NAM model assignment

Student: Zhenchen Zhang
Number: 1074448
Locker number: 336

Exercise 1

1.2 Have a look at the input data and results. What additional plots could also be of interest for you? Create two new plots of model results and describe them.

I draw these graphs after calibration. So I not only describe them but also explain the relation and influence between different values shown in these figures. The first diagram shows the change in L/L_{max} over time. The value of L/L_{max} increases at the beginning of time because of the precipitation and snow melting and decreases from March to September, which is a dry season. I also add three threshold values as three lines in this diagram. It is obvious that the value of L/L_{max} is always larger than the value of CLIF and CLG, which means the precipitation must produce the interflow and groundwater. However, the value of L/L_{max} is not always larger than CLOF along time, and it is smaller than the value of CLOF between May and November, which is equal to no outland flow in this period. This is because the lower zone storage in this model decrease during the dry season due to high evaporation and relatively low precipitation.
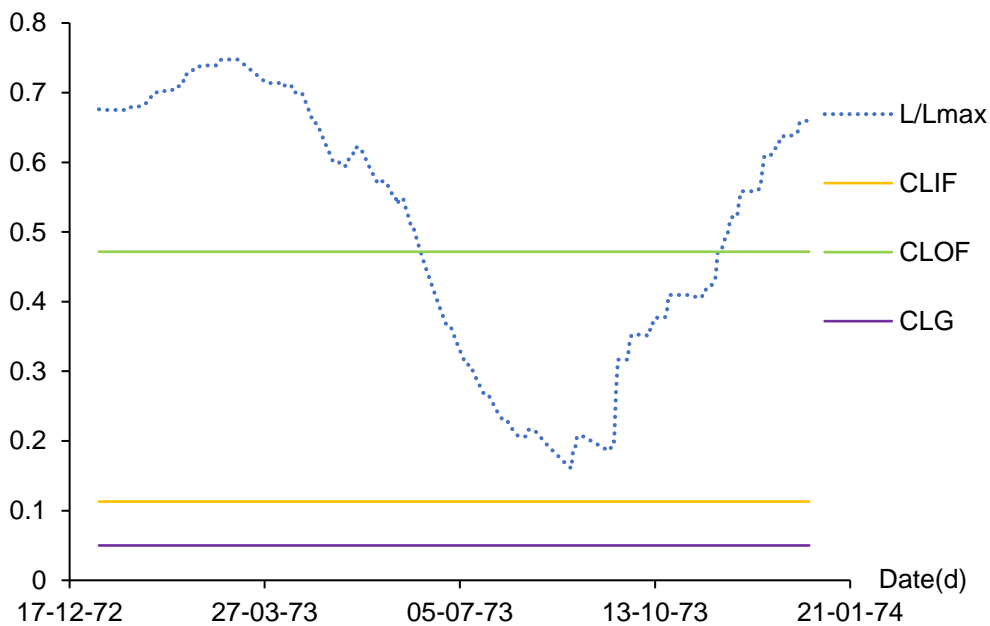

