Geophysical Research Abstracts
Vol. 19, EGU2017-18078, 2017
EGU General Assembly 2017

Forecasting monthly inflow discharge of the Iffezheim reservoir using data-driven models

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River stream flow is an essential element in hydrology study fields, especially for reservoir management, since it defines input into reservoirs. Forecasting this stream flow plays an important role in short or long-term planning and management in the reservoir, e.g. optimized reservoir and hydroelectric operation or agricultural irrigation.
Highly accurate flow forecasting can significantly reduce economic losses and is always pursued by reservoir operators. Therefore, hydrologic time series forecasting has received tremendous attention of researchers. Many models have been proposed to improve the hydrological forecasting. Due to the fact that most natural phenomena occurring in environmental systems appear to behave in random or probabilistic ways, different cases may need a different methods to forecast the inflow and even a unique treatment to improve the forecast accuracy. The purpose of this study is to determine an appropriate model for forecasting monthly inflow to the Iffezheim reservoir in Germany, which is the last of the barrages in the Upper Rhine. Monthly time series of discharges, measured from 1946 to 2001 at the Plittersdorf station, which is located 6 km downstream of the Iffezheim reservoir, were applied. The accuracies of the used stochastic models – Fiering model and Auto-Regressive Integrated Moving Average models (ARIMA) are compared with Artificial Intelligence (AI) models - single Artificial Neural Network (ANN) and Wavelet ANN models (WANN).
The Fiering model is a linear stochastic model and used for generating synthetic monthly data. The basic idea in modeling time series using ARIMA is to identify a simple model with as few model parameters as possible in order to provide a good statistical fit to the data. To identify and fit the ARIMA models, four phase approaches were used: identification, parameter estimation, diagnostic checking, and forecasting. An automatic selection criterion, such as the Akaike information criterion, is utilized to enhance this flexible approach to set up the model. As distinct from both stochastic models, the ANN and its related conjunction methods Wavelet-ANN (WANN) models are effective to handle non-linear systems and have been developed with antecedent flows as inputs to forecast up to 12-months lead-time for the Iffezheim reservoir. In the ANN and WANN models, the Feed Forward Back Propagation method (FFBP) is applied. The sigmoid activity and linear functions were used with several different neurons for the hidden layers and for the output layer, respectively.
To compare the accuracy of the different models and identify the most suitable model for reliable forecasting, four quantitative standard statistical performance evaluation measures, the root mean square error (RMSE), the mean bias error (MAE) and the determination correlation coefficient (DC), are employed. The results reveal that the ARIMA (2, 1, 2) performs better than Fiering, ANN and WANN models. Further, the WANN model is found to be slightly better than the ANN model for forecasting monthly inflow of the Iffezheim reservoir. As a result, by using the ARIMA model, the predicted and observed values agree reasonably well.