으로서 초기 토양함수량이 풍부한 홍수에 대해서는 정확도가 매우 높다. 그러므로 홍수예보를 하는데 있어서 新安江模型이 광범한 실용가치가 있다고 예상된다.

핵심용어 : 三水源新安江模型, 홍수예보, 위천유역

1. Introduction

The flood forecasting is involved highly dependent on the accurate and timely of hydrological models' results. Xinanjiang model, which is a conceptual hydrological model, has been successfully and widely applied in humid and semi-humid regions in China since its development in 1973 and published in 1980 (Zhao et al.,1980). The main feature is runoff production occurs on repletion of storage to capacity values which are assumed to be distributed throughout the basin. The objective of this paper is to analyze and discuss results of the application of Xinanjiang model in Wi River in Korea, so as to improve the method of flood forecasting.

2. Methodology

2.1 The structure of Xinanjiang model

The outflow hydrography from each of the sub-basin is first simulated and then routes down the channels of the main basin outlet. The flow chart of Xinanjiang model is shown in Fig. 2.1

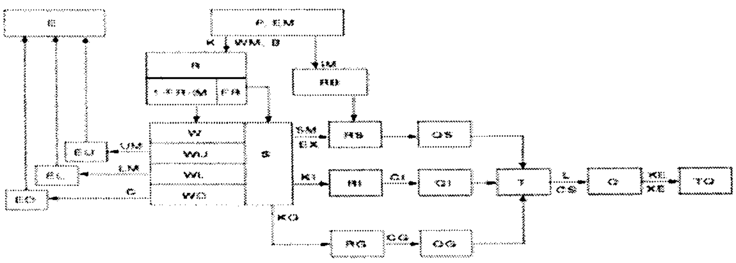

Fig. 2.1 The flow chart of Xinanjiang model

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K: Ratio of potential evapotranspiration. WM: The areal mean tension water capacity. B: The exponent of the tension water capacity distribution curve. IM (%): Percentage of impervious and saturated areas in the catchment. C: Coefficient of the deep layer. SM: Areal mean free water capacity of the surface soil layer. EX: Exponent of the free water capacity curve. KG, KI: Outflow coefficients of the free water storage to groundwater, interflow relationships. CG, CI: Recession constants of the groundwater, interflow storage. CS: Recession constant in the lag and route method for routing through the channel system within each sub-basin. KE, XE: Parameter of the Muskingum method. L: Lag time.

2.2 The method of model calculation

(1) The calculation of evapotranspiration

The evapotranspiration is calculated using three-layer soil moisture model, which divides the total areal mean soil moisture capacity into three portions to calculate.

(2) The calculation of runoff production

A distribution of tension water capacity in Fig.2.2 is suggested to solve the whole basin runoff production.

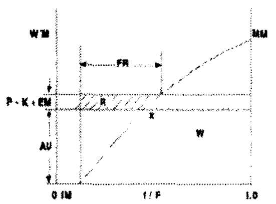


Fig 2.2 Distribution of tension water capacity

$$(1 - f/F) = (1 - W'M/MM)^{B} \cdot (1 - IM) \quad (1.1)$$

$$MM = WM \cdot (1 + B)/(1 - IM) \quad (1.2)$$

If $P - K \cdot EM + AU < MM$

$$R = P - K \cdot EM - WM + W + WM \cdot (1 - (P - K \cdot EM + AU)/MM)^{(1+B)} \quad (1.3)$$

else $R = P - K \cdot EM - WM + W$ (1.4)

(3) Separation of runoff components

A distribution of free water capacity as shown in Fig 2.3 is used. The runoff R generated in accordance with Fig.2.2 and expressed as the depth $P - K \bullet EM$

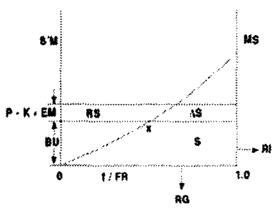


Fig 2.3 Distribution of free water capacity

If $BU + P - K \cdot EM < MS$

$$RS = \left(P - K \cdot EM - SM + S + SM \cdot (1 - (P - K \cdot EM + BU)/MS)^{(1+EX)}\right) \cdot FR \quad (1.5)$$

else $RS = (P - K \cdot EM + S - SM) \cdot FR$ (1.6)

$$RI = S \cdot KI \cdot FR \quad (1.7)$$

$$RG = S \cdot KG \cdot FR \quad (1.8)$$

(4) Flow concentration and routing

The surface runoff is treated to be unmodified and the interflow RI and groundwater RG runoff with the linear reservoir method, outflow QI and QG from these reservoirs is calculate by 1.9 and 1.10. After the outflow for each sub-basin is calculated, then it routes through channels to the main basin outlet with the Muskingum method.

$$QI(t) = QI(t-1) \cdot CI + RI(t) \cdot (1 - CI) \quad (1.9)$$

$$QG(t) = QG(t-1) \cdot CG + RG(t) \cdot (1-CG) \qquad (1.10)$$

3. Application of Xinanjiang model in Wi River

3.1 Study area

Wi River is a tributary of the main Nakdong River. The catchment area is about 472㎢ and the stream length is about 30.48km. The annual average precipitation is about 1130mm. This district is situated within the transitional zone from wetter to drier regime. It is a humid and semi-humid region and a quite steep mountain watershed with the elevation arises from less than 100m to the elevation over 1190m. The topography and river networks of Wi River are generated from the Korea service 1:25,000 scale DEM based on GIS technology.

