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Rainfall- Rain off Modeling Using Artificial Neural Network

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Abstract

The objective of this work is studying the transformation of the rainfall into rain off in area scale catchment of North East of Algeria by artificial neural networks (ANNs). In this paper, we used simulation and the forecast per ANN and we adopted model conceptual GR2M to validate the results obtained per ANN. In this case, it is necessary to bring a sample of hydro meteorological data to knowing the rains, the evapotranspiration and the flows of the station to be modeled. Results obtained per ANN show superior result compared to the traditional modeling approaches (GR2M). Indeed, the coefficient of correlation is very significant (R^2 exceeds 0.95) and the very weak quadratic error.

Keywords: GR2M, Rain fall, Modeling, Algeria, Runoff.

1. Introduction

The scientific literature has a very great diversity of models which very little found a use operational. The question of using this models in hydrology to carry out stock management out of water, the regional planning, to dimension structures, to delimit easily flooded zones, arises in particular for the basins slopes for which one has series of measured flows.

ANN models have been widely and largely used by hydrologists particularly in modeling of the rainfall-runoff process (Jain and Srinivasulu 2006; Dechemi et al .2003). This study adopts a type of ANN perception multi-layer is an intelligent technique which provides a structure connexionist in the capacities of training to the systems not flax fields, the systems which have the capacity of training of the neural networks, one gained

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in popularity in the control of the nonlinear systems (Farag et al. 1998; Lin et al. 2002). For validation of the network ANN we applied approach mathematics in hydrology GR2M. The principle of this model articulates around an ascending flow chart of basins of the blade precipitated to the streamed blade passing by the evapotranspiration and the infiltration. We have a data base including the rain, rain off and the evapotranspiration with the step of monthly time. The goal being to adopt a behavior known as intelligent, in order to be able to apprehend complex phenomena and in order to identify the most effective model for modeling.

2. Material

2.1. Presentation of area study

The area of Souk-Ahras is in the North-East of Algeria, in the south of the wilayas of Annaba and El-Tarf. This zone located in the Telling Atlas represented here by the mounts of Medjerda, consisted two mountainous axes of direction NE-SO. The Northern axis is consisted Djebels Ras El Alia, Arous, and has DJ.Mesid which reaches the altitude of 1406 m. In the south, the second axis parallel with the precedent is consisted Djebels: Zellez (1110 m), Berda (1129 m) between these two assembly lines is located the valley of Medjerda.

2.2. Climate

The whole of all stations situated in the area of Souk-Ahras belongs to the natural area which belong themselves to Souk-Ahras power station, zone of hinge between a North of an area telling mountainous cold and rainy and the South of high area hill, a continental climate. Thus, according to the years and the seasons, the steppes are found under the climatic influence of the moderate zone. The climate of our areas depends on this longitudinal swinging of atmospheric circulation, as it in addition undergoes the effect of the altitude of the continentality and relief.

2.3. Data

The rain fall data represent a major element in this study of modeling. The data of precipitation is taken from the organizations responsible for network rainfall namely the National Agency of Hydraulic Resources (ANRH). For our need for modeling to the step of monthly time, we have chosen station pluviometric for the size of 1965-1995 and quality with knowing the station of Souk-Ahras which does not comprise gaps. The characterization of this station is showed in the Table 1.

Table 1. Characteristics of the pluviometric stations

Code	Station	River	Latitude (Lambert)	Longitude (Lambert)	Altitude m	Years
120101	Souk - Ahras	Medjerda	967,25	342,25	590	1965-1995

3. Material

3.1. Neuron Network ANN

The network of neurons used is of type feed-forward (Lin 1997) having the following structure: a layer of fixed connections, located between the input units, the retina, and units of association. The second layer connects the units of association and the units of answer: it is on these weights that the adaptation acts. The linear neuron with threshold thus realizes a partition of the vectors of entry which are subjected to him in entry in two fields. The algorithm of retro-propagation of the gradient of the error at summer creates by generalizing the rules of trainings of Widrow-Hoff (Roger Jang and Sun 1995) with the multi-layer networks with nonlinear transfer function.

The retro propagation of the gradient of the error (E) is used to adjust the parameters of chock in order to minimize the quadratic error between the exit it is the simulated flow and the flow observed. The criterion of minimization of error is as follows:

$$e = \sum_k \left(d_k - y_k^{[s]}\right)^2 \tag{1}$$

Or: d_k: The exit obtained. $y_k^{[s]}$ **: The exit obtained on the last layer at time t.**

3.2. Model GR2M (Model of the Agricultural engineering with 2 parameters Monthly)

Model GR2M is a model total rain-flow with two parameters. Its development was initiated at the CEMAGREF at the end of the years 1980, with objectives of applications in the field of the water resources and the low water levels. This model knew several versions, proposed successively by (Kabouya.1990), (Kabouya and Michel 1991), (Makhlouf and Michel 1994), (Mouelhi 2003) and Mouelhi et Al (2006b), which made it possible to gradually improve the performances of the model. Its structure associates a reserve of production and a reserve of routing as well as an opening on outside other than the atmospheric medium. These three functions make it possible to simulate the hydrological behavior of the basin.

