The Hybrid Method for seasonal streamflow forecasting

Huynh Ngoc Phien* and Jean Wei-Haw
Asian Institute of Technology, P.O. Box 2734, Bangkok 10501, Thailand.

Abstract

The amount of water stored in a reservoir can be utilized more efficiently if it is possible to forecast future inflows. However, not many techniques for seasonal streamflow forecasting have been devised. Recently, a particular scheme has been introduced, in which regression analysis is used in model identification and parameter estimation, and a time series approach is used in providing forecasts with long lead times. Because of this combination, the scheme has been referred to as the Hybrid Method.

In this study, the Hybrid Method is evaluated along with its two simplified versions through practical applications to monthly streamflow forecasting. It is found that the Hybrid Method and these simplified versions produce satisfactory forecasts for stations with large drainage areas. However, for stations with small drainage areas they seem to perform very poorly.

Introduction

Although the forecasting of seasonal streamflows is very important in the efficient use of the amount of water stored in reservoirs, it has not attracted due attention from researchers. Apart from a few publications which appeared irregularly in the literature (e.g. Hino and Ishikawa, 1975; Rao and Kashyap, 1973, 1974), three general surveys have recently been conducted by Dyhr-Nielson (1982), O'Connell (1983) and Phien (1983a). These surveys mainly addressed the important techniques which are likely to be useful for the forecasting of seasonal streamflows and simple applications were given for illustrative purposes. The attempt made by Phien (1983b) may also be considered as an illustration of the use of the Kalman filter and Group Method of Data Handling techniques in this regard. Therefore, it is desirable to have a systematic evaluation of the most promising methods in seasonal streamflow forecasting.

The present study evaluates a particular scheme introduced by O'Connell (1983). In this scheme, known as the Hybrid Method, two useful techniques, regression analysis and time series, are combined in order to make the maximum use of the available data. Moreover, two simplified versions which are based on the models developed by Thomas and Fiering (1962) and Sen (1978) for data generation are also considered to see whether simpler methods can be used as well.

As in the paper by Phien and Twu (1984), a monthly basis is adopted here. Accordingly, forecasts with lead times from one to six months are of importance. With a lead time greater than one month, the Thomas-Fiering and Sen models cannot be readily used and hence suitable extensions are presented. They are then applied along with the model obtained from the Hybrid Method to the data from the Mekong and Tachia basins, whereby conclusions can be made.

The Hybrid Method

Basically, the Hybrid Method employs the stepwise regression scheme in the selection of the explanatory variables and in the estimation of the parameters of the resulting equations. Then in the forecasting stage, the Box-Jenkins approach is used to produce forecasts corresponding to lead times greater than one season by replacing unknown values of the explanatory variables by their forecast values when they become available. This approach can readily be adopted to make the Thomas-Fiering and Sen Models capable of serving the same purpose.

The Hybrid Model

General considerations

In the model development stage, several factors affecting monthly streamflows are considered as explanatory variables. The resulting equations obtained by means of stepwise regression analysis are referred to as the Hybrid Model in this study for brevity. Typically, the following problems are considered:

Problem 1: Forecast the flow in month (m + 1) from:
- monthly flows in months m, m - 1, m - 2, . . .
- explanatory variable 1 in months m, m - 1, . . .
- explanatory variable 2 in months m, m - 1, . . .

Problem 2: Forecast the flow in month (m + 2) from:
- monthly flows in months m + 1, m, m - 1, . . .
- explanatory variable 1 in months m, m - 1, . . .
- explanatory variable 2 in months m, m - 1, . . .

Problem 3: Forecast the flow in month (m + 3) from:
- monthly flows in months m + 2, m + 1, m, m - 1, . . .
- explanatory variable 1 in months m, m - 1, . . .
- explanatory variable 2 in months m, m - 1, . . .

In these problems, the flow in the preceding month is explicitly listed as an explanatory variable. This is done because for a given month, the flow in the preceding month can always be viewed as the integrating factor of all other explanatory variables which influence the monthly flows until that month. Clearly, the performance of the Hybrid Model depends heavily on this variable. The other variables may include monthly rainfall, last day's flow, etc. As the lead time increases, the latter variables would have decreasing influences.

It should be noted that the explanatory variables other than the monthly flow are considered up to the present month, m. Otherwise, their forecasts are needed before a forecast for the flow can be made. The forecasting of these variables is in most cases even more difficult than the forecasting of monthly flows.

*To whom all correspondence should be addressed. Received 24 May 1985.