The Thiessen polygon as shown in Fig. 3.1 method is adopted to generate the average precipitation used in model calculation for Wi River, which is divided into 9 sub-basin as shown in Fig. 3.2.

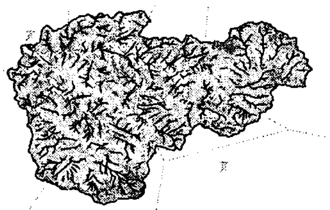


Fig. 3.1 Thiessen polygon

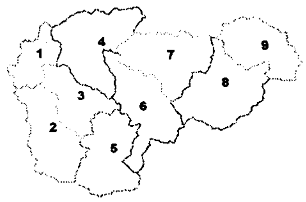


Fig. 3.2 Sub-basin

3.2. Results analysis

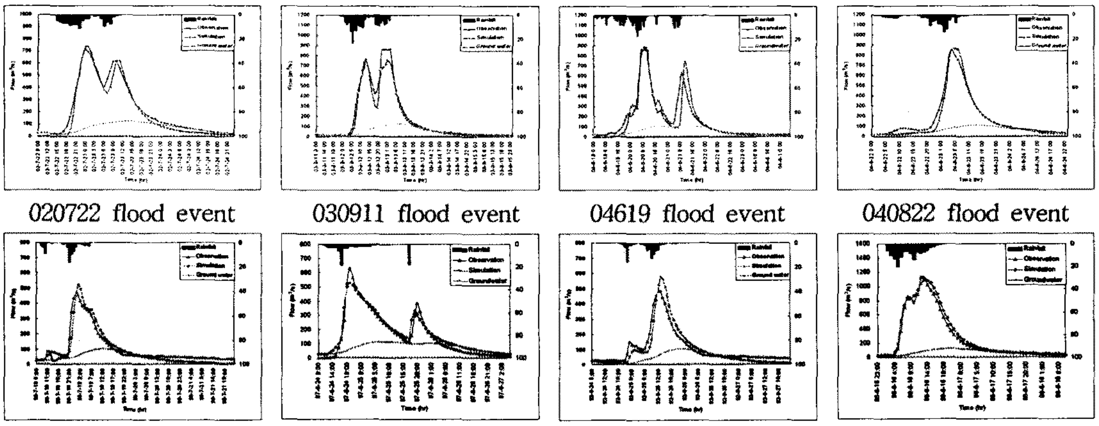
Four flood events in three years' (2002-2004) with hourly rainfall data were run in a continuous mode for calibration of the model. Table 3.1 shows the calibrated parameters values. Table 3.2 and Fig 3.3 show the calibrated and verified results for the selected flood events. The results show that the average

Table 3.1 The calibrated parameter values for the selected flood events

K	0.93	WD	27	CI	0.01	X	0.22
IM	0.01	B	0.34	KG	0.05	L	0.95
WM	125	C	0.12	KI	0.75	CS	0.785
WU	14	EX	1.20	SM	18		
WL	84	CG	0.95	KE	0.99		

Table 3.2 Calibrated and verified results for selected flood events

	Event	Oberved Runoff	Modeled Runoff	Absolute Error	Relative Error(%)	Determined Coefficient	Peak Discharge			Time Interval(hr)
							Obs	Sim	REP	
Calibrated	020722	95.35	104.86	9.51	9.97	0.97	743.67	713.81	0.04	1
	030911	146.51	144.93	-1.57	1.07	0.96	867.00	763.28	0.12	0
	040619	163.49	164.05	0.56	0.34	0.88	867.00	839.85	0.03	0
	040822	91.38	94.30	2.92	3.20	0.97	867.00	859.52	0.01	0
Verified	900718	70.49	66.74	-3.75	5.31	0.90	471.71	523.00	0.11	1
	920715	66.36	63.22	-3.14	4.73	0.91	426.45	438.44	0.03	2
	920824	73.84	68.02	-5.82	7.88	0.86	485.67	573.67	0.18	1
	960616	124.97	132.19	7.23	5.78	0.98	1127.00	1082.53	0.04	0
	970624	85.14	92.84	7.70	9.05	0.96	628.50	526.41	0.16	0
	970705	143.39	157.11	13.72	9.57	0.91	1331.90	1026.12	0.23	0
	970803	76.27	81.51	5.24	6.87	0.93	956.75	782.79	0.18	1



020722 flood event | 030911 flood event | 04619 flood event | 040822 flood event

900718 flood event | 970624 flood event | 920824 flood event | 960616 flood event

Fig. 3.3 Simulated and observed hydrographs of selected flood events

average Determined Coefficient and "Relative Error for Peak discharge " (REP) of forecast peak discharge are qualified. For the 970705 flood event which the PEP is above 20% because the low initial soil moisture. As the Xinanjiang model is a storage model, it can not simulate very well for the drying situation.

4. Conclusion

At the present stage of research, the forecast quality sometimes considerably varies between selected flood events as well as between the different models. There was increased uncertainty in the simulations of flood events during the early and late phases of rainy season. The simulation result is well when the ante-precipitation is plentiful. It much match the topography characteristics of the catchment and the conception of repletion of storage of Xinanjiang model. That is, the volume of the runoff mainly depend on the initial soil moisture in Xinanjiang model, also it happened 1 or 2 hours lag time of peak discharge if there is little ante-precipitation in some flood events, such as 900718, 920715, 920824. Further efforts are necessary in particular towards an improved consistency of the forecasting results. Alternatively Shanbei model can be introduced for the further research in Wi River which is applied well in drying regions in China.

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