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Preliminary study on relation between temperature, humidity and Night Sky Brightness in Yogyakarta

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Preliminary study on relation between temperature, humidity and Night Sky Brightness in Yogyakarta

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Abstract. The meteorological data is important to be collected especially at the observatory. Temperature and humidity are two parameters that can be monitored as part of meteorological data collections. The observatory site also need to be protected from light pollution. The light pollution level is usually measured by the value of Night Sky Brightness (NSB). In this paper, the relation between temperature, humidity and NSB will be studied. The temperature and humidity were measured by DHT11 Sensor that is assembled and monitored using Internet of Thing method. The NSB was measured using Sky Quality Meter. The measurements have been done in Observatorium UAD, Yogyakarta. The correlation calculation was employed to perform relationship analysis. The correlation value of temperature on NSB are in the range of -0.767 to 0.576. Hence, there is no particular pattern for the relationship between temperature and NSB. The correlation value of humidity on NSB are in the range of -0.812 to 0.977. Here, the humidity tend to have more number positive relationship to NSB. As the humidity increased, the NSB is increasing. However, the investigation on temperature and humidity data changes in particular duration of time measurement will give complete information about the relationship between temperature, humidity, and NSB. The conclusion can be used to create prediction model of NSB monitoring system.

Keywords: Night Sky Brightness, temperature, and humidity parameter

1. Introduction

The monitoring of night sky brightness in observatory is important for observatory protection. Since, the light pollution is main threat for observation activity. The Mount Wilson Observatory, National Observatory at Kilt Peak and many other new telescopes in China, Arizona, Hawaii, and the Canary Islands are constantly got threat by increasing level of light pollution [1]. Although the night sky brightness is decreasing as the moon is above the horizon [2]. Night sky brightness can be measured by Sky Quality Meter (SQM). Night sky observation is also facing the problem of cloud coverage and seeing. Hence, the night sky brightness as the measurement of sky quality for observation should be supported by the meteorological data. Hence, seeing, night sky brightness and meteorological information are three important factors for observation, especially at observatory [3]. The stability of temperature and humidity are needed to obtain the high quality data on SQM [4]. Temperature and humidity can be used to forecast the weather condition. They are also important to be measured to

assess the condition of sky quality meter that is located outside of the building. Cloud coverage, cloud height and aerosol parameter were measured at CESAR to investigate the effect of atmospheric conditions on the night sky brightness [5]. This research is intended to measure the relationship between the temperature and humidity to the nigh sky brightness. Hence, modelling for night sky brightness can be completed with the meteorological data as input parameter.

2. Methodology

The research has been done using the observational method. The location of measurement is located at 7º48' South and 110º22'59" East. It is located at the compound site of Controversial Ahmad Lahnda Observatory. The duration of data collection is January 2018 until April 2018. Optometry method for measuring the NSB was employed. The NSB was measured by SQM LE that was connected to the computer. The SQM LE is the type of SQM that is connected to the computer via Ethernet. The SQM is powerful and versatile instrument that can be used not only for measuring the NSB but also the sky brightness changing during the day. The measurement of sky brightness changing during the total solar eclipse has been done using SQM [6]. Temperature and humidity data were collected by DHT11 Sensor. The sensor is controlled by Wemos D1 Mini to act as microcontroller and access point to internet. The Real Time Clock (RTC) is also connected to the Wemos D1 Mini as shown in Figure 1.
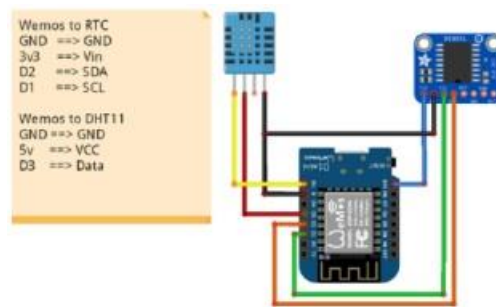

Figure 1. The electrical circuit of the temperature and humidity measurement and data transmision. The Wemos D1 Mini is connected to the DHT11 Sensor and the Real Time Clock (RTC).

