Forecasting of Air Temperature in Cilacap Regency with Triple Exponential Smoothing (Holt-Winter) Method

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Abstract

This research discusses the forecasting of maximum air temperatures and minimum air temperatures in Cilacap for 2019. The method used in this forecast is Triple Exponential Smoothing (Holt-Winter) with additive type. The research results show that forecasting for the next year is accurate with MAPE size errors ranging from 2%. Research data shows that forecasting for minimum air temperatures will increase in 2019.

Keywords:
air temperature, forecasting, triple exponential smoothing (Holt-Winter).

1. Introduction

According to the Big Indonesian Dictionary (KBBI), the weather is the state of the air (regarding temperature, sunlight, humidity, wind speed, etc.) at a particular place with a limited period of time. Factors that influence the weather include air temperature, air pressure, wind, humidity and clouds, and precipitation (rainfall). One very important weather element is the temperature of the air. Air temperature in the past few decades has continued to increase. This is one indicator that shows the phenomenon of climate change. Climate change can affect many things, ranging from environmental problems, health, to development planning.

In Indonesia, the Meteorology, Climatology and Geophysics Agency (BMKG) is an official body whose job is to provide and distribute weather conditions data to those who need the data. Therefore, BMKG is demanded to be able to provide fast, accurate and accurate information.

Weather forecasting is one solution that can be used in an effort to solve the problem of providing data. A good forecast must have a high value of accuracy and precision. Previous research was conducted by Samsul Anwar (2017) by predicting air temperatures in the city of Banda Aceh using the ARIMA (Autoregressive Integrated Moving Average) method. With this method, forecasting results are quite accurate. Therefore, this research discusses the forecasting of air temperatures in Cilacap Regency with the Triple Exponential Smoothing (Holt Winter) method to determine the accuracy of this method in predicting air temperatures. In this forecasting it is assisted with Zaitun Time Series software to make it easier to find the optimum smoothing parameters and MINITAB16 for forecasting.

2. Materials dan Methods

The model in this study is the forecasting model of air temperature in cilacap regency. The method used in this is triple exponential moothing (holt-winter).

2.1 Basic Theory
2.1.1 Data Plots

Time series (time series) is a series of observational data that occur based on time indexes in sequence with fixed time intervals. This method is used if the goal is to try to predict the future using data in the past (Jacob and Chase, 2014: 256). An important step in choosing an appropriate time series method is to consider the type of data pattern. So the most appropriate method with that data can be tested. Data patterns can be divided into four, namely:

1. Horizontal pattern, occurs when data values fluctuate around a constant average value (stationary series of mean values).
2. Seasonal pattern, occur when a data is influenced by seasonal factors (for example certain year quarter, month, or days of a particular week).
3. Cyclic pattern, occurs when the data is influenced by long-term economic fluctuations.
4. Trend pattern, occur when there is a long-term secular increase or decrease in the data.

2.2.2 Exponential Smoothing Method

According to Najmudin (2012: 75), the exponential smoothing method is a procedure that repeats calculations continuously using the latest data. The moving average method only calculates current observations, while the simple smoothing method calculates the exponential weighted moving average of all the values of the previous observations. The goal is to estimate the current value which is then used as a prediction of future values.

Various exponential methods:

1. Single Exponential Smoothing Method

The single expoential smoothing (SES) method is more suitable for predicting things whose fluctuations are random or irregular (Subagyo, 2002: 7). The SES method is used in short-term forecasting, usually only 1 month ahead. The data pattern is fluctuating and without trend.

2. Double Expoential Smoothing

   The double exponential smoothing (DES) method provides weighting (the contribution of the parameter value approach to the model) to multiple past observations. DES method is usually more appropriate to be used to predict data that is experiencing an upward trend (Subagyo, 2002: 8).

