Forecasting of Wind Speed in Nasiriya City by Using ARIMA Model

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Abstract

ARIMA model is used for forecasting average daily wind speed of Nasiriya city, Iraq. The results of ARIMA model have been compared with observed data on the basis of Root Mean Square Error (RMSE), Mean Absolute Error (MAE), Determination Coefficient and Mean Absolute Percentage Error (MAPE). Results obtained indicate that ARIMA model can successfully be used for the prediction of average daily wind speed for Nasiriya city. The main objective to make the prediction starts from the beginning of the time series even distinguish random process and then to forecasting the future values. The technique is accurate but requires a lot of computational skill.

Key Words: ARIMA Model, Wind Speed Data and Nasiriya City.

تنبؤ سرعة الرياح في مدينة الناصرية باستخدام نموذج ARIMA

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الخلاصة

استخدم نموذج اريما لتنبؤ متوسط سرعة الرياح اليومية لمدينة الناصرية العراق .نتائج نموذج اريما تمت مقارنتها مع البيانات المرصودة على اساس خطأ جذر مربع المعدل(RMSE) وخطأ المعدل المطلق (MAE) ومعامل التحديد (R^2) وخطأ معدل النسبة المئوية المطلقة (MAPE) . النتائج تشير الى ان نموذج اريما نجح في تنبؤ معدل سرعة الرياح اليومية لمدينة الناصرية .الهدف الرئيسي من جعل التنبؤ يبدأ من بداية السلسلة الزمنية حتى يميز العملية العشوائية وبعد ذلك يتنبأ بالقيم المستقبلية .التقنية دقيقة لكن تتطلب مهارة عالية.

الكلمات المفتاحية : نموذج ARIMA, بيانات سرعة الرياح و مدينة الناصرية.

Introduction

During last year's many techniques were used to forecast wind speed data. Forecasting models can be distinguished by: Forecasting interval and type of a forecasting model. The type of a forecasting model can be classify into physical, statistical or a combination of these two. Temporal forecasting horizons can be separated mainly into very short term, short term, medium term and long term forecasting (Hannele and Sillanpaa, 2013).

A physical model tries to refine the wind field in a site by using information from the area of interest, such as local orography, roughness and obstacles. The assumptions and theories are based on the physical behavior of wind in the atmospheric boundary layer .

A statistical model does not try to reform the wind field inside a numerical weather prediction grid. However, a statistical model tries to find dependencies between produced wind power (dependent variable) and explanatory variables such as wind speed and wind direction forecasted from Numerical Weather Production (NWP). Typically the dependencies are found by minimizing a loss function, which is a function of actual power production and forecasted power values from a statistical model (Gnana, 2011).

Forecasting of wind speed has much more interest rather than other meteorological parameters forecasting, this is mainly due to fast growth of using wind for power production, thus the direct application of wind forecasting is the wind power forecasting, which can be used for example in economical estimation of wind power production for different sits.

The wind is considered one of the most difficult meteorological parameters to forecast. The major difficulty in wind forecasting arise from the complex behavior of wind it's self. Beside the stochastic behavior of wind, which is its major characteristic, The wind has seasonal and annual behavior (Shun-jyh, *et al.*, 2001).

The aim of this analysis is to determin an appropriate model for forecasting the average daily wind speed in Nasiriya city.

Materials and Methods

The pioneers in this area was George Box and Gwilym Jenkins who popularized an approach that combines the moving average and the autoregressive models. Although both autoregressive and moving average approaches were already known, the contribution of Box and Jenkins was in developing a systematic methodology for identifying and estimating models that could incorporate both approaches. This makes Box-Jenkins model a powerful class of model (Samir, 2009).

ARIMA Model

Time series model can be divided into three part: Auto-regressive model AR(*p*) , Moving average model MA(*q*), Auto-regressive moving-average model ARMA(*p, q*) (Samir, 2009).

i) Auto-regressive Model AR(p)

The notation AR(p) indicates an autoregressive model of order p . The AR(p) model is defined as (Soder, 1993):

$$\bar{y}_t = C + \emptyset_1\, y_{t-1} + \cdots + \emptyset_P\, y_{t-p} \qquad (1)$$

where are the parameters of the model, c is a constant (often omitted for simplicity).

ii) Moving Average Model MA(q)

The moving-average MA model is a common approach for modeling univariate time series models. The notation MA(q) refers to the moving average model of order q (Kamal and Jafri,1997):

$$\bar{y}_t = \varepsilon_t - \theta_1\, \varepsilon_{t-1} - \ldots - \theta_q\, \varepsilon_{t-q} \qquad (2)$$

Where $\theta_1, \theta_2, \ldots, \theta_q$ are the moving average parameters, $\varepsilon_t, \varepsilon_{t-1}, \varepsilon_{t-q}$ are the white noise terms. The value of (q) is called the order of the MA model.

iii) Auto-regressive Integrated Moving Average Model

The notation ARIMA (p, d, q) refers to the model with p=order of AR; d=number of differencing done on the non stationarity time series ; q=order of MA (shamshad *et al.*, 2003).

