Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 10, Issue, 12, pp.76394-76398, December, 2018
DOI: https://doi.org/10.24941/ijcr.33657.12.2018

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

ANALYZE OF THE GLOBAL CLIMATE CHANGE SCALE WITH BOX-JENKINS METHOD: ANKARA/TURKEY

[1,]*Simge AKŞİT and [2]Beril S. AKIN

[1]Environmental Science Department, Institute of Science, Gazi University, Turkey
[2]Department of Environmental Sciences, Gazi University, Turkey

ARTICLE INFO

Article History:
Received 09th September, 2018
Received in revised form
10th October, 2018
Accepted 30th November, 2018
Published online 31st December, 2018

Key Words:
Global Climate Change,
ARIMA,
Box-Jenkins,
Ankara,
Turkey

ABSTRACT

Global climate change is a situation caused by natural causes and human activities. There is a balance between the light coming from Sun and beam of light reverberated from Earth's surface to the atmosphere. The main reason for global climate change is that the current balance is not protected due to external factors. The aim of this research is to determine the rate of global climate change on Ankara. In this study, the stationary temporal climate series of temperature, precipitation and evaporation series for Ankara were analyzed using by Box-Jenkins method. The analysis completed using temperature, precipitation and evaporation data for Ankara, which are taken from Meteorology General Directorate, until 2017. There is a relation between temperature, precipitation, evaporation data, and global climate change trends. Using by Box-Jenkins method, future predictions are made. For temperature data, predictions include the next 15 years data (2018-2033). 15 years predictions are made for evaporation data (2018-2033). And for precipitation data, predictions include just 5 years period, that is because of previous data of precipitation includes 14 years process. According to Box-Jenkins (ARIMA) method, the findings indicated as, a decrease of 0.6 0C in temperature, an increase of 21.54 mm in evaporation and a decrease of 19.91 mm in precipitation have been predicted. According to these analyses, the Ankara city will be affected by global warming and there will be a drought climate for the feature.

***Citation: Simge AKŞİT and Beril S. AKIN,* 2018.** "Analyze of the global climate change scale with box-jenkins method: Ankara/Turkey", *International Journal of Current Research*, 10, (12), 76394-76398.

INTRODUCTION

Global climate change is the temperature increase on the earth surface and oceans,it is caused by theeffect of the accumulated greenhouse gases (GHGs) on the atmosphere, increasing fossil fuel consumption, destruction of forests and increasing industrial activity. In the global climate change, the external factors that occur during the rotation of the earth around the sun and volcanic activities play a role. From the late 19th century the temperature of the Earth's surface has increased by 0.6 degrees. The amount of this increase is not uniformly distributed worldwide. In the meantime, some part of the world has cooled down (Jadhav, 2009). According to IPCC (Intergovernmental Panel on Climate Change) report, the GHGs (carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons) concentration has increased since 1750, caused by fossil fuel consumption and human activities. GHGs have affected the existing energy circulation of the earth and order of climate, by absorbing the solar radiation. According to the IPCC report, the earth's surface temperature will be increased by 0.6 degrees from the late 20th century and with this increase, it will show some deterioration and changes in climate elements. This deterioration can be observed as a reduction in snow-covered areas, an increase of 0.1-0.2 m at average sea level, El Nino and La Nina climatic changes and increased droughts in Asia and Africa continents (Betsill, 2003).Anthropogenic greenhouse gas emissions have been increasing due to the presence of economic factors and an increase in population rates since the industrial revolution. The highest rate of greenhouse gas emission measured between 2000 and 2010. The main source of driving energy for climate comes from the sun. The earth surface hinders solar radiation that is short wave radiation and 2 out of 3 of solar radiation is absorbed by the atmosphere, earth, and oceans. The balance between earth and atmosphere system basically depends on this energy cycle (IPCC Scientific, 1991). GHGs absorb long wave radiation coming from the Sun and provide warming in the atmosphere. This situation can explain as blanket effect. With blanket effect, Earth's surface temperature increases by almost 35 ^{0}C (Morrissey and Justus, 2001). If GHG's does not exist at all, Earth's surface temperature would be almost -18 ^{0}C and there would be no life in the world (Spence, 2007). Researches show that there are 4 anthropogenic greenhouse gases in the atmosphere, which are carbon dioxide, methane, nitrous oxide

***Corresponding Author: Simge AKŞİT,**
Environmental Science Department, Institute of Science, Gazi University, Turkey.

and chlorofluorocarbons (Morrissey and Justus, 2001). One of the most important problems of the world is global climate change which is basically caused by human activities and GHGs. One of the most important gas is CO2 that is coming from fossil fuel consumption. Although CO2 is the most important gas but not the only one. There is also methane, nitrous oxide, and chlorofluorocarbons (Remuzgo and Trueba, 2017). Besides GHGs, there is also suns magnetic field and solar wind coming from electron and proton activities and shield of the sun which protects the sun from cosmic radiation. Sun's activities are changing with the time and this situation causes a weakening of the shield. Cosmic radiation amount has increased and causes global climate change (Batan, 2014).