The NSB as a function of time will be plotted together with temperature and humidity as function of time. The correlation coefficient (r) is calculated using the Pearson Product Moment. The correlation coefficient value is between -1 and +1. The positive coefficient means both variable are increasing together or proportionally relation. While one variable increasing and the other decreasing, it means that the coefficient is negative. With the value of X as an independent variable and Y as an independent variable, the coefficient can be calculated as

$$r = \frac{\sum(X,Y)}{\sqrt{S_X^2 S_Y^2}}$$

(1)

The value of $\Sigma(X,Y)$ can be calculated as

$$\sum(X,Y) = \frac{\sum(X - \overline{X})(Y - \overline{Y})}{n-1}$$

(2)

The variant of X data can be calculated as

$$S_X^2 = \frac{\sum(X - \bar{X})}{n-1} \tag{3}$$

The variant of *Y* data can obtained by calculating

$$S_Y^2 = \frac{\sum(Y - \bar{Y})}{n-1} \tag{4}$$

Those equation are necessary to have the average value of X and Y data. The average of X data can be calculated as

$$\bar{X} = \frac{X}{n} \tag{5}$$

The average of Y data is

$$\bar{Y} = \frac{Y}{n} \tag{6}$$

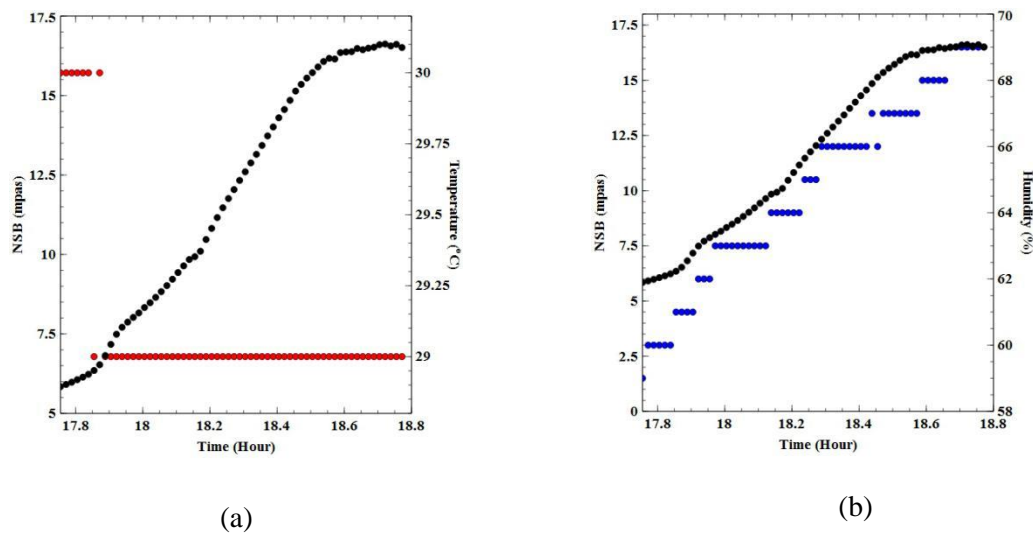which *n* is the number of data.

(a)

(b)

Figure 2. The black dots, red dots and blue dots are the data of NSB, temperature and humidity, respectively. The time is local time (UTC + 07 Hour). (a) The graph of NSB and temperature versus time on March, 9th 2018 on increasing NSB. (b) The graph of NSB and humidity versus time on March, 9th 2018 on increasing NSB.

3. Result and Discussion

The result of the observation is explained in this section. The data need to be divided into 3 parts since the characteristic of the NSB changing is different. They are region of increasing NSB, constant NSB and decreasing NSB. The division is basically similar with the division of dawn, night and dusk.
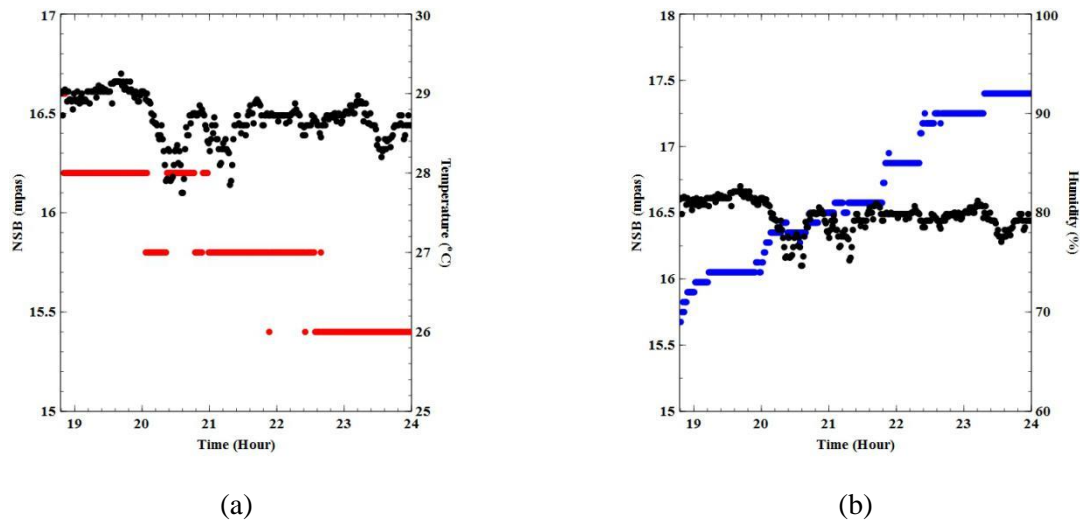

