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Forecasting models for flow and total dissolved solids in Karoun river-Iran

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SUMMARY

Water quality is one of the most important factors contributing to a healthy life. From the water quality management point of view, TDS (total dissolved solids) is the most important factor and many water developing plans have been implemented in recognition of this factor. However, these plans have not been perfect and very successful in overcoming the poor water quality problem, so there are a good volume of related studies in the literature. We study TDS and the water flow of the Karoun river in southwest Iran. We collected the necessary time series data from the Harmaleh station located in the river. We present two Univariate Seasonal Autoregressive Integrated Movement Average (ARIMA) models to forecast TDS and water flow in this river. Then, we build up a Transfer Function (TF) model to formulate the TDS as a function of water flow volume. A performance comparison between the Seasonal ARIMA and the TF models are presented.

1. Introduction

The Karoun, also written as Karoon, (30.4275°N, 48.1653°E) is Iran's most effluent river and the only navigable one. This river flows from Zagros mountain, receives Dez and Kuhrang tributaries, goes through Ahvaz, one of Iran's large cities, and finally flows into the Persian Gulf. Karoun's watershed covers 65,230 square kilometers in two provinces of Iran, i.e., Khouzestan and Chaharmahal and Bakhtiari Provinces. It is about 950 km long and has an average discharge rate of 575 cubic meters per second (Fig. 1).

Freshwater is a basic human need for survival and good health. But most global and Iran's natural water sources contain impurities among which the TDS. However, numerous factors affect the concentration of total dissolved solids (TDS) in these natural water systems. Some of these solids occur naturally while some others are the product of people's daily activities. But one of the most important factors influencing TDS concentration is the water flow (J. O'Connor (1976)). Because of the fact that TDS is a water impurity and that variation in water flow affects TDS level, their prediction may help to make quality fresh water available, for domestic, industrial, and agricultural consumption.

Time series forecasting is a powerful and classic method used in forecasting the future of stochastic processes. In this area, Univariate ARIMA (Autoregressive Integrated Moving Average) models for time series are among the primary models whose prediction efficiency is well supported in the literature. Box et al. (2008) developed a methodology for obtaining ARIMA models with wonderful results. Moreover, they discussed some tools to fit periodic ARIMA models to data with seasonal or any periodic patterns.

The Transfer Function-noise (TF) model is another way of forecasting TDS, with the provision of accepting more variables into the model for more accurate predictions. This is where the TF model can have a competitive edge over the Univariate ARIMA model. Many studies have been done on how to forecast water characteristics through forecasting methods and time series analysis to ascertain the efficiency of ARIMA models, TF models, and other water quality forecasting models. Firstly, various models are developed to predict the amount of TDS (e.g., Lenz and Sawyer (1944), Hem (1959), Toler (1965)). In a fundamental study by Fuller and Tsokos (1971), water pollution is discussed and a forecasting model is presented. Another model, proposed by J. O'Connor (1976), forecasts the dissolved solid materials in water. Other studies have also disclosed some additional factors such as

