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RESEARCH ARTICLE

Estimation of Dusty Days Using the Model of Time Series: A Case Study of Hormozgan Province

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Study Area: Hormozgan Province of Saravan, Iran,
Coordinates: 27°22'15" N 62°20'03" E

Key words: Dust Hazard, AMIRA Modelling

Abstract

Dust storm is one of the climatic hazards in the arid and semi-arid regions. Southern Iran with its hot and dry climate is more likely affected by the adverse consequences of dust storms due to the proximity to the dusty deserts of Saudi Arabia and Iraq, on one hand, and the synoptic situation for the occurrence of the dust storms in the Persian Gulf, on the other hand. In this study, the frequency of dusty days in Hormozgan Province was investigated and predicted. To this end, data were collected from the three synoptic stations in Bandar Abbas, Bandar Lengeh and Bandar-e Jask from the Iran Meteorological Organization during the statistical period of 1968-2008. Then, using the non-seasonal ARIMA (p, d, q), were analyzed in 16Minitab and the frequency of the dusty days in the region were predicted. Results of the study show that the ARIMA (1, 1, 1)noc was the most appropriate pattern for predicting the frequency of dusty days in Hormozgan Province. The results showed that the predictions for Bandar-e Jask, compared to those of Bandar Abbas and Bandar Lengeh are more accurate in terms of continuous increasing trend and the interval stability of the time series prediction and the smaller difference between the observed values with the predicted values.

Introduction

Dust storms as the most common phenomenon in many parts of the world, notably in the arid and semi-arid regions are a serious threat to human societies. The frequency of dust storms in different parts of the world with its increasing, decreasing, or cyclic patterns is a global pattern (Goudiee & Middleton, 1992). Southern Iran with its hot and dry climate is more likely affected by the adverse consequences of dust storms due to the proximity to the dusty deserts of Saudi Arabia and Iraq, on one hand, and the synoptic situation for the occurrence of the dust storms in the Persian Gulf, on the other hand. Thus, further studies on dust frequency in these regions

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should be conducted in order to do predictions based on the previous behavior of the time series in long-term and to cope with this natural hazard. A high number of studies have already been conducted on modelling as one of the most efficient statistical methods for predicting the frequency of the climatic phenomena. In Greece, the seasonal trends, and annual temperature were investigated using the time series method and the relationship between observed trends with circular patterns were discussed using satellite and surface data (Feidas *et al.*, 2004). Using the Mann-Kendall and ARIMA modelling, spatial distribution of stratospheric ozone in both northern and southern hemispheres was analyzed (Chattopadhyay *et al*., 2012). Seasonal long-term trends of monthly average temperatures in Alaska were analyzed using time series (Gil-Alana, 2012). The results of the modelling of the variability of time series of the rainfall in Peninsular Malaysia show the favorable seasonal ARIMA model for a series of monthly average rainfall in the region (Yusof & Lawal Kane, 2013). Over recent years, a large number of studies on using the time series models have been conducted in Iran in order to achieve a variety of certain goals. Using the ARIMA modelling for investigating the number of frost days in North Khorasan shows the decreasing trend of frequency of this phenomenon in this region (Rabani & Karimi, 2009). By modelling and predicting the rainfall amount in Kabudarahang plain, Hamadan using ARMA (4, 4), the non-cyclical nature of rainfall in this region was determined (Aghapour *et al.*, 2010). For analyzing and predicting the precipitation trends and temperature of Kermanshah using the ARIMA model, daily, monthly, and annual rainfall amounts were compared with the corresponding actual values (Veisipour *et al.*, 2010). In order to predict and determine the climatic parameters of Isfahan, appropriate time series models of seasonal and non-seasonal ARIMA were used (Dodangeh *et al.*, 2012). Using the time series methods and artificial intelligence, monthly flow discharge of Karkheh River was predicted at the various stations (Tarazkar & Sedghamiz, 2008). Analytical results of the Box-Jenkins models for the detection of the climate change in the half-west of Iran show the meaningful and oriented trends of the variables of temperature and lack of the meaningful trends in moisture and precipitation data (Azizi *et al.*, 2008). Using artificial neural networks for predicting the dust storms in the Zabol showed the higher level of accuracy in short-term predictions (Tajabadi *et al.,* 2010). Hidden cycles of the annual temperatures of Bushehr were estimated using the spectral analysis and then, annual temperature was predicted using the ARIMA model (Jalali & Kargar, 2011).

