



## ***Interactive comment on “Artificial Intelligence Techniques for river flow forecasting in the Seyhan River Catchment, Turkey” by M. Firat***

**M. Firat**

Received and published: 1 October 2007

Firstly the author would like to thank the reviewers for their contributions and comments. I submitted the revised version of paper Artificial Intelligence Techniques for river flow forecasting in the Seyhan River Catchment, Turkey, (revised title of paper is Comparison of Artificial Intelligence Techniques for river flow forecasting in the Seyhan River Catchment, Turkey).

The technical corrections suggested by reviewers can be given as;

Reviewer 1

Page 1370, Line 8: the term of river flow gauges station was corrected as river flow gauging station. Page 1370, Line 9: the term of the data set are divided was corrected

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as The data set is divided. Page1378, Line 14: the term of these parameters affects was corrected as these parameters affect.

1. River flow depends on many variables: Rainfall, antecedent moisture content, catchment physiographic characteristics, antecedent river flow, etc. This is said in the paper, but models have been built solely with antecedent river flow variables. It can be very difficult to forecast future river flows, mainly peak flows, without taking into account the rainfall and proposed models in the paper could be improved including some more nodes of rainfall and antecedent moisture content variables.

Other input variables such as rainfall, evaporation, moisture content, and other catchment characteristics might have an influence on daily River flows. However, in the current study, river flow records at the different time lags have been used without other input variables to forecast the daily river flow and the applicability and forecasting capability of ANFIS and ANN methods has been investigated by using only river flow records. The parameters in the input vector are the number of runoff values at different time lags that can best represent the time series by ANFIS and ANN models.

2. The number of flow records used in training, testing and verification processes is not clear. Firstly, it is said in the abstract that The training and testing data set include totally 5114 daily river flow data and the number of verification data points is 731.

The sentences between in line 9-12 were rearranged as; The data set includes total 5114 daily river flow data and data set is divided into three subsets, training, testing and verification data set. The training data set includes total 2922 and the testing data set consists of 1461 daily river data records. The verification data set consists of 731 daily river data records measured at the time 1998-2000 years.

RC: In Page 1378; Line 19: Totally 4383 daily river flow data were obtained [...] for the time period 1986-2000.. Page 1379; Line 11: The verification data set consisted of the last two years (1998-2000). The training and testing data set include the daily river flow record at time period 1986-1998. This must be clarified.

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The sentences between in line 19-22 were rearranged as; The data set includes total 5114 daily river flow data and data set is divided into three subsets, training, testing and verification data set. The training data set includes total 2922 daily river flow records measured at the time period 1986-1994 years, the testing data set consists of 1461 daily river data records measured between in 1994 and 1998 years. The verification data set consists of 731 daily river data records measured at the time 1998-2000 years. Fig. 6 shows the time series data of daily river flow.

RC: Title: It seems very general and it could include the word comparison, because this is the main issue of the paper.

The title of paper was changed as Comparison of Artificial Intelligence Techniques for river flow forecasting in the Seyhan River Catchment, Turkey.

RC: P.1370, L. 4. The paper compares four models: An ANFIS model, two ANN models and an Autoregressive model. This must be best clarified in the abstract.

The sentences, The results of ANFIS, GRNN, FFNN and AR models are compared and evaluated based on their performance of training, testing and verification. The best fit forecasting model structure and method is determined according to criteria of performance evaluation, was added to the line 20 in page 1370 in the abstract.

In addition, in line 20 in page 1370 in the abstract, the sentence was corrected.

RC: P. 1370, L. 10. It could be clarified how many daily river flows are available and how many have been used for every process.

This sentence in line 10 in page 1370 was rearranged as; The data set includes total 5114 daily river flow data and data set is divided into three subsets, training, testing and verification data set. The training data set includes total 2922 daily river flow records measured at the time period 1986-1994 years, the testing data set consists of 1461 daily river data records measured between in 1994 and 1998 years. The verification data set consists of 731 daily river data records measured at the time 1998-2000 years.

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RC: P. 1371, L. 14. (Sajikumar et al., 1999) must be included in References.

In the list of references in line 29 in page 1386, the reference, (Sajikumar, N. and Thandaveswara, B. S.: A non-linear rainfall-runoff model using an artificial neural network, *J. Hydrol.*, 216, 32–55, 2000), was corrected as (Sajikumar, N. and Thandaveswara, B. S.: A non-linear rainfall-runoff model using an artificial neural network, *J. Hydrol.*, 216, 32–55, 1999).

RC: P.1371, L. 21. Reference Tingsanchali and Gautam, 2000 seems to be Tingsanchali and Gautam, 1999.

In line 21 in page 1371, the reference of (Tingsanchali and Gautam, 2000) is OK. But in the list of references in line 33 in page 1386, the reference, (Tingsanchali, T. and Guatam, M. R.: Application of tank, NAM, ARMA and neural network models to flood forecasting, *Hydrol. Processes*, 14, 1362–1376, 1999), was corrected as (Tingsanchali, T. and Guatam, M. R.: Application of tank, NAM, ARMA and neural network models to flood forecasting, *Hydrol. Processes*, 14, 2473–2487, 2000)

RC: P.1371, L. 26. (Zadeh 1965) must be included in References.

