RESEARCH ARTICLE

# Runoff coefficient estimation for various catchment surfaces

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**Abstract:** The definition of runoff coefficient is the portion of rainfall that turn into direct runoff throughout an occurrence, and it is a significant perception in engineering hydrology and is extensively applied for design and as a diagnostic variable to show runoff creation in catchments. Event runoff coefficients may also be applied in event-based developed flood frequency models that measure flood frequencies from rainfall frequencies and are valuable for recognizing the flood frequency controls in a specific hydrologic or climatic regime. Only a few previous studies worked on hydrological systems and processes deeply at catchment scale. Also in many catchments because of lacking data sets, analysis of land use change and water management and risks causes uncertainty in predictions of hydrological processes can be decreased. This problem is more important for predicting hydrology of ungauged basins in developing countries. The purpose of this study is to review predicting hydrology of ungauged basins.

**Keywords:** runoff coefficient estimation, catchment, hydrology, surface

## 1 Introduction

The definition of runoff coefficient is the portion of rainfall that turn into direct runoff throughout an occurrence, and it is a significant perception in engineering hydrology and is extensively applied for design and as a diagnostic variable to show runoff creation in catchments. Event runoff coefficients may also be applied in event-based developed flood frequency models that measure flood frequencies from rainfall frequencies and are valuable for recognizing the flood frequency controls in a specific hydrologic or climatic regime. Only a few previous studies worked on hydrological systems and processes deeply at catchment scale [1, 2]. Also in many catchments because of lacking data sets, analysis of land use change and water management and risks causes uncertainty in predictions of hydrological processes can be decreased. This problem is more important for predicting hydrology of ungauged basins in developing countries [3, 4]. The purpose of predicting hydrology of ungauged basins is to develop hydrology models for basins with insufficient or no data, therefore the uncertainty in prediction can decrease. Most of the models are usually based on realizing the hydrological operating systems for various landscapes in several climate conditions, instead of model calibration.

Measuring of predicting hydrology of ungauged basins and then basin inter-comparison are significant aspects of hydrological working efforts.

Evaluating rainfall and discharge for short time period is easy and needs low cost. Information about hydrology system depends on studying rainfall and runoff data from a series of rainfall events. With time series of a length of at least one year, estimation of the annual water budget in most hydro-climatic regions can be gotten. One parameter that can describe the water budget is runoff coefficients which shows the general reaction of the catchment to rainfall (with using flow event). Also some other parameters which depend on this process and rainfall input (such as peak flow rates, lag times, response times) can extract from hydrograph.

By estimating the runoff coefficient for single event (event-based runoff coefficients), more information about watershed response can get. By calculating the changes in runoff coefficient values for different events and various seasons, the hydrological functioning of the catchment under different conditions can be estimated.

In order to realize how various landscapes transform rainfall into event-based runoff, the runoff coefficient can use for different catchments. Then, the observed differences by basin characteristics and related runoff mechanisms should explain and analyze.

By comparison the values of runoff coefficients with coefficients estimated for well understood catchment characteristics, more information about hydrological processes can be gotten. In some catchments such as Malalcahuello catchment in Southern Chile, the value of the event-based runoff coefficient which estimated, is very low (coefficient runoff (CR) $< 2\%$), because of the extremely high porosities of volcanic ash soil and the lack of anthropogenic effects such as soil compaction [5, 6].

For estimating the runoff coefficient, separating the event hydrograph into two elements (*e.g.* baseflow and direct/event flow) is necessary. The estimation of runoff coefficient depends on different types of the separation techniques.

Between the various types of separation methods, tracer-based methods [7, 8] can provide the most realistic results. However, tracer-based methods are difficult and costly, so, there is limitation for small number of events and catchments to use the methods.

Actually, the number of events is very small, so statistical analysis also is very difficult.

Determining the end point of event flow and the interpolation of the base flow hydrograph during the event with using further methods like graphical methods and digital filters, is not easy.

So the aim of this chapter is to determine event runoff coefficients for the investigation of rainfall–runoff response with different conditions.