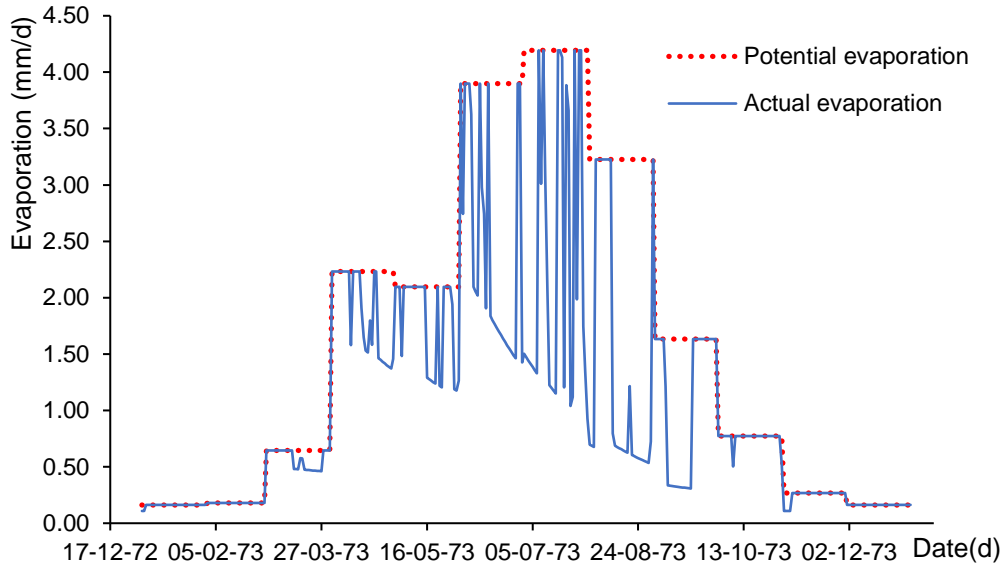*Figure 1 L/L_{max} changing with time*

Figure 2 Potential and actual evaporation changing with time

This diagram depicts the changes in potential and actual evaporation over the course of the year. Potential evaporation rises in summer and falls in winter. Actual evaporation can be equal to potential evaporation in winter and sometimes smaller than potential evaporation in summer. The reason is as follows. Actual evaporation in this model is equal to the sum of surface evaporation and lower zone evaporation. Due to the

equations $\quad Ep = MIN \begin{cases} U + Ps + P \\ Epot \end{cases}$ and $\quad Ea = MIN \begin{cases} Epot * \frac{L}{Lmax} \\ Epot - Ep \end{cases}$, the actual

evaporation is related to the storage (surface storage U and lower zone storage L) and precipitation P. In summer, the precipitation and storage are both lower. Thus actual evaporation has some values lower than the potential evaporation.
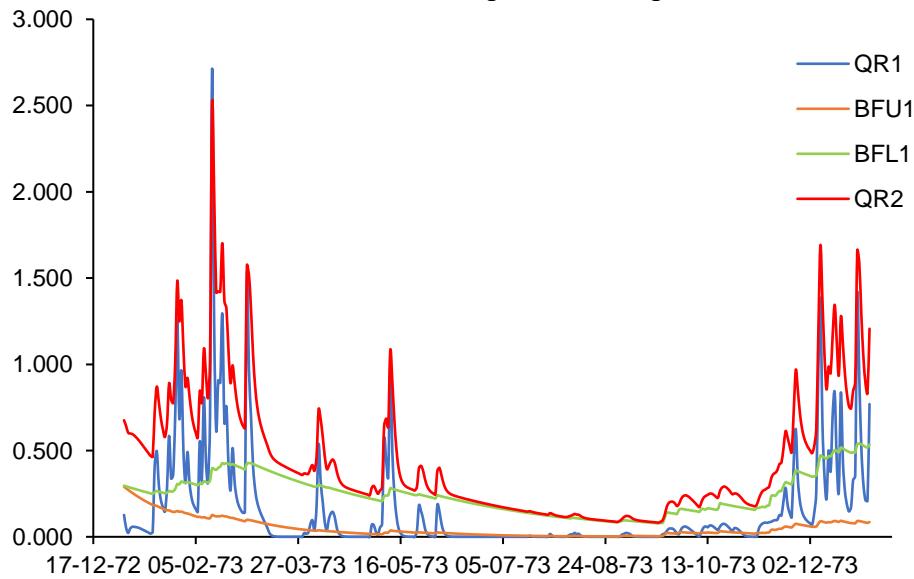

Figure 3 The distribution of river flow

The third chart shows the composition of the river. The whole river flow discharge

(QR2) is composed of QR1(overland and interflow), QFU1(upper baseflow), and QFL1(lower baseflow). In this simulation result, the base flow always keeps a relatively stable and low value, which is composed of upper and lower baseflow, and the overland flow provides the discharge at the peak of the figure.

