INTERCOMPARISON OF REAL-TIME HIGHFLOW FORECASTING MODELS FOR YAMUNA CATCHMENT

by

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CERTIFICATE

This is to certify that the thesis entitled, 'Intercomparison of Real-Time High-Flow Forecasting Models for Yamuna Catchment' being submitted by A.K.Gosain, to the Indian Institute of Technology, Delhi for the award of the degree of Doctor of Philosophy, is a record of bonafide research work carried out by him under my guidance and supervision. In my opinion, the thesis has reached the requisite standard fulfilling the requirements of the regulation relating to the said degree. The material contained in this thesis has not been submitted, in part or full, to any other University or Institute for the award of any degree or diploma.

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SYNOPSIS

Real-time flood forecasting is an important non-structural method which can be utilized for reducing flood damages. Two important aspects of a forecast are its accuracy and its lead time. An accurate flood forecast well in advance can help the water managers in taking emergent actions to mitigate some of the adverse effects of flooding. The accuracy of the forecast depends mainly on the capability of the model to represent the system. On the other hand the forecast lead time depends primarily on the physiography of the catchment and on the telemetry of the input components essential for using the model. Therefore, the latter component, i.e., the forecast lead time, remains fixed for a catchment with a given hydrometeorologic/hydrometric system until and unless the system is updated to improve the information on input, e.g., the forecasted values of precipitation and/or runoff are used in the model.

The need for accurate and relaible forecasting has resulted in the development of variety of models. These models vary from very simple models based on simple correlation diagrams to the complex conceptual models of Stanford Watershed Type. Quite often, the availability of innumerable models for short-term forecasting creates difficulty for the user in choosing appropriate model.

This difficulty of the users was realised and the WMO proceeded with an evaluation and intercomparison of a specific category of models, viz., conceptual hydrological models used for short-term streamflow forecasting (WMO,1975)). Besides conceptual models, there are many varieties of models used for the purpose of short-term streamflow forecasting. But, so far, no attempt has been made to carry out an inter-comparison of these various categories of models. So it is decided to undertake such a study. In order to carry out this study three models, which belong to different categories and are commonly used, are selected. These being, a model based on unit hydrograph theory which is developed for the purpose of real time forecasting, an ARMAX (autoregressive moving average with exogeneous input) model and a conceptual model.

The first one, the UH (unit hydrograph) model, as name suggests, is based on unit hydrograph theory. Traditionally the unit hydrograph method required the availability of effective rainfall for its application. But in real time it is not feasible to fulfil this requirement. So, a procedure is developed whereby the total rainfall values and the current discharge information is used to compute the rainfall excess. The rainfall excess is convolved with the unit hydrograph to obtain the forecast hydrographs. The parameters of the model, i.e., the unit hydrograph ordinates, remain fixed but the updating is done through changing the rainfall excess.

The second one, the ARMAX model is a stochastic model. The models of this category postulate that the future values of runoff at a point can be expressed in terms of some finite number of current and past values of runoff and rainfall. The data required for this model are the total rainfall, observed runoff and observed inflows (if required). The main features of this model are the simplicity in structure and the adaptability to upgrade the parameters.

The third model is a conceptual watershed model known as NWSRFS (National Weather Service River Forecast System) model. The model has many components but for this study only two of its components, i.e., the soil moisture accounting and runoff routing components have been used. The programme has been modified to run in real time forecasting mode. The soil moisture accounting portion of NWSRFS involves seventeen parameters. All these parameters have real physical significance and most of them can be evaluated from the past historical data whereas the others can be evaluated through calibration. As the model is deterministic the parameters are not supposed to change once calibrated but in this study, provision is made to account for the variability of rainfall by changing the time delay histogram.

The three models described above are used on an Indian catchment, namely, Yamuna catchment for the purpose of inter-comparison. The raw meteorological and hydrological data as available are not suitable for use as such in the models. The raw data have been processed, analysed and checked before it is utilized. This itself is an extensive project and is described adequately in the study. Once the data base as required collectively by these three models is ready, split sample procedure is used to divide the data into calibration and test data sets. The parameters of the models are determined using the calibration set. For example, the unit hydrograph required by the unit hydrograph model is derived, the order of the ARMAX model is determined, and the NWSRFS model is calibrated to evaluate the model parameters. The test set data is used to run the models in real-time forecasting mode.

The models belonging to different categories should be compared with respect to certain common criterion. In this study two criteria are used, one based on the accuracy of the forecasts and another based on the user's requirements of the model. With respect to the second criterion, Chander and Kumar (1982) have suggested certain attributes to assess different types of models used for real time highflow forecasting. The attributes suggested by them are:

1. The model should be able to formulate a forecast of the desired quality with maximum lead time.
2. It should have the ability to update the parameters on the basis of the observed errors in the earlier forecasts.
3. The model should preferably be capable of operation with interrupted data sequences as forecasts may be needed only at highflows.
4. The requirement of the model in terms of computer storage should be as minimum as possible as it is more likely that the small computer systems are only available at the forecast sites.
5. Development and operation of the model should be possible with limited hydrometric/hydrometeorologic data as very limited data becomes available in extreme situations.

The capability of a forecast model can best be judged by its ability to formulate an acceptable forecast with maximum lead time. The three models have been compared with respect to the graphical and numerical criteria. This comparison reveals that with this criteria all the models on the whole perform equally well.

A comparison is also made with respect to the attributes which a general user desire the model to possess. With respect to this criteria, the UH model fared the best followed by the ARMAX model in which the model identification is a tedious job. The NWSRFS model has the disadvantage of being a complex model which needs lot more expertise for its calibration and requires comparatively larger computer storage and run time than the other two models.

It is concluded that the user should keep into consideration the attributes defined above while making the choice of the model. It is also observed that the simple models possess most of these attributes. Therefore an attempt should be made to identify a model fulfilling maximum of these attributes.

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