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THE USE OF BOX-JENSKIN METHOD (ARIMA) TO PREDICT EARTHQUAKES REGARDING ACEH REGIONAL PLANNING

Eri Saputra,[1], Samsul Bahri[1], Cut Azmah Fithri[2], Abdul Kadir[1]*
[1]Matematika, Architecture Study Program, Faculty of Engineering, Malikussaleh University
[2] Arsitektur, Architecture Study Program, Faculty of Engineering, Malikussaleh University
*Corresponding Author : erisaputra@unimal.ac.id

ABSTRACT

An earthquake is the result of a sudden energy release in earth crust, which creates waves, vibrations or shocks that happen on earth surface. The purpose of this study is to predict the number of earthquake in Aceh based on previous data using ARIMA (Box-Jenkins) method to see the accuracy level of earthquake prediction and strength. The data that were used is earthquake data in Aceh taken from January 2010 until August 2017 from BMKG website. The results show that the ARIMA diagnostic examination models ([2], 1, [1]) are the best models for observation data. Based on the results of earthquakes prediction in Aceh in 2018 by Arima method, the highest earthquake strength of 4,647 occurs in January 2018 and There is no earthquake strength that has tsunami potential.

KEY WORDS: Arima (*Box-Jenkins*) Method , Earthquake

INTRODUCTION

An earthquake is the result of a sudden release of energy in the earth crust, which creates waves, vibration or shock that happens on the surface of the earth. The earthquakes manifest themselves by trembling and sometimes moving the land. Earthquakes occur due to errors in the earth crust, the uppermost layer on Earth. This happens when there is a discontinuity in the rock, so it seems as if there are two plates slide or slip one another. Earthquake usually happens anytime and anywhere regardless the season and time. Earthquake disasters are a major threat to the population especially in Indonesian.

Indonesia is located between the confluence of four large earth plates: the Indian, Australian, Eurasian, and Pacific plate. In the western region of Sumatra, earthquakes often occur due to its position along the collision lane of two earth plates, where the Indian plate (ocean) moves down the Sumatra plate (continent). Sumatra and the island arc in the west are part of the Eurasian plate while the other plates are under the Indian Ocean. The collision edge of these two plates can be observed in the form of a deep-sea trough in the west of Sumatra to Andaman Island (Natawidjaja, 2007).

Aceh is a province in Indonesia and is located on the western tip of the island of Sumatra. Aceh is an area with high seismicity and it is evidenced by the frequent occurrence of earthquakes with close time intervals between the earthquakes with a range of medium to upper Magnitude. Aceh can be categorized as an earthquake-prone area.

There are four major earthquakes in the approximately 17 years time span that rocked Aceh and attracted public attention. The first was the earthquake on December 26, 2004 with 9.2 Richter scale that caused tsunami. The tsunami was triggered by a large earthquake that occurred under the sea due to the slamming of Indian - Australia plates that moved to the north pounding the Eurasian plate. The second was the earthquake in Simelue on April 11, 2012. The third was the earthquake in Aceh Tengah on July 2, 2013 that caused landslides. The fourth earthquake was happened in Pidie Jaya on December 7, 2016 that destroyed many buildings.

Learning from the history of earthquakes in Aceh that caused the deaths of hundreds of thousands of people and the loss of countless property, efforts are needed, both from the government and the community to anticipate and reduce the risk of earthquake and tsunami disasters. One of the efforts that can be done is by predicting how many earthquakes might happen in the future.

According to Makridakis, et al (1995), predicting is an activity of calculating the values of a variable in the future based on the known value of the variable in the past, present, or based on related variables. The predicting process is very important in the time series data because it is needed in decision-making. At present, the predicting method is developing quite rapidly. There are many methods that can be used to predict data according to the need to get predicting results with high accuracy. In this study, the authors carried out the application of ARIMA (Box-Jenkins) Method to predict the occurrence of earthquakes in Aceh and to predict its strength in the future. The data taken is the data of earthquake incidents that have occurred in Aceh.

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LITERATURE REVIEW

1. Data Collection

The data used in this study is the Aceh earthquake data taken from the BMKG website in the period 2010 to 2017. The data obtained are earthquake position data (latitude, longitude), time of occurrence and earthquake magnitude values.

2. Predicting with *Box-Jenkins* (ARIMA) method

The Box-Jenkins method is commonly referred to as the Autoregressive Integrated Moving Average (ARIMA) method. In solving problem from time series data through this method, some stages were done.

a. Model Identification

$$\Delta X_t = X_t - X_{t-1}$$

With;

ΔX_t = First order data difference
X_t = Data at time t
X_{t-1} = Data at time t-1

If the first order differencing has not produced stationary data then second order differencing can be done, with the equation:

$$\Delta^2 X_t = \Delta X_t - \Delta X_{t-1}$$
$$\Delta^2 X_t = (X_t - X_{t-1}) - (X_{t-1} - X_t)$$
$$\Delta^2 X_t = X_t - 2X_{t-1} - X_{t-2}$$

With;