1.3 Try to calibrate the model and find an optimal parameter set for the given data set. Report your findings.

Table 1 Parameter table of NAM model

Parameter	Name	Value	Constraints
Lower zone storage capacity	Lmax	207.01	>0
Upper zone storage capacity	Umax	5.03	>0
Snow melt coefficient	Cmelt	0.74	>0
Overland flow runoff coefficient	CQOF	0.64	0-1
Interflow runoff coefficient	CQIF	0.05	0-1
Groundwater flow coefficient	CBFL	0.90	0-1
Threshold value interflow	CLIF	0.11	0-1
Threshold value overland flow	CLOF	0.47	0-1
Threshold value groundwater flow	CLG	0.05	0-1
Time constants for routing			
Time constant overland and interflow	CK1	1.16	>0
Time constant river flow	CK2	0.91	>0
Time constant upper groundwater flow	CKBFU	30.83	>0
Time constant lower groundwater flow	CKBFL	80.29	>0

Table 2 Objects of NAM model

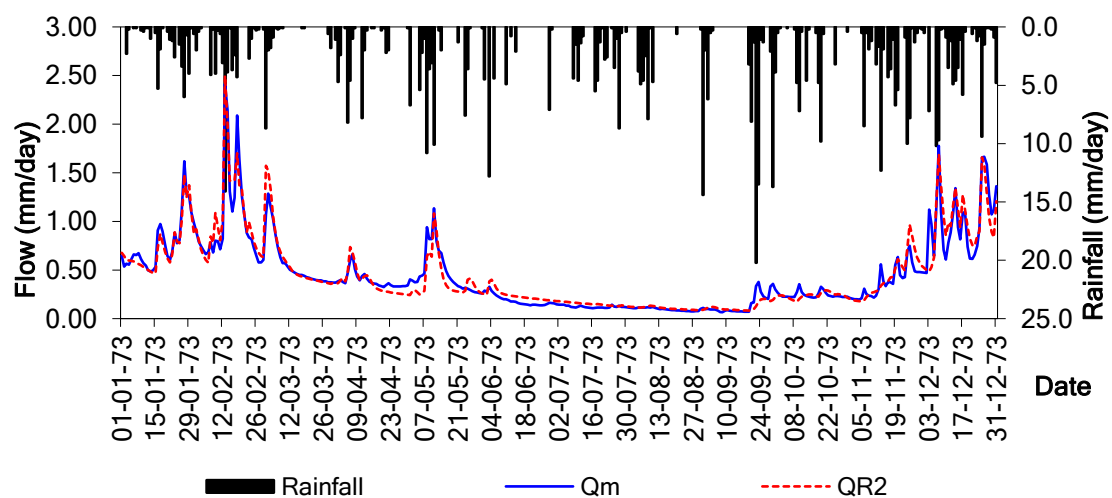| Object	Value
SSE	3.84
R_{eff}	0.93
Log R_{eff}	0.93

Figure 4 the measured and simulated runoff in 1973

After the calibration, an appropriate result that is very close to the measured value appears. The object R_{eff} is equal to 0.93, and the two hydrographs have the goodness of fit. The baseflow simulated is good, while some peaks of runoff simulated have differences with the true situation. Although the model must not be the true situation as the natural one, this simulated result has a very fit peak and dry season. So this NAM model is very suitable in this area. The only fly in the ointment is the errors that occurred at the small peaks and the peaks, which has a small duration.

1.4 Have a look at the objective functions R_{eff} and log R_{eff}. What is its meaning? Have also a look at the water balance calculations and report the results of your calibrated model with the given data set.

R_{eff} and log R_{eff} describe the goodness of fit between the simulated hydrograph in relation to the variations of the measured hydrograph. R_{eff} is written by:

$$R_{eff} = 1 - \frac{\sum(Q_{obs} - Q_{sim})^2}{\sum(Q_{obs} - \overline{Q_{obs}})^2}$$

And log R_{eff} is written by:

$$log\ R_{eff} = 1 - \frac{\sum(ln\ Q_{obs} - ln\ Q_{sim})^2}{\sum(ln\ Q_{obs} - \overline{ln\ Q_{obs}})^2}$$

In these both function Q_{obs} is measured runoff at a time step, Q_{sim} is simulated runoff at a time step, and $\overline{Q_{obs}}$ is mean measured runoff of the investigation period. The perfect fit is for $R_{eff}=1$.