Because of uncertainty of the terminology and multitude of methods that can be used to determine runoff coefficients, so the objectives of this chapter are:

1) To suggest a strong hydrograph separation method. The method must permit for the purpose and feasibly programmed determination of the end point of event flow. Also the method should have ability to consider events with multiple peaks. In addition, the method should be based on hydrological concept easily, specifically the theory of linear storage (regularly applied for modeling base flow in conceptual hydrological models).

2) To represent how various techniques of hydrograph separation can make several runoff coefficients for different events.

# 2 Concept and descriptions

## 2.1 Runoff coefficients

The runoff coefficient usually is applied as a parameter which shows catchment response annually or catchment response for a specific event.

Annual runoff coefficient can show overall runoff over full precipitation (*e.g.* on an annual percentage of precipitation that is not used for evapotranspiration, or for storing in groundwater) [9, 10], or total quick flow over total precipitation (percentage of fast response) [11, 12].

However, the terminology of the runoff coefficient is vary in the scientific literature and runoff coefficient defined in different methods. The definition of the runoff coefficient depends on the aim of a research. For example, in the study by Javadinejad *et al.* [13], the parameter is known as a response factor, but in Javadinejad *et al.* [14] it is known as hydrologic response, in Javadinejad *et al.* [15] event-based runoff coefficients (in technical terms) defined using either the ratio of overall flow to whole rainfall, or, afterward hydrograph separation, it means the percentage of event-flow volume over whole rainfall, *i.e.* the ratio of the rainfall quantity that creates runoff throughout, or immediately after, a rainfall happening [16, 17].

During high base flow circumstances, using total flow can cause higher runoff coefficients. Sometimes, the runoff coefficient in this condition is known as water yield [18, 19] introduced the runoff coefficient as new water contributing portion of a watershed.

In previous works such as Javadinejad [20] and Mirramazani *et al.* [21] the ratio of runoff which comes from total precipitation named conversion efficiency.

As explained above, there are various names and definitions for the runoff coefficient. Therefore, it causes some confusions and comparison of the results from several studies is not easy.

Sometimes runoff coefficient refer to the overall flow or quick flow as a portion of precipitation, however, some other hydrology parameters describe the similar definition.

In a research, the ratios for runoff coefficients defined where the denominator contained through fall instead of overall precipitation [22, 23].

In another study, runoff coefficient expressed the fraction of rainfall and snowmelt which flows off as rapid flow [24].

Runoff coefficient values depend on soil and land use which formulated in rational method. The values described the ratio of runoff to rainfall roughly. Nevertheless, when considering the rational method formula (Eq (1)), it showed clearly that C is equal to the percentage of particular peak runoff (mm h-1) to rainfall intensity (mm h-1), as the basin area A (km$^2$) and the conversion factor F simply transfer discharge (m$^3$ s$^{-1}$) to specific discharge (mm h-1). In this case, no hydrograph separation leads the calculation:

$$QP = F \times C \times i \times A \quad (1)$$

Where QP shows peak discharge (m$^3$ s$^{-1}$), C represents a runoff coefficient, and i displays rainfall intensity (mm h-1).

In this chapter, event-based runoff coefficients are defined as the ratio of event flow over whole precipitation.

Using event flow rather than total flow can help for examining rainfall-runoff response for a single event, whereas using total flow would mix the response of the single event with the pre-event flow circumstances, being high flow in the wet season or low flow throughout summer.

Javadinejad *et al*. [25] estimated runoff coefficients for many plot and catchment studies for overland flow which controlled hydrology systems or subsurface storm flow which controlled systems and where both mechanism are significant.

In regions creating runoff as subsurface storm flow and saturation overland flow, it is not easy to select a description of storm runoff coefficient, and several researches used various descriptions.

Estimating direct runoff is very important and direct runoff can separate from base flow by different techniques. In one case, direct or event flow contains simply of the rainwater of the specific event, in another case, event flow also includes fast subsurface responses and, so, is a combination of "old" and "new" water [26].