3.3. Performance Evaluation of criteria

For a more rigorous comparison between the flows calculated by the two models and the flows observed, a series of criteria of numerical validation (example: coefficient of determination and criteria of NASH) will be established for the periods chock and test as well as a graphic criterion which makes it possible to judge the evolution of the sample calculated compared to observed.

- The coefficient of determination is given by:

$$R^2 = [\frac{Cov(x,y)}{\sigma_x.\sigma_y}]^2 \tag{2}$$

R^2 : Coefficient of determination enters the flows calculated and observed. σ_x et σ_y : Standard deviations of the series of flows observed and calculated. X and y : Flows observed and calculated.

- The comparison criterion of Nash is defined by the following formula:

$$Nash\ (\%) = 100.\left(1 - \frac{\sum_{i=1}^{n}(Q_i c - Q_i o)^2}{\sum_{i=1}^{n}(Q_i o - \overline{Q}_O)^2}\right) \tag{3}$$

$Q_i o$: Flow observed (m^3/s), $Q_i c$: flow calculated en (m^3/s) and $\overline{Q_O}$: Mean of flow observed (m^3/s).

4. Results and Discussion

For the application of model GR2M, we had the chronicles of rain and potential evapotranspiration over 360 months (1965-1995). Model GR2M thus enables us to easily obtain the simulation of the water blades run out over this same period subject to: To give the values of the X1 parameters and X2 of the model; to give the initial state of the tank ground and to give the initial state of the underground tank.

For the chock of the model, we launched several handling of the two X1 parameters and X2 of the model until optimum obtaining the values of the coefficients of determination and the criterion of Nash. The period chosen for the chock is that ranging between 1966- 1994. After applying this model for the data set, the results show an evident relationship between run off observed and simulation (R^2=0.85). We have introduced a natural transformation values to perfect this relation (Table 2, Fig. 1, Fig. 2).