The water balance is written by WB=P-Ea-Ep-ΔS-R. The value of water balance is

1.4mm after calibration. For a catchment the input water should be equal to the sum of output water and the change of storage. So water balance almost can be arrived with these parameters.

Exercise 2

2.1 Select one of the following parameters of the NAM model: Lmax,Umax,Cmelt,CQOF,CQIF,CBFL,CLIF,CLOF,CLG,CK1,CK2,CKBFU or CKBFL. Describe the parameter and its role and connections within the model setup. Discuss before changing the value of this parameter what effect you expect for the model output.

CLOF is Threshold value overland flow. The value gives an indication of the importance of the relative storage of the low zone reservoir. It works in the equation

$$QOF = MIN \begin{cases} \begin{cases} \dfrac{Pn}{\dfrac{L}{Lmax}} & > CLOF; Pn * CQOF * \left(\dfrac{\dfrac{L}{Lmax} - CLOF}{1 - CLOF}\right) \\ \dfrac{L}{Lmax} < CLOF; 0 \end{cases} \end{cases}$$

as threshold value so that no overland flow is generated if L/L_{max} is less than CLOF. In other words, the parameter CLOF has an influence on the overland flow directly. After effecting overland flow, another influence will be produced on the storage L in the lower

zone. And then, with the change of the storage L, all the discharge in soil (QIF), groundwater flow (G), and actual evaporation have changed.

For a smaller CLOF, it means overland flow produced more easily. So the probability of runoff from rain-less rainfall is increased. Thus the amount of runoff peak will be more. Meantime for the peak of precipitation also increases with CLOF decreasing. As mentioned above, declining CLOF causes L less. Less storage of lower zone makes the groundwater flow less due to the equation as follows.

$$G = \begin{cases} \dfrac{L}{Lmax} > 1; Pn - QOF \\ \dfrac{L}{Lmax} < 1 \begin{cases} \dfrac{L}{Lmax} > CLG; (Pn - QOF) * \left(\dfrac{\dfrac{L}{Lmax} - CLG}{1 - CLG} \right) \\ \dfrac{L}{Lmax} < CLG; 0 \end{cases} \end{cases}$$

Thus the baseflow will be lower with a lower parameter CLOF.

2.2 Look at the differences between the new simulated runoff and the "recorded" one by changing your selected parameter from EX2.1. Describe the effects of the changed parameter value to the model output.
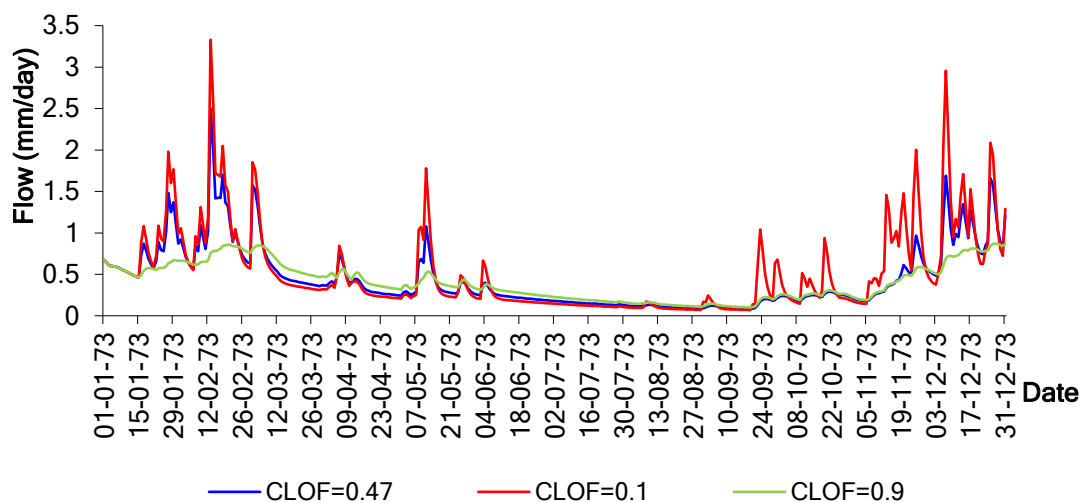