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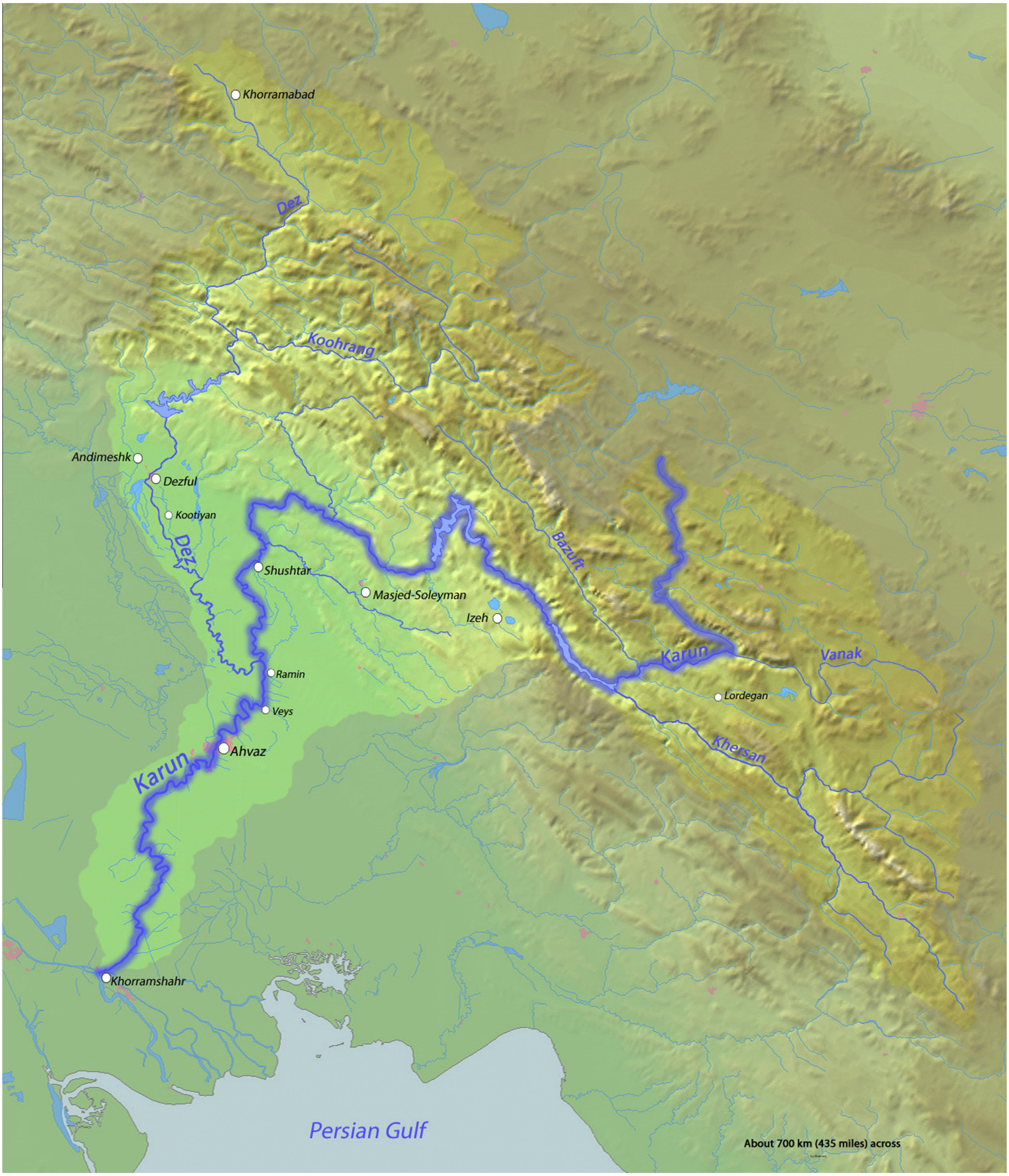

Fig. 1. Geographic location of Karun river (Scale: 1/2850000).

season and temperature (see McDiffett et al. (1989), Britton et al. (1993), Davis and Keller (1983), Petts (1989)). Furthermore, Dallas and Day (1993) showed that flow alteration can bring about chemical and physical changes in water characteristics, which in turn may strongly affect the aquatic biota. The flow concentration model is an approach which has been iteratively used in quality control modeling (for example, see Gregory and Walling (1973), Kronvang (1992), Malan and Day (2002a), Smith et al. (1996)). The latter showed that flow iteration could improve water quality while Rossouw et al. (1999) calculated the median monthly values of water quality. King and Louw (1998) invented the Building Block Methodology, which estimates the environmental flow of rivers. DWAF (1999) and King et al. (2000) later extended the study. Afterward, Malan and Day (2002b) concluded their water flow model.