Table 2. Criteria of simulation

Station	Model	Nash%	R^2
Souk-Ahras	GR2M	87.3	0,85
	ANN	95.5	0.99

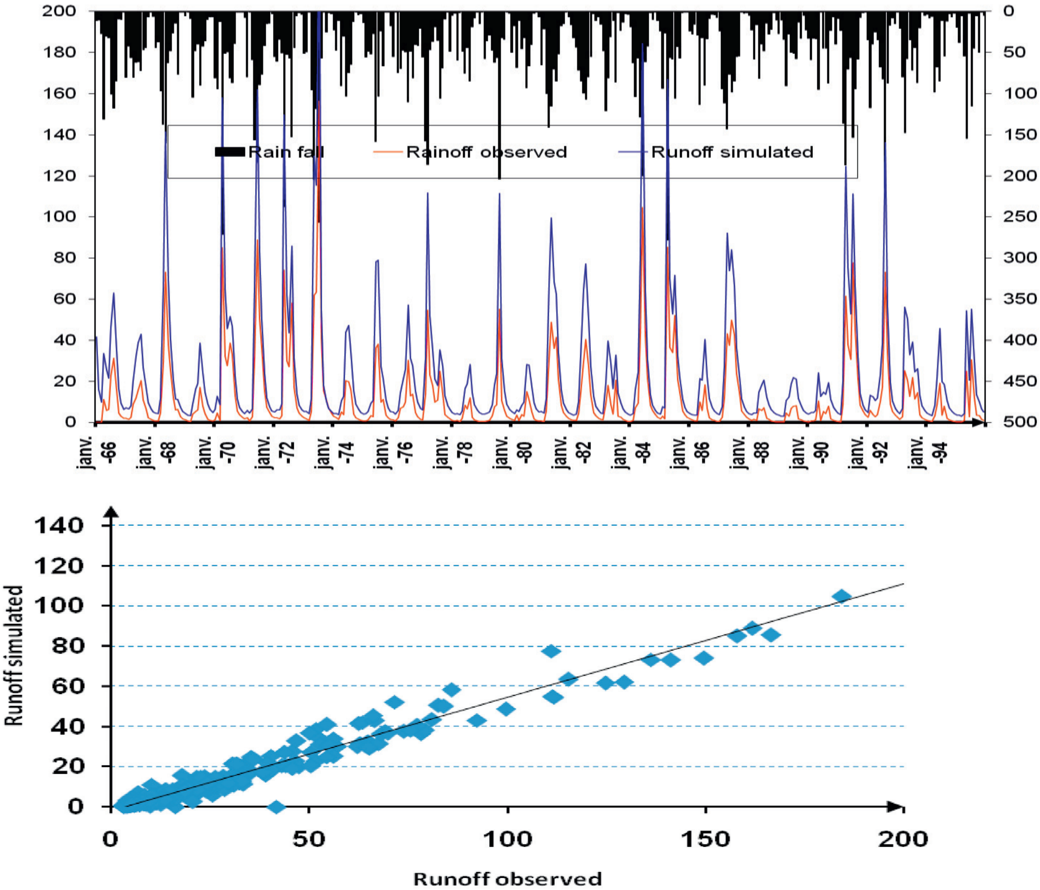

Fig. 1. Results obtained with GR2M model

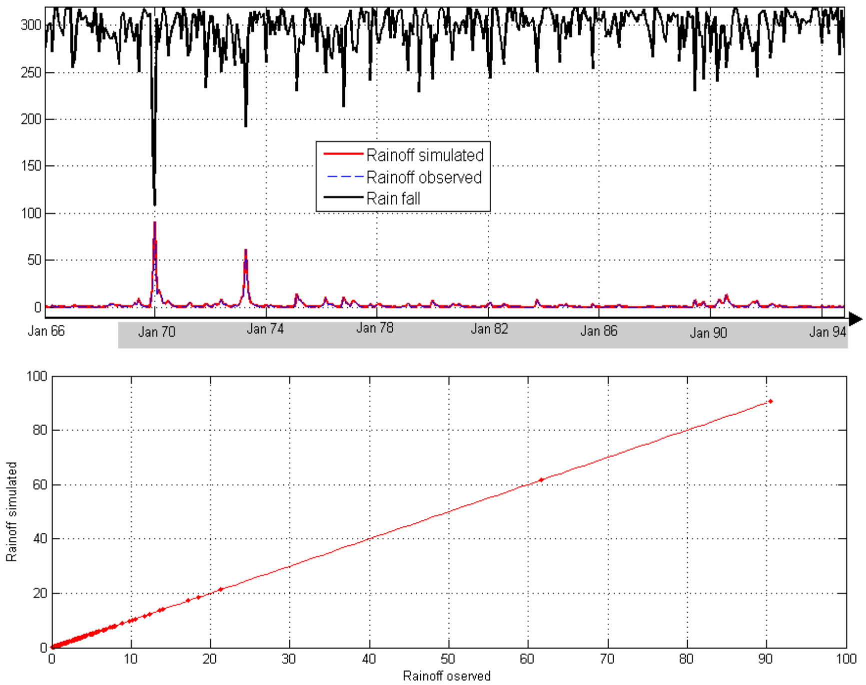

Fig. 2. Results obtained with ANN model

According to the Figures (1et 2) obtained in this study the potential of ANN for simulation confirms, and clearly show and the good superposition of the two curves (simulated and observed) and that they can bring very satisfactory answers for modeling rain-flow and the monthly prediction of the flows to the step of time with a very high degree of fidelity.

The Fig. 3 shows the variation of the quadratic error given by the model ANN with an average of the error is equal $1.5*10^{-4}$. Considering this criterion is too `severe', the quality of the chock is still checked.

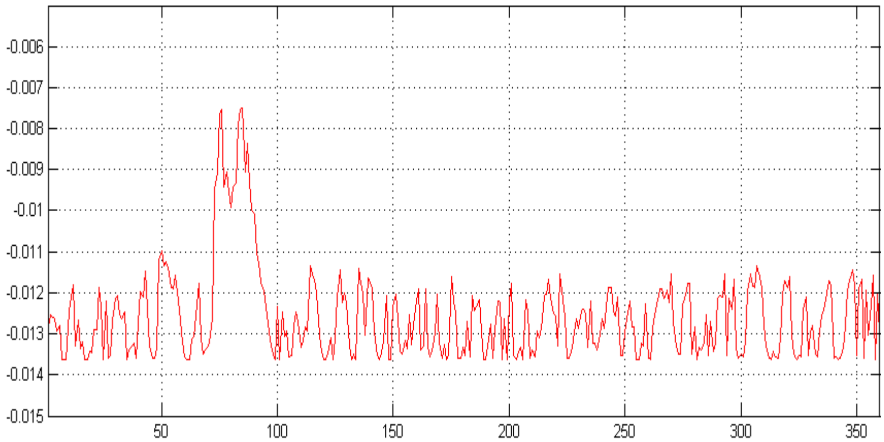

Fig. 3. Error variation obtained with NANN

5. Conclusion

In this article, we studied the relation rain-flow with the step of monthly time by the model ANN and GR2M. The choice of the model for modeling allows a better comprehension of the hydrological behavior of the catchment area and it guarantees then a better reliability with the applications which use simulations of the model in an operational context. According to the results obtained the model ANN showed its superiority in modeling rain flow and one chose this model like a powerful tool of modeling.

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