Figure 5 The runoff with different parameters CLOF

As analyzed, the figure compared with different values of CLOF is shown below. The peak of discharge is more, and the discharge at dry season gets lower with lower CLOF. Opposite, the peak decreases while baseflow increasing for a higher CLOF.

Exercise 3

Have a look at the file Data_Dreisam.xls and import the data to your NAM model. Choose a suitable calibration and validation period. Report your findings. What are your impressions concerning the model performance?

Choose 1996 and 1997 as calibration, 1998 as validation, and Reff as the object of this project. The results are as follows in tables and figures.

Table 3 Parameter result table of 1996-1997

Parameter	Name	Value	Constraints
Lower zone storage capacity	Lmax	161.98	>0
Upper zone storage capacity	Umax	0.00	>0
Snow melt coefficient	Cmelt	0.45	>0
Overland flow runoff coefficient	CQOF	1.00	0-1
Interflow runoff coefficient	CQIF	1.00	0-1
Groundwater flow coefficient	CBFL		0-1
		1.00	
Threshold value interflow	CLIF	0.00	0-1
Threshold value overland flow	CLOF	0.82	0-1
Threshold value groundwater flow	CLG	0.41	0-1
Time constants for routing			
Time constant overland and interflow	CK1	1.18	>0
Time constant river flow	CK2	2.94	>0
Time constant upper groundwater flow	CKBFU	199.87	>0
Time constant lower groundwater flow	CKBFL	9998.05	>0

Table 4 Objects of calibration in 1996-1997

Object	Value
SSE	535.42
Reff	0.81
logReff	0.67

Table 5 Objects of validation in 1998

Object	Value
SSE	368.23
Reff	0.74
logReff	0.71

The objective value gets 0.81 in the calibration period 1996-1997 and 0.74 in validation in 1998. The runoff calculated by the model in 1998 shows a trend very consistent with the measured runoff. While at some peaks and dry seasons, there are obvious differences between actual and simulated runoff. The difference is inevitable. The real situation cannot be arrived, because the model is simplified by the actual hydrological process; the parameters are also through other years value calibrating; these errors will lead to the model error.

The method of calibration is the method of manual trial and error, and after getting a good result, using solver in Excel gets a better result. It needs to be mention specially that the parameter CKBFL is very large. It means the value of $\exp(-1/CKBFL)$ is approximately equal to 1. If $\exp(-1/CKBFL)$ is equal to 1, the lower baseflow is only related to the lower baseflow in last time, and the groundwater cannot distribute to the lower baseflow. The reason for calibrating this parameter like this way is that the

recession curve in the study area is very steep; in another word, the peak of runoff goes down at very fast velocity. And the baseflow is very small. To simulate the discharge as this situation, the baseflow needs to be small and steady, and the overland flow needs to be a quick response to the precipitation. With this idea, try the parameters and use solver in Excel many times to get the final result.

The initial inputs, such as L, QR2, are set as the value of the last day in 1997. The first error is that the velocity of flood subsidence is faster than the fact situation. It is because, in 1996 and 1997, which is the period of calibration, the flood subsidence is too fast while that in 1998 becomes more smooth. The second error is the change of baseflow is obviously larger than the calculated one. This is also because of the difference between the calibration period and the validation period, which leads to the parameters ignoring the lower baseflow.

