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A PORTABLE EASY TO USE PRESSURE, TEMPERATURE AND HUMIDITY REAL- TIME SENSING SYSTEM

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ABSTRACT

This study focuses on the creation of a real-time environmental monitoring system that measures pressure, temperature, and humidity, critical parameters in the context of climate change. Utilizing a Raspberry Pi 4 and a BME280 sensor, the system collects data every two seconds and displays it graphically. The implementation employs Python code on the Raspbian platform. The collected data is transmitted to the cloud via Corlysis, making it accessible online through devices like personal computers or smartphones. Local data visualization is achieved using Matplotlib, while online visualization is facilitated by Grafana. The data is stored in the Corlysis database, ensuring easy access and integration into the Internet of Things (IoT) ecosystem. This system is particularly valuable for both calibration purposes and research, providing high-frequency, real-time data both locally and remotely.

1. INTRODUCTION

Physics has provided a basic foundation for technological evolution and progressive advances in the physical sciences, specifically in areas such as sensor systems, remote control devices, electronic circuits (integrated circuits/microcontrollers/microprocessors), and many other devices, making a considerable impact on the development and advancement of technology [1]. Due to the increasing advances in modern technology, smart systems are increasingly being employed in obtaining measured readings or data. These systems allow a range of professionals in various fields including scientists, technicians, administrators, and managers, to monitor and control the performance of data and various measurements from remote locations. These monitoring systems are very important in the case of field-work, where the data or measurement maybe required for analysis, sometimes on a continuous scale; some users and companies use smart monitoring systems with proprietary software programs [2,3].

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These programs are installed on the user's computers, smart phones or other smart devices to allow operators or employers to be able to access the data, measurements or readings, and be able to carry out required analysis, decisions or research as the case may be. The introduction and growth of open-source electronics group has assigned scientists and technologists, fresh tools in developing technologies intended for lab as well as field research [4]; these include automated data loggers [5]. The innovations have created important advances in doing research work as well as monitoring [6].
Some previous works on Raspberry Pi's where temperature, pressure (altitude) as well as humidity sensors were used: [7] in the study titled **"**IoT Based Weather Monitoring System for Effective Analytics", used a Raspberry Pi 2 connected to sensors; including DHT 11, SDS 011, the software used for implementation are python code, python 3 and HTML, CSS JavaScript, aimed at collecting weather parameters in a geographical location in order to study the effect of smog and PM 2.5 concentration in the place**.** Weather parameters like temperature, humidity, PM 2.5 and PM 10 concentrations and Air Quality Index (AQI) were monitored and visualized in graphical means using the Raspberry Pi as server and the data collected can be accessed over the intranet or internet in a specified subnet or world wide web. [8], in India did a study work titled "Cloud Based Weather Monitoring System", made-up of a compact circuitry built around Raspberry Pi (ARM11) microcontroller, for software; Programs are developed in Embedded C. sensors connected to the Raspberry Pi Board are DHT 22 Humidity & Temperature Sensor, Wind Speed Sensor, Wind direction Sensor. The data collected by the system can be logged into cloud so that any one (authenticated person) from any place can observe the specific data. In case of any disasters like fire, heavy rain, heavy wind, temperature or humidity, instant information can be conveyed around the world using cloud by authenticated persons, even if his hardware is destroyed in emergency. They collected the data and stored it in a file as a local database, the data can also be logged into cloud through data.sparkfun.com, and the basic aim of this study was to develop an embedded weather monitoring system that monitors some weather parameters. [9] Designed a data collecting system using Raspberry Pi 3 Model B, connected to a DHT11 temperature and humidity sensor, FC-37 sensor for rain fall. The MQ135 sensor detects the presence of hazardous gasses. The aim of the work was IoT application for environmental monitoring and control. [10] Used the Raspberry pi 3 as Gateway between sensor nodes and the cloud, python software was used for programming the Raspberry pi, Sensors used are DHT 22, BMP 280 and wind ananometer sensors, the data was transmitted via Master (Gateway) onto the cloud and displayed as webpage using HTTP. The purpose of the research is to help local farmers in India as indicators which can be used to assist them to decide on which crop (cotton, jowar or redgram) to be cultivated or reaped. [11] Designed a data collection system, using Raspberry Pi 3 model B connected to an Arduino Uno R3 with SparkFun weather Shield sensor and weather meter for Weather Shield and prediction, the aim of the work is for an authenticated user to be able to receive notifications regarding the weather condition at a particular place.

2. MATERIALS AND METHODOLOGY

The study is divided into two sections which are: the task done locally and that done in the cloud. In the instrument location/site section; the system is developed using a powerful development platform Raspberry Pi 4 board shown in PLATE 1, since the board is helpful in minimizing the system hardware, and BME 280 sensor shown in Plate 2. The basic flow-chart of the methodology and approach for the study is shown in Figure 1, the component parts were connected to their respective sections for the system. After which the Raspberry Pi 4 was configured and programmed using python on the raspbian OS with the raspbian Integrated Development Environment (IDE); to actuate and read pressure, temperature and humidity data from the BME 280 sensor and graph the data using "matplotlib".

(i) COMPONENT HARDWARE FOR THE SYSTEM

Circuit schematics and hardware connection for the system is shown in figure 2, the component Hardware used for the system was assembled connected and the system was powered up as shown in Plate 3. In programming the system, all the relevant libraries were installed in order to programme the system; the CircuitPython BME280 Library was installed, followed by the Adafruit BME280 CircuitPython library. After the programming for the sensor readings and offline graphing were done, then the code for linking the Raspberry Pi 4 and BME 280 system to Corlysis (online). For the cloud section or online, an account was registered with "Corlysis" the IOT provider, for data collection in a data base, and graphing of the sensed data from the BME 280 sensor in the cloud using Grafana..