3. Triple Exponential Smoothing Method

   According to Makridakis, et al (1999: 122-127) the triple exponential smoothing (TES) or winter method is used when the data shows seasonal trends and behavior. This method is based on three parameter equations, namely stationarity, trend, and seasonality. This method also uses three weights or smoothing parameters namely α, δ, and γ.

The Winter Method has two forms, namely multiplicative seasonality and additive seasonality. If the magnitude of seasonal influence changes over time, the form of the model used is multiplicative (miltiplicative). Whereas if the magnitude of seasonal influences is constant over time, the form of the model used is seasonal additives.

3. Result and Discussion

The data used in this forecast are daily maximum and minimum temperature data in Cilacap from 2017 to 2018. The output data plot results from the Minitab16 application are shown in Figure 2.5 for the plot data for maximum temperatures and minimum temperatures in 2017-2018.

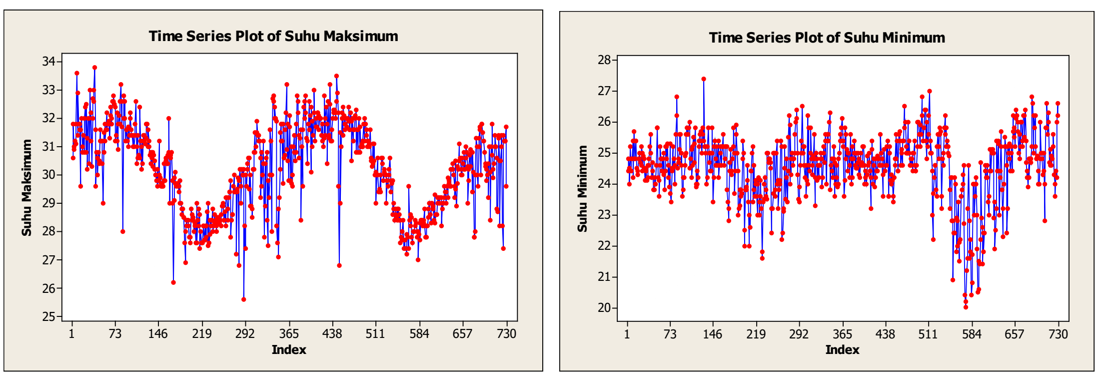

Figure 2.1 Data plot of the realization of maximum and minimum air temperatures in 2017-2018

In Figure 2.1 the horizontal axis states days or periods, while the vertical axis states the realization of the maximum temperature and minimum temperature in Cilacap. The scatter plot process shows that the maximum temperature and minimum temperature data have a seasonal data pattern seen by the pattern of changes in the rise and fall of data that recurs from year to year called fluctuations, the fluctuation of data is influenced by the rainy season and summer. Because both of these data have seasonal data patterns (data experiencing fluctuations or tidal waves), the appropriate forecasting method used is Triple Exponential Smoothing (Subagyo, 2002: 26).

Figure 2.1 shows the process of fluctuations that tend to be constant and seasonal patterns do not depend on the average level or size of the data so that the forecasting Triple Exponential Smoothing type additive is appropriate.

With the help of the Zaitun Time Series program, obtained accuracy measurement values to test smoothing constants (smoothing constant) for the three parameters in the forecasting, namely alpha, gamma, and delta. Also used is the minimum MAPE value.

Table 2.1 Maximum Temperature Prediction Error Parameters

No	Parameter			MAPE (%)
	Alpha	Gamma	Delta	
1	0.4	0.1	0.1	1.62917
2	0.3	0.1	0.1	1.63185
3	0.5	0.1	0.1	1.63655
4	0.6	0.1	0.1	1.64772
5	0.2	0.1	0.1	1.63315
6	0.1	0.1	0.1	1.64049
7	0.7	0.1	0.1	1.66801
8	0.1	0.1	0.2	1.71163
9	0.1	0.1	0.3	1.78404
10	0.1	0.1	0.4	1.85708