According to Milutin Milankovitch, who is the Serbian astronomer and geophysicist, every 100000 years there is a stretch in the Earth's orbit passes from the circle to the ecliptic shape, and every 41000 years there is a 3-degree difference in Earth's slope. This situation explains as Milankovitch theory. Milankovitch theory has affected the world's order of climate (Levy, 2011). IPCC 5th Assessment Report (AR5) includes the observed climate change and the reasons for this change, the risks to the future, the policies to adapt to this situation and policies to reduce climate change rate. The highest level of the world history has been achieved in anthropogenic greenhouse gas emissions. If the emission rates continue to be the same amount, tragic damage will occur to the ecosystem and human existence and this situation will be irreversible. According to all scenarios that have been tried, the constant and long-term heat wave will occur, oceans temperature will increase and sea level will increase. According to the AR5, it is possible to decrease 2 0C temperature compared to the pre-industrial revolution era. For this, in the short-term, it is necessary to limit the emission rate and for the long-term, it is necessary to decrease the emission rate to zero (Zengin, 2015).

Purpose

The aim of this research is to determine the rate of global climate change on Ankara. The rate of global climate change and its effects on the area is important. Therefore, the temperature, precipitation and evaporation changes in trends, correlations and reveal the future projections of climate in the region is necessary for the detection of climate oscillations. Making similar studies across the country will play a role in determining the rate of climate change.

MATERIALS AND METHODS

Time series analysis is based on the assumption that the values of a data file represent consecutive measurements taken at equally spaced time intervals. Time series analysis method is a stochastic process. In the method of Box-Jenkins time series has only one variable data. Time series forecasting based on the series' present and past data. For the time series forecasting, there are multiple methods. One of these methods is the Box-Jenkins method. Explain the margin of error obtained by using previous period data on the linear-based and create a valuation for the future data. The method is using as ARIMA method (Özer and İlkdoğan, 2013).

Study area

Ankara is the capital of the Turkish Republic. Ankara is located in $39^{0}55'38''$ N $32^{0}51'19''$ E / 39.92725^{0}Latitude and 32.85521^{0}Longitude. Ankara is the second crowded city in Turkey.

Figure 1. The map of Ankara/Turkey

Figure 2. The detailed map of Ankara province

The ARIMA Model

In an autoregressive integrated moving average model, the forecasting data is assumed as a linear function and the previous data has random error values (Zhang, 2003). Screening methods for non-stationary features in time series are trend analysis and seasonal effects. Initially, the series is converted to a static series using time and delay functions. The time series is recovered from the effect of seasonality and trend, by using differential (Commandeur and Koopman, 2007). Many of the empirical time series behave as if they had no fixed average value. Even so, a part of the series still acts like all the remaining parts to provide homogeneity. To describe this kind of homogeneous non-stationary time series, assumptions are made on the stationary differences in some parts of the time series (Box, Jenkins, Reinsel, and Ljung, 2015).

AR (p) model

$$y_t - \emptyset_1 y_{t-1} - \emptyset_2 y_{t-2} - \cdots - \emptyset_p y_{t-p} - \delta = \varepsilon_t$$

In this formula, y_t values are previous observations and y values are actual data ε_t is a random error at time period t and $\emptyset_i$ (i=1,2, 3, …, p) are model parameters and p is an integer.
MA(q) model

$$Y_t = \varepsilon_t - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \cdots - \theta_p$$

In this formula, ε_t values are previous actual data and θ_i (I=1, 2, 3, …, p) values are model parameters(Kırçil, 2013).

For the non-stationary linear model, AR and MA models can be merged and the model is basically called as ARMA model. If this formula repeated d times, model called as ARIMA (p, d, q). the p-value is autoregressive parameter and q is moving average parameter and d is the differential of series. That is the process that generates this time series has the form as,

$$w_t = \emptyset_1 w_{t-1} + \emptyset_2 w_{t-2} + \cdots + \emptyset_p w_{t-p} + \varepsilon_t - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \cdots - \theta_q \varepsilon_{t-q}$$

(Commandeur and Koopman, 2007).