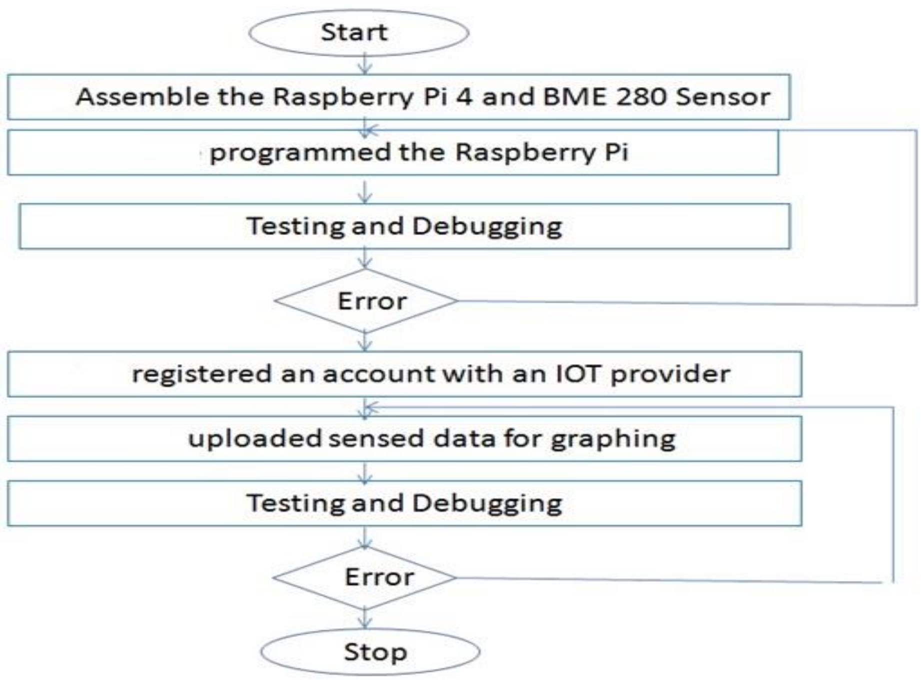


FIGURE 1: basic flow-chart of the methodology and approach for the study.