Material and Methods:

Modeling is a new technique for describing, dating, recreating, and predicting that is widely used by the climatologists. However, probabilistic statistical climatic models are of particular importance with numerous applications (Asakareh, 2009). One of the most common of the statistical models is ARIMA that is used for predicting the future values of time series based on their past behavior. Using this model in this study, the observed frequency of dusty days in the Hormozgan was analyzed and the behavior of this phenomenon was predicted. To this end, data were collected from the three synoptic stations in Bandar Abbas, Bandar Lengeh and Bandar-e Jask from the Iran Meteorological Organization during the statistical period of 1968-

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2008. Data were arranged in Excel using the non-seasonal ARIMA (p, d, q) in 16Minitab. In order to verify the model's predictability, three-step process of diagnosis, fitness, and accuracy of the model was conducted and the appropriate model was selected. Then, regression analysis was carried out and the proportional differencing was considered based on the fitted pattern on the time series. After that, for determining the order of p and q, the autocorrelation function (ACF) and partial autocorrelation function (PACF) of the time series were plotted and the autocorrelation (AR) and moving average (MA) parameters were determined for the individual stations. Testing and fitting of the ARIMA patterns showed that by adding a fixed parameter (èo), better results are obtained. Therefore, the fixed parameter was used for all models. Then, the results of the obtained predictions by these models were compared. Finally, of the fitted patterns of the time series models, the most appropriate and stable pattern was selected as the final model for of the future prediction of the time series. At last, for measuring the accuracy and precision of the accepted patterns, their residuals were tested in terms of normality and independence, respectively, using the normal probability and autocorrelation diagrams.

Results and Discussion:

In this study, because of the high volume of the work and the lack of providing a complete process for all stations in the region, Bandar Abbas station was selected as the sample research. After describing the process, results of Bandar Lengeh and Bandar-e Jask were shown.

Bandar Abbas: the results of regression analysis of time series of the average annual frequency of dusty days in Bandar Abbas showed fitness of a linear model with an increasing trend (Figure 1), according to which, first order differencing of the time series was conducted.

Then, according to the autocorrelation diagram and ACF significant values in the first and second delays, two patterns of ARIMA (0,1,1) and ARIMA (0,1,2) were respectively considered as the M1 and M2 patterns . In the partial autocorrelation diagram, the ARIMA (1,1,0) was determined and called M3, with respect to the significance of PACF value in the first delay.

No accepted pattern of prediction was obtained by fitting the three patterns of M1, M2, and M3. Therefore, with respect to the autocorrelation diagram, fitting and testing the other patterns, M4 as ARIMA $(1, 1, 1)_{noc}$ showed effective results compared to those of other selected patterns that is expressed as follow:

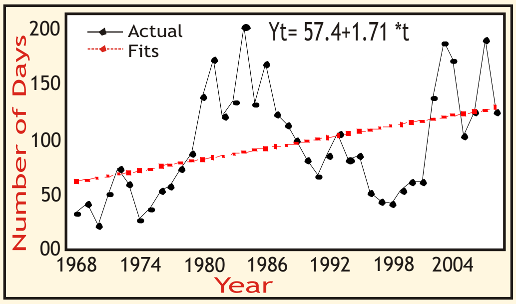

Figure 1: Linear Trend Model: Annual average frequency of dusty days in Bandar Abbas station in the statistical period of 1968-2008

$$Z_t \quad {}_0 \; Z_{t-1} \quad {}_1 Z_{t-1} \; a_t \quad {}_1 a_{t-1} \qquad (1)$$

After verification of normality and residual independence of the selected patterns, Akaike Information Criterion (AIC) was calculated for four fitted models to ensure the selection of the best model that is explained as follows:

$$AIC = n \,\text{in}(S_a^2) + 2(m) \qquad (2)$$

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Where $S_a^{\,2}$ is the total variance of time series; n is the time series length; m is the number of model parameters including the values of p and q and finite trend term ($_0$) if it is significant in the model. The results of the different patterns of ARIMA for time series of Bandar Abbas station are summarized in table 1.

Table 1: Features of the selected patterns for the average frequency of the dusty days in Bandar Abbas

Pattern	Model	Variance of Residuals	AIC
1M	ARIMA (0, 1, 1) con	1252.03	296.41
2M	ARIMA (0, 1, 2) con	1206.38	296.69
3M	ARIMA (1, 1, 0) con	1280.23	297.31
4M	ARIMA (1, 1, 1) con	1166.24	291.50

Table 1 shows that M4 pattern with the minimum variance of residuals has the minimum AIC. Before selection of M4 as the final pattern of the prediction, the model residuals were verified in terms of normality and independence, respectively using the diagrams of normal probability and autocorrelation (ACF) (figure 2).

Thus, ARIMA $(1, 1, 1)_{noc}$ as the final pattern was used for predicting the frequency of the dusty days in Bandar Abbas. The above-mentioned process was considered for Bandar Lengeh and Bandar-e Jask and the results were shown in figure 3 and table 2.

