

Selection for the best ETS (error, trend, seasonal) model to forecast weather in the Aceh Besar District

Chesilia Amora Jofipasi, Miftahuddin, and Hizir

Department of Statistics, Faculty of Mathematics and Science, Syiah Kuala University, Banda Aceh, Indonesia

Email: chesilia.amora@students.stat.unsyiah.ac.id; miftah@unsyiah.ac.id;

Abstract. Weather is a phenomenon that occurs in certain areas that indicate a change in natural activity. Weather can be predicted using data in previous periods over a period. The purpose of this study is to get the best ETS model to predict the weather in Aceh Besar. The ETS model is a time series univariate forecasting method; its use focuses on trend and seasonal components. The data used are air temperature, dew point, sea level pressure, station pressure, visibility, wind speed, and sea surface temperature from January 2006 to December 2016. Based on AIC, AICc and BIC the smallest values obtained the conclusion that the ETS (M, N, A) is used to predict air temperature, and sea surface temperature, ETS (A, N, A) is used to predict dew point, sea level pressure and station pressure, ETS (A, A, N) is used to predict visibility, and ETS (A, N, N) is used to predict wind speed.

1. Introduction

Weather and climate is component of the natural ecosystem that affects the life processes of human, animal and even plants. Based on data collected by the Intergovernmental Panel on Climate Change (IPCC), the earth temperature has increased by 0,8 °C measured from the beginning of the 20th and estimated at the end of the 21st the earth's temperature will be increased to 2,4°– 6,4 °C [1]. Weather can be predicted using data in previous periods with studying trend data. Forecasting for time series data can be done with a time series univariate and can also be multivariate.

In this study, ETS (Error, Trend, Seasonal) was chosen as the method to be used to forecast weather elements (air temperature, visibility, wind speed, dew point, station pressure, sea level temperature and sea surface temperature). The purpose of this research is to get the best ETS model for every weather element in Aceh Besar.

2. Literature Review

2.1. Weather Elements

Weather is a physical phenomenon from the atmosphere at the place and at a shorter time. While, the climate is the average of the weather on a year that investigation in a long time (minimum 30 years) and covers a large area [2].

The air temperature is the degree of heat of the molecular activity in the atmosphere, expressed in Celcius (C), Reamur (R) and Fahrenheit (F) [3]. Air pressure is the power to drive air masses within each area, expressed in Celcius (C), Reamur (R) and Fahrenheit (F) [4]. Wind speed is the speed of air that moves horizontally or vertically at 2m above ground level, expressed in knots [3]. Visibility is the



ability to see an object horizontally and expressed in miles [5]. Sea surface temperature is one of the parameters that determine the quality of the waters, expressed in Celcius (C). SPL is an important factor influencing the dynamics of regional climate and global climate [6].

2.2. ETS (Error, Trend, Seasonal)

ETS (Error, Trend, Seasonal) method is an approach method for forecasting time series univariate. This ETS model focuses on trend and seasonal components [7]. The flexibility of the ETS model lies in its ability to trend and seasonal components of different traits.

The components are as follows:

Table 1. ETS Components [8]

Trend Component	Seasonal Component		
	N (None)	A (Additive)	M (Multiplicative)
N (None)	NN	NA	NM
A (Additive)	AN	AA	AM
Ad (Additive Damped)	AdN	AdA	AdM
M (Multiplicative)	MN	MA	MM
Md (Multiplicative Damped)	MdN	MdA	MdM

The combination of ETS models obtained from the above components:

Table 2. Combination ETS model [8]

Model	Model	Model
ETS (M, M, N)	ETS (A, M, A)	ETS (M, N, M)
ETS (M, A, N)	ETS (A, Md, N)	ETS (M, N, A)
ETS (M, A, M)	ETS (A, Md, M)	ETS (M, N, N)
ETS (A, M, N)	ETS (A, N, A)	ETS (M, A, A)
ETS (A, N, N)	ETS (M, Ad, M)	ETS (A, Ad, M)
ETS (A, A, M)	ETS (M, Ad, N)	ETS (M, M, A)
ETS (M, M, M)	ETS (M, Md, M)	ETS (A, A, A)
ETS (A, N, M)	ETS (A, Ad, N)	ETS (A, Ad, A)
ETS (A, A, N)	ETS (M, Md, A)	ETS (M, Ad, A)
ETS (A, M, M)	ETS (M, Md, N)	ETS (A, Md, A)

From the ETS model above, there are 15 models with additive errors and 15 models with multiplicative errors. In time series analysis it is possible to have some models that meet the assumptions. Related to that, to determine the best model of 30 ETS model can be used several criteria such as Akaike's Information Criterion (AIC), Akaike's Information Criterion correction (AICc) and Bayesian Information Criterion (BIC) [9].

