Zero: Jurnal Sains, Matematika, dan Terapan
E-ISSN: 2580-5754
P-ISSN: 2580-569X
Vol. 3, No. 2, December 2019,
pp. 80-87

Data Analysis Time Series For Forecasting The Greenhouse Effect

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Article Info

Article history:

Received October 12, 2019
Revised November 14, 2019
Accepted December 3, 2019

Keywords:

Time Series,
Models, Forecasting,
ARIMA,
Greenhouse Effect.

ABSTRACT

The greenhouse effect is a term used to describe the earth having a greenhouse effect where the sun's heat is trapped by the earth's atmosphere. This study aims to model the greenhouse effect and then predict the greenhouse effect in the coming period using the Autoregressive Integrated Moving Average (ARIMA) method. In this case, time series analysis and reference data for 31 months are used, from the period January 2017 - July 2019, the results of the ARIMA model that are suitable for forecasting the greenhouse effect are ARIMA (4.2.0) with Mean Square Error (MSE) of 161885

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1. INTRODUCTION

Inventory is a resource or raw material that is stored and will be used now or in the future to meet customer needs. For the smooth production process, inventory is very important.

The greenhouse effect is a term used to describe the earth having greenhouse gas emissions, which the earth's atmosphere captures heat from the sun. As a result of the greenhouse effect itself, some of the heat that should illuminate the earth's surface in the earth's atmosphere captures heat from the sun. Which makes the earth warmer from time to time.

Increasing the earth's temperature causes another change, which causes an increase in the intensity of extreme weather and rising sea levels on the surface (Smart, 2011). Global warming events (global warming) is a cause of temperature changes, extreme weather, floods, landslides and other natural disasters. The term greenhouse effect appears not without reason.

The contribution of the greenhouse effect to global warming can be seen from the type of gas. The most influential greenhouse gas (GRK) effect on global warming is carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbon (PFC), hydrofluoro-carbon (HFC) and sulphur hexafluoride (SF_6).

The analysis used to predict the greenhouse effect is data time series (Wiyanti, 2012). Analysis Time series is a method in which past data is used as projecting data for the future

2. RESEARCH METHODE

Data Stationarity and Non-Stationarity

In forming a time series data analysis model, the first thing to do is to station the data. time series data can be said to be stationary if there are not too sharp changes in variance and averages. Stationarity is there is no sharp increase or decrease in data.

$$Cov(Z_t, Z_{t+k}) = E[Z_t - \mu)(Z_{t+k} - \mu)] = \gamma_k \tag{1}$$

Autocorrelation Function (ACF)

Stationarity means that there is no Autocorrelation measuring the direction (positive or negative) and the closeness of the relationship between observations within single time series Z_t when separate observations over time periods k = 1, 2, . . ., K.

$$\rho_k = \frac{E\left[\left(Z_t - \mu_z\right)\left(Z_{t+k} - \mu_z\right)\right]}{\sqrt{E\left[\left(Z_t - \mu z\right)^2\right].E\left[\left(Z_{t+k} - \mu z\right)^2\right]}} = \frac{Cov(Z_t \cdot Z_{t+k})}{Var(Z_t)} = \frac{\gamma k}{\gamma_0} \tag{2}$$

Partial autocorrelation function (FAKP)

Partial autocorrelation is used to measure the closeness of the relationship between observations time series that is Z_t and Z_{t+k}.

$$\phi_{kk} = Corr(Z_t, Z_{t+k} \left| Z_{t+1}, \cdots, Z_{t+k-1} \right. \tag{3}$$

Partial autocorrelation is denoted by $\{\phi_{kk} : k = 1,2,\ldots\}$, is a set of partial auto correlation on lag k. Partial autocorrelation is defined as follows:

$$\phi_{kk} = \frac{\left|p_k^*\right|}{\left|p_k\right|} \tag{4}$$

With P_k is an autocorrelation sized matrix $k \times k$, and P_k^* is P_k which column the latter was replaced with the following:

$$p_{k \times 1} = \begin{bmatrix} \rho_1 \\ \rho_2 \\ \vdots \\ \rho_k \end{bmatrix} \tag{5}$$

Autocorrelation matrix P size $k \times k$ defined as follows:

$$P_{k \times k} = \begin{bmatrix} 1 & \rho_1 & \rho_2 & \cdots & \rho_{k-1} \\ \rho_1 & 1 & \rho_1 & & \rho_{k-2} \\ \rho_2 & \rho & 1 & & \rho_{k-3} \\ \vdots & & & \ddots & \vdots \\ \rho_{k-1} & \rho_{k-2} & \rho_{k-3} & \cdots & 1 \end{bmatrix} \tag{6}$$