Direct runoff is usually known as a fraction of individual storm rainfalls. However, because there is no universal and standard hydrograph separation method, so, understand the runoff coefficient for a watershed system is difficult. Therefore, estimation of the runoff coefficients based on the several separation techniques.

## 2.2 Hydrograph separation

In order to estimate runoff coefficients for particular happenings, separated event flow from base flow is necessary. However, understanding the term of the base flow is not easy.

In one study, base flow described as groundwater exfiltration from surface aquifers which is greater in dynamics and variation than the slow flow elements deliberated as base flow in traditional flood hydrology [27, 28].

Javadinejad *et al*. [29] investigated differences among the engineering explanation for base flow as basic dry weather runoff (which depends on groundwater discharge and system analysis for slow flow) and the scientific explanation for base flow as old flow which is related to tracer analysis.

In this chapter, the definition of flow is same as "event flow" which also Javadinejad *et al.* [30] described well. It means the flow that can be related to a particular event. In addition, base flow in this chapter means flow that cannot be related to a specific event, *i.e.* agreeing to the "base line" of flow.

Event flow does not need to create directly from the rainfall input of this particular event, however, it is possible to be a combination of elements (surface runoff, interflow, quick groundwater response which develop as runoff, being a direct response to rainfall input throughout the storm event.

As indicated before various separation methods can use:

(1) Graphical methods (as defined in Javadinejad *et al.* [31];

(2) Algorithms/digital filters [32];

(3) Analytical solutions to base flow recession [33].

All of these three techniques are conditional on two important complications: (1) recognizing the point in time while event flow ends and stream flow contains fully of base flow and (2) the development or interpolation of the base flow hydrograph throughout the storm occurrence.

There is no physical basis in many hydrograph separations. Javadinejad *et al*. [34] mentioned that just a small number of graphical and filter methods performed with a physical basis and only throughout stream flow recession.

Thus, selecting one or more method creates an unattractive component of vagueness and unpredictability into the examination and contrast of runoff coefficients.

In this chapter, the flow time concentration and exclusive separation of occasion hydrographs by natural tracers for example environmental isotopes and geochemical constituents have not been considered deeply, in spite of the fact that this is possibly the single method to examine runoff elements accurately [35]. This study concentrated on a graphical method which usually applied by researchers that worked in basin investigations for whom hydrograph separation is not the aim of the examination however only a means to estimate runoff coefficients as a particular factor for describing of the basin.

### 2.3 The recession curve

Safieh *et al*. [36] reviewed on base flow recession analysis very deeply. Also Javadinejad *et al*. [37] provided a clear overview of techniques applied for hydrograph examination. Estimating the end of storm runoff is one of the complicated points of base flow separation. It is difficult to understand the point on the decreasing limb of the hydrograph (on the recession curve) quick flow end and base flow start to take over. It is possible to estimate this point only by examining the recession curve.

Hydrodynamic possessions of the aquifer, geological and geomorphological features, the features of the soil horizons (*e.g.* thickness, saturation) and also climate can affect the form of the recession curve [38]. Aguilar *et al*. [39] mentioned that the recession curve divided into the linear elements of surface, unsaturated and saturated flow traditionally. The elements have to show several flow paths in the basin. Each element distinguished through several residence times.The outflow speed of groundwater flow from a basin being smaller than the recession speed of the other flow elements. Alcamo *et al*. [40] obtained the basic nonlinear differential equation leading passing flow from an unconfined aquifer to a stream.

The linearized version of this equation, supposing that vertical flow elements and capillary influences overhead the water table are insignificant, is usually named the Dupuit-Boussinesq equation (or sometimes known as the Maillet equation) and takes the following form:

$$Q(t) = \ Q0 \ \times exp\ (-kt) \tag{2}$$

Where *Q(t)* shows discharge at time *t* ($m^3$ $s^{-1}$), Q0 displays discharge at start of recession ($m^3$ $s^{-1}$), and *k* represents the recession coefficient (L $s^{-1}$).

Also Ali *et al*. [41] presented a nonlinear solution, however more appropriate mathematical possessions of the exponential equation can use for the explanation of base flow recessions and Eq 2 is explained the base flow recessions [42].