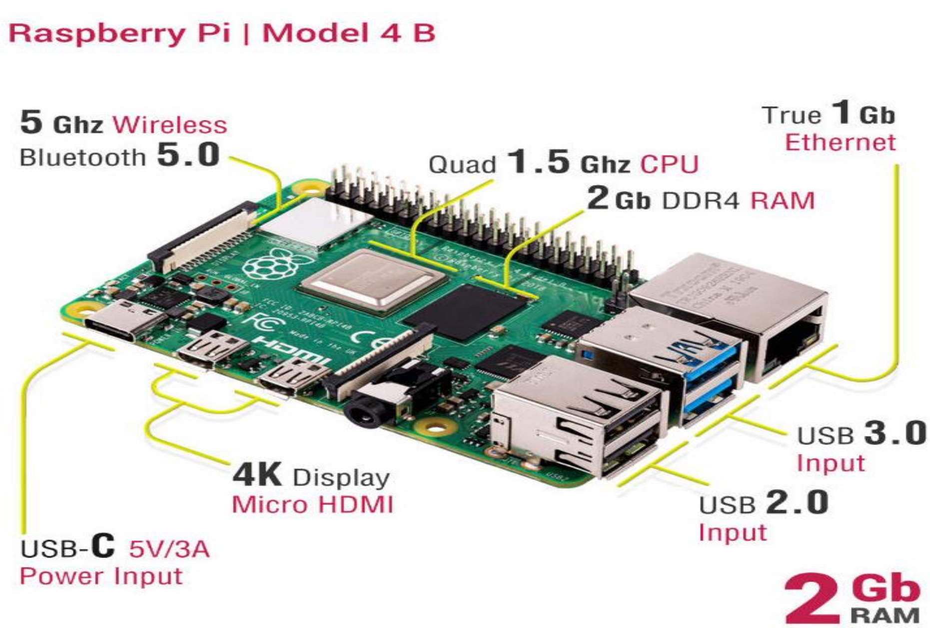


PLATE 1: Raspberry Pi 4 showing the labels of some of its parts

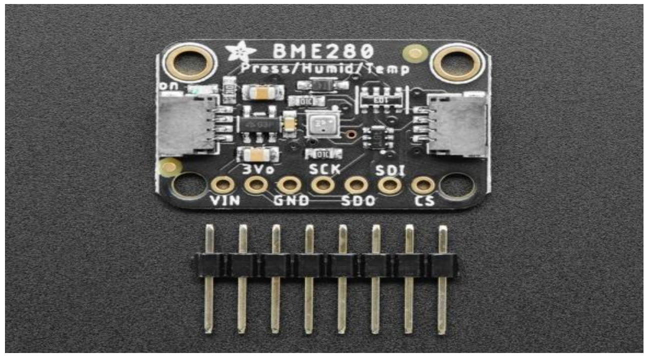


PLATE 2: BME 280 sensor showing positions of connection pins

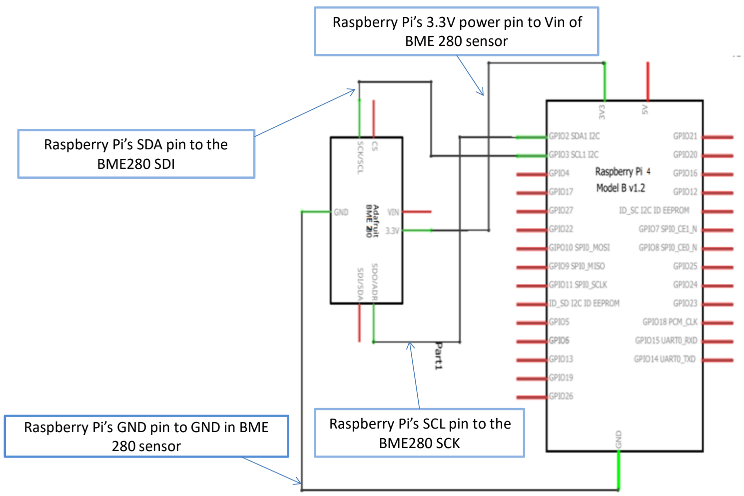


FIGURE 2: Circuit Schematics for the Raspberry Pi 4 and BME 280 system

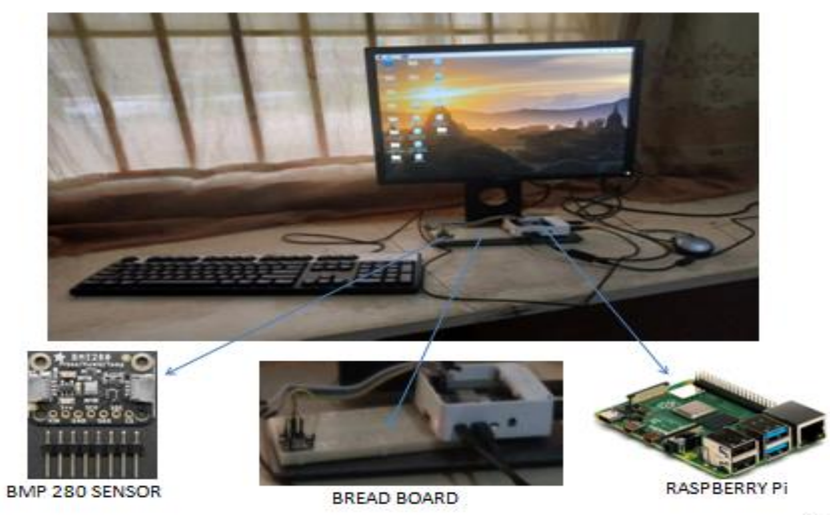


PLATE 3: The Raspberry Pi 4 and BME 280 sensor system

(ii) PROGRAMMING CODE

The sample of the programming code for the system is given bellow:

```
port = 1

address = 0x77

bus = smbus2.SMBus(port)

bme280.load_calibration_params(bus, address)

data = bme280.sample(bus, address)

# SPDX-License-Identifier: MIT
import time
import board
import adafruit_bme280
# Create sensor object, using the board's default I2C bus.
i2c = board.I2C()  # uses board.SCL and board.SDA
bme280 = adafruit_bme280.Adafruit_BME280_I2C(i2c)
# OR create sensor object, using the board's default SPI bus.
# spi = board.SPI()
# bme_cs = digitalio.DigitalInOut(board.D10)
# bme280 = adafruit_bme280.Adafruit_BME280_SPI(spi, bme_cs)
# change this to match the location's pressure (hPa) at sea level
bme280.sea_level_pressure = 1013.25
while True:
print("\nTemperature: %0.1f C" % bme280.temperature)
print("Humidity: %0.1f %%" % bme280.relative_humidity)
 print("Pressure: %0.1f hPa" % bme280.pressure)
 time.sleep(2)
```

3. EXPERIMENTAL RESULTS

The offline data for pressure, temperature and humidity senescent by the BME 280 sensor of the system are displayed every second when running the program on the Raspbian OS, the sample of sensed data output is as shown in PLATE 4, The graph for the temperature and pressure against time is shown in PLATE 5. The graph for humidity and temperature against time in shown in PLATE 6, When the command to sense temperature data online is initiated by running it on “thony python”, the data is sensed every two seconds and stored on the data base in Corlysis with a time stamp on each data sent online, this data can be updated whenever the page is refreshed, PLATE 7, show the sample of data stored in the data base on Corlysis. In order to view the graph, we click on Grafana where a dash board has been created for the graph for real time, with temperature set to refresh its values every five seconds as it plots for real time values of the temperature data. PLATE 8, show the temperature for real time temperature graph. When the command to sense pressure data online is initiated by running it on “thony python”, the data is received on the Corlysis data base, but this time the real time graph plotted will be that of pressure as shown in PLATE 9. The Online graph from Grafana for real time temperature variation from 9.15 am to 11.15 am from Grafana, on 20/07/2021, is given in PLATE 10. The Online graph of on Grafana for real time temperature variation on from 9.25 am to 12.08 pm, on 01/08/2021, is given in PLATE 11. Plate 12, shows an online temperature online graph on Grafana, obtained from 7:33am to 6:08pm on the 22nd of August, 2021, the sky was cloudy from 4pm and there was rain till about 5pm this affected the temperature variation drastically as can be seen on the temperature variation for that day.