For persial autocorrelation in lag 1 and lag 2 respectively are defined as follows:

$$\phi_{11} = \rho_1 \quad \phi_{22} = \frac{\begin{vmatrix} 1 & \rho_1 \\ \rho_1 & \rho_2 \end{vmatrix}}{\begin{vmatrix} 1 & \rho_1 \\ \rho_1 & 1 \end{vmatrix}} = \frac{\rho_2 - \rho_1^2}{1 - \rho_1^2} \tag{7}$$

Partial autocorrelation between Z_t and Z_{t+k} is ϕ_{kk} which is defined as follows:

$$\phi_{kk} = \frac{\begin{bmatrix} 1 & \rho_1 & \rho_2 & \cdots & \rho_1 \\ \rho_1 & 1 & \rho_1 & & \rho_2 \\ \rho_2 & \rho_1 & 1 & & \rho_3 \\ \vdots & & & & \\ \rho_{k-1} & \rho_{k-2} & \rho_{k-3} & \cdots & 1 \end{bmatrix}}{\begin{bmatrix} 1 & \rho_1 & \rho_2 & \cdots & \rho_{k-1} \\ \rho_1 & 1 & \rho_1 & & \rho_{k-2} \\ \rho_2 & \rho_1 & 1 & & \rho_{k-3} \\ \vdots & & & \ddots & \vdots \\ \rho_{k-k} & \rho_{k-2} & \rho_{k-3} & \cdots & 1 \end{bmatrix}} \quad (8)$$

White Noise Procces

A process $\{a_t\}$ called by white noise process if a process is identical and independent and a random variable that does not correlate with each other but streak and follows distribution.

white noise process $\{a_t\}$ stationary with the following properties:

Auto-variation function:

$$\gamma_k = \begin{cases} \sigma_a^2, for, k = 0 \\ 0, for, k \neq 0 \end{cases} \quad (9)$$

Autocorrelation function:

$$\rho_k = \begin{cases} 1, for, k = 0 \\ 0, for, k \neq 0 \end{cases} \quad (10)$$

Partial autocorrelation function:

$$\phi_{kk} = \begin{cases} 1, for, k = 0 \\ 0, for, k \neq 0 \end{cases} \quad (11)$$

Method Autoregressive Integrated Moving Average (ARIMA) Autoregressive Process (AR)

The autoregressive process has the meaning of regression in itself. More specific, autiregressive process $\{Z_t\}$ orde p:

$$Z_t = \phi_1 Z_{t=1} + \phi_2 Z_{t=2} + \cdots + \phi_P Z_{t=p} + a_t \quad (12)$$

Where is assumed that Z_t is statistician and $E(Z_t) = 0$

the formula for finding the autocorrelation values for the AR (p) process can generally be obtained as follows:

$$\rho_k = \phi_1 \rho_{k-1} + \phi_2 \rho_{k-2} + \cdots + \phi_p \rho_{k-p,} untuk, k \geq 1 \quad (13)$$

The Yule-Walker equation is as follows:

$$\begin{aligned} \rho_1 &= \phi_1 + \phi_2 \rho_1 + \cdots + \phi_p \rho_{p-1} \\ \rho_2 &= \phi_1 \rho_1 + \phi_2 + \cdots + \phi_p \rho_{p-2} \\ \rho_p &= \phi_1 \rho_{p-1} + \phi_{p-2} + \cdots + \phi_p \end{aligned} \quad (14)$$

Model Moving Averange (MA)

Model MA (q) is a method for predicting Z_t as a function of error forecasting in the past (past forecast error) in predicting Z_t. In general the model MA (q) is as follows:

$$Z_t = a_t - \theta_1 B - \cdots - \theta_1 B^q)a_{t-q} \quad (15)$$

The above equation can be written in the form:

$$Z_t = (1 - \theta_1 B - \cdots - \theta_1 B^q)a_{t-q} \quad (16)$$

The above equation can be written with operator B to be:

$$Z_t(1 - \theta_1 B^2 - \cdots - \theta_q B^q)a_t \quad (17)$$

ARMA Model

The ARMA (p, q) model is a combination of the AR (p) and MA (q) models, which are:

$$Z_t = \phi_1 Z_{t-1} + \cdots + \phi_p Z_{t-p} + a_t - \theta_q a_{t-q}$$

$$Z_t - \phi_1 Z_{t-1} - \cdots - \phi_p Z_{t-p} = a_t - \theta_1 a_{t-1} - \cdots - \theta_q a_{t-q} \quad (18)$$