Wind Speed Data

The average daily wind Speed data for the year 2007 have been used in this work. These data were obtained from Iraqi meteorological organization and seismology for Al Nasiriya station located at south west of Iraq as shown on Iraqi map in Figure (1) below:

Fig.(1) Show Map of Iraq, and Location of Nasiriya City/ Iraq

The time series of the average daily wind speed for the year 2007 were shown in Fig.(2). in order to apply certain techniques for identifying ARIMA model, the data must determine the form of trend of the time series. It was clear from this figure a random trend for the average daily wind speed.

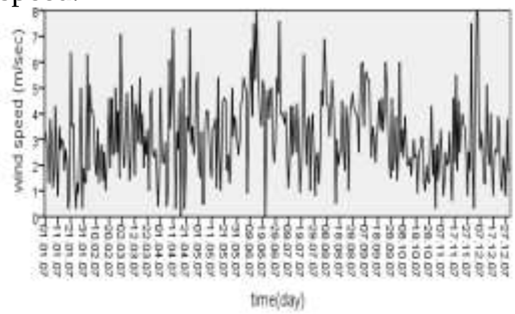

Fig.(2) Time Series of Observed Average Daily Wind Speed in Nasiriya City / Iraq.

Results and Discussion

Among all the possible forecasting models which can be result from using ARIMA with different p , I, and q values, only three of them have been chosen because the close results to the observed time series of the average daily wind speed data. These models are ARIMA(2,2,3), ARIMA(2,3,3) and ARIMA(2,4,5). For testing the results, we used firstly both the autocorrelation function (ACF) and the partial autocorrelation function (PACF). As general rule for an ACF, if there were residuals greater than 2 standard errors away from the zero (confidence limits) means that there were statistically significant autocorrelation. While PACF is the amount of correlation between a variables and its lag that is not explained by correlations at all lower-order lags. Fig.3 show type of correlation, which mainly due to the behavior of the observed data.

