A Survey Paper on Prediction of Runoff for Ungaued Catchment

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Abstract— **An efficient accurate prediction of watershed runoff is important for watershed management studies, safe yield and design of flood control structures. The relation between rainfall and runoff at the watershed scale is one of the important problems faced by hydrologists and engineers. The runoff generation process is known to be highly nonlinear and complex. In addition to rainfall, run off is dependent on numerous factors such as initial soil moisture, land use, watershed geomorphology, evaporation and infiltration. Rainfall-runoff relationship is further complicated by uncertainty in parameter estimates, heterogeneity in rainfall, soil properties and spatial variability of hydrologic components. Since extensive instrumentation of a watershed is very costly and impractical, engineers are often faced with little or no information to make predictions.**

Keywords: prediction, rainfall-runoff,ungaued catchment

I.INTRODUCTION

The difficulty in estimating model parameters a-priory through measurement and the ultimate necessity of model calibration against observed catchment responses has a serious practical consequence. The non-uniqueness of the model parameters estimated through model calibration makes it difficult to associate any of the parameters with the readily measurable physical catchment characteristics. Therefore, the parameters may partly loose their physical significance; even though they have physical meanings in the model structure they are used in. This, consequently, limits the transferability of the model parameters to other catchments based on physical properties of the catchments. The model should then be calibrated separately for each catchment for which prediction of the catchment response is sought. Since model calibration needs one or more observed response data, application of the model to ungauged catchments will be difficult.

Prediction of the impact of changes in the catchment properties, like land use, on the response of a catchment also requires quantification of the model parameters corresponding to the changed catchment properties. Unless there is a relationship between the model parameters and the catchment properties, such quantification cannot be done in a physically meaningful way, thus limiting the applicability of the model for prediction of the effect of changes.

In order to address the problems mentioned above, several studies have been made during the past years in an attempt to develop schemes of regionalization of model parameters, based on readily measurable physiographic, land cover, and climatologically attributes of catchments. Many of the works in the earlier days were focused on developing a means of relating event based catchment responses with rainfall and topographic factors using a multiple regression approach (Heerdegen and Reich, 1974; Waylen and Woo, 1984; Nathan and McMahon, 1992).

Recent works, however, have been focusing on development of a regionalization scheme to estimate the parameters of a more general class of continuous water balance models of time scales ranging from monthly to hourly from readily measurable catchment properties. Abdulla and Lettenmaier (1997) applied a method of regionalization of the parameters of the VIC-2L land surface hydrologic model (Liang et al., 1994) for the construction of daily stream flow for catchments in the Arkansas-Red River basin based on distributed land surface characteristics and climatologically characteristics derived from station meteorological data. Sefton and Howarth (1998) also employed a similar parameter regionalization scheme for the IHACRES model (Jakeman et al., 1990; Littlewood et al., 1997) to estimate daily flows for catchments in England and Wales using physical catchment descriptors indexing topography, soil type, climate, and land cover. Some more similar works are documented in Xu and Singh (1998) for estimation of monthly flow, Post and Jakeman (1999), and Seibert (1999).

All of the parameter regionalization approaches mentioned in the foregoing paragraph follows a general two-step procedure of parameter regionalization. The first step is to find optimum sets of parameters for a number of gauged catchments by calibrating the model against observed responses for each of the catchments independently. The second step is trying to establish a relationship between the optimum model parameters and the catchment characteristics. In many previous studies, this has taken a linear or non-linear regression form. However, such an approach has met with limited success. As mentioned in the previous section, model calibration results in only one realization among many other possible parameter sets that lead to a similar model performance. The relationships established between such set of model parameters and the catchment characteristics are therefore likely to be weak or “random”.

Fernandez, et al. (2000) implemented a different approach that would take care of the problem cited above. Instead of following the two-step procedure implemented in the previous studies, they treated them concurrently. They calibrated the “abcd” monthly water balance model (Thomas, 1981) for 30 gauged catchments in the South eastern part of the US with the dual objective of reproducing the observed catchment response and, additionally, to obtain good relationships between model parameters and catchment characteristics. Their approach resulted in a nearly perfect regional relationship between model parameters and catchment properties, but didn’t lead to improvement in the ability of the regionalized model to model stream flow at validation catchments located within the same study area. Unfortunately, many of the catchment descriptors they used for regionalization require analysis of stream flow data and, therefore, its application to ungauged catchments is not possible.