If the two segments in the equation are multiplied by Z_{t-k} the result:

$$Z_t Z_{t-k} = \phi_1 Z_{t-1} Z_{t-k} + \cdots + \phi_p Z_{t-p} Z_{t-k} + a_t Z_{t-k} - \phi_1 a_{t-1} Z_{t-k} - \cdots - \phi_q a_{t-q} Z_{t-k} \quad (19)$$

If the above equation is expected then:

$$\gamma_k = \phi_1 \gamma_{k-1} + \cdots + \phi_p \gamma_{k-p} + E\left[a_t Z_{t-k}\right] - \cdots - \theta_q E\left[a_{t-k} Z_{t-k}\right] \quad (20)$$

ARIMA Model

Model Autoregressive Integrated Moving Average (ARIMA) is a method that does not explain certain patterns in predicted past data and the full method does not see independent variables in making predictions because this model used is the present and past of the dependent variable to produce accurate short-term predictions.

The ARIMA model is usually used for data that is already stationary and data that is not yet stationary.
General formula of the ARIMA model (p, d, q) is as follows:

$$Z_t = (1 + \phi_1)Z_{t-1} + \phi Z_{t-2} + a_t + \theta a_{t-1} \quad (21)$$

3. RESULT AND ANALYSIS

Location and Time of Research

This research was conducted at the Climatology and Geophysics Meteorology Agency (BMKG), Jl. Meteorologi Raya No.17, Tembung, Kec. Percut Sei Tuan, Deli Serdang Regency, North Sumatra. Held in July until finished.

Research Types and Variables

This type of research is a quantitative approach that is by taking and collecting raw data as needed, and analyzing it with data time series.
In this study the time variable as (Y_t)

which is assumed to be influenced by variables time series i.e. carbon dioxide emissions (CO_2) as (Xt).

Data analysis

In this research analysis is used time series with forecasting methods namely forecasting. This research data is processed using software IBM SPSS 22 and MINITAB 19. Data analysis used is as follows:

1. Collecting data from BMKG.
2. Describe carbon dioxide estimation data (CO_2)
3. Describe the data, After the data is described, the next step is analyze data.
4. Do stationarity test.
5. In this research, ARIMA modeling is used.
6. Interpret the results of the analysis.

After getting the results of the analysis, the next step is to explain the models formed and the results of forecasting.

This research will discuss the results of the data time series by determining the model for the greenhouse effect using the ARIMA model.

Based on the data it has been found that carbon dioxide emissions (CO_2) highest month April 2019 which is 410 and carbon dioxide emissions (CO_2) lowest in the month January 2018 which is equal to 360.

Identifying and Estimating Model Parameters

The ACF diagram (Figure 4.3) shows that the correlation coefficient is high in some lags and there is a slow decline in the ACF plot. This indicates that the time series data is not stationary.

The ACF diagram (Figure 4.6) shows a high correlation coefficient in part of the lag and a slow decline in the ACF plot. This can be seen because the data is not stationary.

From Figure 4.9 and 4.10 it can be seen that in the Trend Analysis plot the changes in carbon dioxide emission data are parallel to the horizontal axis. All points on the plot tend to point to 0. While the Autocorrelation plot and Partial Autocorrelation results differencing order 2 in Figures 4.6 and 4.7 have shown stationary in the mean, so the data has met the stationary conditions in the variance and the mean. Therefore, it can be directly used to get the best ARIMA model for the intervention model.

ARIMA model diagnostic check

For the diagnostic examination stage, each ARIMA model consists of a parameter significance test and a model suitability test (normal distribution). The following is a diagnostic check for each ARIMA model:

ARIMA Model (0,2,1)

To estimate the ARIMA model parameters (0,2,1), it is used software Minitab 19, using analysis time series ARIMA method. Statistical parameters test is used to see the significance of the parameters in the model from the time series data with the ARIMA model (0,2,1).

The estimated model table addresses the magnitude Mean Square Error (MSE) the model is 180760 and the degree of freedom (df) of the model is 27. By seeing the MSE value, it can be seen which model is the best, the smaller the MSE value, the better the model.

