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Modeling of Weather Parameters Using Stochastic Methods (ARIMA Model)(Case Study: Abadeh Region, Iran)

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Abstract. Climate change in world is always one of the most important topics in water resources. Weather parameters including precipitation, monthly Temperature and relative humidity forecasting could be practically useful in making decisions, risk management and optimum usage of water resources. These three parameters have undeniable effects on hydrological cycle, production of crops products cycle, water usage specifically agricultural usage, people activities and the environments. Time series analysis has two goals, perception or modeling random mechanism and prediction of future series quantities according to the past. In this research 20 years statistics of relative humidity and monthly average temperature and precipitation of Abadeh Station have used by ITSM time series analysis software. According to the ARIMA model, ACF, PACF and evaluation of all eventual samples, precipitation model: ARIMA (0 0 1) (1 1 1)12 and monthly average temperature : ARIMA (2 1 0) (2 1 0)12 and relative humidity : ARIMA (2 1 1) (1 1 0)12 were obtained.

Keywords: Climate change, Precipitation, Temperature, Relative Humidity, Stochastic methods.

1. Introduction

Climate change in world is always one of the most important topics in water resources. Weather parameters including precipitation, monthly Temperature and relative humidity forecasting could be practically useful in making decisions, risk management and optimum usage of water resources. These three parameters have undeniable effects on hydrological cycle, production of crops products cycle, water usage specifically agricultural usage, people activities and the environments. Time series analysis has two goals, perception or modeling random mechanism and prediction of future series quantities according to the past. Precipitation, monthly average temperature and relative humidity are three main effective parameters in drought creation of an area. The minimum fluctuations of these three parameters would extremely damage the agricultural and economic. Prediction of weather parameters can be applied on huge and long-term schematization specifically for resistance to nature disasters. In order to modeling and forecasting, stochastic methods are useful. Time series analysis method have been applied to a large number of practical problems including modeling and forecasting economic time series and process and quality control that one aspect of time series analysis is the use of discrete linear transfer functions to model the interrelationships between input and output time series.

In a study, the mean monthly temperature of Tabriz station was investigated based on Box & Jenkins ARIMA model and using that model, the monthly temperature of Tabriz for a 40 year statistical period

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(1959-98) was examined based on autocorrelation and partial autocorrelation methods as well as controlling the normality of residues. Based on the models so obtained, the variations in the mean temperature of Tabriz station up to the year 2010 are forecasted (9). In another study conducted for the purpose of analysis of the climate of Birjand synoptic station and gaining knowledge on climatic fluctuations, especially years of drought and years of wetness, and providing a suitable model for forecasting of climatic fluctuations, and the best model is fitted to data. Among the necessities for conducting this study are climatic forecasting to be used in the state planning at large concerning natural calamities and thus, the precipitation and temperature of Birjand Station has been studied for the purpose of identification of climatic fluctuations and their possible forecasting (3). In Khorassan Province, using SARIMA model and MINITAB software, seasonal precipitations were modeled for the statistical period 1970-2002 and at last, using the models found at any station, the precipitation levels for the spring, fall and winter of the year 2004 were forecasted and in comparison with the long-term mean of each season, anomaly maps were drawn (7). In a study, modeling of drought in Fars Province was made using Box-Jenkins method and ARIMA model and after zoning of different regions, the model for forecasting drought in any region was obtained (8). Climatic zoning, examination of drought years and wetness years and climatic forecasting were made using different methods such as Palmer Drought Severity Index, Markov chain, moving average, autoregressive, and ARIMA (5). A study is conducted in Turkey to investigate the variability of the trend of mean annual temperature. The findings on a regional scale show the trend of increase in eastern anomaly temperature and the trend of its reduction in coastal regions of Turkey in the past two decades (4). In another study, it is reported that due to the presence of autocorrelation in climatic data such as temperature, the ARIMA modeling method is one of the most valid methods for studying climatic variations (6). Annual temperature and precipitation in Portugal have been forecasted using autoregressive models and the findings showed that annual temperature and precipitation, in addition to changing year by year, change decade by decade, too. In other words, it has annual and decade fluctuations (10). Thus, considering the importance of climatic parameters and their modeling and forecasting by stochastic methods is a necessity and could be a basic role in agricultural and water resource managements.

The aim of this research is analysis of the weather parameters of monthly precipitation and mean temperature and relative humidity modeling and prediction using the statistical models of time series analysis and stochastic methods in the Abadeh region in Iran.

2. Methodology

In this research, the weather parameters (precipitation, mean temperature and relative humidity) of Abadeh Station are used. The studied statistical period was the crop years 1989-90 to 2008-2009. Towards modeling the data after preparing the time series of observations of precipitation, mean temperature and relative humidity separately, the data were fixed. Time series are of different types: single variable and multivariable, correlated and non-correlated, fixed and unfixed. Fixedness means that the laws governing the process remain unchanged with time. Since fixedness is the initial condition in modeling time series, at first we should fixate the data series. A time series may be unfixed in the mean, variance or both. The appropriate method for fixation of a time series that is unfixed in the mean is the differencing method and that for a time series unfixed in variance, is Box-Cox transformations.

