

# Flood forecasting for the upper reach of the Red River Basin, North Vietnam

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## Abstract

Flood forecasting remains a very important task. Good forecast values with sufficient lead times can help reduce flood damages significantly. This paper proposes two types of black-box model obtained by using multiple regression analysis and back-propagation neural networks in forecasting 6-h water levels at three important stations on the upstream section of the Red River basin, North Vietnam. The results obtained show that highly accurate forecast values can be obtained with lead times of up to 18 h by using two most recent past values of the water level at the station considered or two most recent past values at this station and two most recent values of an upstream station.

**Keywords:** water level forecasting, lead time, neural networks, back-propagation.

## Introduction

Flood forecasting remains very important in any relief activities. In many cases, this task may rely on many different approaches. Due to the availability of data required, a daily basis has been widely adopted. This, in turn, leads to the forecasting of daily discharges at a number of selected stations - treated as reference stations - in the forecasting task, as well as in the alleviation of possible flood damages. In many cases, some conceptual rainfall-runoff models are used when these models are not really intended for forecasting purposes (Phien and Danh, 1997). These authors have made some slight changes to the way to treat input data to render these models suitable for forecasting. However, they may not perform as well as black-box models (Jain and Indurthy, 2003).

In the case of a number of stations in the Red River basin, North Vietnam (Fig. 1), 6-h water level data are available during the flood season, from 1 June to 30 September. To deal with these cases, we propose the use of black-box models for the following reasons:

- Generally speaking, these models are data-driven: The model to be selected for use at a station should be based on the data available. For example, for conceptual models, data on evaporation (and several other factors) are required. Unfortunately, such data are not available (or at least unobtainable) to us. Therefore most conceptual models cannot be used.
- Most conceptual rainfall-runoff models normally produce values for discharge rather than for water levels. In order to obtain water-level values from such a model, the drainage area of, and the rating curve at the station concerned are required. Due to the inaccuracy in the rating curve to convert discharge values to water-level values (and vice versa), the forecast values obtained for the water level may be far from accurate.
- From the experience gained in previous studies (Phien et al., 1990; Danh et al., 1999; Phien and Sureerattanan, 1999), it was decided to make use of two general models, namely the multiple linear regression model and the back-propagation neural network model, for forecasting the water level at three stations, one on each main tributary of the Red River (Fig. 1):

- Ta Bu station on the Black (Da) River
- Yen Bai station on the Thao River, and
- Vu Quang station on the Lo River.

Located on the upper reach of the Red River basin, these stations do not have any tidal effect. As such, no tidal data are needed for forecasting purposes.

## Multiple linear regression (MLR) model

The general forecasting equation based on MLR can be written as follows:

$$H_{t+\tau} = A + \sum_{j=1}^{m_1} a_j H_{t-j+1} + \sum_{j=1}^{m_2} b_j U_{t-j+1} + \sum_{j=1}^{m_3} c_j R_{t-j+1} + \dots \quad (1)$$

where:

- H : water level at the station under consideration
- U : water level at the upstream station(s)
- R : rainfall
- A,  $a_j$ ,  $b_j$ ,  $c_j$  : regression coefficients
- $\tau$  : forecast lead time.

Using the least squares method, the regression coefficients can readily be obtained.

## Back-propagation (BP) neural network model

This is a multilayer feed forward neural network with a back-propagation algorithm used for updating its weights. The BP neural network model has been extensively used in many applications, including forecasting problems.

- Atiya et al. (1999) applied BP neural networks to forecast the flow of the Nile in Egypt with fairly good results.
- Maier and Dandy (2000), in their survey, found that out of 43 papers dealing with the use of neural networks for forecasting of water resources variables, 41 papers employed BP models.
- Hsieh et al. (2001) applied the BP neural network model for flood forecasting for two different scale watersheds, namely the Sala River in Croatia and a segment of the Mississippi River, USA. They found that good downstream river-flow forecasts could be obtained from upstream gauges for the Sala River, and very good river-flow forecasts from two upstream

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