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EXTENDED ABSTRACT

Multistep Modeling of Hydroclimatic Phenomena Using Wavelet-Neural Network Seasonal Model

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1. Introduction

In the present paper, the ability of the Artificial Neural Network (ANN) and combined wavelet-neural network (WANN) model were investigated for multistep modeling of hydroclimatic processes with the least input. For this purpose, the ANN model and then the WANN model were used to predict one to twelve steps in advance. Finally, the efficiencies of all models were examined using the evaluation criteria, and all models were compared with each other.

2. Methodology

2.1. WANN model

WANN combined model was designed for combining the capabilities of the ANN model and wavelet transform in a single structure for rainfall-runoff and temperature modeling. In this model, the data preprocessing is carried out by the wavelet transform and the results of this processing are used as inputs in ANN. In this type of modeling, discrete wavelet transform provides opportunities for different time scales that are assessed and evaluated separately. In that case, the input time series in different time scales are decomposed by discrete wavelet transform, and then its various combinations are used as inputs in the ANN model (Grossmann and Morlet. 1984; Addison, 2002; Nourani et al, 2011; Nourani et al, 2014).

2.2. Case study

The monthly rainfall-runoff data in this paper are from the Murrumbidgee catchment for 39 years (1975-2014), located in Australia. Also, the 39 years (1975-2014) data of Tabriz temperature were used for monthly minimum temperature modeling.

2.3. Efficiency criteria

Validation of predictive models is done for assessing the performance of the predictions. For this purpose Nash-Sutcliffe (E) and Root Mean Square Error (RMSE) criterion have been used.

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3. Results and discussion

For multistep modeling, at first, the ANN model was used without any data preprocessing, and then the WANN model with the capability of considering the seasonal and periodic properties of time series was used. The input combinations of ANN and WANN as multivariate models were selected by linear correlation (CC) and mutual information (MI). To this end, the linear and nonlinear properties of inputs were examined by MI and CC criteria, and then the best input combinations were selected by trial and error (Sharghi et al, 2018; Khanghah et al, 2012).

3.1. Comparison of models

To assess the performance of the used models, for each studied monthly time series (runoff and temperature), the results of ANN and WANN models were compared with each other according to the Nash-Sutcliffe efficiency in the validation phase. Therefore in Figs. 1 and 2 the best structure of each model were compared.

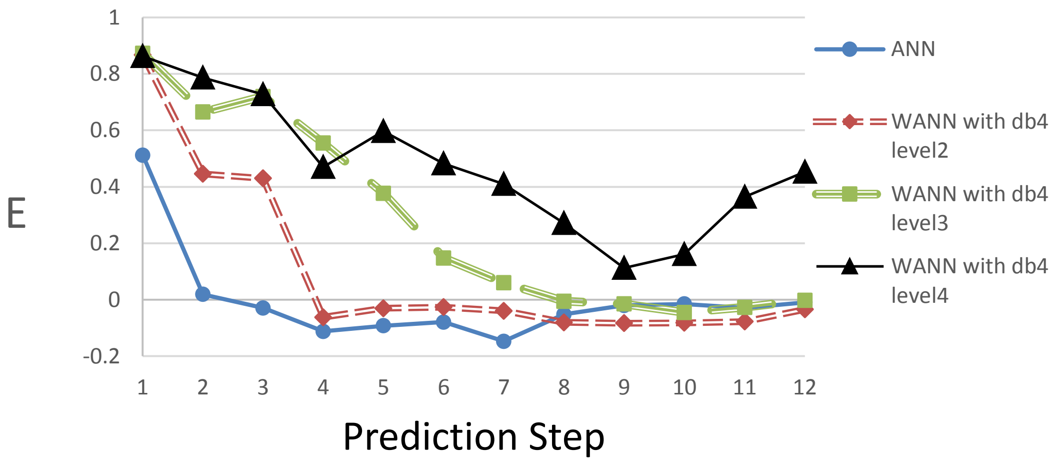

Fig. 1. Comparison of different monthly runoff modeling results in the validation phase

As can be seen in Fig. 1, using wavelet transform caused a considerable increase in the accuracy of models in all steps of monthly runoff modeling. Also by increasing the wavelet transform decomposition level, accuracy increased in all time steps. But because of the weak autoregressive component of the monthly runoff time series, by increasing the time step, the accuracy of models decreased and the prediction of more than three steps included weak results.

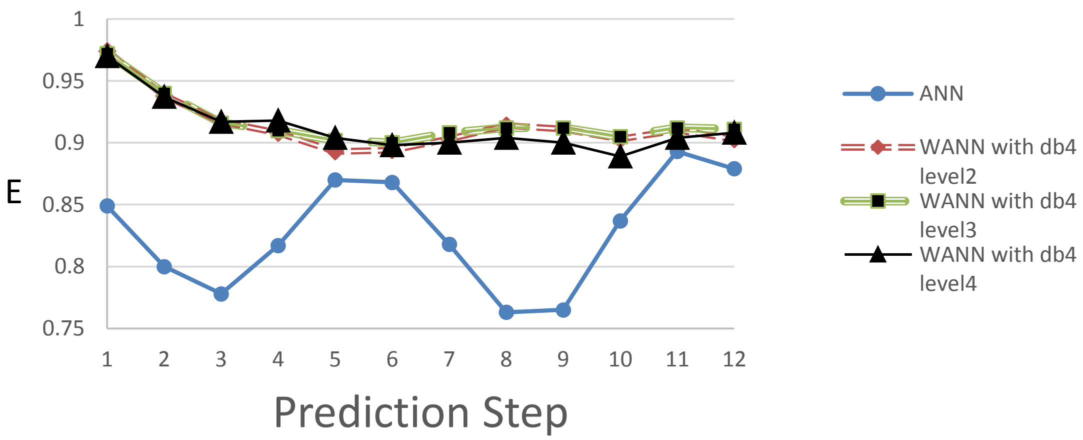

Fig. 2. Comparison of different monthly temperature modeling results in the validation phase

As can be seen in Fig. 2, using wavelet transform caused a considerable increase in accuracy of all time steps of monthly temperature modeling and because of the strong autoregressive component of monthly temperature time series, all 12 steps in advance included good results. But with increasing the wavelet transform decomposition level, the accuracy of models has not considerably increased because of the strong autoregressive and single frequency properties of monthly temperature time series, decomposition level increasing does not give new useful information to the model.

4. Conclusions

Hydroclimatic time series components such as autoregressive, seasonality and stochastic, play the most important role in the selection of models. ANN is an autoregressive model and in dealing with time series that have weak autoregressive properties did not include proper results. But WANN model because of time series preprocessing and its ability to handle seasonal multi-frequency mode, included good results. Therefore for the selection of appropriate models, it is necessary to pay attention to the type of time series components and time scales of time series.

In terms of multistep modeling, it is necessary to pay attention to the type, components and time scales of time series. Because the results of this paper indicated that in dealing with time series which have a weak autoregressive component, by increasing time steps, the accuracy of results was decreased. In order to complete the current study, it is recommended to use the presented methodology with replacement ANFIS and SVM models instead of ANN.

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