$\Delta^2 X_t$ = Second order data difference
ΔX_{t-1} = Data at time t-1
X_{t-2} = Data at time t-2

b. Parameter Estimation

$$\hat{y} = a + \beta x_i, i = 1,2,3,\ldots n$$

The equation for the sum of squared errors in simple linear regression is:

$$J = \sum_{i=1}^{n} e_i^2 = \sum_{i=1}^{n} (y_i - \hat{y}_i)^2$$

For example, in model MA(1), then $\bar{y}_i$ is replaced with x_t, e_i with θ_0, β, with θ_1, x_i, with e_{t-1}. Then, the equation for the number of errors becomes:

$$J = \sum_{i=1}^{n} e_i^2 = \sum_{i=1}^{n} (x_i - \bar{x}_i)^2$$

c. Diagnostic Test

1. Residual Independence Test
2. Residual Normal Test
3. Mean Square Error (MSE)

One of statistics measures that are used to see the accuracy of a model is Mean Square Error (MSE) (Makridakis et al, 1999). The MSE criteria are formulated as follow:

$$MSE = \frac{1}{n} \sum_{i=1}^{n} (x_t - \hat{x}_t)^2$$

With:

x_t = Data for periods t, t = 1,2,3, ..., n
$\hat{x}_t$ = Prediction data period t
n = Number of data n

d. Predicting

1. Data Predicting Training.
2. Data Predicting Testing.
3. Predicting for the future, the prediction results data on data testing is used.

RESULTS AND DISCUSSION

1. Model Identity

The first step that must be done is to make a data plot. In this case, to create an earthquake data plot to see if it is stationary. If the data is not stationary, it is necessary to do differencing process. The first analysis shows that the data is not stationary as the original data. It can be seen that the data still contains the trend element where plot ACF and plot PACF do descending in a sine so the data tends to be non-stationary. Non-stationary data in the original first data can be stationary by doing differencing. The next analysis is significant autocorrelation differencing. It can be seen in the plot of ACF and PACF not descending in a sine so that the data tends to be non-stationary. In addition to graphs observation and calculation results of autocorrelation function, data stationary examination can also be carried out based on the correlogram calculation and testing results of partial autocorrelation function.

2. Differencing process

In using ARIMA method, it requires stationary data. Non-stationary earthquake data must have differencing process. The differencing process is done by replacing the original data (Xt) by the first difference of the original data.

$$\Delta X_t = X_t - X_{t-1}$$

The result of the differencing process is illustrated in the graphic form:

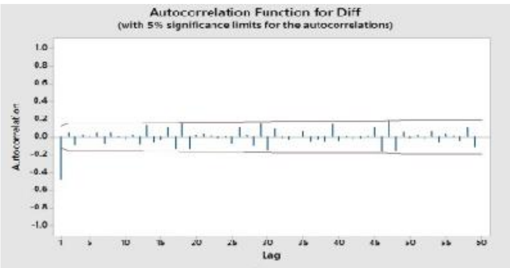

Figure 1. ACF graph

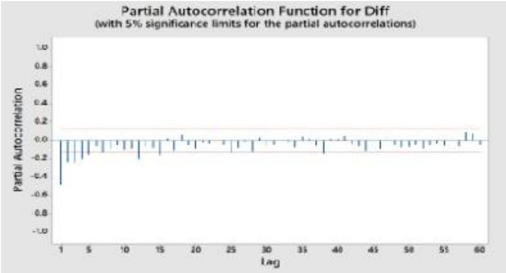

Figure 2. ACFP graph

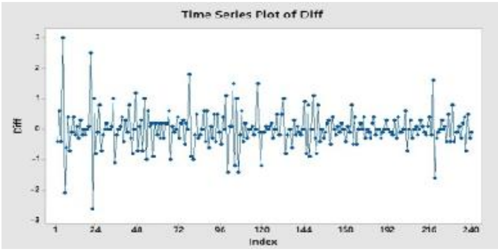

Figure 3. Graph Plot

In Figure 2, the earthquake data has had differencing process as much as 1. From the sequence graph, it can be seen that the graph shows no trend and moves around the average. Thus, it can be said that the data is already stationary.

3. Parameter Estimation

After obtaining the temporary model, the next step is to estimate the temporary parameter model by using least squares method. To simplify the calculation, Minitab software is used to measure RMSE (root mean square error), MAPE (mean absolute percentage error), MAE (mean absolute error), and P-value. A model that has smaller provision value than the other models is obtained: ARIMA ([2], 1, [1]) of RMSE = 0.458, MAPE = 6, 035, MAE = 0.310 and P-value Constant is greater than 0.975 (P-value constant is 0.979) so the ARIMA diagnostic examination model ([2], 1, [1]) is the best model in the observation data. After obtaining a suitable model, then the predicting process of earthquake in Aceh in 2018 was carried out. The following is a plot of the predicted results of earthquake in 2018.

Table 1. Earthquake Prediction in 2018

No	Month	Earthquake Scale Prediction
1	January 2018	4,619
2	January 2018	4,647
3	January 2018	4,619
4	February 2018	4,645
5	February 2018	4,619
6	March 2018	4,642
7	March 2018	4,619
8	March 2018	4,640
9	April 2018	4,619
10	April 2018	4,638
11	April 2018	4,618
12	Mei 2018	4,636
13	Mei 2018	4,618
14	June 2018	4,634
15	June 2018	4,617
16	June 2018	4,632
17	July 2018	4,617
18	July 2018	4,630
19	July 2018	4,616
20	August 2018	4,629
21	August 2018	4,616
22	September 2018	4,627
23	September 2018	4,615
24	September 2018	4,625
25	October 2018	4,614
26	October 2018	4,624
27	October 2018	4,613
28	November 2018	4,622
29	November 2018	4,612
30	November 2018	4,620
31	November 2018	4,612
32	November 2018	4,619

Based on the earthquke data in Aceh from 2010 to 2017, the earthquake prediction with the Arima method in Aceh in 2018, the highest earthquake power on January 2018 in Aceh is 4.647, while the smallest earthquake prediction is 4.612 in December 2018. Based on the earthquake prediction in 2018 with Arima, there is no earthquake that has potential tsunami.

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