(a)   (b)

Figure 3. (a) The graph of NSB and temperature versus time on March, 9th 2018 on constant NSB. (b) The graph of NSB and humidity versus time on March, 9th 2018 on constant NSB.

The trend on temperature and humidity as function of time are plotted in figure 2 for increasing NSB value. Figure 2a shows the graph of NSB and temperature as function of time. The graph indicate that there is no significant correlation between the NSB changing and the temperature. However, figure 2b shows the humidity changing in similar trend as NSB changing. Analysis can be done also for the constant NSB. Figure 3a shows that the temperature and humidity insignificantly correlate with the NSB. NSB relatively stable regardless the changing of temperature and humidity. Figure 2 and figure 3 show different sky condition. The dusk is represented by figure 2. The figure 3 is the representation of evening or night. The atmospheric condition relatively changing especially the humidity due to the changing of water vapor content in the atmosphere. This is related to the sun light intensity that fall on the earth surface.
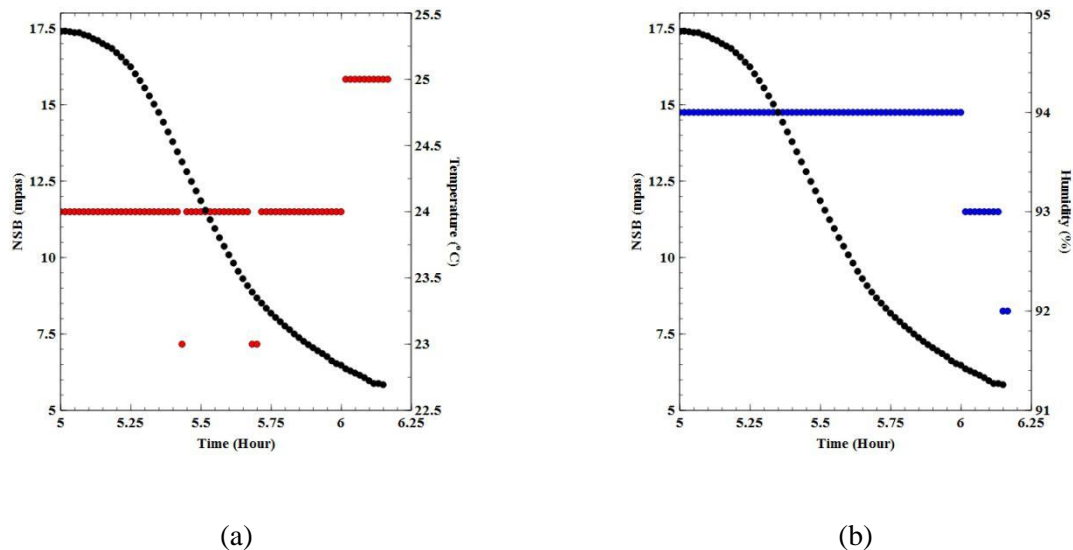
(a)   (b)

Figure 4. (a) The graph of NSB and temperature versus time on January, 28th 2018 on decreasing NSB. (b) The graph of NSB and humidity versus time on January, 28th 2018 on constant NSB.

At dawn, the water vapor supposed to be have similar behaviour. However, the changing of humidity did not correlate significantly with the NSB changing. Positive correlation is found on this particular date and condition. As the NSB decrease, the humidity also decrease but it was insignificant. The temperature and NSB behave indifferent way. As the sun rising from the eastward direction, NSB decrease and the temperature start to rise. More data is required to obtain the complete description of correlation between NSB and temperature and humidity.