PLATE 12 shows that the temperature peaked at about 4.15 pm, this Temperature was taken indoors and it peaked at about some minutes after 4.00 pm, The graph shown on Figure 3 is a five minute average Temperature Data from the National Center for Energy and Excellence (NCEE) in the University of Benin, Benin City, and Edo State, Nigeria, and the temperature was taken outdoors, the temperature tends to pick at about 3.00pm showing a difference in temperature peak between indoor and outdoor values. This difference in peak temperature can be attributed the type of materials for constructing the building. The table in Figure 3, shows minute by minute fluctuation of temperature with daily variation for three different days.

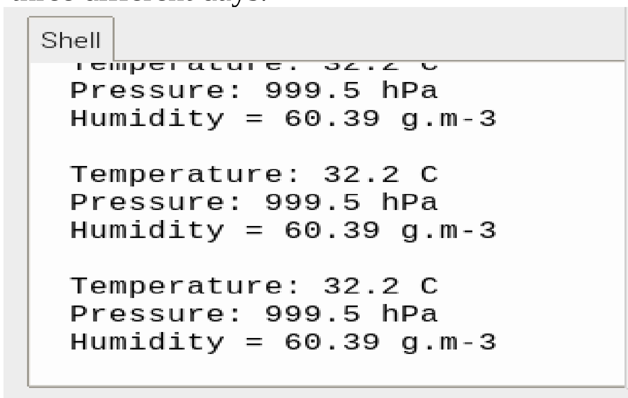


PLATE 4: The sensed data from the BME 280 sensor

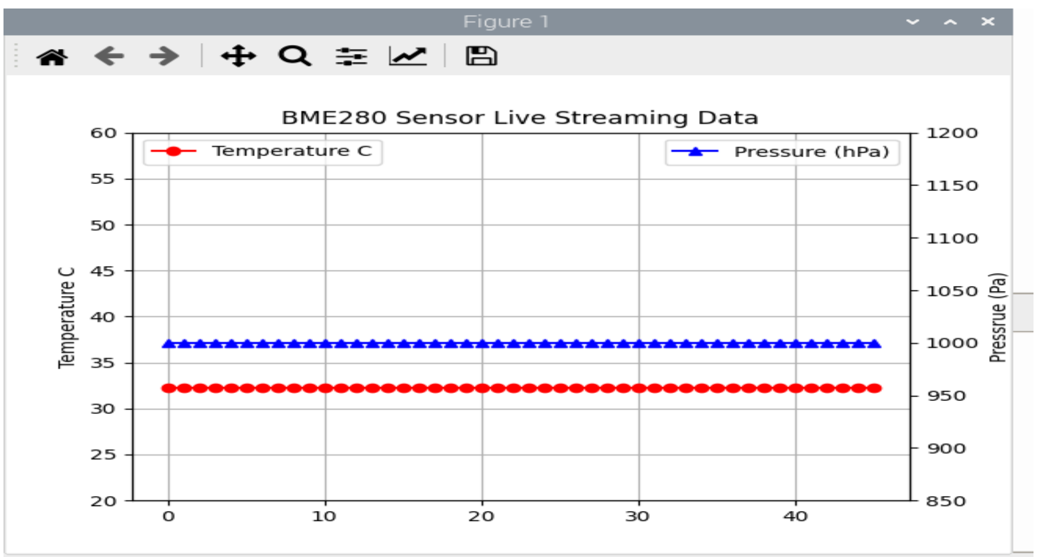


PLATE 5: Graph of temperature and pressure against time from matplotlib

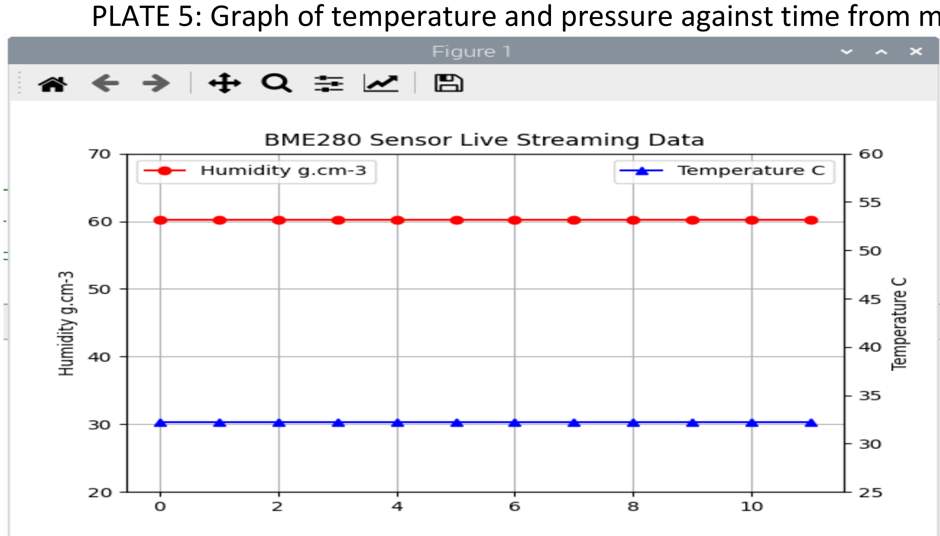
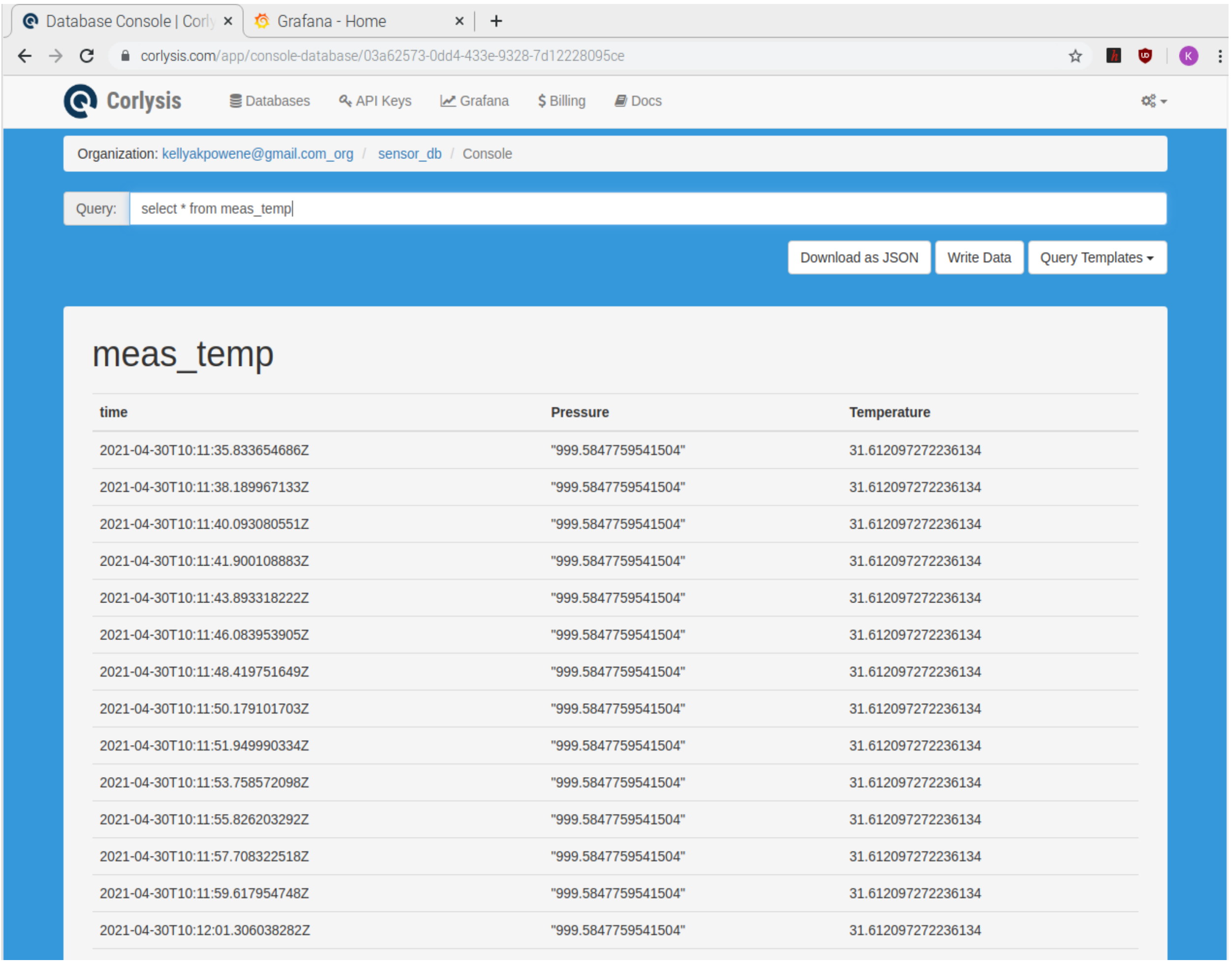


PLATE 6: Graph of humidity and temperature against time from matplotlib



