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ESTIMATION OF EVAPORATION USING ADAPTIVE NEURO-FUZZY INFERENCE SYSTEMS

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Introduction

Water passes to the atmosphere by two ways, evaporation and transpiration. Evaporation process occurs on the water surface and the land surfaces, and transpiration process occurs from the plants. Evaporation can be affected by several factors, such as temperature, wind and energy. The Class A Pan is widely used for measuring the evaporation. The measurement of evaporation with Class A Pan has some difficulties. The amount of evaporation can be affected from the pan temperature, buildings around the measurement area, wind and etc. In order to convert the pan evaporation to the surface evaporation, pan coefficients are used. To determine the total amount of evaporation is very important for the hydrological studies. It is needed for determining the reservoir capacity, management planning of the basins, etc. Because of the nonlinear relationship between hydrological parameters, some models can be used for estimating the required data.

Black box models such as ANFIS have frequently used for modelling of complex systems. The success of ANFIS models have also be proven on hydrological forecasting (Yarar et al., 2009, El-Shafie et al., 2007).

In this study, we investigated the efficiency of ANFIS model on estimating the monthly mean evaporation. For this purpose, monthly mean temperature, monthly total rainfall and monthly mean evaporation data of Gölbaşı were used. The model's performance was evaluated according to the graphs and R^2 value.

Materials and methods

Gölbaşı is a town on the plateau of central Anatolia, 20 km far from Ankara which is capital of Turkey, and having 970 m altitude. Lake Mogan and Lake Eymir are located in Gölbaşı town. Lake Mogan is a natural dam reservoir formed behind the alluvial embankment, at the bottom of the basin, having generally smooth and somewhere bumpy topography. The surface area of the lake is 6 km². Lake Mogan discharges water to Lake Eymir by 5 meter altitude difference. Lake Eymir, having 1.25 km² surface area, gets almost the whole water from Lake Mogan. Gölbaşı has inland climate, cold and rainy in winter, hot and droughty in summer times. Meanly annual rainfall is around 400 mm and meanly annual temperature is around 11.7 0C. Common vegetation of the basin is herbaceous plant but also different vegetations can be seen at the different altitude and different humidity. Wooded area is mostly located at the step slope plateau looking to Lake Eymir.

MATLAB software was used for ANFIS model. Convenient programming code and algorithm were written in m-file, which is a file type in MATLAB. ANFIS, first

introduced by Jang (1993), is a universal approximation methodology and, as such, is capable of approximating any real continuous function on a compact set to any degree of accuracy (Jang et al., 1997). ANFIS is functionally equivalent to fuzzy inference systems.

Results and conclusions

Monthly mean temperature and monthly total rainfall data of Gölbaşı were used for input layer and monthly mean evaporation data were used for output layer. 213 data sets were used for the modeling. 150 of 213 data were selected for training and 63 of 213 were selected for testing. Training process depends on some different parameters such as number and type of membership function, epoch number. The best performance was obtained with 3000 epochs.

Trained models were tested. The evaporation was estimated with the model.

The evaluation of the model was done according to the graphs and R^2 value (Figure 1).

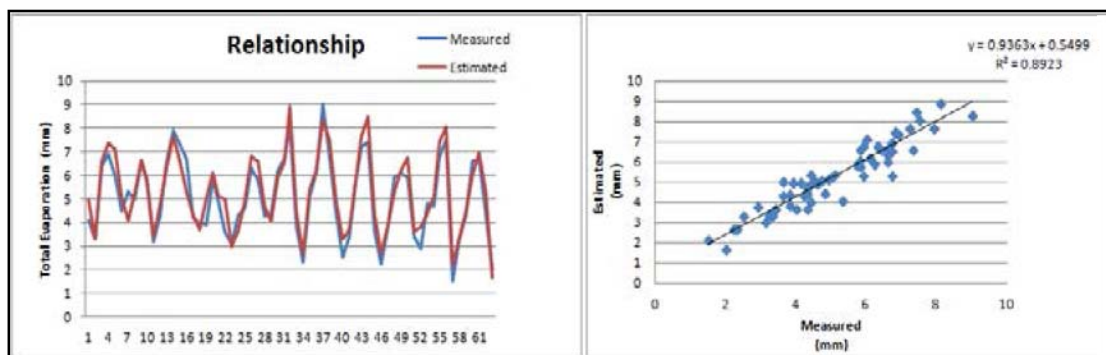


Figure 1. Relationship between measured and estimated evaporation

Since hydrological processes mostly do not show a linear behavior, some artificial intelligent systems such as ANFIS can be used efficiently for determining the relationship between the parameters. In this study, evaporation estimation at Gölbaşı was tried to be set up with ANFIS. Some of the temperature, rainfall and evaporation data belonging to Gölbaşı were trained with ANFIS and they were also subjected to tests for obtaining best approaches. The performance evaluation was made with R^2 values taken from results of the model. And Root Mean Squared Error (RMSE) was also calculated as 0.59.

This modelling study showed that ANFIS is usable method in estimation of evaporation at Gölbaşı. For this reason, it was concluded that this method is a beneficial tool for determining the reservoir capacity, management planning of the basins, etc.