Most of the watersheds in Indian continent are ungauged and do not have the measured values of either rainfall or runoff data. On such circumferences researchers established relationships among the parameters of the models developed for gauged catchment with the physically measurable watershed characteristics. These relationships are then assumed to hold for ungauged watershed having hydro-meteorologically homogeneous characteristics. Rainfall-runoff relationship developed for ungauged catchments can be partitioned into

- Relating the hydrograph characteristics (peak flow rate, base time, etc.) to watershed characteristics (Snyder, 1938; Gray, 1961).
- Based on dimensionless unit hydrograph (Soil Conservation Service, 1972).
- Based on models of watershed storage (Clark, 1943) and
- Based on geomorphology of the watershed (Rodriguez-Iturbe et al., 1979).
- A comparison between the results obtained by geomorphologic model and hydrologic model with was made under the effort to identify their practicability to the study are.

II. LITERATURE SURVEY

Conceptual models contain parameters that may be determined from either rainfall-runoff data or physically measurable watershed characteristics. Therefore, an attempt has been made to establish relationship between model parameters and watershed characteristics. Rainfall-runoff relationship for ungauged catchments has been developed along two complementary lines: (1) Empirical equations have been developed to relate some individual runoff hydrograph characteristics to watershed characteristics. These characteristics can be partitioned into (a) time characteristics (b) discharge characteristics. (2) Procedures have been developed to synthesize the entire runoff hydrograph from watershed characteristics. These procedures or models are either linear or non-linear in character.
Review of literature is important in any research work. Many researchers have carried out research work in the area of models based on geomorphologic and hydrologic characteristics. There are many methods in modern-day hydrology that could be used to calculate geomorphologic and hydrological characteristics at ungauged sites. In the present study literature review carried out in two parts which consist of geomorphologic characteristics of watershed and analysis of hydrograph. Each of this part is discussed in following sections.Review of literature is important in any research work. Many researchers have carried out research work in the area of models based on geomorphologic and hydrologic characteristics. There are many methods in modern-day hydrology that could be used to calculate geomorphologic and hydrological characteristics at ungauged sites. In the present study literature review carried out in two parts which consist of geomorphologic characteristics of watershed and analysis of hydrograph. Each of this part is discussed in following sections.

2.1 Literature Review of Geomorphologic Characteristics of Watershed

The development of relationship between geomorphologic characteristics and the hydrological variables serve as a useful tool to determine the hydrologic response of the basin. Geomorphologic techniques have recently been advanced for hydrograph synthesis provided a new dimension to hydrologic simulation. The approach coupled the empirical laws of geomorphology with the principles of linear hydrological system. Based on the interaction of geomorphology development and runoff generation, Horton (1945) argued that studying this interaction would lead to an understanding of watershed response to precipitation. However, it should be noted that the relaxation time scale of watershed geomorphologic structure is much longer than the response times due to individual hydrologic events. Therefore, watershed geomorphologic characteristics can be considered constant for runoff prediction. The geomorphologic approach suggests that watershed morphology has a dominant control on the temporal pattern of the stream flow hydrograph and should be taken into account in hydrologic prediction. The geomorphologic development of watersheds results in river networks exhibiting specific spatial structure. Many investigators have tried to relate the instantaneous unit hydrograph (IUH) parameters to the geomorphology and thus to obtain the geomorphologic instantaneous unit hydrograph (GIUH).

2.1.1 Literature Review of Analysis of Hydrograph

If actual input (hyetograph) and output (hydrograph) data are available, the transformation can be analyzed by a variety of hydrologic models many are relatively simple, others complex. This kind of examination is called analysis. If one of the two data streams is missing then the activity of predicting behavior is called synthesis. A great deal of engineering design relies on synthetic methods (i.e. estimating behavior without data). Usually in hydrologic studies the missing element is the discharge hydrograph for the reasons already explained, this hydrologic variable is far more difficult to collect than rainfall.

III. CONCLUSION

The success of applying model depends on how accurate the parameters (‘‘n’ and ‘k’) are estimated. However method of moments was considered as a basic one. Even though the large number of methods are available, none of the method have succeed in predicting the important hydrograph features like peak, time to peak and total discharge.. The practice of flow estimation at ungauged sites in India could benefit from improved access to already collected observed .

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