In line 24 in page 1371, the sentence of (On the other hand, fuzzy logic method was first developed to explain the human thinking and decision system by Zadeh (1965)) was revised as (On the other hand, fuzzy logic method was first developed to explain the human thinking and decision system by Zadeh (en, 2001)).

RC: P. 1373, L. 15. Sugeno inference system has been selected. This selection should be justified.

Adaptive Neuro-Fuzzy Inference System (ANFIS) is much more complex than the fuzzy inference systems and is not available for all of the fuzzy inference system options. ANFIS only supports Sugeno-type fuzzy inference systems.

RC: P. 1376, L. 6. 'ls' has been included in the subscript of variable Yout.

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In line 6 in page 1376, the sentence was rearranged as Yout is response of neural network system,

RC: P.1377, L. 18. Seyhan River basin could be described in more detail, including basin area, hydrological and physiographic basin characteristics, rain and discharge gauge stations located in the basin, rain and discharge available data, etc.

In line 18 in page 1377, the section 4, Study area and available data was revised on the manuscript according to reviewer comments.

RC: P. 1379, L. 2. Cross correlations between variables could be included in a Table.

In line 2 in page 1379, the cross correlations between variables were calculated and given in Table. This table was placed in page 1379, and referred as (Table 2) at the end of sentence in line 2 in page 1379. Moreover, numbers of other tables were changed on the manuscript.

RC: P. 1379, L. 19. Equations 14, 15 and 16 could be reviewed. Subscript  $t$  could be included in variables QY and QD to take into account the sum in different lead-times.

In line 19 in page 1379, the equations 14, 15 and 16 were revised according to comments.

RC: P. 1380, L. 6. Nash-Sutcliffe Efficiency coefficient and RMSE could be explained in more detail, commenting their ability to asses the forecast power of the computed hydrograph and to give more power to greater values accuracy.

In line 6 in page 1380, the details of Nash-Sutcliffe Efficiency coefficient and RMSE were added. In addition, In line 7 in page 1380, the sentence was revised according to reviewer comments.

RC: P. 1380, L. 20. It seems that RMSE should be E.

In line 20 in page 1380, the term of RMSE was corrected as E.

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RC: P. 1382, L. 26. AR (2) model could be explained in more detail.

The sentence between in line 26 in page 1382 and in line 1 in page 18383 was rearranged as;

AR(2) model includes two river flow variables at two previous time lags in input vector. In order to get more accurate and reliable evaluation and comparison, the best fit input structure, R-I M2 having two input variables, was used to forecast the daily river flow by using AR model.

RC: P. 1383, L. 6. AR model could be described in more detail. Coefficients obtained from training data set and validation results could be included in the paper. Training, testing and verification graphics of this model could be included in the paper.

The testing and verification performance of AR model have already been given in Table 6. The Coefficients and forecasting equation obtained from training data set was added to the line 9 in page 1383. Comparison of the training and testing results of AR models and observation was given in line 10 page 1383 before section 5.2.4 as Figure 13.

Figure 13 was changed as Figure 14 in 23 in page 1383 and in page 1406. The verification results of AR model were added to the Figure 14.

RC: P. 1383, L. 19-23. It seems like these sentences could be included in the previous section.

In line 19-22 in page 1383, the sentence of The comp Once the estimates 20 of the traditional time series model coefficients have been obtained using the training data set, the model can be validated by computing the performance statistics during both training and testing data sets was removed.

RC: P. 1385, L. 18. Reference Cigizoglu, 2005 has not been cited in the paper.

The reference in line 18 in page 1385 was cited as (Cigizoglu, 2005) in line 24 in page 1371. Moreover, in line 24 in page 1371, the reference of (Cigizoglu, 2006) was

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removed.

RC: P. 1385, L. 26. Reference Fejer et al., 1981 has not been cited in the paper.

In line 26 in page 1385, the reference (Fejer et.al; 1985) was removed. The original paper doesn't include this reference.

RC: P. 1387, L. 9. Reference Sen, 2004 has not been cited in the paper.

In line 9 in page 1387, the reference (en, 2004) was removed.

RC: Table 1. Training and testing statistical parameters could be calculated separately.

Table 1 was revised according to reviewer comments.

RC: Table 4. Title must be corrected.

The title of Table 4 was corrected as (The performance of R-I M2 ANFIS model)

RC: Table 6. Title must be corrected.

The title of Table 6 was corrected as (Comparison of the performances of ANFIS, ANN and AR models)

RC: Fig 1. The arrow between Defuzzification and Decision System seems that could go from Decision System to Defuzzification.

Figure 1 is correct.

RC: Fig. 10. E, CORR and RMSE training values for each model could be included.

Figure 10 was revised according to reviewer comments.

Moreover, some points on the manuscript was corrected.