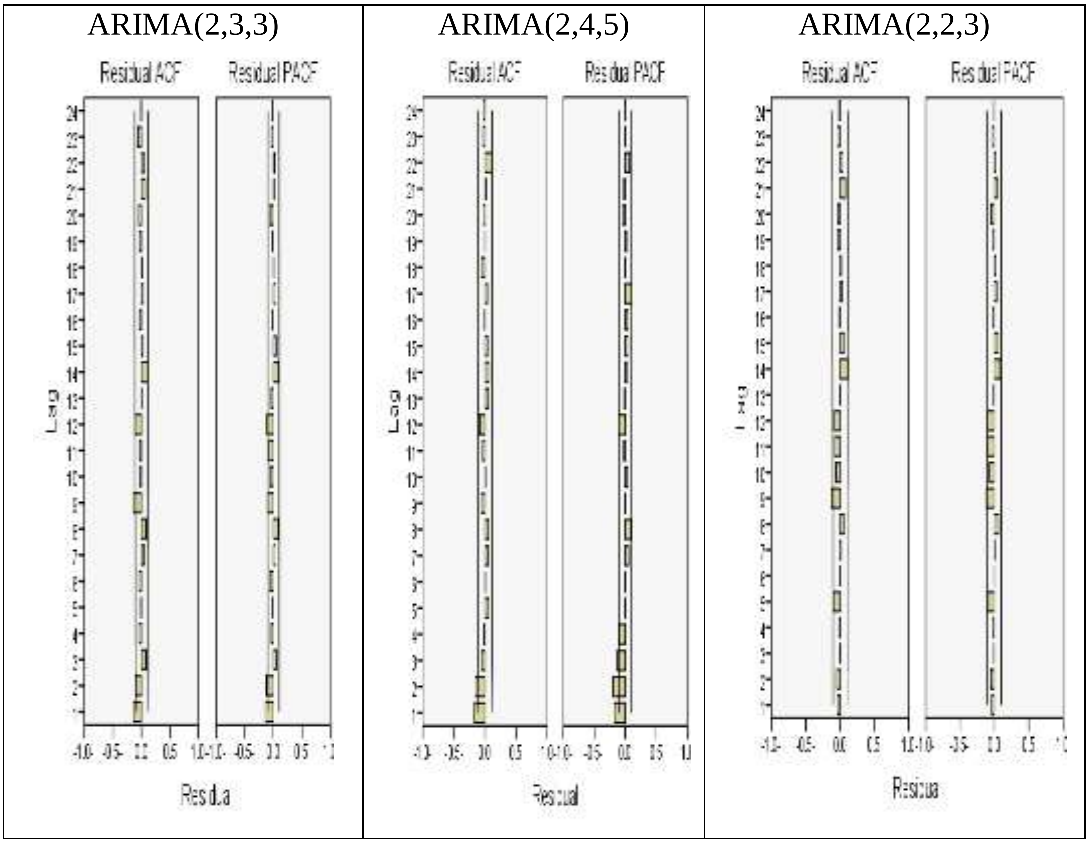

Fig.(3) Residual ACF and PACF with 95% Confidence Limits for Various Models.

The present values of ACF and PACF values were all within the 95% zero-bound-indicating that there was no correlation within the residuals.

In Forecasting calculations, There were many criteria which can be used to detect the forecasting result with minimum errors. The forecasting errors were related to the deferences between the actual wind speed and the predicted obtained from the forecasting models, such as Mean Absolute Error (MAE), Root Mean Square Error (RMSE), Determination coefficient () and Mean Absolute Percentage Error (MAPE). The resulting values for these criteria for the three forecasting data are shown in table (1) below:

Table(1) Statistical Parameters of Selected ARIMA Models for Wind Speed

Possible Model	RMSE	MAE	R^2	MAPE(%)
ARIMA(2,2,3)	0.489	0.024	0.923	4.278
ARIMA(2,3,3)	0.491	0.031	0.845	4.345
ARIMA(2,4,5)	0.496	0.037	0.823	5.236

The relationship between the observed values and fitted values of the most appropriate models was shown in Fig.(4) The fitted values were quite close to the observed values.