If q value equals to 0 then, series will be an AR model. If the p-value is equal to 0 then, series will be a MA model. ARIMA model has built on the order of (p, q) values (Zhang, 2003).

The modeling process of ARIMA has 4 steps,

Step 1: If the time series data is non-stationary then, it should be converted to a stationary state. And after the transformation step, if the autocorrelation function of time series still not stationary then changes should be made.
Step 2: After step 1, the autocorrelation function (ACF) and the partial autocorrelation function (PACF) of W_t series scrutinize and the parameters of ARMA(p, q) are determined. At this point, this process is subjective and the data is not concrete. There is no single way to do that and this identification step is relative.
Step 3: Non-certain ARIMA models calculated by using conditional least squares and maximum likelihood.
Step 4: The chosen model of ARIMA can be tested by analyzing the residuals. If the residuals are in acceptable range then the model is appropriate, or else we repeat all these steps from the beginning (Nairu and Olanrewaju, 2015).

FINDINGS AND ANALYSES

The research data, which are temperature, precipitation and evaporation amount of Ankara between 1975-2017, has been taken from Ankara Meteorology General Directorate. Box-Jenkins method was used to analyze the data and Minitab 17 was used during the analyzing.

Annual Average Temperature (^{0}C)

Average temperature data has been taken from Meteorology General Directorate and the data includes the years between 1975-2017. According to these data, analyzing has made and a graphic has drawn using by Minitab 17. The maximum annual temperature was measured as 14.6^{0}C in 2010 and the minimum annual average temperature was measured as 10.2^{0}C in 1992. The annual trend is determined in the temperature series. Autocorrelation and correlation analysis (Figure 1 and Figure 2) were performed onstationary series. In the graphic of the autocorrelation function, minimum and maximum values are in the limited range, which means this graph is reliable. This time series is stationary so the value of d=0. For making a forecast projection, data was used and a forecast graph was drawn using by Box-Jenkins method, the forecast projection includes next 15 years period (Figure 3).