## 3 Materials and methods

So as to measure runoff coefficients for particular events, this chapter separated event flow from baseflow. Regarding to the term "runoff coefficient", the term "baseflow" is an uncertain term. Baseflow can be described as groundwater exfiltration from shallow aquifers, which is greater in dynamics and variation than the slow flow factors measured as baseflow in traditional flood hydrology. Whereas in the former case, direct or event flow contains only of the rainwater of the specific event, in the latter case, event flow also includes fast subsurface responses and, thus, is a combination of "old" and "new" water.

The methodology of this chapter shows the fact that, normally, event-based runoff coefficients can be estimated by applying total flow, or event flow as a portion of total precipitation. In event flow, the essential prior estimation of the event flow by hydrograph division furthermore rises the uncertainty of this term, as various techniques of hydrograph separation consequence in several amounts of event flow. The uncertainty from the numerous several techniques of base flow separation should consider remarkably.

### 3.1 Base flow separation and runoff coefficients

Runoff coefficients can estimate by:

$$CR = \frac{event\ runoff\ (mm)}{areal\ precipitation\ (mm)} \tag{3}$$

Different graphical separation methods [43], with the simple "straight line" division and a recently advanced method can apply in order to estimate event runoff.

## 4 Novel technique of base flow separation: the constant-*k* method

As explained above, there is no physical basis in interpolating the base flow hydrograph, as well as in determining the end of event runoff of the graphical separation methods.

  

The semi-logarithmic method (SLog) based on a physical basis for the end point estimation, however at the same time presents a particular degree of subjectivity. Recently developed technique is based on the theoretically conceptual and objective in the estimation of the end point, however the interpolation point of the base flow hydrograph depends on non-physically parameters.

With consider to the hypothesis that the groundwater/base flow storage is linear, the base flow recession curve is assumed to decrease dramatically.

In estimating the recession coefficient, *k*, of the exponential function in equation (2) for each point on the hydrograph, it is likely to recognize the point in time, *te*, after which *k* shows roughly to be constant.

Thus, *te* can describe the end of event runoff and k (min-1) can be calculated for all points by differentiating equation (2):

$$\frac{dQ}{dt} = -K \times Q(t) \tag{4}$$

and next dividing by *Q(t)*:

$$k = \frac{dQ}{dt} \times \frac{1}{Q(t)} \tag{5}$$

In the situation where *Q* gets zero in low flow circumstances, *k* becomes extremely sensitive to very minor alterations in *Q*. In order to decline this sensitivity of *k* with regard to the baseline of *Q*, all happenings are standardized with regard to pre-event *Q* and therefore their baseline. This adapted baseline is selected to be the yearly mean discharge (0.4 $m^3$ $s^{-1}$).

Nevertheless, applying equation (5) with this modified time series of discharge did not include in the calculation of *k* (the real recession coefficient), however that of *k** (the stabilized recession coefficient) is included in the equation. This adaptation is feasible, as the particular value of *k* is not of interest here, however rather its development over time.

The hydrograph for a given occurrence and also principles for *k** and the 2-hour moving average of *k** are presented in Figure 3. In the following step, the slope of a regression line of *k** can be estimated for each data point across the episode of the following five hours.

The end point of event flow, *te*, is described as the point where the slope of *k** becomes roughly zero (± 10-7 $min^{-2}$), it means the point where *k** becomes persistent.

It is too hard to select the exact value zero for this standard, as *k** tends to oscillate a little, even at late times. The cut-off value of 10-7 $min^{-2}$ is usually two to three orders of quantity smaller than greatest slopes.

The interpolation of the base flow hydrograph among the initiating of the occurrence and the estimated end point of event flow is random and implausible to come near to actuality (tracer-based hydrograph separations often consequence in hydrographs of pre-event water which are alike in form to the storm hydrograph).

Nevertheless, as replicating the actual base flow (or pre-event water) hydrograph is not possible, an easy, objective technique of interpolation appears suitable.

Thus, the simplest technique-the straight line, supposing constant base flow with the rate of the pre-event discharge-is applied.

