IMPACT ASSESSMENT OF DIFFERENT TIME SCALES ON MODEL PARAMETERS FOR THE SMALL CATCHMENT OF THE HUPSELSE BEEK

I. Bistinas, P. Warmerdam, P. Torfs

Wageningen University, Chair Hydrology and Quantitative Water Management
Piet.Warmerdam@wur.nl

Introduction

The increasing necessity for prediction of the extremes as peak discharges not only in large rivers, but also in streams, leads to forecasting applications in small catchments. The small spatial scale forecasting needs the adaptation of the rainfall-runoff model structures into the suitable time-step for each process (Sivapalan *et al.*, 2003). The suitable time step for a catchment can be defined by the size and the characteristics of the catchment, as well as the model structure.

The right choice of the time scale for the input data, especially in case of applying regional modeling in ungauged catchments, is a very crucial step that can determine the success of the model results (Littlewood, 2006).

During the last decades catchment hydrological modeling have concentrated mainly on the spatial distribution and the geomorphologic aspects, whereas the influence of different time scales of observed variables on model structure and model parameters has not or almost not been investigated.

The common way of model testing is to employ two split samples of the observed data, one for calibration and one for validation. The estimated parameter values are 'effective' for the (sub)catchment scale and prevalent moisture condition.

If for one catchment the model is calibrated against several periods, for example individual years, the resulting parameter sets are often different probably due to different catchment moisture conditions or other impacts.

It means that (some) parameters are not constant as conditions change and that models cannot represent well the low flow and peak flow behaviors with one single parameter set. Likely some dynamics of the catchment has not been properly represented in the model.

This study is an effort to study the parameter change of the conceptual Wageningen rainfall runoff model, using both daily and three hourly intervals of time series applied to the Hupselse Beek.

The catchment and model used

The studied area is the "Hupselse beek" catchment, located on the East of Netherlands. It is a rather small rural catchment covering 6.5 km^2, with minor slopes of about 0.2-0.5 %.

For this area hourly time series of precipitation and discharges are obtained. Also temperature, relative humidity and global radiation are measured at short intervals allowing the calculation of the reference evapotranspiration with Makkink method at hourly time steps. The data are transformed into three hourly intervals.

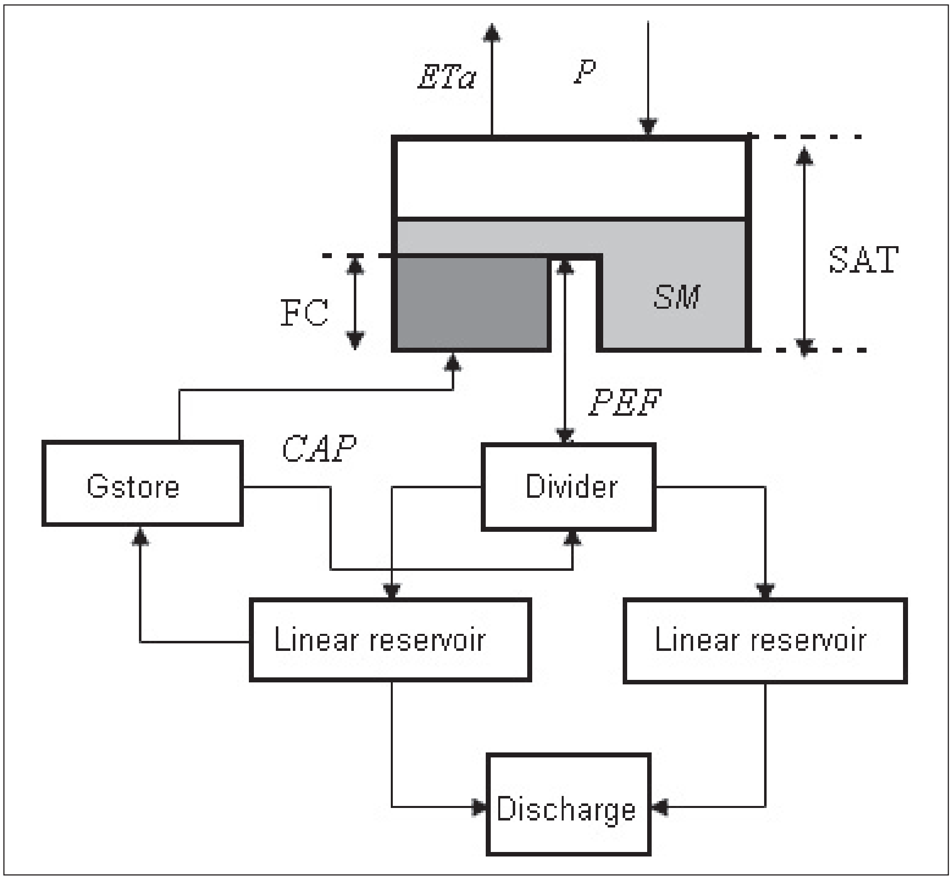

Figure1. The structure of the Wageningen Rainfall runoff model

In this study the model input consists of five time series of seven years in the 1990's period transformed into five hydrological years (covering April to April next year): 92-93, 93-94, 94-95, 97-98 and 98-99. The period of 97-98 is the driest and 98-99 is the wettest.

Because the Hupselse Beek is a small catchment the respond time of runoff on a rainfall event should be rather small. To display the dynamics of the hydrological extremes a 3-hourly time step appears to be the right choice in order to compare with the daily. The Wageningen model has been calibrated for each of the years.