Akaike's Information Criterion (AIC) can be calculated using the following equation:

$$AIC = -2 \left(\frac{LL}{T} \right) + \frac{2t_p}{T} \quad (1)$$

with:

AIC = Akaike Information Criterion

LL = log likelihood

t_p = Total Parameters

T = Number of observations

Akaike's Information Criterion correction (AIC_c) can be calculated using the following equation:

$$AIC_c = AIC + \frac{2k(k+1)}{n-k-1} \quad (2)$$

with $\frac{2k(k+1)}{n-k-1}$ is bias correction.

Bayesian Information Criterion (BIC) can be calculated using the following equation:

$$BIC = -2LL + k \ln(n) \quad (3)$$

with:

LL = log likelihood
 k = Estimation of parameter model
 n = Number of observations

3. Research Methods

3.1. Data

This study uses data obtained from the website www.noaa.gov. The data is a monthly data of weather elements in Aceh Besar (Satellite Station Blang Bintang). The data used were 132 observations from January 2006-December 2016 for each variable, but the SST variable used data from September 2006 to August 2016 with missing data from January 2013-April 2015. Data analysis was done with software R 3.0.3. Here are the variables:

Table 3. Weather elements

No	Variables	Unit
1	temp (Air Temperature)	°C
2	dewp (Dew Point)	°C
3	slp (Sea Level Pressure)	mb
4	stp (Station Pressure)	mb
5	visib (Visibility)	miles
6	wdsp (Wind Speed)	knot
7	sst (Sea Surface Temperature)	°C

3.2. Analytical Procedures

The data analysis procedure in this study consists of:

1. Data of weather elements (air temperature, visibility, wind speed, dew point, station pressure, sea surface pressure and sea surface temperature) are inputted into software R 3.0.3.
2. To descriptive analysis by looking at the characteristics of data through data summary.
3. To inferencing analysis using 30 combinations of ETS models for each weather element.
4. Choose the best ETS model based on the smallest AIC, AIC_c and BIC values for each weather element.

4. Results and Discussion

4.1. Descriptive analysis

To know the characteristics data of weather elements can be seen in the following table:

Table 4. Summary of weather element in Aceh Besar district on 2006-2016

Variable	Characteristics	Value	Variable	Characteristics	Value
Air temperature	Maximum	29,28	Visibility	Maximum	6,25
	Minimum	25,72		Minimum	4,00
	Mean	27,29		Mean	5,86
	Median	27,31		Median	6,00
	Quartile 1	26,72		Quartile 1	5,75
	Quartile 3	27,81		Quartile 3	6,00
	Maximum	24,59		Maximum	8,00
Dewpoint	Minimum	21,01	Wind speed	Minimum	0,67
	Mean	22,87		Mean	3,76
	Median	22,90		Median	3,75
	Quartile 1	22,24		Quartile 1	3,19
	Quartile 3	23,50		Quartile 3	4,30
Sea level pressure	Maximum	1012	Sea surface temperature	Maximum	30,71
	Minimum	1007		Minimum	28,26
	Mean	1010		Mean	29,25
	Median	1010		Median	29,22
	Quartile 1	1009		Quartile 1	29,00
Station pressure	Quartile 3	1010	Quartile 3	29,33	
	Maximum	1009	Data lost	34	
	Minimum	1005			
	Mean	1007			
	Median	1007			
	Quartile 1	1007			
	Quartile 3	1008			

Based on Table 4. we can know the characteristics of weather elements in Aceh Besar 2006 to 2016 as follows:

1. Water temperature obtained an average of 27,29 °C with a minimum temperature of 25,72 °C and a maximum temperature of 29,28 °C. The water temperature obtained the mean, median and quartile three which ranges from 27 °C.
2. Dewpoint, obtained an average of 22,87 °C with a minimum temperature of 21,01 °C and a maximum temperature of 24,59 °C. At dew point the mean and median values at the same temperature that is 22 °C.
3. Sea level pressure obtained the average of 1010mb with the lowest pressure of 1007mb and the highest pressure is 1012mb. The sea level pressure obtains the mean, median and quartile three values are precisely the same value of 1010mb.
4. Station pressure, obtained an average of 1007mb with the lowest pressure of 1005mb and the highest pressure is 1009mb. Also the station pressure also obtained the same value for the mean, median and quartile 1 is equal to 1007mb.
5. Visibility obtained an average of 5,86 miles with the closest distance of 4,00 miles and the farthest distance of 6,25 miles. On visibility also obtained the same value for median and quartile three that is equal to 6,00 miles.

6. Wind speed obtained an average of 3,76 knots with a late speed of 0,67 knots and the fastest speed of 8.00 knots. Besides, wind speed has a more significant range value when compared with other weather elements that are equal to 7.
7. Sea surface temperature, obtained an average of 29,25 °C with a minimum temperature of 28,26 °C and a maximum temperature of 30,71 °C. Also, the correct values of the mean, median, quartile 1 and quartile 3 are in the same value of 29 °C. As well as on variable sea surface temperature there are lost data as much as 34 periods.