Table 2.2 Minimum Temperature Prediction Error Parameters

No	Parameter			MAPE (%)
	Alpha	Gamma	Delta	
1	0.7	0.1	0.1	1.92902
2	0.8	0.1	0.1	1.92473
3	0.6	0.1	0.1	1.94377
4	0.9	0.1	0.1	1.93276
5	0.8	0.1	0.2	1.94526
6	0.9	0.1	0.2	1.94351
7	0.5	0.1	0.1	1.97352
8	0.7	0.1	0.2	1.95830
9	0.9	0.1	0.3	1.95428
10	0.8	0.1	0.3	1.96587

From Table 2.1 it can be seen that the smallest MAPE value is 1.62917% with an alpha value (level) of 0.4, a delta value (seasonal) of 0.1, and for a gamma value (trend) of 0.1. And based on Table 2.2 it can be seen that the smallest MAPE value is 1.92473% with alpha (level) value 0.8, delta value (seasonal) is 0.1, and for gamma value (trend) is 0.1.

The next step is to predict the maximum temperature and minimum temperature in Cilacap using parameters that have been obtained by the Triple Exponential Smoothing (Holt-Winter) method for the next year. Results of forecasting maximum air temperatures and minimum air temperatures in Cilacap using the MINITAB16 application are as follows:

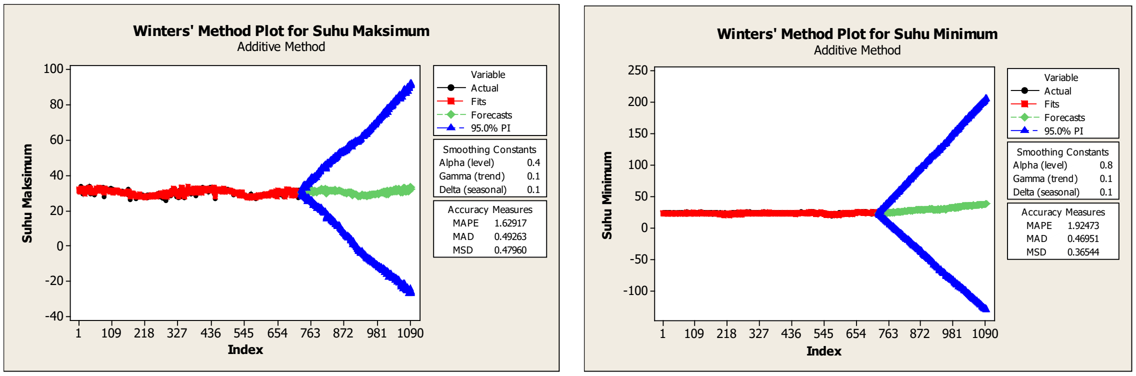

Figure 2.2 Plot forecasting the maximum and minimum temperatures with the additive type Winter method

Figure 2.2 shows that the actual values drawn by the black lines almost coincide with the model (fit) estimation values drawn by the red lines. This means that the forecasting model has good accuracy. While the forecast value is illustrated by a green line which is enclosed in two lines above and below which is the upper and lower limit of the forecast value. Results of forecasting maximum air temperatures and minimum air temperatures in Cilacap will be shown in Table 2.3 and Table 2.4 as follows:

Tabel 2.3 Results of forecasting maximum air temperatures in 2019

Date	Jan	Feb	Marc	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	30.6	31.4	31.2	31.8	31.1	29.7	29.1	29.1	29.7	30.7	31.7	29.9
2	30.0	30.9	31.5	31.7	31.2	30.0	29.3	28.9	29.1	30.8	31.9	31.8
3	30.2	31.2	31.8	31.2	31.0	29.8	29.0	28.2	29.3	29.6	31.6	32.7
4	29.5	31.8	31.2	31.6	31.3	30.7	29.0	28.6	29.2	30.5	32.0	31.9
5	29.7	30.8	31.0	31.3	31.8	30.3	29.0	27.9	29.3	30.3	31.7	33.2
6	29.8	32.2	32.0	31.5	31.5	30.8	28.4	28.3	29.6	31.2	30.8	32.7
7	30.7	31.9	31.2	31.8	31.5	30.4	28.6	28.5	29.4	29.1	31.0	33.5
8	31.8	31.2	31.3	31.8	31.7	30.5	28.1	28.6	29.7	30.3	30.9	32.3
9	30.4	30.0	32.2	31.6	31.3	30.5	27.9	28.9	29.8	30.9	31.8	32.4
10	31.0	31.0	32.6	31.8	31.3	30.6	28.6	28.7	29.9	30.9	32.5	30.7
11	31.1	31.3	31.7	31.4	31.0	30.6	28.3	28.9	29.9	30.6	32.3	30.7
12	30.6	30.1	31.5	31.2	31.0	30.7	28.4	28.6	29.6	31.7	31.5	31.5
13	31.5	30.9	31.7	31.7	30.9	29.7	28.5	28.7	29.1	31.3	30.6	30.4
14	30.4	30.6	31.3	31.3	30.9	30.5	28.3	28.9	29.7	31.3	32.1	31.3
15	31.2	30.6	31.5	30.8	30.8	30.4	28.3	29.4	29.3	31.2	31.7	30.9
16	30.6	31.4	31.9	31.8	31.3	30.7	28.0	28.5	29.9	28.8	32.1	31.5
17	30.5	31.2	31.5	31.8	30.7	30.3	28.3	29.1	30.1	30.1	32.6	33.0
18	30.4	31.2	31.3	30.9	30.5	30.1	28.2	28.4	30.1	30.0	31.4	32.7
19	30.8	30.9	31.6	31.2	30.5	28.3	28.6	28.7	29.8	31.2	31.1	32.3
20	29.0	30.7	32.1	31.7	30.7	29.5	29.5	29.0	30.0	31.0	32.3	30.4

21	30.9	30.1	32.4	31.2	30.3	30.1	29.0	29.0	30.3	31.6	31.5	32.6
22	30.4	31.3	32.5	31.4	30.3	30.3	29.0	29.3	30.4	31.4	32.2	32.3
23	30.6	30.7	32.4	30.6	30.8	29.5	28.8	29.4	30.4	31.7	32.3	32.5
24	31.8	31.1	30.4	31.9	29.9	29.6	28.8	29.4	29.8	31.9	30.9	31.4
25	31.3	31.1	29.4	30.9	30.1	29.6	28.5	29.0	30.0	31.2	30.2	31.3
26	30.5	30.9	29.5	30.9	30.2	29.4	28.5	29.0	30.1	30.7	31.4	33.8
27	31.8	31.3	30.3	31.5	30.2	29.4	28.3	29.5	30.0	30.6	31.0	32.5
28	31.5	31.8	31.7	31.0	30.4	29.4	29.0	29.4	30.5	30.5	31.2	32.3
29	30.3		31.8	31.0	30.0	29.4	28.3	29.3	31.0	30.6	32.1	33.0
30	31.1		32.2	31.2	29.7	29.7	28.9	29.2	30.7	30.7	32.1	32.3
31	30.6		31.1		29.7		28.8	29.0		31.4		32.2

