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EXTENDED ABSTRACT

Probabilistic Forecasts of Streamflow Scenarios Using ESP Approach (Case study: Halil River)

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Introduction

Stream flow forecast is a fundamental tool that could be utilized for appropriate water resource management. The enhancement of accuracy as well as the increase of time horizon for stream flow forecasts is essential especially for agricultural sector which is the most vulnerable sector during water shortages. In this regard, the application of stochastic approaches like Ensemble Streamflow Prediction (ESP) procedure for long-term forecast with respect to streamflow uncertainty can be proposed. The ESP procedure produces streamflow forecasts in the form of multiple hydrographs, each a possible realization of seasonal streamflow (Day, 1985). One example of ensemble streamflow forecasts is the National Weather Service's ESP procedure. Faber and Stedinger (۲۰۰۱) successfully combined reservoir operation models with updated information from ESP of the National Weather Service (Faber and Stedinger, 2001). Using ESP forecasts, Eum et al. (2011) also developed a procedure to calculate optimal water release curtailments during droughts using a future value function derived with a sampling stochastic dynamic programming model.

The main objective of this paper is to present a probabilistic approach and forecast the inflows to Jiroft dam reservoir. In this regards, using ESP approach as well as Artificial Neural Networks (ANNs) the 1- to 12- month ahead probabilistic scenarios of Halil river were forecasted.

Methodology

In this section, the meteorological, as well as hydrological data of Halil river were employed to forecast cumulative streamflow using ANNs. Finally, using ESP models, the probabilistic scenarios of inflows were forecasted. First, we carried out a correlation analysis to select the most appropriate input variables for the ANN models. Based on available data, the maximum, mean, and minimum temperature (Tmax, Tmean, Tmin), precipitation (R), and past inflows (Q) were selected as the most relevant input variables (predictors). Then, the next 1-month to 12-month cumulative inflows were forecast by using different ANNs. The models were of three-layer feed-forward network type with a sigmoidal activation function trained by the Levenberg-Marquardt (LM) algorithm. 70% and 30% of data were used for training and testing purposes, respectively. The number of neurons in the hidden layer was determined by trial and error. Moreover, input and output data were rescaled in 0.1-0.9 range (ASCE 2000; Wang et al. 2006; Besaw et al. 2010). Finally, the performance of ANN models was compared based on the indices of determination coefficient (R2), root mean squared error (RMSE), and mean absolute error (MAE).

Case study

The Hamoon Jazmoorian Lake is an important lake of Kerman province, with a variable capacity of water. The same does not account as a permanent lake of this region. The Halil Rood and Bampour Rivers flow into this lake from the west and east, respectively. Jazmoorian Basin covers an area of 69,600 km2. This lake is located between the provinces of Sistan and Baluchestan and Kerman, and the western section of its basin encompasses the townships of Baft, Kahnooj and Sabzvaran.

Data description

Precipitation (Rain), temperature in three scales i.e. minimum, average and maximum (Tmax, Tmean, Tmin) as well as discharge (Q) are the data that used in this paper. All data are in monthly scale and cover a period of 21 water years from 1989–2009 water years.

Artificial Neural Networks (ANNs)

Neural networks are parallel processing systems. These networks can map linear and nonlinear relations between input—output pairs in any phenomenon of interest (ASCE Task Committee, 2000a,b). The ANNs used in this paper are three-layer feed-forward networks with sigmoid function and LM training algorithm (Coulibaly et al., 2000). Optimum number of neurons in the hidden layer was determined through trial and error (Saghafian et al.; 2013).

ESP approach for generation of stochastic streamflow scenarios

ESP is a forecasting procedure that combines physical modeling of the river basin with a probabilistic representation of the future using historical weather data. The National Weather Service River Forecast System (NWSRFS) Operational Forecast System generates short-range streamflow forecasts by inputting observed and forecast precipitation and temperature data into conceptual hydrologic and hydraulic models that simulate the snow accumulation and ablation, rainfall/runoff, watershed routing, and channel routing processes to produce simulated streamflow (Day, 1985; Faber and Stedinger, 2001).

The general idea of using ESP forecasts is similar to that proposed by Faber and Stedinger (2001), but with a clear distinction. In the current study, ANNs are used to generate monthly cumulative forecasts as the fundamental elements in ESP generation, rather than using a linear regression approach. To calculate ESP scenarios, the following equations have been employed (Chow, 1981):

$$f_x(X) = \frac{1}{\sigma\sqrt{2\pi}} \exp[-0.5(\frac{x-\mu}{\sigma})^2] \quad (1)$$

$$F_x(X) = P(X \leq x) = \int_{-\infty}^{x} f_x(X)dx \quad (2)$$

Conclusions and future challenges

The aim of this study is to present a probabilistic approach and forecast the inflows to Jiroft dam reservoir. In this regard, using ESP approach as well as ANNs the 1- to 12-month ahead probabilistic scenarios of Halil river were forecasted. Results showed that by an increase of forecast horizon, the accuracy of ANN forecasts will be decreased. Also, combination of ANN with the artificial approach of ESP could accurately forecast the probabilistic scenarios of streamflow. Also, the ANNs with the number of 1-5 neurons in hidden layers had the best performance.

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