In total, this model can be used in this area for flooding forecasts and other aims. But clearly, this area is not belonging to the most applicable area. In my view, the liner reservoir and the dividing method of the underground water system are not very suitable for this area and can be improved by changing the model. On the other hand, the period for calibrating the parameters is too short; if having a long series of time, the calibration will be better.
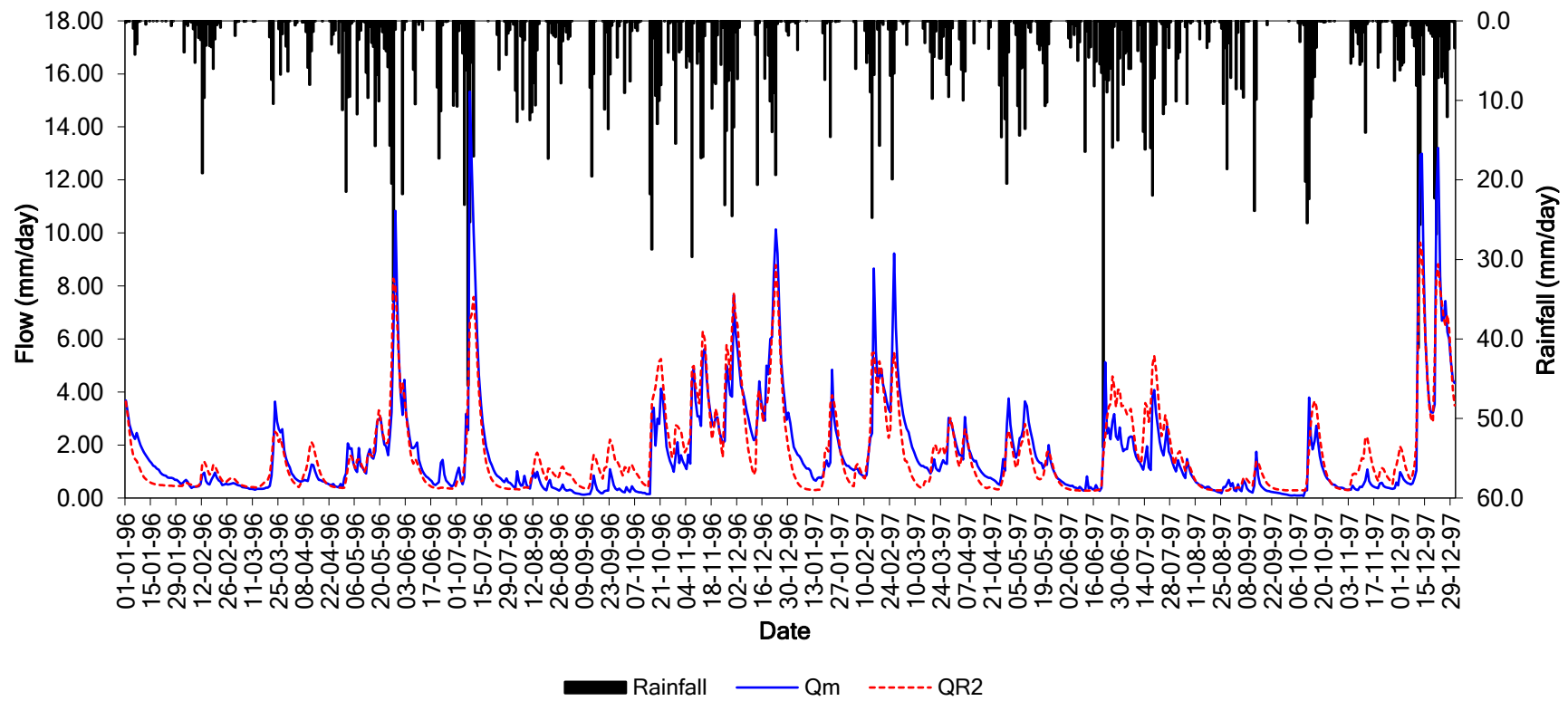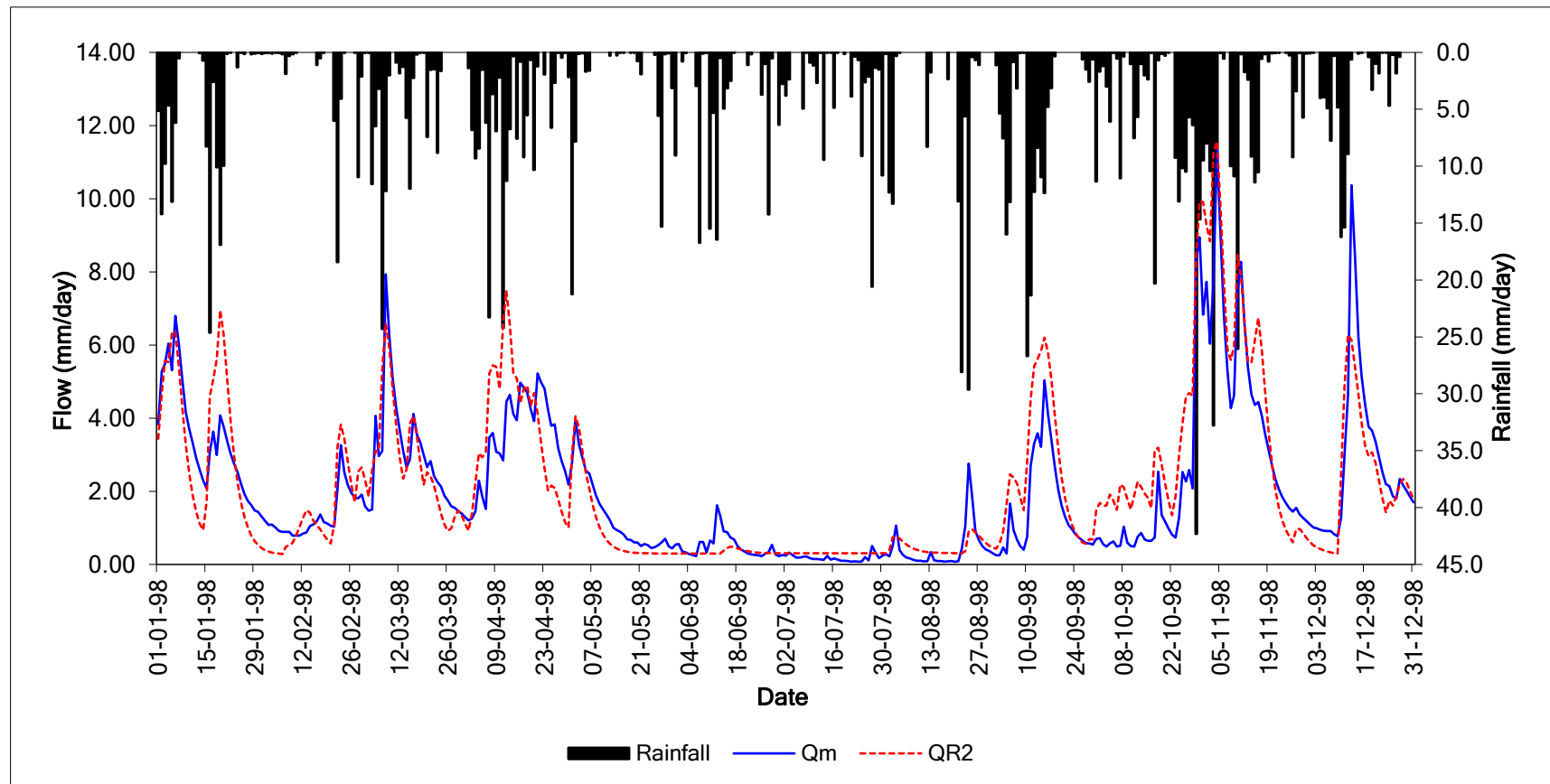
Figure 6 The result of calibration

Figure 7 The result of validation