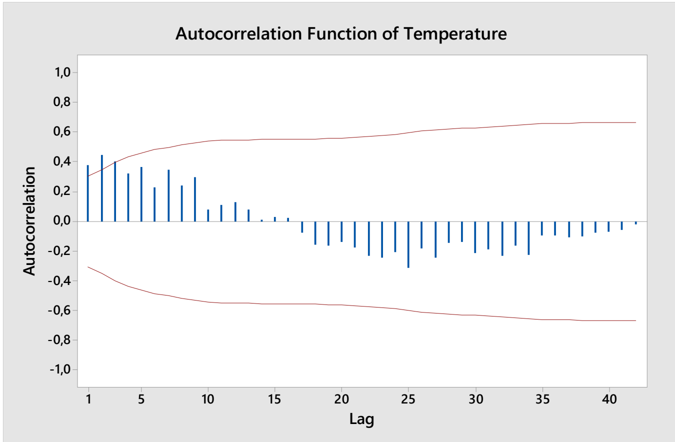

Figure 1.The autocorrelation function for Temperature

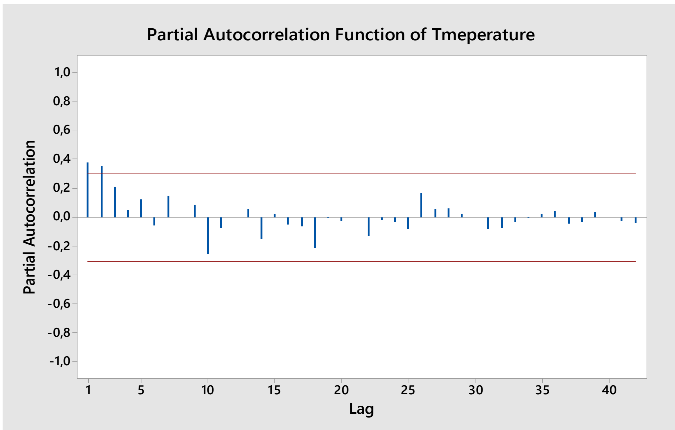

Figure 2. Partial Autocorrelation function for Temperature

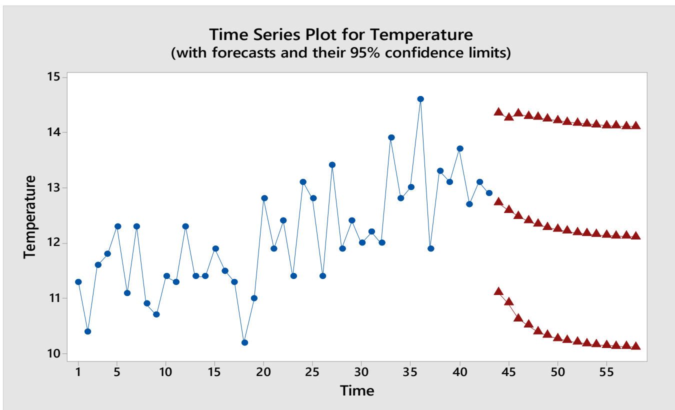

Figure 3. ARIMA graphic for Temperature

According to this scenario, the minimum annual temperature measured as 12 ^{0}C and the maximum annual temperature degree measured as 14 ^{0}C. In this scenario, according to average data, the temperature will decrease by almost 0.6 degrees.

Annual Evaporation Data (mm)

Annual evaporation data has been taken from Meteorology General Directorate and the data includes the years between 1975-2017. According to these data, analyzing has made and a graphic has drawn using by Minitab 17. The maximum annual evaporation was measured as 1526.9 in 1994 and the minimum annual average evaporation was measured as 904.3 mm in 1982. The annual trend is determined in the evaporation series. Autocorrelation and correlation analysis (Figure 4 and Figure 5) were performed on stationary series. In the graphic of the autocorrelation function, minimum and maximum values are in the limited range, which means this graph is reliable. This time series is stationary so the value of d=0. For making a forecast projection, data was used and a forecast graph was drawn using by Box-Jenkins method, the forecast projection includes next 15 years period (Figure 3).

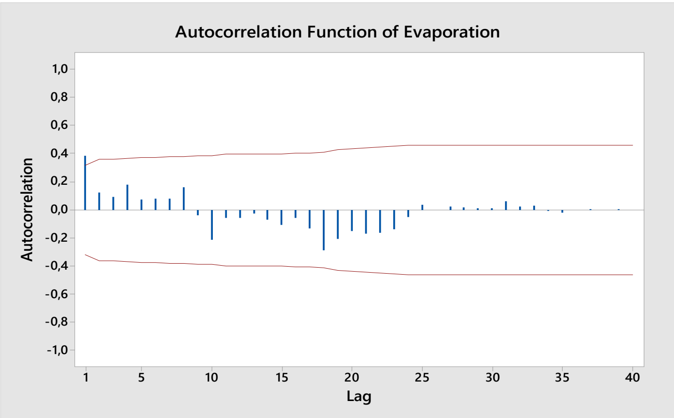

Figure 4. Auto correlation function for evaporation

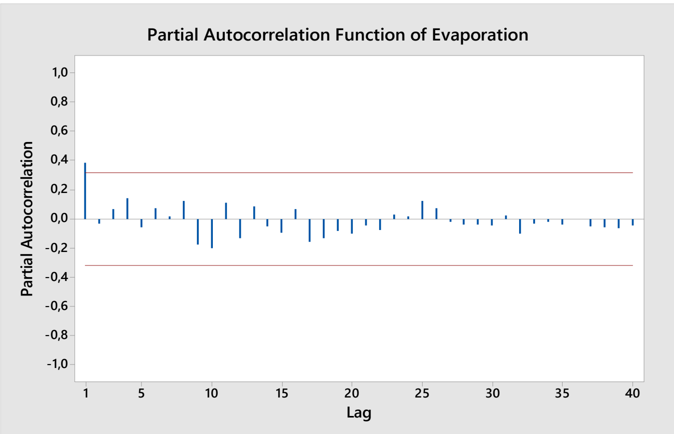

Figure 5. Partial Autocorrelation function for evaporation

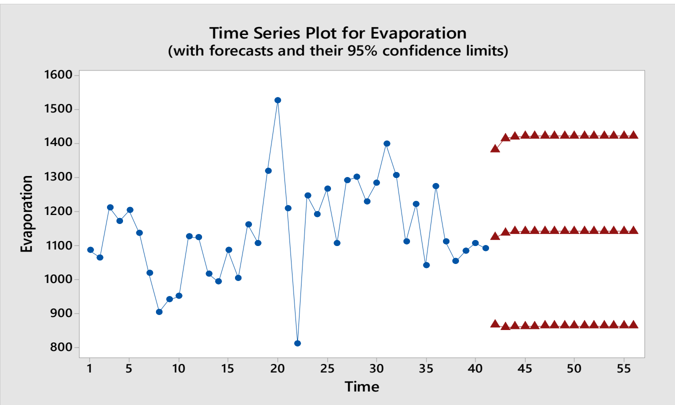

Figure 6. ARIMA forecast graph for evaporation

According to this scenario, the forecast shows that the minimum annual evaporation measured as 860 mm and the maximum annual evaporation measured as 1422 mm. In this scenario, according to average data, the evaporation will increase almost 21.54 mm (Figure 6).