time	Pressure	Temperature
2021-04-30T10:11:35.833654686Z	"999.5847759541504"	31.612097272236134
2021-04-30T10:11:38.189967133Z	"999.5847759541504"	31.612097272236134
2021-04-30T10:11:40.093080551Z	"999.5847759541504"	31.612097272236134
2021-04-30T10:11:41.900108883Z	"999.5847759541504"	31.612097272236134
2021-04-30T10:11:43.893318222Z	"999.5847759541504"	31.612097272236134
2021-04-30T10:11:46.083953905Z	"999.5847759541504"	31.612097272236134
2021-04-30T10:11:48.419751649Z	"999.5847759541504"	31.612097272236134
2021-04-30T10:11:50.179101703Z	"999.5847759541504"	31.612097272236134
2021-04-30T10:11:51.949990334Z	"999.5847759541504"	31.612097272236134
2021-04-30T10:11:53.758572098Z	"999.5847759541504"	31.612097272236134
2021-04-30T10:11:55.826203292Z	"999.5847759541504"	31.612097272236134
2021-04-30T10:11:57.708322518Z	"999.5847759541504"	31.612097272236134
2021-04-30T10:11:59.617954748Z	"999.5847759541504"	31.612097272236134
2021-04-30T10:12:01.306038282Z	"999.5847759541504"	31.612097272236134

PLATE 7: Data for Pressure and temperature stored in data base online in Corlysis