The structure of the Wageningen model is schematically shown in Figure1. Characteristic is that the amount of dischargeable or effective precipitation *(PEF)* is calculated with the water budget method for the unsaturated zone with soil moisture volume SM in excess of FC the field capacity. The effective precipitation is subsequently divided (Divider) between respectively the slow with time constant Ks and the fast runoff with time constant Kf.

This division of effective precipitation depends on the volume of groundwater stored (Gstore), introducing a non-linear element in the model. In dry periods capillary upward flow to the soil moisture store can be accounted for (CAP).

Impact of time scales in model parameters

It is found that the shorter the timescale the stronger the nonlinearity of flow processes becomes. If the model would be linear parameters would not change. Annual series are considered as linear, whereas daily series show nonlinearity. Using hourly time steps strong non-linearity should be expected in the rainfall runoff relation.

When comparing two different time scales, the usual method of study is to examine the performances in different time steps and to see if the model complexity is adequate for each time scale (Mathevet *et al*., 2004).

The Wageningen model has a simple structure and low complexity (five free parameters).The model shows a good performance with 3-hourly time step input and computing the dynamics of the discharge from the Hupselse Beek catchment very well. Figure 2 shows the model outflow of the year 1993-94.

In the current study the parameters having the most direct interpretation, i.e. the slow (Ks) and fast (Kf) time coefficients are compared of both three hourly and daily time steps for each of the five hydrologic years used.

In general a strong dependency appears between the parameters and the time step of the input data, but results change from year to year. However there appears no systematical change of parameter values in relation to the time step. This means that also other impacts will affect the optimal values. For example the effect of attenuating the rain and discharge signals with increasing time step. The rainfall signal attenuates faster than that of the discharge. Both the attenuating effect of the time step and that of the model at larger time step will affect the parameter values, but these cannot determined separately.

It should be noted that interdependency between parameters and difference in parameter sensitivity will not only hamper the calibration process but could also affect the resulting parameter value.

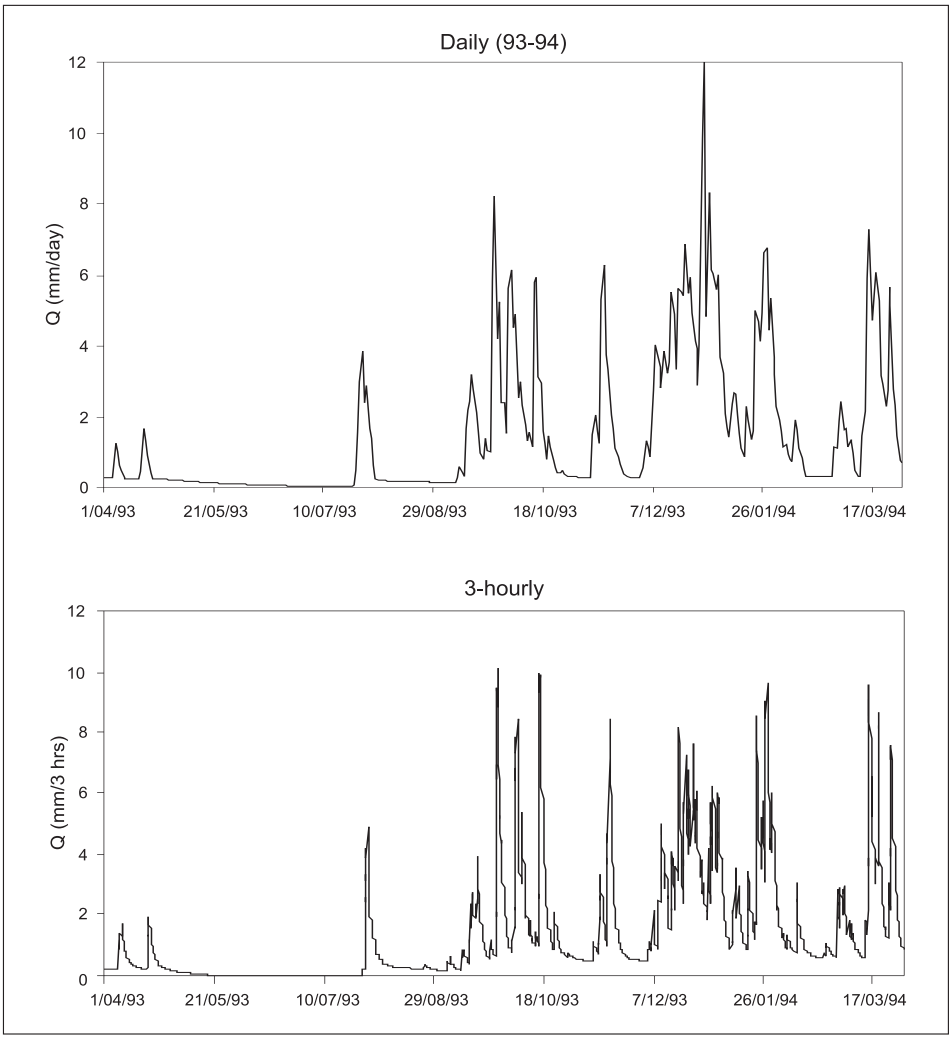

Figure 2. Computed outflow of Hupsel for the year 93-94 at daily ($mm{\cdot}d^{-1}$) and 3-hourly ($mm{\cdot}3h^{-1}$) time steps

References

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