4.2. Inference Analysis

Inference analyzes were performed using 30 combinations of ETS models, and only a few model can be used to predict the weather elements. From the model used the best model is chosen by looking at the smallest AIC, AICc and BIC values.

Here are the combinations ETS model for air temperature in Aceh Besar in 2006-2016:

Table 5. ETS model air temperature

Model ETS	AIC	AICc	BIC
M, M, N	500,5896	500,9046	512,1208
M, A, N	500,7238	501,0387	512,2550
M, Ad, M	439,5239	444,8978	488,5370
A, N, N	497,6485	497,7415	503,4141
M, Md, M	442,1614	477,5299	491,1691
A, A, N	501,9201	502,2351	513,4513
A, N, A	433,8487	437,4385	474,2080
M, N, M	438,6933	442,2830	497,0525
M, N, A	432,5406	436,1304	472,8998
M, N, N	496,5606	496,6536	502,3262
M, Ad, A	437,5158	443,1233	486,7625
A, A, A	439,5158	444,2462	485,6406

From the Table 5 obtained the best model is ETS (M, N, A) to predict water temperature in Aceh Besar in 2017-2018 with AIC of 432,5406, AICc of 436,1304 and BIC of 472,8998.

Here is the combinations ETS model for dew point in Aceh Besar in 2006-2016:

Table 6. ETS model dew point

Model ETS	AIC	AICc	BIC
M, Md, N	547,9749	548,4511	562,3889
M, A, N	545,5890	545,9039	557,1202
M, Ad, M	476,1028	481,4712	525,1104
A, N, N	541,3037	541,4003	547,0729
M, Md, M	475,3339	480,7023	524,3415
A, A, N	545,3121	545,6270	556,8433
A, N, A	468,0783	471,6681	508,4376
M, N, M	470,4469	474,0366	510,8061
M, N, A	468,2307	471,8205	508,5899
M, N, N	541,7574	541,8504	547,5230
M, A, A	475,8386	480,5691	521,9635
A, A, A	473,5571	478,2876	519,6820

From the Table 6 obtained the best model is ETS (A, N, A) to predict dew point in Aceh Besar in 2017-2018 with AIC of 468,0783, AICc of 471,6681 and BIC of 508,4376.

Here is the combinations ETS model for sea level pressure in Aceh Besar in 2006-2016:

Table 7. ETS model sea level pressure

Model ETS	AIC	AICc	BIC
M,M,N	655,1631	655,4781	666,6943
M,A,N	654,9047	655,2196	666,4359
M,Ad,M	595,0740	600,4424	644,0816
A,N,N	651,5644	651,6574	657,3300
M,M,M	491,5557	496,2861	537,6805
A,A,N	565,4636	565,7786	576,9948
A,N,A	484,7299	488,3196	525,0891
M,M,N	485,2665	488,8563	525,6258
M,N,A	485,1053	488,6951	525,4646
M,N,N	561,3579	561,4509	567,1235
M,Ad,A	492,3699	497,7383	541,3775
A,A,A	492,4421	497,1725	538,5669

From the Table 7 obtained the best model is ETS (A, N, A) to predict sea level pressure in Aceh Besar in 2017-2018 with AIC of 484,7299, AICc of 488,3196 and BIC of 525,0891.

Here is the combinations ETS model for station pressure in Aceh Besar in 2006-2016:

Table 8. ETS model station pressure

Model ETS	AIC	AICc	BIC
M,Md,N	565,7366	566,2128	580,1506
M,A,N	563,7944	564,1094	575,3256
M,A,M	489,2061	493,9365	535,3309
A,N,N	559,8000	559,8930	565,5656
M,M,M	489,5715	494,3019	535,6963
A,A,N	563,8278	564,1428	575,3591
A,N,A	481,8738	485,4636	522,2331
M,N,M	482,4092	485,9990	522,7684
M,N,A	481,9825	485,5722	522,3417
M,N,N	559,7663	559,8593	565,5319
M,A,A	491,1983	495,9287	537,3231
A,Ad,A	490,1326	495,5011	539,1403

From the Table 8 obtained the best model is ETS (A, N, A) to predict station pressure in Aceh Besar in 2017-2018 with AIC of 481,8738, AICc of 485,4636 and BIC of 522,2331.