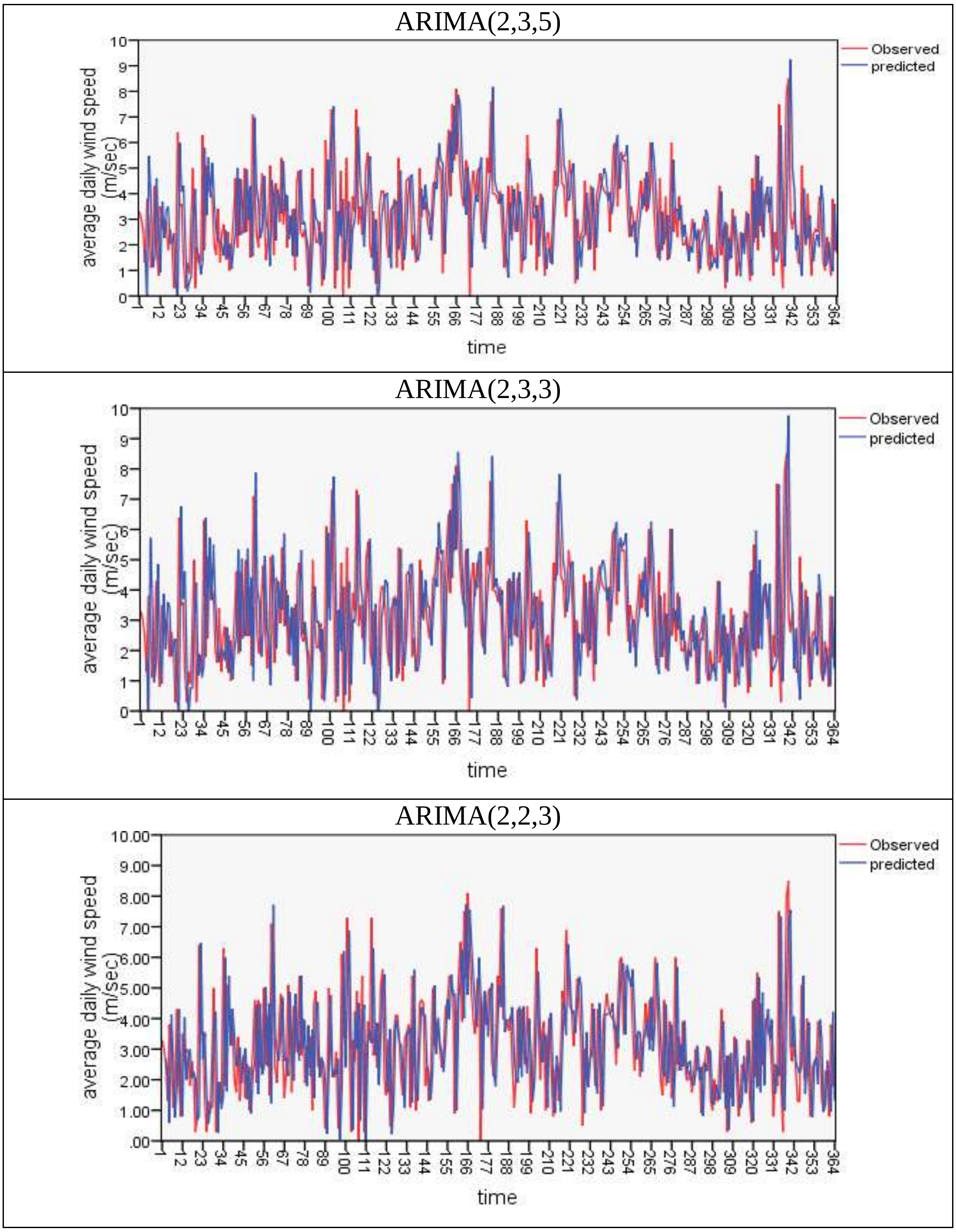

Fig.(4) Comparison of Actual Values and Predicted Values Wind Speed Time Series by Applying ARIMA Model.

Forecasting

The three previous ARIMA models were used for calculating the forecasted average daily wind speed for the twelve days from 1-12 Jan. 2008. The resulting data were compared to real data measured in Iraqi meteorological organization and seismology as shown in Table (2) .

Table (2) Actual and Forecasting Results of ARIMA Models

Time(day)	Observed values(m/sec)	Forecasting values for ARIMA(2,2,3)	Forecasting values for ARIMA(2,3,3)	Forecasting values for ARIMA(2,3,5)
01/01/2008	1.8	1.91	2.08	1.60
02/01/2008	2.5	2.31	2.95	2.04
03/01/2008	1.0	1.01	2.01	0.50
04/01/2008	1.6	1.49	2.11	2.09
05/01/2008	3.5	3.89	4.01	4.11
06/01/2008	6.3	6.30	6.07	6.89
07/01/2008	2.3	2.29	1.50	1.09
08/01/2008	0.8	0.50	0.71	0.73
09/01/2008	1.9	1.71	1.61	2.10
10/01/2008	1.8	1.77	1.92	1.72
11/01/2008	3.3	3.32	2.66	2.51
12/01/2008	2.3	2.30	2.51	1.69

The resulting data for the best model were plotted in blue color to forecasted value and observed data in red color to the last four months from the year 2007. Because, It is best period to get forecast with minimum error as shown in Fig.(5).

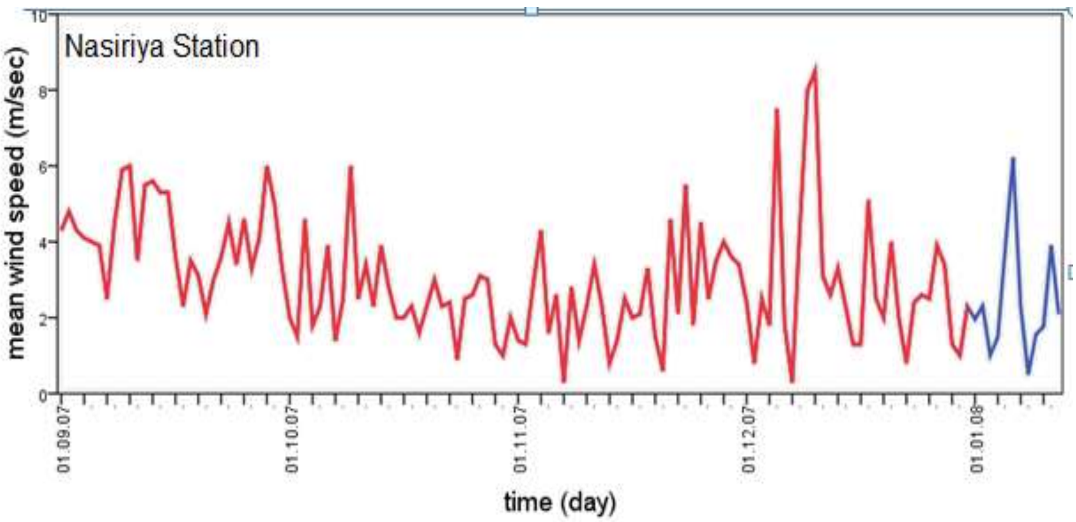

Fig. (5) Time Series of Actual and Forecasted Values for Nasiriya Station.

From all of our tests, It can be note that the best model is the ARIMA(2,2,3) for the original time series for AL- Nasiriya city, which has the minimum errors in comparison with others.

Conclusion

It has been found from forecasting of wind speed that ARIMA(2,2,3) was the best forecasting model among the three ARIMA models which has been tested.

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