Table 2.4 The result of minimum air temperature forecasting in 2019

Date	Jan	Feb	Marc	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	25.1	26.1	27.4	28.5	30.3	30.3	31.1	32.6	33.1	36.6	38.0	39.1
2	24.5	25.9	27.2	29.0	30.0	29.6	31.7	31.9	33.7	35.7	37.3	38.6
3	24.7	26.3	27.5	27.9	30.1	30.8	32.5	31.7	33.2	36.6	38.2	37.9
4	25.3	26.5	26.9	28.0	30.1	30.5	31.7	31.4	33.2	35.5	37.3	38.5
5	25.9	26.3	27.8	28.9	30.1	30.9	31.4	31.9	34.2	34.7	37.7	38.4
6	25.1	26.1	27.9	29.0	30.3	31.2	30.2	31.0	34.7	35.2	37.5	38.4
7	25.5	26.5	27.8	29.0	31.1	30.9	30.3	31.0	34.5	36.2	37.6	38.9
8	25.2	26.7	27.6	28.8	31.1	30.6	30.4	31.2	34.0	36.0	36.9	38.0
9	25.8	26.3	27.4	29.2	30.8	31.7	31.7	32.9	35.1	36.3	37.0	38.8
10	25.3	26.1	27.2	29.5	31.8	31.9	31.4	33.0	35.3	36.2	36.6	38.5
11	25.6	26.5	27.8	29.4	30.6	31.8	31.0	32.0	34.7	36.3	37.4	38.9
12	25.4	26.6	27.2	29.7	31.0	31.8	30.6	32.5	34.8	36.9	37.5	39.4
13	26.0	26.2	27.9	29.8	30.7	31.9	30.7	32.9	33.3	37.1	37.4	38.8
14	25.5	26.4	27.3	30.5	30.9	31.9	31.7	33.1	33.9	36.8	36.7	39.1
15	25.9	26.4	27.4	30.3	30.7	32.2	32.3	32.2	33.3	37.1	37.2	39.3
16	25.7	25.7	27.7	29.6	30.9	31.0	31.2	30.9	33.7	36.5	37.8	38.9
17	25.2	26.2	28.2	29.4	31.4	31.2	30.0	30.3	34.7	36.1	38.6	38.3
18	25.5	27.0	27.7	29.5	30.9	31.1	30.4	31.2	35.7	36.2	38.2	38.6
19	25.9	27.8	27.4	29.1	31.4	30.9	31.8	31.8	33.8	36.2	37.7	38.5
20	26.2	27.1	28.3	29.8	31.4	30.8	31.8	32.0	34.4	37.0	38.1	38.5
21	25.8	26.7	27.9	29.7	30.7	31.5	32.0	32.5	34.8	37.6	38.1	38.8
22	26.0	26.8	27.8	29.9	30.4	32.5	32.2	33.6	33.7	37.4	38.4	38.7
23	25.7	26.1	28.3	29.7	31.3	32.0	32.7	32.7	35.0	38.0	38.0	39.0
24	26.0	26.8	28.7	29.7	31.4	32.5	32.3	32.5	35.5	37.2	37.9	38.8

25	26.1	27.4	29.0	30.0	30.4	31.9	30.6	32.7	35.3	37.0	37.9	38.8
26	26.0	27.1	27.5	29.0	31.2	32.1	30.0	33.2	35.4	37.3	37.5	38.9
27	25.9	27.1	27.8	29.2	32.1	32.2	29.7	32.9	35.1	36.7	37.5	39.2
28	26.2	27.2	28.2	29.3	31.2	32.3	30.7	33.2	33.7	36.7	37.7	39.2
29	25.7		28.5	29.4	31.1	32.6	31.2	34.3	34.7	37.3	37.8	40.3
30	26.0		28.9	29.5	31.0	31.4	31.8	34.2	35.7	36.9	38.0	40.8
31	26.0		29.4		30.6		32.7	34.2		36.8		40.3

Based on Table 4.5 and Table 4.6 obtained the results of forecasting the maximum air temperature and minimum air temperature in Cilacap with the Triple Exponential Smoothing Holt-Winter method) with additive type using the Minitab16 application.

4. Conclusion

The results of this study indicate that the maximum air temperature forecasting with $\alpha = 0.4$, $\delta = 0.1$, and $\gamma = 0.1$ obtained MAPE values of 1.62917% and the minimum temperature forecasting with $\alpha = 0.7$, $\delta = 0.1$, and $\gamma = 0.1$ obtained MAPE value is 1.92473%. Because MAPE values are in the range $0 < x < 10$, then the results of this forecast are said to be accurate.

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