Analysis of Air Temperature and Humidity in Kedunggalar Against BMKG Data Based on DHT11 Sensor

A D Saputro*, M Yantidewi
Jurusan Fisika, Universitas Negeri Surabaya

*E-mail: andrian.17030224018@mhs.unesa.ac.id

Abstract. This research was conducted to compare the temperature and humidity data presented by the BMKG against realtime data based on the DHT11 sensor readings in Kedunggalar, Ngawi. Data was collected for 14 days (8-21 September 2020) at the same time interval between 07-10 AM according to the data update on the BMKG website. Temperature and humidity readings are recorded periodically with the DHT11 sensor every second for one minute, so that 60 data generated every one day. The average temperature and humidity data produced by the DHT11 sensor is 29.18 ℃ and 68.16% with a comparison of the average data from the BMKG website 28.79 ℃ and 65.36%. So that from the comparison of direct measurements of DHT11 and from the website it has a sensor reading error against a temperature of 1.59 ℃ and a humidity of 5.24%. The conclusion is that the measurement of temperature and humidity in Kedunggalar with the DHT11 sensor is very valid against the data on the BMKG website. Even though the humidity exceeds the accuracy limit of the DHT11 sensor which is a maximum tolerance value of 5%, on the other hand the temperature reading is very accurate because the tolerance value is less than 2 ℃.

1. Introduction
Climate is an average of a very long period such as daily, monthly or yearly. Climate can also be interpreted as data from elements such as temperature, humidity, rainfall, wind flow and others [1]. Climatic data is obtained by adding the highest and lowest values which are then divided by two, in intervals of 3-4 hours [2]. Climate can also be interpreted as data from elements such as temperature, humidity, rainfall, wind flow and others [2]. The benefit of knowing this is to get the accuracy of the data, so that it is expected to be useful for life. For examples in agriculture, the accuracy of temperature and humidity data is needed to control plant diseases [3].

Climate change in Indonesia can be easily accessed through the BMKG website. On the BMKG website, the latest climate data are available every day for all regions in Indonesia including Kedunggalar sub-district. Kedunggalar is located near the city center of Ngawi which tends to be hot and close to the Jogorogo sub-district which is cold, because it is included in the area at the foot of Mount Lawu. Climatic data that can be observed for the Kedunggalar area are temperature and humidity. Temperature is the degree of hot or cold molecular activity on a certain scale and can change at any time [4]. Meanwhile, humidity is the water content contained in the air which is expressed in percent [5].

The temperature and humidity data are available on the BMKG website with dynamic values. Evidenced by changes in temperature and humidity information every 3 hours, this change applies to all regions in the world including Indonesia [6]. The problem arises, whether the data presented is
truly accurate, especially for remote areas such as Kedunggalar. From these problems, in the end a comparative analysis will be carried out using a supporting instrument system.

2. Method
The method applied in this research consists of designing hardware and software and testing the instrument system.

2.1. Hardware Design
The hardware design used in this study is the Arduino UNO. Arduino UNO has a microcontroller type ATmega328 made by Atmel Corporation, combined with its performance using a DHT11 sensor. These components (Arduino UNO and DHT11 sensor) are assembled to form a device system as shown in Figure 1. The input comes from the DHT11 sensor reading the temperature and humidity values in the surrounding area, then sent to Arduino to be processed and displayed on the serial monitor on a PC or laptop.

Figure 1. Arduino and DHT11 device systems and communication to serial PC or laptop monitors

The DHT11 sensor is connected to the Arduino UNO using a male to female jumper cable on the 5V input, ground as power for the DHT11 sensor and pin 2 as data transfer to the serial monitor in the Arduino IDE program. The Arduino module interface is connected to the computer via the USB port [7]. The sketch view of the test circuit is shown in Figure 2 along with a real preview of the components shown in Figure 3.