Annual Total Precipitation (mm=kg/m^2)

Annual precipitation data has been taken from Meteorology General Directorate and the data includes the years between 2004-2017. This period is too short then this is not a reliable database. According to these data, analyzing has made and a graphic has drawn using by Minitab 17. The maximum annual precipitation value was measured as 216 kg/m^2 in 2007 and the minimum annual average precipitation was measured as 508.1 kg/m^2 in 2014. The annual trend is determined in the precipitation series. Autocorrelation and correlation analysis (Figure 7 and Figure 8) were performed on stationary series. In the graphic of the autocorrelation function, minimum and maximum values are in the limited range, which means this graph is reliable. This time series is stationary so the value of d=0. For making a forecast projection, data was used and a forecast graph was drawn using by Box-Jenkins method, the forecast projection includes the next 5 years period (Figure 9).

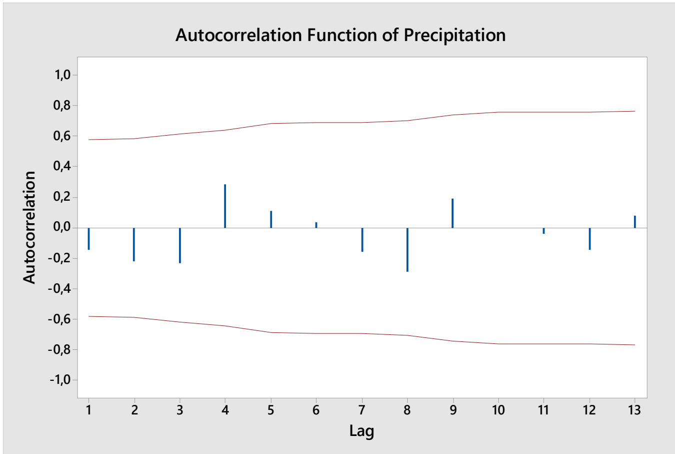

Figure 7. Autocorrelation function for precipitation

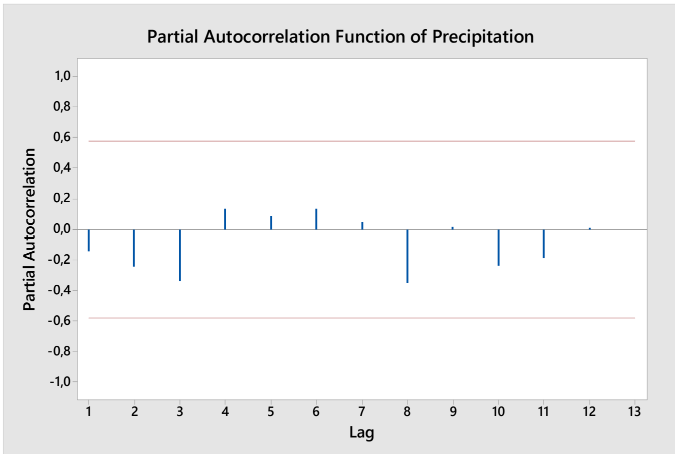

Figure 8. Partial autocorrelation function for precipitation

The low rate of reliability has been seen because of the data are included short term range. For this reason, the forecast is limited and includes 5 years. According to this scenario, the forecast shows that the minimum annual precipitation measured as 99 mm and the maximum annual precipitation measure as 668 mm. In this scenario, according to average data, the precipitation will decrease almost 19.91 mm (Figure 9).