## 4.1 Linear statistical model

In order to examine runoff progressions without additional field operations and detailed modelling interrelationships between event runoff coefficients and different factors defining input rainfall and hydrograph features examined. This can be achieved through correlation matrices (Hastie and Chambers, 2017), or by statistical models (McCuen, 2016) which applied for forecasting storm flows.

Linear statistical models can examine with the logit-transformed CR (equation (6)) which include the response variable and several parameters defining the input rainfall or hydrograph features as feasible predictor variables.

The logit transformation of *CR* is essential as the values of *CR* limited between 0 and 1, whereas the transformed principles arrange between $-\infty$ and $\infty$. Lacking this transformation, a linear statistical model could forecast nonsensical event runoff coefficients minor than 0 or greater than 1.

The logit transformation is defined through the equation in below:

$$CR\,trans = \ln\left(CR/\,1 - CR\right) \tag{6}$$

Probable forecaster variables were overall precipitation, pre-event discharge, quantity of precipitation throughout the first two hours of the occurrence, highest hourly precipitation intensity, average hourly precipitation intensity, period of precipitation, response lag, lag times among precipitation and runoff centroids as well as end points.

With consideration of the importance of forecaster variables and the model's goodness of match defined via *R2*, the best model can be selected and its functioning assessed through "jack-knifing".

Jack-knifing permits one to renovate the model whereas, in turn, releasing one input value after the other. Finally *n* models (*n* shows the size of the sample applied to build the model) is the outcome of this process.

Then each of these models can be applied in order to forecast the particular value left out through the model calibration.

Therefore, it is likely to justify a model with no necessity for further data. Model functioning can then estimate via its Nash-Sutcliffe efficiency:

$$NS = 1 - \frac{\Sigma(CR\ obs - CR\ mod)2}{\Sigma(CR\ obs - CR\ obs)2} \tag{7}$$

(where *CR*obs shows observed runoff coefficients, *CR*mod displays modelled runoff coefficients, and obs *R C* represents the mean observed runoff coefficient), as well as by its mean absolute error (MAE) and its mean absolute error (in percent) (MAEP):

$$MAE = \frac{1}{n}\,\Sigma\,(CR\ obs - CR\ mod) \tag{8}$$

$$MAEP = \frac{1}{n}\,\Sigma\,(\frac{CR\ obs - CR\ mod}{CR\ obs}) * 100 \tag{9}$$

# 5 Results

The graphical separation methods, the "straight line" separation and the novel method are presented in Figure 1-3.

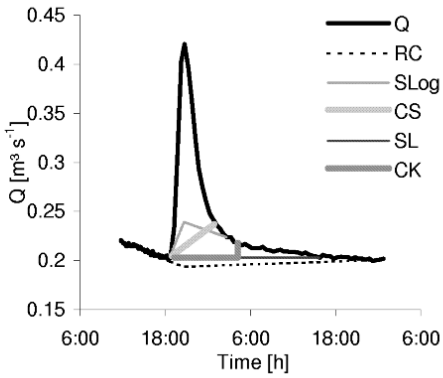


**Figure 1** Methods of hydrograph separation containing the new CK method(RC: recession continued; SLog: semi-logarithmic plot; CS: constant slope, SL: straight line, CK: constant-k method) [44]

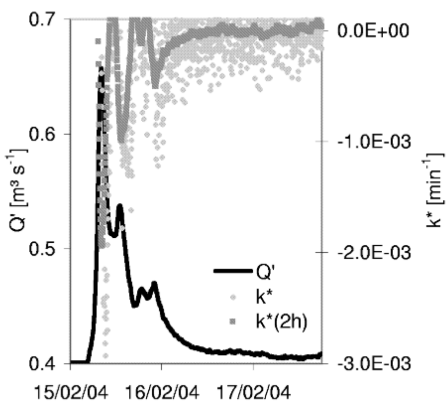


**Figure 2** Constant-k technique: estimation of k* and its 2-h shifting average for each data point; Q' = discharge with adapted baseline (0.4 $m^3\ s^{-1}$ for all events) [45]