The correlation coefficient between NSB and temperature and humidity are shown in table 1. The table shows the coefficient for each observation date as well as the division of NSB characteristics. The correlation coefficient between NSB and temperature for increasing NSB show 4 negative values from 4 data sets. The minimum is -0.229 and the maximum is -0.767. It means that as the sky getting darker, the temperature is getting colder. The correlation coefficient between NSB and humidity for increasing NSB show 4 positive values from 4 data sets. The minimum is 0.713 and the maximum is 0.904. As the sky getting darker, the air become more humid. The dependencies NSB to the humidity is stronger compared to the temperature.

The correlation coefficient between NSB and temperature for decreasing NSB show 4 negative values from 4 data sets. The minimum is -0.229 and the maximum is -0.767. It means that as the sky getting darker, the temperature is getting colder. The correlation coefficient between NSB and humidity for increasing NSB show 4 positive values from 4 data sets. The minimum is 0.713 and the maximum is 0.904. As the sky getting darker, the air become more humid. The dependencies NSB to the humidity is stronger compared to the temperature.

Table 1: Correlation coefficient between NSB and temperature (r_T) and NSB and humidity (r_H)

Date	Time	Correlation Coefficient	
January, 12th	17:46 - 19:44	r_T	-0.229
	(increasing NSB)	r_H	0.904
	21.32 - 22.35	r_T	-0.197
	(constant NSB)	r_H	0.156
February, 27th	17:53 - 19:00	r_T	-0.767
	(increasing NSB)	r_H	0.858
	20:15 - 24:00	r_T	0.367
	(constant NSB)	r_H	-0.316
February, 28th	00:00 - 04:59	r_T	-0.842
	(constant NSB)	r_H	0.878
	05:00 - 06:09	r_T	-0.419
	(decreasing NSB)	r_H	0.533
March, 9th	17:45 - 18:46	r_T	-0.537
	(increasing NSB)	r_H	0.978
	18:47 - 23:59	r_T	0.288
	(constant NSB)	r_H	-0.356
March, 10th	00:00 - 01:58	r_T	0.576
	(constant NSB)	r_H	-0.322
April, 4th	18:17 - 18:59	r_T	-0.418
	(increasing NSB)	r_H	0.713
April, 5th	00:00 - 03:24	r_T	0.485
	(constant NSB)	r_H	-0.812
	03:24 - 05:00	r_T	-0.631
	(increasing NSB)	r_H	0.488
	05:00 - 06:01	r_T	-0.816
	(decreasing NSB)	r_H	0.406

There is 1 data of increasing NSB that was occurred on April, 5th in the interval of 03:24 - 05:00, as shown in table 1. This is a peculiar data since it was occurred during the night. The temperature correlation coefficient and humidity coefficient correlation are negative and positive, respectively. However, both values are in the medium range, since they are close to -0.5 and 0.5. At this interval, the analysis can be composed in the specific way since probably there are some complexity conditions on the weather and astronomical phenomena occurred. The following discussion is about the coefficient temperature at the interval of constant NSB. There are 6 data sets. There are 2 negative values and 4 positive values of temperature coefficient. The negative values are -0.197 and -0.842. The positive values are 0.288, 0.367, 0.485, 0.576. From these results, temperature can be stated that it did insignificantly correlate the NSB. The humidity correlation coefficients are -0.812, -0.316, -0.322 , -0.356, 0.156, 0.878. Hence, there is no conclusive the dominant correlation coefficient. Since, the NSB is constant or very small changing. Any changing of the humidity and temperature did not effect the NSB. There are 2 data set of decreasing NSB. The temperature correlation coefficients are-0.419 and -0.816. The humidity correlation coefficients are 0.533 and 0.406. Hence, the humidity correlation coefficients are more consistent compared to the temperature correlation coefficient. As the sky getting brighter, the humidity decrease since the sun rising. The variation of correlation coefficient can be explained by different sky condition, for example cloud coverage and moon phase. The lunar phase on January 12th, 2018 was the third quarter. Hence, the illumination by the moon will be significant from the beginning of midnight to dawn. The similar lunar phase also occur on March 9th and April, 4th and 5th, 2018. However, the lunar phase on February 27th and 28th, 2018 was almost full moon. Hence, the moon will be above the horizon from dusk till dawn. The lunar phase should be included into the analysis since it can effect the NSB especially to the beginning of the astronomical twilight [2][7].

4. Conclusion

The NSB correlation coefficient to the temperature and humidity are vary with the time. However, the humidity tend to have positive relation to the NSB. It means, the changing of water vapor concentration correspond to the changing of the sky quality. Hence, the model of NSB can be composed by including the humidity factor.

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