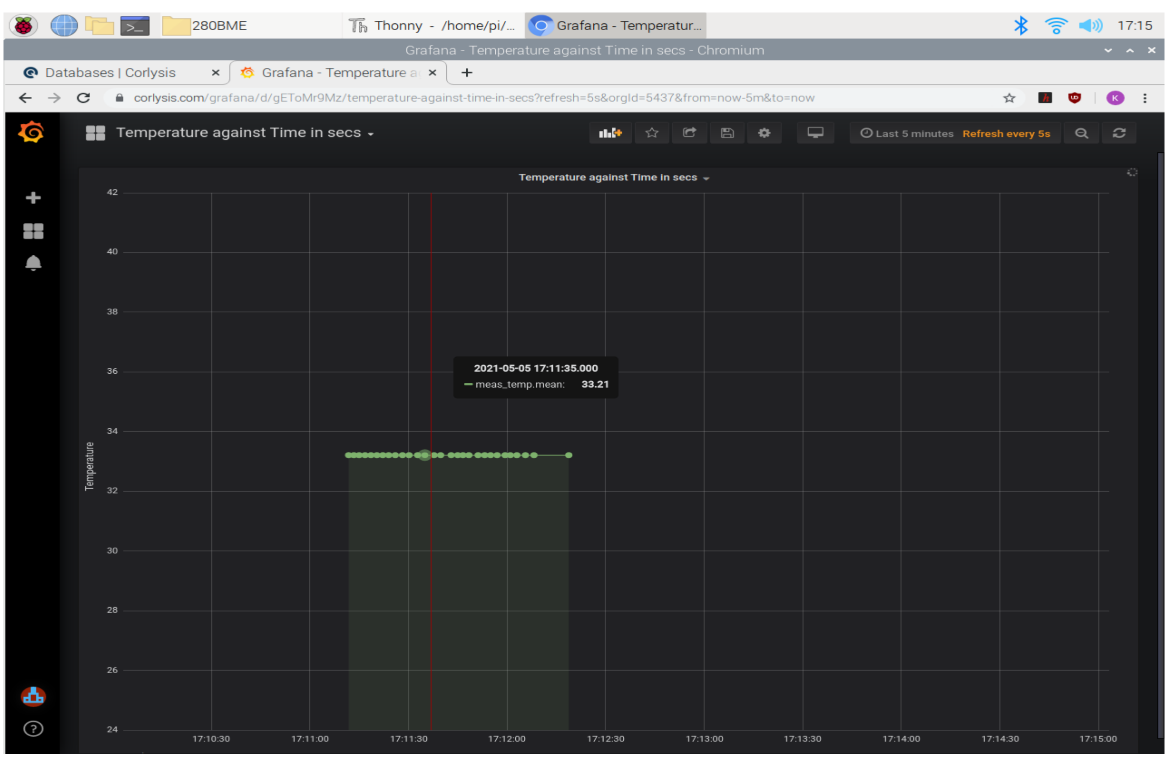


PLATE 8: Real time graph for temperature on Grafana

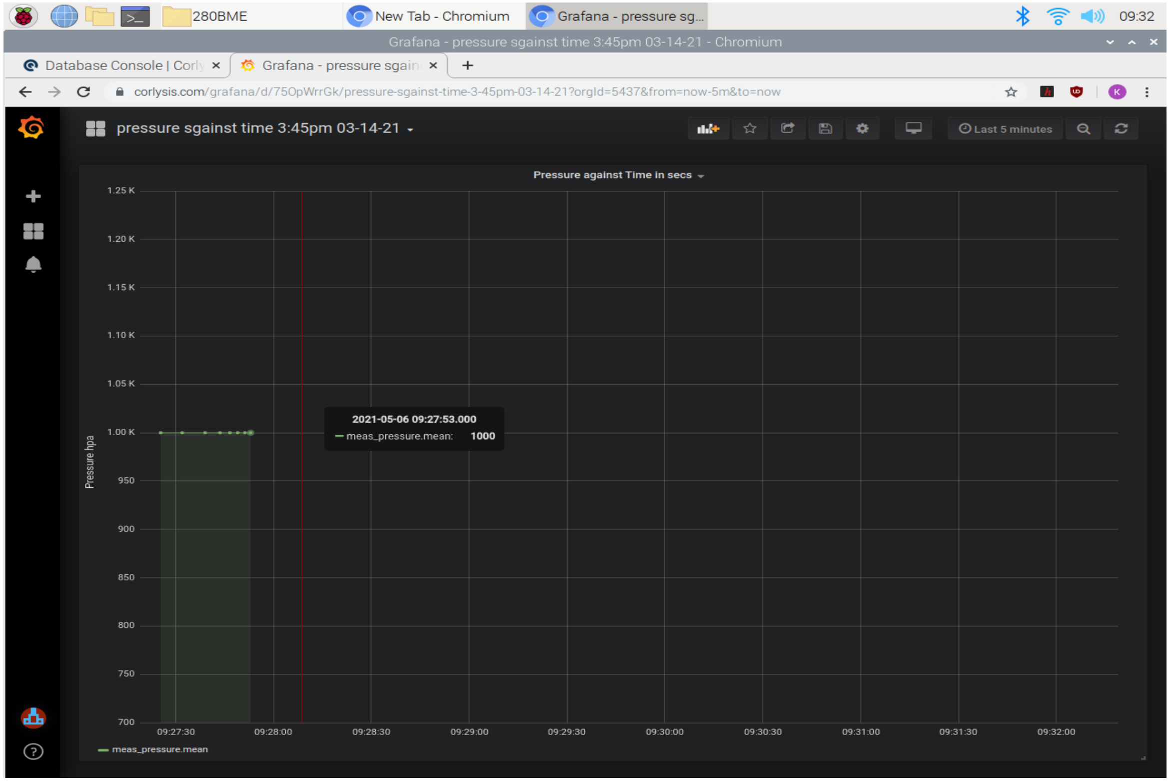


PLATE 9: Graph for real time pressure as sensed by the BME 280 sensor on Grafana