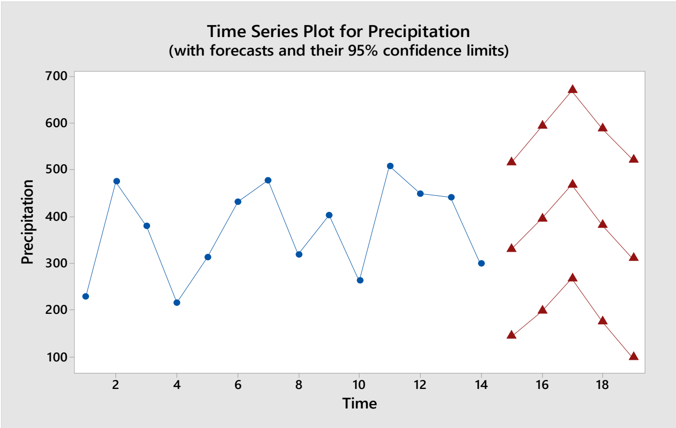

Figure 9. ARIMA forecast for precipitation

Conclusion

In this study, the method of Box-Jenkins called as ARIMA and the program named as Minitab 17 have been used. Study data belongs to Ankara-Turkey. To determine the rate of global climate change, 3 main parameters of climate (temperature, precipitation, and evaporation) have been used. The data were taken from Ankara Meteorology General Directorate. The main data of temperature includes years between 1975-2017. Using this data, the forecasting graph has been made using by ARIMA. Forecast period includes 15 years (2018-2032).In this scenario, the minimum annual temperature measured as 12 ^{0}C and the maximum annual temperature measured as 14 ^{0}C. According to this scenario, the temperature will decrease by almost 0.6 degrees as regards average forecast graph of data. The main data of evaporation includes years between 1975-2017. Using this data, the forecasting graph has been drawn using by ARIMA. Forecast period includes 15 years (2018-2032). In this scenario, the minimum annual evaporation 860 mm and the maximum annual evaporation measured as 1422 mm. According to this scenario, the evaporation will increase almost 21.54 mm as regards average forecast graph of data. The main data of precipitation includes years between 2004-2017. The main data insufficient for forecast scenario because of that this scenario is not reliable. For this reason, the forecast period includes 5 years (2018-2022). In this scenario, the minimum annual precipitation measured as 99 mm and the maximum annual precipitation measured as 668 mm. In the first 3 years period the precipitation amount will increase substantially and after that the last 2 years period the precipitation amount will decrease substantially. According to this scenario, precipitation will decrease almost 19.91 mm as regards average forecast graph of data.

REFERENCES

Batan, M. 2014. Küreselİklim Değişikliğive BeklenenSonuçları. Doktora Tezi. Diyarbakır: Dicle Üniversitesi.

Betsill M., B. H. 2003. Cities and Climate Change: Urban Sustainability and Global Environment Governance. Londra.

Box, G., Jenkins, G., Reinsel, G., and Ljung, G. 2015. Time Series Analysis: Forecasting and Control. Wiley.

Commandeur, J., and Koopman, S. 2007. An Introduction to State Space Time Series Analysis (Practical Econometrics). Oxford University Press.

IPCC Scientific, A. 1991. Cambridge: Cambridge University Press.

Jadhav H. V., P. S. 2009. Global Warming and Environmental Concerns. Mumbai: Himalaya Publishing House.

Kırçil, M. 2013. Box-Jenkins Yöntemiile Konut Doğalgaz Talebinin Tahminlenmesi: İzmir İli Örneği. Yüksek Lisans Tezi. Isparta: Süleyman Demirel Üniversitesi.

Levy, M. (2011). Why the Wind Blows: A History of Weather and Global Warming. Upper Access Inc.

Morrissey, W., and Justus, J. 2001. Global Climate Change. Congressional Research Service, The Library of Congress.

Nairu, M., and Olanrewaju, S. 2015. Forecasting Airline Fatalities in the World Using a Univariate Time Series Model. *International Journal of Statistics and Applications*, 5(5): 223-230.

Özer, O., and İlkdoğan, U. 2013. Box-Jenkins Modeli Yardımıyla Dünya Pamuk Fiyatının Tahmini. Tekirdağ Ziraat Fakültesi Dergisi, 10(2).

Remuzgo, L., and Trueba, C. 2017. Statistical Polarization in Greenhouse Gas Emissions: Theory and Evidence. Environmental Pollution (230), 291-301.

Spence, C. 2007. Küresek Isınma Sağlıklı Bir Dünyaİçin Çözümler. Pegasus Yayınları.

Zengin, I. 2015. Küresel İklim Değişikliği Rejiminin Oluşmasında Hegemonik Güçlerin Önemi. Yüksek LisansTezi. İstanbul: Beykent Üniversitesi.

Zhang, G. 2003. Time Series Forecasting Using a Hybrid ARIMA and Neural Network Model. Neurocomputing (50), 159-175.

****