Normal distribution test is used test Anderson Darling P-value < 0.05. So, the results of Anderson Darling's test shows that P-value < 0.05 so that it can be concluded that the data has normal distribution.

ARIMA Model (0,2,3)

To estimate the ARIMA model parameters (0,2,3) is used software Minitab 19, using analysis time series ARIMA method. This parameter statistical test is used to see the significance of the parameters in the model from the time series data with the ARIMA model (0,2,3).

The estimated model table addresses the magnitude Mean Square Error (MSE) the model is 155182 and the degree of freedom (df) of the model is 25. By looking at the MSE value, it can be seen which model is the best, the smaller the MSE value, the better the model.

Normal distribution test is used test Anderson Darling P-value < 0.05. So, the results of Anderson Darling's test shows that P-value < 0.05 so that it can be concluded that the data has normal distribution.

ARIMA Model (1,2,0)

To estimate the parameters of the ARIMA model (1,2,0), it is used software Minitab 19, using analysis time series ARIMA method. This parameter statistical test is used to see the significance of the parameters in the model from the time series data with the ARIMA model (1,2,0).

The estimated model table addresses the magnitude Mean Square Error (MSE) the model is 327267 and the degree of freedom (df) of the model is 27. By seeing the MSE value, it can be seen which model is the best, the smaller the MSE value, the better the model.

Normal distribution test is used test Anderson Darling P-value < 0.05 So, the result of Anderson Darling's test shows that P-value < 0.05 so that it can be concluded that the data has normal distribution.

ARIMA Model (2,2,0)

To estimate the ARIMA model parameters (2,2,0) it is used software Minitab 19, using the ARIMA method time series analysis. This parameter statistical test is used to see the significance of the parameters in the model from the time series data with the ARIMA model (2,2,0).

The estimated model table shows the magnitude of the Mean Square Error (MSE) model of 212151 and the degree of freedom (df) of the model of 26. By looking at the value of MSE it can be seen which model is the best, the smaller the MSE value, the better the model.

Normal distribution test is used test Anderson Darling P-value < 0.05. So, the results of Anderson Darling's test shows that P-value < 0.05 so that it can be concluded that the data has normal distribution.

ARIMA Model (4,2,0)

To estimate the ARIMA model parameters (4,2,0), it is used software Minitab 19, using analysis time series ARIMA method. This parameter statistical test is used to see the significance of the parameters in the model from the time series data with the ARIMA model (4.2.0).

The estimated model table addresses the magnitude Mean Square Error (MSE) the model is 161885 and the degree of freedom (df) of the model is 24. By seeing the MSE value, it can be seen which model is the best, the smaller the MSE value, the better the model.

Normal distribution test is used test Anderson Darling P-value < 0.05. So, the results of Anderson Darling's test shows that P-value < 0.05 so that it can be concluded that the data has normal distribution.

Model Selection Criteria

The selection of the best ARIMA model, namely ARIMA (0,2,3), has passed the significant test and normality test with Mean Square Error (MSE) the lowest is 155,182

Forecasting

Forecasting results using Minitab 19, showed a decrease in carbon dioxide emissions in July 2019 that is 405 pmm to 375 and those that experienced an increase in carbon dioxide emissions in October 2018 namely 361 to 404. The first forecast results showed 401, the second forecast 394, the third forecast 391, the fourth forecast is 387, and the fifth forecast shows the number 381. From this forecasting it can be concluded that the forecasting of the greenhouse effect has increased and decreased which is not constant.

To overcome the greenhouse effect in Indonesia by greening the land by planting as many trees as possible and preserving the forest, because the tree is able to absorb carbon dioxide that flies freely in the air.

4. CONCLUSION

Based on the results of the discussion about data analysis time series for forecasting the greenhouse effect, the following conclusions can be drawn:

1. The best model of data analysis time series by using the ARIMA model, namely:
   ARIMA (0,2,3) with Mean Square Error (MSE) the model is 155,182 and the degree of freedom (df) of the model is 25 and the model equation is:

$$Z_t = (1+\phi_1)Z_{t-1} + \phi Z_{t-2} + a_t + \theta_1 a_{t-1}$$

$$Z_t = (1+1,037)Z_{t-1} + 1,037 Z_{t-2} + a_t + 0,1423 a_{t-1}$$

2. Based on the results of forecasting using Software Minitab19, obtained Greenhouse effect forecasting results for the next 31 months.

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