Figure 2. Arduino and DHT11 Scheme [8]
Figure 3. Image of the Arduino UNO circuit and the DHT11 sensor for measuring temperature and humidity with a downloader cable that will be connected to the USB port on a PC or Laptop

2.2. Software Design

The computation in this experiment uses the Arduino IDE (Integrated Development Environment) software which uses the C ++ programming language and is facilitated by the existence of a library in its programming [9]. Arduino IDE software is open source software so it can be downloaded for free. This software is used to create and enter programs into Arduino [10].

The Arduino IDE software interface consists of a Program Editor, Compiler, and Uploader, shown in Figure 4. The design of the software used in this study is based on the Arduino IDE software version 1.8.10 with the algorithm from the Arduino IDE which has a way of working as illustrated in the flow diagram in the figure 5 [11].
Figure 5. Arduino Programming Algorithm

The algorithm design shows that the program that has been created will be uploaded to Arduino through the Arduino IDE software intermediary. The function of the programming algorithm is to give commands to the sensor to read temperature and humidity data around the location by collecting data every second for one minute. The simple program is shown as Figure 6.

Figure 6. DHT11 Sensor Program on the Arduino IDE
2.3. **Instrument System Testing**

DHT11 sensor testing with the Arduino UNO platform is carried out in the same place, at home and close to the window. Consistently with the same time interval from 07.00 to 10.00, data collection was carried out. This is useful for narrowing the field of observation, on the other hand the BMKG website is updated every three hours.

Then, the data collection experiment was carried out periodically at the same hour for two weeks using a DHT11 sensor and an ATmega328 microcontroller based (Arduino UNO). This type of microcontroller is widely used because of its practicality in programming, signal processing capabilities, and reliable computation capabilities [12]. DHT11 is a type of sensor that can read temperature and humidity data at one time. The measurement limit at temperature ranges from 0 °C - 50 °C with tolerance limits + - 2 °C and for humidity ranges from 20% - 95% with a tolerance limit of 5% [13].

Furthermore, the programming algorithm will display the data using the Monitor serial which is directly available on the Arduino IDE software as in Figure 7.

3. **Result**

The instrument system that has been created consists of a DHT11 connected to an Arduino uno connected to a serial monitor on a laptop. The test was carried out in the Kedunggalar area, Ngawi Regency on September 8-21 2020. The experiment was carried out to obtain real time temperature and humidity data using the BMKG website reference on the link [https://www.bmkg.go.id/cuaca/prakiraan-cuaca bmkg?AreaID=5008537&Prov=12&lang=ID](https://www.bmkg.go.id/cuaca/prakiraan-cuaca bmkg?AreaID=5008537&Prov=12&lang=ID) [14].

From the data collection, the data in Table 1 are generated.

| Data collection date | Temperature (°C) | Humidity (%) |
|----------------------|-----------------|--------------|
|                      | 7 am | 10 am | 7 am | 10 am |
| 8 Sep 20             | 25   | 32    | 85   | 50    |
| 9 Sep 20             | 27   | 32    | 75   | 70    |
| 10 Sep 20            | 27   | 30    | 80   | 70    |
| 11 Sep 20            | 27   | 30    | 70   | 55    |
| 12 Sep 20            | 26   | 30    | 75   | 45    |
| 13 Sep 20            | 27   | 32    | 70   | 50    |
| 14 Sep 20            | 27   | 32    | 65   | 55    |
| 15 Sep 20            | 27   | 32    | 60   | 75    |
| 16 Sep 20            | 26   | 30    | 70   | 70    |
| 17 Sep 20            | 27   | 30    | 80   | 65    |
The data in table 1 is taken at 7 and 10 am based on the BMKG website update, where the calculation is done every three hours. From this it is known that the maximum and minimum data are then added up and then divided in half to find the average value as shown in Table 2.

| Date       | Temp 1 | Temp 2 | Temp 3 | Temp 4 | Temp 5 | Temp 6 |
|------------|--------|--------|--------|--------|--------|--------|
| 18 Sep 20  | 28     | 30     | 80     | 45     |        |        |
| 19 Sep 20  | 27     | 31     | 75     | 50     |        |        |
| 20 Sep 20  | 24     | 34     | 70     | 50     |        |        |
| 21 Sep 20  | 28     | 32     | 70     | 55     |        |        |