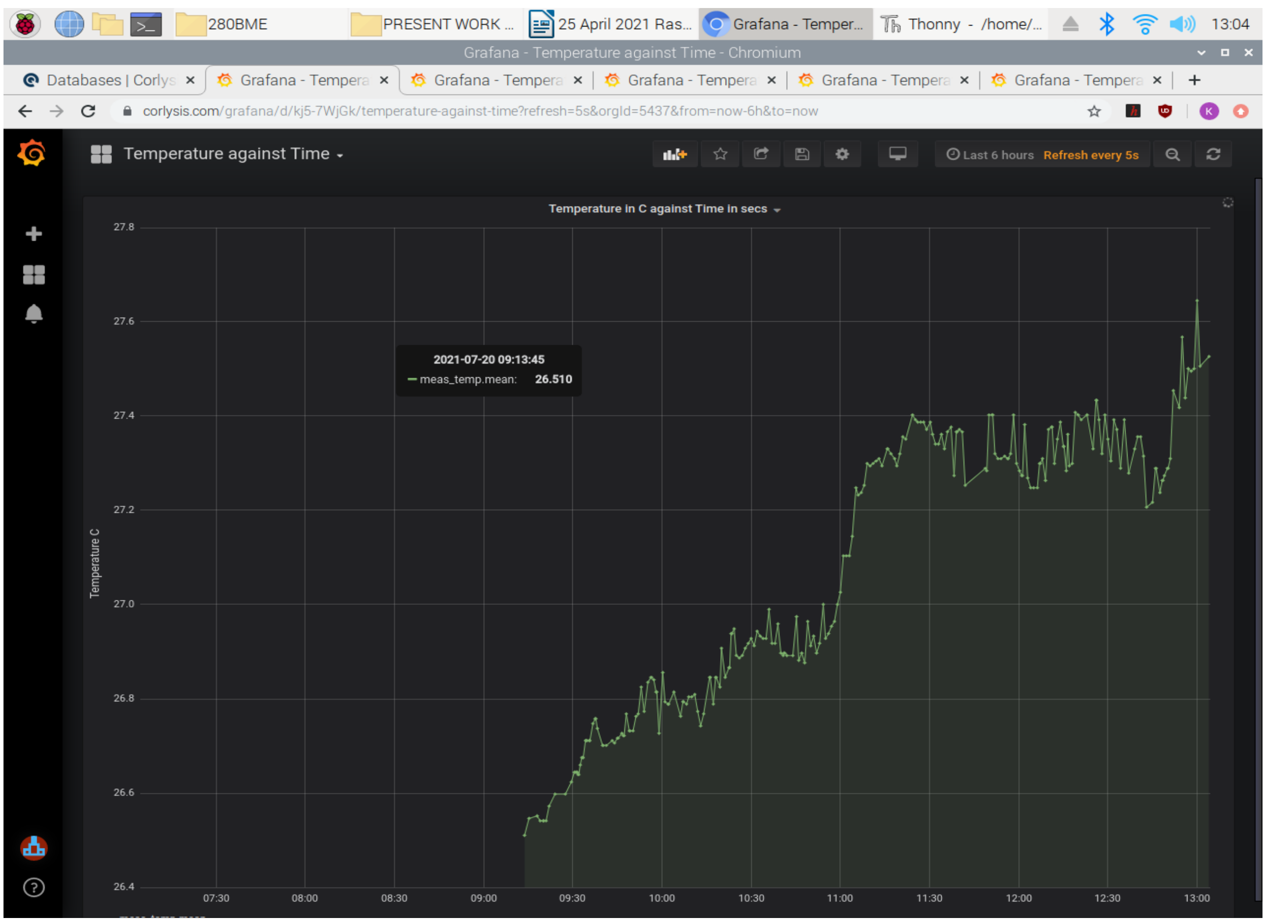


PLATE 10: Online graph from Grafana for real time temperature variation from 9.15 am to 11.15 am from Grafana, on 20/07/2021.