  

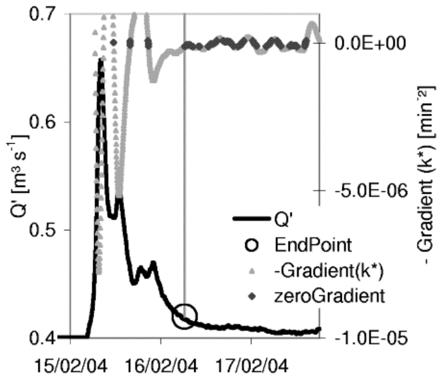


**Figure 3** Constant-k technique: estimation of the slope of k* (here represented as negative principles for better visualization), points of zero slope and the consequential end point of event runoff; Q' = discharge with adapted baseline (0.4 $m^3$ $s^{-1}$ for all happenings) [47]

The graphical separation methods include different methods which are explained below:

(1) For the first technique (RC), the recession before the event is continued under the peak and then linked to a point on the hydrograph *N* days after time of peak with *N* = 0.827 × *A*0.2 and *A* as the drainage region in km2 [43].

(2) For the second technique (SLog) the hydrograph is plotted semi-logarithmically, a straight line is matched to the end of the recession curve, transmitted back to the arithmetic plot and then applied to project the recession backwards under the peak. This point is then linked to the beginning point of the increasing limb [45].

(3) The third method (CS) applies a line with a persistent gradient of 0.05 (ft3 $s^{-1}$) × *A* (mi2) per hour, which is equal to 1.415 × 10-3 ($m^3$ $s^{-1}$) × 2.59-1 × *A* (km2) per hour, linking the first point of rise with the point at which it interconnects the recession curve [46].

(4) The straight line technique (SL) easily links the point at which discharge first rises with the point on the recession curve of equivalent discharge.

(5) The newly developed method (CK) is described in the following section.

# 6 Discussion

All computations linking to the functioning of rainwater catchment systems and rainwater harvesting in a catchment contain the applying of runoff coefficient to account for losses because of spillage, leakage, infiltration, catchment surface wetting and evaporation, which will all participate to decreasing the amount of runoff. Runoff coefficient for any catchment or basin is the ratio of the volume of water that runs off a surface to the volume of rainfall that falls on the surface, so, it is very important for calculating water harvesting.

Although comparing runoff coefficient seems to be easy and standard approach to assess, however, differences in rainfall runoff responses for various study areas and various time, so calculating runoff coefficient in terms of terminology and methodology is very difficult.

Usually the estimation of runoff coefficients depends on hydrograph separation that can analyze the event response from background flow.

In this chapter, different graphical separation techniques compared. Usually, the recession coefficient *k* for a given event cannot be a constant until at the end of event. Though, if it becomes a persistent at late times, one can contemplate late-time recession as outflow from a linear storage, a normal conceptualization applied in numerous meso-scale hydrological models [48]. It is very important to understand the data to describe the point where *k* becomes persistent (*te*) as the point where event flow stops and base flow overcomes. The novel developed technique includes three important benefits: (1) it is as a minimum partly hypothetically based; (2) it is not affected from a subjective estimation of the end point of event flow, (for instance the SLog technique can also be applied with multiple peak events); (3) It does not need further information about the development of base flow between the starting and finishing of the occurrence flow. Also the routine of the method can automate simply and permitting for quicker data dispensation in the case of greater data sets. The relative variation of runoff coefficients can estimate via different separation techniques relates on hydrograph shape significantly.

Recognizing the great variation of "separation techniques" causes the suitability of inter-comparison of runoff coefficients appears unconvinced, because they can be estimated through various techniques.

The linear statistical model usually represents that simple inter-relationships can be applied to forecast runoff coefficients with remarkably good outcomes. In order to get good result, the model must not apply outside of the range of rainfall and discharge amounts.

The predictor variables which can make the best model functioning can develop our knowledge of the basin and its response to precipitation. For calculating runoff coefficient overall rainfall and pre-event discharge are very significant factors. Runoff coefficients can rise with full rainfall [49].