Table 2. BMKG average temperature and humidity data

| Average Temperature (°C) | Average Humidity (%) |
|--------------------------|----------------------|
| 28,5                     | 67,5                 |
| 29,5                     | 72,5                 |
| 28,5                     | 75                   |
| 28,5                     | 62,5                 |
| 28                       | 60                   |
| 29,5                     | 60                   |
| 29,5                     | 60                   |
| 29,5                     | 67,5                 |
| 28                       | 70                   |
| 28,5                     | 72,5                 |
| 27                       | 62,5                 |
| 29                       | 62,5                 |
| 29                       | 60                   |
| 30                       | 62,5                 |
| 28,79                    | 65,36                |

Data obtained from the experiment as many as 60 pieces for one minute and will be averaged using the Ms. program Excel. So that the average value will be generated as in table 3.

| Average Temperature (°C) | Average Humidity (%) |
|--------------------------|----------------------|
| 26,3                     | 78                   |
| 27,7                     | 72,3                 |
| 31,6                     | 65                   |
| 31,5                     | 62                   |
| 29,1                     | 63,8                 |
| 29,1                     | 67,4                 |
| 27,9                     | 66,1                 |
| 31                       | 59,7                 |
| 27,2                     | 67,3                 |
| 27                       | 76,5                 |
| 29,4                     | 69                   |
| 29,9                     | 70,7                 |
| 28,9                     | 72,1                 |
| 31,9                     | 64,4                 |
| 29,18                    | 68,16                |
3.1. Data Processing

Data processing is done by comparing the measurement results of the DHT11 sensor with the data on the BMKG website. The data comparison aims to determine the difference between the two values, which means that the final average value will produce a conclusion.

| Table 4. Difference in BMKG website data on DHT11 sensor measurements |
|---|---|---|---|---|---|
| Temperature (ºC) | BMKG | DHT11 | Error | Humidity (%) | BMKG | DHT11 | Error |
| 28,5 | 26,3 | 2,2 | 67,5 | 78 | 2,2 |
| 29,5 | 27,7 | 1,8 | 72,5 | 72,3 | 0,2 |
| 28,5 | 31,6 | 3,1 | 75 | 65 | 10 |
| 28,5 | 31,5 | 3 | 62,5 | 62 | 0,5 |
| 28 | 29,1 | 1,1 | 60 | 63,8 | 3,8 |
| 29,5 | 29,1 | 0,4 | 60 | 67,4 | 7,4 |
| 29,5 | 27,9 | 1,6 | 60 | 66,1 | 6,1 |
| 29,5 | 31 | 1,5 | 67,5 | 59,7 | 7,8 |
| 28 | 27,2 | 0,8 | 70 | 67,3 | 2,7 |
| 28,5 | 27 | 1,5 | 72,5 | 76,5 | 4 |
| 27 | 29,4 | 2,4 | 62,5 | 69 | 6,5 |
| 29 | 29,9 | 0,9 | 62,5 | 70,7 | 8,2 |
| 29 | 28,9 | 0,1 | 60 | 72,1 | 12,1 |
| 30 | 31,9 | 1,9 | 62,5 | 64,4 | 1,9 |
| 28,79 | 29,18 | 1,59 | 65,36 | 68,16 | 5,24 |

The experimental data using DHT11 in the Kedunggalar shows a constant value with the error rate still at the sensor accuracy limit as shown in the following data in Table 5.

| Table 5. DHT11 Sensor Air Temperature Reading Error Value |
|---|---|---|---|
| Temperature (ºC) | BMKG | DHT11 | Error |
| 28,79 | 29,18 | 1,59 |

| Humidity (%) |
|---|---|---|---|
| BMKG | DHT11 | Error |
| 65,36 | 68,16 | 5,24 |

The reading of the DHT11 sensor for temperature has an error value of 1.5 C, the maximum error limit for the sensor is 2 C. While the sensor reading for humidity has an error value of 5.24%, in this case it exceeds the maximum sensor limit which is only 5%. This can be due to environmental factors that cause the DHT11 sensor error in reading the humidity to be imprecise. This can also be due to environmental factors themselves.