Here is the combinations ETS model for visibility in Aceh Besar in 2006-2016:

Table 9. ETS model visibility

Model ETS	AIC	AICc	BIC
M,M,N	341,4413	341,9175	355,8553
M,A,N	335,6049	355,9199	347,1361
M,Ad,M	350,9936	356,3621	400,0013
A,N,N	334,6036	334,6966	340,3692
M,M,M	361,7591	367,1275	410,7667
A,A,N	333,5488	333,8638	345,0080
A,N,A	341,3315	344,9213	381,6908
M,N,M	381,2393	384,8291	421,5986
M,N,A	339,6880	343,2777	380,0472
M,N,N	335,0598	335,1528	340,8254
M,A,A	354,9128	360,2812	403,9205
A,A,A	344,7034	350,0718	393,7110

From the Table 9 obtained the best model is ETS (A, A, N) to predict visibility in Aceh Besar in 2017-2018 with AIC of 333,5488, AICc of 333,8638 and BIC of 3345,0800.

Here is the combinations ETS model for wind speed in Aceh Besar in 2006-2016:

Table 10. ETS model wind speed

Model ETS	AIC	AICc	BIC
M,M,N	677,9229	678,2379	689,4541
M,A,N	674,6547	674,9697	686,1859
M,A,M	687,8231	692,5517	733,9461
A,N,N	666,8980	666,9910	672,6636
M,M,M	682,0401	686,7705	728,1649
A,Ad,N	667,8871	668,3633	682,3011
A,N,A	676,8035	680,3932	717,1627
M,N,M	678,1830	681,7727	718,5422
M,N,A	675,8602	679,4500	716,2195
M,N,N	673,3369	673,4299	679,1025
M,Ad,A	682,6962	688,0647	731,7039
A,A,A	683,3426	688,0730	729,4674

From the Table 10 obtained the best model is ETS (A, N, N) to predict wind speed in Aceh Besar in 2017-2018 with AIC of 666,8980, AICc of 666,9910 and BIC of 672,6636.

Here is the combinations ETS model for sea surface temperature in Aceh Besar in 2006-2016:

Table 11. ETS model sea surface temperature

Model ETS	AIC	AICc	BIC
M, Md, N	314,9518	315,5401	328,3625
M, A, N	314,6889	315,0773	325,4175
M, Ad, M	315,7892	322,5892	361,3854
A, N, N	312,5315	312,6458	317,8957
M, Md, M	314,4385	321,2385	360,0347
A, A, N	316,3125	316,7009	327,0410
A, N, A	305,2927	309,8088	312,8425
M, N, M	304,9535	309,4696	312,5033
M, N, A	304,7735	309,2896	312,3233
M, N, N	311,0270	311,1413	316,3912
M, A, A	312,8845	318,8626	355,7986
A, A, A	313,6343	319,6123	356,5484

From the table 11 obtained the best model is ETS (M, N, A) to predict sea surface temperature in Aceh Besar in 2017-2018 with AIC of 304,7735 AICc of 309,2896 and BIC of 312,3233.

5. Conclusion and Suggestion

5.1. Conclusion

Based on AIC, AICc and BIC the smallest values obtained the judgment that the ETS (M, N, A) is used to predict air temperature and sea surface temperature, ETS (A, N, A) is used to predict dew point, sea level pressure and station pressure, ETS (A, A, N) is applied to predict visibility, and ETS (A, N, N) is used to predict wind speed.

5.2. Suggestion

This study focuses on trend and seasonal components for weather forecasting in Aceh Besar with variable air temperature, dew point, sea level pressure, station pressure, visibility, wind speed and sea

surface temperature, for the next researchers to forecast the elements weather with more attention to the error.

References

- [1] Solomon S, Qin D, Manning M, Chen Z, Averyt K B, Tignor M and Miller H L 2007 Contribution of working group i to the fourth assessment report of the intergovernmental panel on climate change intergovernmental panel on climate change *Climate Change 2007: The Physical Science Basis*
- [2] Wuryatno 2000 *Klimatologi* (Bandung: ITB Press) (in Indonesian)
- [3] Tjasjono B 2004 *Klimatologi* (Bandung: ITB) (in Indonesian)
- [4] Sarjani 2004 Cuaca dan Iklim www.scribd.com (Accessed on 5 August 2017) (in Indonesian)
- [5] Nugroho F 2009 Visibility, RVR dan Konversi RVR ke visibility *Penerbangan* (in Indonesian)
- [6] Qu T, Du Y, Strachan J, Meyers G and Slingo J 2005 Sea surface temperature and its variability in the Indonesian region *Oceanography* **18**(4) 50
- [7] Sindhanuru Hemanth 2016 Exponential Smoothing (ETS) Framework www.latenview.com/idealab/exponential-smoothing-ets-framework (Accessed on 7 April 2017)
- [8] Hyndman R J and Khandakar Y 2008 Automatic time series forecasting: The forecast package for R *J. Statistical Software* **27** (Monash University)
- [9] Hyndman R, Koehler A B, Ord J K and Snyder R D 2008 *Forecasting with Exponential Smoothing the State Space Approach* (Germany: Springer)