Normally, more precipitation makes greater fraction of event flow throughout the event, however, it is not meant that it is the precipitation water lonely which moved to the stream (something that can happen during the overland flow). Because increasing groundwater tables, groundwater mounding (rising hydraulic slopes), pipe flow, and saturation overland flow can cause the happening. Nevertheless, in some basin, because of the very high porosities and also hydraulic conductivities of the volcanic ash soil, overland flow cannot happen (Chen *et al.*, 2019).

If there is positive correlation of pre-event discharge, so it can show that this parameter can be a good indicator of a given basin state prior to precipitation. Recognizing pre-event discharge can define groundwater and soil water storage and related to the temporariliy active runoff progressions.

Previous studies such as Bronstert *et al.* [50] did not find that rainfall intensity can influence on storm runoff significantly, however, linear statistical model for runoff coefficient can display the effect clearly and also can represent that with using *P*IntMax parameter(the parameter which can describe the hydrograph and its relationship to input rainfall *e.g.* peak flow rates, lag . . . performance by adding the PIntMax parameter), the model can be developed remarkably [45].

In order to characterize the various precipitation, highest station rainfall can be as proxy for the characteristics.

The purposes and aspects of estimation of runoff coefficient, in the basins with no available data are very important. Because normally rainfall and runoff are the initial parameters that need to estimate for the ungauged basins. Understanding the catchment response to rainfall for a few events for a region is compulsory. Therefore, event based runoff coefficients are the initial parameters that can be extracted from the short time series and contain the initial information on rainfall runoff response of a basin with insufficient data. The technique of linear statistical model for runoff coefficients can apply in order to understand runoff progressions. Also the method is suitable for a basin with insufficient data. Nevertheless, in order to gather an adequate number of rainfall happenings, at least some months of higher-resolution discharge and rainfall data are required.

With further data (such as hydrology or soft data like observations of local residents, physics of the soil) which can collect on a given field, the better statistical analysis and results can get. Nevertheless, event-based runoff coefficients may not compared if their estimation have been done by using several techniques of hydrograph separation. In addition, it is not possible to recognize a systematic level or interdependence of runoff coefficients estimated with various hydrograph separation techniques. Therefore, the estimation of bias that can modify for retrospectively is difficult.

It should be noted that a standard process of base flow division and estimation of runoff coefficients can develop the possibilities of basin inter-comparison with regard to their precipitation reaction. Actually a standard process must be demonstrable and permittable for quick and simply automated division and also it must be appropriate to happenings with various peaks. Event-based runoff coefficients which related to standard process can permit for basin grouping with regard to runoff reaction and for judgment of runoff progressions. It should be noted that catchment classification can assist to choice of model for forecasting the hydrology processes in ungauged catchments. Because of lack of data in many catchments in the world, the probability of catchment inter-comparison can develop understanding of runoff origination in the catchment and also can help to understand hydrological similarity as an occasion of the precipitation circumstances and the bio-physiographic setting of the landscape, like soils morphology, and vegetation cover.

# 7 Conclusion

Overall, monthly and annual runoff coefficient can get from various techniques. These techniques can make information like the period of runoff, its amount, runoff coefficient variation with time, etc. Furthermore, they provide a common basis for many qualitative interpretations about catchment responses to precipitation. Also this work can make the basis for explaining the method for runoff coefficients for ungauged catchments. It shows that a geological framework, including detailed information on the degree of secondary permeability and spatial organisation of the lithological units, provides a useful basis for interpreting the distribution of runoff coefficients in many regions. This chapter provides explanation that suggests that progress toward resolving the problem of predicting flood response (with calculating an important parameter of runoff coefficient) in ungauged basins can be made by explicitly structuring the analysis of streamflow using climatic information and geo-hydrologic landscape types. However, the information about hydrologically-relevant characteristics of the geological formations is only rarely available at the regional scale. Results from this chapter suggest that a major task within the predictions in ungauged basins initiative may be to characterize these geo-hydrologic landscape types and to evaluate their relationships with flood regimes.

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