Modeling is made using time series analysis by several methods. One of them is the ARIMA or Box-Jenkins method, being called the (p,d,q) model, too (2). In the (p,d,q) model, p denotes the number of autoregressive values, q denotes the number of moving average values and d is the order of differencing, representing the number of times required for bringing the series to a kind of statistical equilibrium. In an ARIMA model, (p,d,q) is called the non-seasonal part of the model. P denotes the order of connection of the time series with its past and q denotes the connection of the series with factors effective in its construction. Analysis of a time series is made in several stages. In the first stage, the initial values of p, d and q are found using the Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF). By a careful study of the autocorrelation and partial autocorrelation diagrams and their elements, a general view on the existence of the time series, its trend and its characteristics. This general view is usually a basis for selection of the suitable model. Also, the diagrams in question are used to confirm the degree of fixedness and accuracy of selection of the model.

In the second stage, it is examined whether p and q (representing the autoregressive and moving average values, respectively) could remain in the model or must exit it. In the third stage, it is examined whether the residue (the residue error) values are stochastic with normal distribution or not. It is then that one can say the model has a good fitness and is appropriate. If the time series is of seasonal type, then the modeling has a two-dimensional state, and in principle, a part of the time series variations belongs to variations in any season and another part of it belongs to variations between different seasons. A special type of seasonal models that shows good results in practice and coin sides with the general structure of ARIMA models is devised by box and Jenkins (1976), which is called multiplicative seasonal model. It is in the form ARIMA (pdq) (PDQ). For the model being ideal, one must use schemes for testing the model and for the comparison purpose, so as the best model is chosen for forecasting.

The criterion for choosing the model in analysis of time series, or, generally, in analysis of data, is that several models appropriate for representing a given set of data may be used. Sometimes, the choice is easy but in other times, it may be much difficult. Therefore, numerous criteria are introduced for comparing models that are different from methods for model recognition. Some of them are based on statistics summarized from residues (that are computed from a fitted scheme) and others are determined based on the forecasting error (that is computed from forecasting outside the sample). For the first method one can mention AIC (Akaike Information Criterion), BIC (Bayesian Information Criterion) and SBC (Schwartz-Bayesian Criterion) and for the scheme based on the forecasting error, one can mention the Mean Percent Error (MPE) method, the Mean Square Error (MSE), the Mean Absolute Value Error (MAE), and the Mean Absolute Value Percent Error (MAPE). The model, in which the above statistics are the least, is chosen as the appropriate model. In using ARIMA model, the AIC is more accurate, and in comparison between the two models, ARIMA acts as the best fitted model (1).

In the present study, ARIMA model, ITSM software and AIC and BIC test were used for modelling the precipitation, temperature and relative humidity examination of their effects on each other

3. Results and Discussion

For modeling by ACF and PACF methods, examination of values relative to auto regression and moving average were made and at last, an appropriate model for estimation of precipitation values for Abadeh Station were found: ARIMA (0 0 1) (1 1 1)12. To prevent from excessive fitting errors, AIC statistic was used. In comparison of the schemes obtained considering the least AIC and BIC value, the final model with the best fitting of data using the method of maximum likelihood is shown in equation (1).

(1)

X(t) = .1124 X(t-1) - .6589 X(t-2) - .0345(t-3) -.5619X(t-6)-.8771(t-9)-.2691(t-13)-.4351X(t-15) - .2456 X(t-22) - .0347 X (t-23) -.1279(t-24)+ Z(t)

AICC = .1148961E+02

BIC= -.24898 E+03

After precipitation modelling procedures, an appropriate model was found for estimation of the mean monthly temperature at Abadeh Station, which is the ARIMA (2 1 0) (2 1 0)12 model. For comparison of the schemes obtained, the least AIC and BIC value were determined. The final model with maximum fitness of data using the maximum likelihood method is shown in equation (2).

(2)

X(t) = - .4532 X(t-1) - .2890 X(t-2) - .2710 X(t-3) - .3812 X(t-4) - .1292 X(t-5) - .0954 X(t-6)- .3490(t-8) -.3512(t-9) - .1275(t-10) -.6832 X(t-12) - .4682 X(t-13) - .3631 X(t-14) -.1038 X(t-15) -.0672(t-16) -.0651(t-20) - .3448 X(t-24) - .1471 X(t-25) - .1030 X(t-26) + Z(t)

AICC = -.195691E+03

BIC= -.18981 E+03

As with the relative humidity modeling, after modeling procedures, an appropriate model was found for estimation of relative humidity at Abadeh Station, which is the ARIMA (2 1 0) (2 1 0)12 model. For comparison of the schemes obtained, the least AIC and BIC value were determined. The final model with maximum fitness of data using the maximum likelihood method is shown in equation (3).

(3)

$$X(t) = 0.7417X(t-1) -0.3794\, X(t-2) + 0.4823\, X(t-3) - 0.4495\, X(t-4)+ 0.2007X(t-5)- 0.3361X(t-6)+0.3405\, X(t-7) - 0.3559\, X(t-8) + 0.1801\, X(t-9) + 0.5521\, X(t-11) - 0.5695\, X(t-12) +0.0537\, X(t-13) -0.4753\, X(t-14) + 0.5612\, X(t-15) - 0.1242\, X(t-16) + 0.05672\, X(t-17) - 0.09374X(t-18) - 0.1837X(t-20) - 0.2281\, X(t-24) + Z(t)$$

AICC = 0.165117E+03

BIC= 0.178514E+03

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