On the other hand, the flow of mountain winds which may have an influence on data collection, wind also affects climate change which also affects evaporation in plants [15]. So that the evaporation will affect the humidity of the surrounding air [16]. The location of the Kedunggalar area which is close to the foot of Mount Lawu is one of the causes. Such as the observation that Bruce found in 2015 in analyzing Synop and Metar stations that one of the causes of changes in humidity percentage is the wind factor [17].
Figure 8. Effect of wind speed on humidity

On the other hand, it was also found that the error will get bigger in proportion to the increasing percentage of humidity, as shown in Figure 9.

Figure 9. Increase in Error percent

Figure 9 explains that the percent error generated is due to changes in the data obtained. The increasing humidity value also results in a significant increase in error, especially at humidity values approaching 100%.

4. Conclusion
DHT11 sensor reading in the singular area shows the level of measurement stability. It is proven by the constant temperature and humidity measurement data and has a value that is very close to the data available on the BMKG website, it can be seen in table 3 and table 4. The comparison of the two data shows similar values, and it can be concluded that the two data either came from BMKG or readings of sensors directly, can be ascertained accurate. Furthermore, the error value in reading the temperature data has a limit below the DHT11 specification, while the humidity reading has an error value outside the DHT11 specification limit. These mistakes.

References
[1] Djoko S 2009 Buku Panduan Kerentanan dan Dampak Perubahan Iklim untuk Pemerintah Daerah (Jakarta: Kementrian Negara Lingkungan Hidup Indonesia).
[2] Tjasyono B 2004 *Klimatologi* (Bandung: Penerbit ITB).
[3] Taufik M, Surawa, Hasan A, and Amelia K 2013 *J. Agroteknos* 3 95.
[4] Ance 1986 *Klimatologi Pengaruh Iklim Terhadap Tanah dan Tanaman* (Jakarta: Bina Aksara).
[5] Neiburger 1995 *Memahami Lingkungan Sekitar Kita* (Bandung: Penerbit ITB).
[6] BMKG 2006 *Peraturan Kepala Badan Meteorologi dan Geofisika No. SK. 32/TL.202/KB/BMG-2006 tentang Tata Cara Tetap Pelaksanaan Pengamatan dan Pelaporan Data Iklim dan Agroklimat* (Jakarta: BMKG).
[7] Effendi D A 2014 *S E T R U M* 3 48.
[8] Cronyos 2017 Giri W P [https://www.cronyos.com/cara-mengukur-suhu-dan-kelembapan-menggunakan-arduino-dan-sensor-dht-11/](https://www.cronyos.com/cara-mengukur-suhu-dan-kelembapan-menggunakan-arduino-dan-sensor-dht-11/) link accessed November 25, 2020
[9] Jauhari A, Leni N Z and Hermawansyah 2016 *J. Media Infotama* 12 91.
[10] Dian A 2012 *Interaksi Arduino dan LABview* (Jakarta: Elex Media Komputindo)
[11] Arief H S 2014 *J. Infotel* 6 51.
[12] Zakzouk N E, Elsaharty M A, Abdelsalam A K, Helal A A, and Williams BW 2016 *IET Renew. Power Gener.* 10 567.
[13] Dwi T R, Didik E S, Pringgo D L, and Anif J 2016 8th Int. Conf. Phys. Appl. (ICOPIA) 776 012096.
[14] Prakiraan Cuaca 2020 BMKG [https://www.bmkg.go.id/cuaca/prakiraan-cuaca.bmkg?AreaID=5008537&Prov=12&lang=ID](https://www.bmkg.go.id/cuaca/prakiraan-cuaca.bmkg?AreaID=5008537&Prov=12&lang=ID) link accessed September 8, 2020
[15] Rahmi F, Yohanes S G, Erva F, and Syahrun M 2018 *J. Agroteknol. Ilmu Pertan.* 2 134.
[16] Bengtsson L 1994 *Agric. Meteorol.* 73 16.
[17] Bruce I 2015 *Q. J. R. Meteorol. Soc.* 141 507.