Table 2 predicted values of average frequency of dusty days in Hormozgan using the ARIMA $(1, 1, 1)_{noc}$

Year	Bandar Abbas	Bandar Lengeh	Bandar-e Jask
2009	129	164	123
2010	132	166	118
2011	135	169	116
2012	137	172	117
2013	140	175	118
2014	142	179	119
2015	144	182	121
2016	146	185	122
2017	148	188	125
2018	151	191	125
Observed average	93	58	80
Predicted average	140	177	120

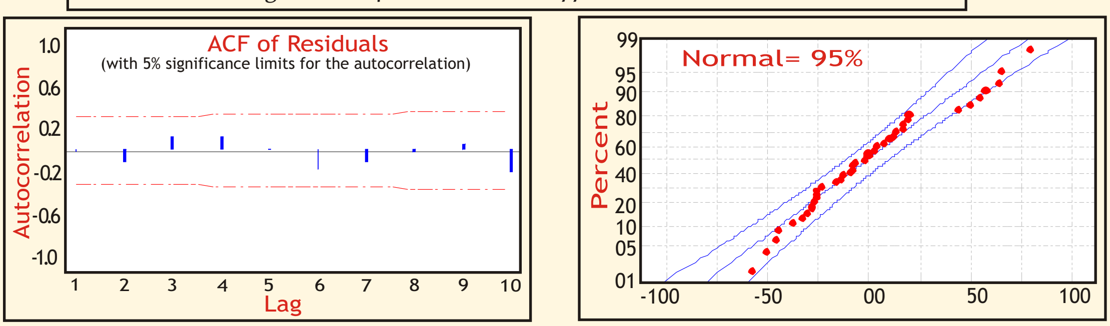

Figure 2: Independence (left) and normal probability (rught) of the residuals of M4 model using the confidence interval of 95% for Bandar Abbas station

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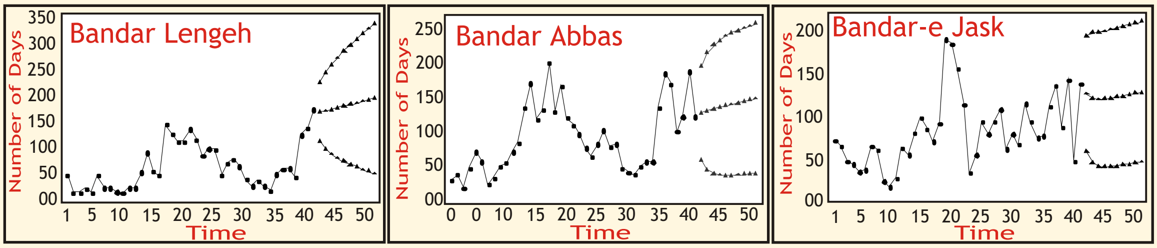
Figure 3: Time Series Plot: annual average frequency of dusty days in Bandar Lengeh, Bandar Abbas and Bandar-e Jask using the ARIMA $(1, 1, 1)_{noc}$



Conclusion:

In this study, non-seasonal ARIMA (p, d, q) noc was used for predicting the frequency of the dusty days in Hormozgan Province. This model was separately used for three stations of Bandar Abbas, Bandar Lengeh and Bandar-e Jask. Due to the time series compliance of the of all three stations with the linear pattern and similar autocorrelation diagrams in significant delays, nearly similar patterns were used for predicting the series; however, selection of the most appropriate pattern was based on the optimum fitness and a more acceptable and precise prediction. To this end, trial and error method was implemented for the selected patterns by adding or subtracting the parameters and comparing the results. It is worth noting that adding the fixed parameter ($_0$) led to the effective results for all the patterns used. Therefore, this parameter was used for all selected patterns. Finally, in spite of the fitness of the different patterns of the time series for all the stations, ARIMA $(1, 1, 1)_{noc}$ was considered as the most appropriate pattern for prediction. This pattern was selected among the four patterns in Bandar Abbas station and five patterns in Bandar Lengeh and Bandar-explanatory Jask. Results of the observed and predicted values were shown in table 2. Generally, results show the more precise predictions in Bandar-explanatory Jask station compared to those of Bandar Abbas and Bandar Lengeh stations. Minimum difference between the observed and predicted values demonstrates the higher stability of the predicted confidence interval.