In line 28 in page 1385, the reference was revised as; (the surname of the first author was changed as Firat) Firat, M. and Güngör, M.: Estimation of the Suspended Concentration and Amount by using Artificial Neural Networks, IMO Technical Journal, 15(3),

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In line 16 in page 1371, the reference (Firat and Güngör, 2004) was revised as (Firat and Güngör, 2004)

In line 30 in page 1385, the reference was revised as; (the surname of the first author was changed as Firat)

Firat, M. and Güngör, M.: River Flow Estimation using Adaptive Neuro-Fuzzy inference System, Mathematics and Computers in Simulation, 75 (3-4), 87-96, 2007.

In line 3 in page 1372, the reference (Firat and Güngör, 2007) was revised as (Firat et.al., 2007) In line 25 in page 1372, the reference (Firat and Güngör, 2007) was revised as (Firat et.al., 2007) In line 2 in page 1373, the reference (Firat and Güngör, 2007) was revised as (Firat et.al., 2007)

Reviewer 2

The aim of study published by Firat and Güngör (2007) in Mathematics and Computers in Simulation journal was to investigate the applicability and capability of ANFIS method for daily river forecasting. For this aim, the data set was divided into four subsets using cross validation method. The models were trained and tested by ANFIS and the best fit model structure was determined. At end of study, only the best fit model having two input variables was trained and tested by Feed forward neural network and multiple linear regression methods. On the other hand, the aim of this paper published in HESSD is to compare and evaluate the performances of ANFIS, GRNN, FFNN and AR models for river flow forecasting. For this aim, the data set was divided into two sets, training, testing and verification. All models were trained and tested by ANFIS, GRNN and FFNN methods and the best fit models were determined based on their training and testing performances. Moreover, AR traditional time series method was used in order to compare and evaluate the results of ANFIS, GRNN and FFNN models. In addition, ANFIS, GRNN, FFNN and AR models were verified using verification

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data set. Moreover, some sentences in the section of ANFIS are similar within paper published Firat and Gungor (2007) in Mathematics and Computers in Simulation journal because the ANFIS method was used in both study. Therefore, similar sentences in the methodology section can be used for the detail description of ANFIS method. However, the paper was cited on this study. In addition, in order to define clearly the aim of this study the sentences, (The results of ANFIS, GRNN and FFNN models are compared and evaluated based on their performance of training, testing and verification. The best fit forecasting model structure and method is determined according to criteria of performance evaluation), was added to the line 20 in page 1370 in the abstract.

The title of paper was rearranged as Comparison of Artificial Intelligence Techniques for river flow forecasting in the Seyhan River Catchment, Turkey.

Other input variables such as rainfall, evaporation, moisture content, and other catchment characteristics might have an influence on daily River flows. However, in the current study, river flow records at the different time lags have been used without other input variables to forecast the daily river flow and the applicability and forecasting capability of ANFIS and ANN methods has been investigated by using only river flow records. The parameters in the input vector are the number of runoff values at different time lags that can best represent the time series by ANFIS and ANN models.

Moreover, on the manuscript, the section of study area was revised according to comments.

RC: Abstract, p.1370, lines 8-12: It is not clear how many river flow data are used for the training, testing and verification. See also Sec. 5.1, p.1378, lines 19-21.

In lines 8-12 in page 1370 in abstract section, the sentence was revised. Moreover, Sec. 5.1, p.1378, lines 19-21, the sentences were revised. Moreover, in line 10 in page 1370, the sentence was revised.

RC: Sec. 5.2, p.1379, line 20. A Bracket is missing in eq. 15.

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Equations 14, 15 and 16 in page 1379 were revised according to comments.

RC: Sec. 5.2.1, p.1380, line 19: Reference to figure 5 is wrong.

Sec. 5.2.1, p.1380, line 19, the reference to Figure 5 was corrected as Figure 7.

RC: Sec. 5.2.1, p.1380, lines 19-20: This statement should be corrected. Probably RMSE at line 20 should be E.

In line 20 in page 1380, the term of RMSE was corrected as E.

RC: Sec. 5.2.2, p.1381, line 18: Probably a of RMSE is missing: the value (of RMSE) of R-I M2 GRNN model is also lower than...

Sec. 5.2.2, p.1381, line 18, the sentence, (In addition the value of R-I M2 GRNN model is also lower than that of other models) was corrected as (In addition the value of RMSE of R-I M2 GRNN model is also lower than that of other models).

RC: Sec. 5.2.4, p.1383, lines 19-22: This sentence has no meaning in this section.

In line 19-22 in page 1383, the sentence was removed.

RC: Table 4 and Table 6: The titles are wrong. Moreover Table 4, 5 and 6 are quite repetitive.

The title of Table 4 was corrected as (The performance of R-I M2 ANFIS model). The title of Table 6 was corrected as (Comparison of the performances of ANFIS, ANN and AR models)

RC: Just one table with the values of the statistics for training, testing and verification for the four models could be presented (for example adding the values of the statistics for the training data set to Table 6 and eliminating Table 4 and 5).

Table 4 demonstrates the performance of ANFIS model. In table 5, the comparative of performances of two different ANN methods is given in order to compare the results of GRNN and FFNN model for river flow forecasting. Table 6 shows the performances of

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all models.

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Interactive comment on *Hydrol. Earth Syst. Sci. Discuss.*, 4, 1369, 2007.

4, S1125–S1135, 2007

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