Moreover, in previous studies conducted in Japan and China, dust events were investigated using the time series (1972-2004), data obtained from weather stations and Southern Oscillation Index (SOI). The results indicated a significant decreasing trend in the number of days with dust in Gobi desert. In the last years of the study period, an increasing trend was observed in Japan. Polar air raid plays an important role in the formation of dust in the region. Importantly, dust transfer route is changed in El Nińo and La Nińa phases in this region (Levy *et al.*, 2007; Taei Samiromi *et al.,* 2014). Indoitu *et al.* (2012) examined the temporal and spatial variations of the dust in Central Asia during the last seventy years. Results showed that the main source of dust is in sand desert and the deserts that are mainly affected by human activities, which form a belt of dust from West to East and covers a vast area of northern deserts of the Caspian Sea, southern part of Balkans Lake, and Aral Sea. Azizi et al (2012) conducted a Statistical Analysis of the Synoptic of the phenomenon of dust in the western half of Iran using a combination of Statistical Analysis of the Synoptic and telemetry. The results showed the maximum of days with dust in the months of May, June and July and the minimum in December and January. Results also showed that East Syria, Iraq, and deserts in Saudi Arabia are the main dust sources in western half of Iran.

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References:

Aghapour, S.M., Yazdani, S., & Salami, H. (2010): Patterning and predicting of the rainfall rate and determining the obtainable water of the agriculture sector in Kabudarahang plain. *J.Agricul. Econom.*, 1: 9-30.

Asakareh, H. (2009): Patterning of ARIMA for annual average temperature of Tabriz. *J. Geographic.Res.*, 93, 3-24.

Azizi, Gh., Shamsipour, A.A. & Yarahmadi, D. (2008): Detection of climate change in half-west of Iran, using multivariable regression analysis. *Physical Geog. Res.*, 66: 19-35.

Azizi, Gh., Shamsipour, A., Miri, M., & Safarrad, T. (2012): Statistic and Synoptic Analysis of Dust Phenomena in West of Iran. *J. Environ. Stud. Fall*, 38(3): 31-33.

Chattopadhyay, P., Chakraborthy, P., & Chattopadhyay, S. (2012): Mann-Kendall Trend Analysis of Tropospheric Ozone and its Modelling Using ARIMA. *Theor. Appl. Climatol.*, 110: 321-328.

Dodangeh, E., Abedi Koupai, J., & Gohari, S. A.R. (2012): Application of Time Series Modeling to Investigate Future Climatic Parameters Trend for Water Resources Management Purposes. *J. Sci. Technol. Agricul. Natural Resources.* 59: 59-74.

Feidas, H., Makrogiannis, T., & Bora-Senta, E. (2004): Trend Analysis of Air Tempreture Time Series in Greece and their Relationship with Circulation Using Surface and Atellite Data: 1955-2001. *Theor. Appl. Climatol.,* 79(3): 185-208.

Gil-Alana, L. A. (2012): Long memory, Seasonality and Time Trends in the Average Monthly Temperatures in Alaska. *Theor. Appl. Climatol.,* 108(3): 385-396

Goudiee, A.S., & Middleton, N. J. (1992): The Changing Frequency of Dust Storms Through Time. *Climatic Change*, 20: 197-225.

Indoitu, R., Orlovsky, L., & Orlovsky, N. (2012): Dust storms in Central Asia: Spatial and temporal variations. *J. Arid Environ.,* 85: 62-70.

Jalali, M., & Kargar, H. (2011): Analysis and modeling for temperature of Bushehr station. *J. Geographic. Space,* 39: 149-173.

Levy, R.C., Remer, L.A., & Dobovik, O. (2007): Global aerosol optical properties and application to Moderate Resolution Imaging spectroradiometer aerosol retrieval over land. *J. Geophys. Res.* 112: D13210, doi:10.1029/2006JD007815.

Rabani, F. & Karami, F. (2009): Frequency trend of frost days in Northern Khorasan province. *J. Physic. Geography*, 4: 85-94.

Taei Samiromi, S., Moradi, H., Khadagholi, M., & Ahmadi, M. (2014): Study of factors affecting dust phenomenon in west of Iran. *Human & Environment*, (27): 1-10.

Tajabadi, J.M.R., Moghadamnia, A., Piri, J., & Ekhtesasi, M.R. (2010): Application of artificial neural networks in dust storm prediction (case study: Zabol city). *Iranian J. Range Desert Res.*, 17(2):205-220.

Tarazkar, M.H., & Sedghamiz, A. (2008): Comparing monthly discharge forecasting for Karkheh river by using time series and artificial Intelligent traits. *J.Res. Construction, Natural Resources*, 80:51-58.

Veisipour, H., Masompour Samakoosh, J., Sahneh, B., & Yusefi, Y. (2010): Analysis of precipitation and temperature trend prediction with using time series models (ARIMA) (case study: Kermanshah Township). *J. Geography,* 12: 63-77.

Yusof, F. & Lawal Kane, I. (2013): Volatility modeling of rainfall time series. *Theor. Appl. Climatol.,* 113(1):247-258.