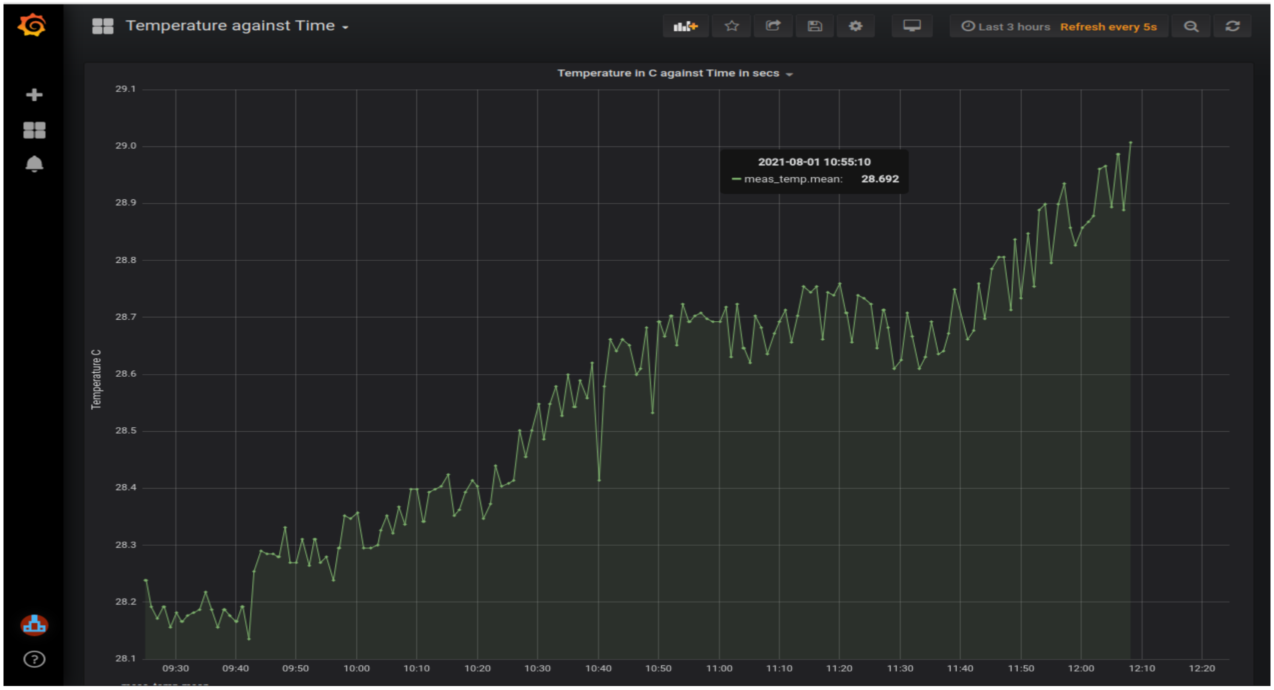


PLATE 11: Online graph of on Grafana for real time temperature variation on from 9.25 am to 12.08 pm, on 01/08/2021,

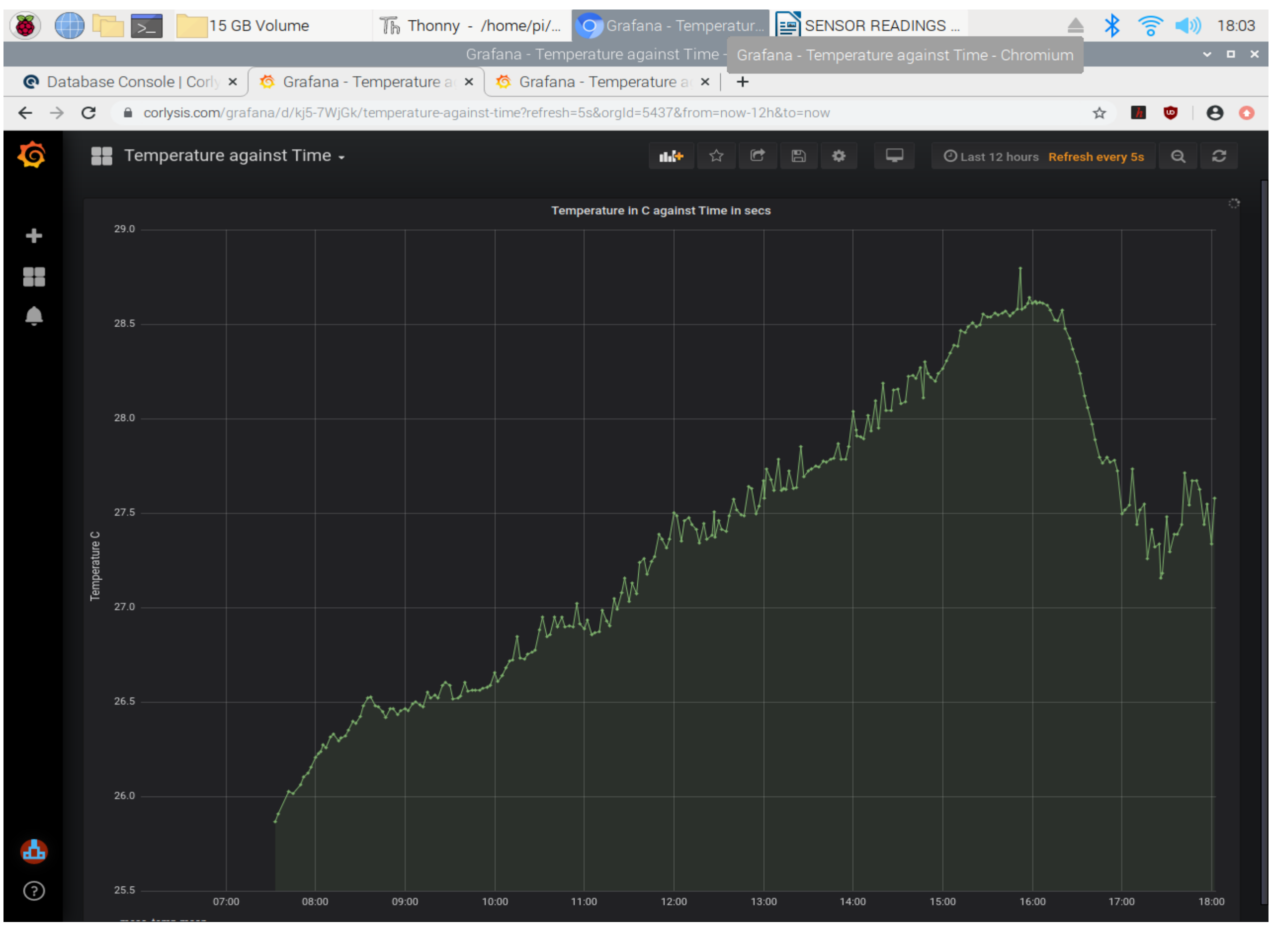


PLATE 12: Online real time temperature graph on Grafana from 7:33am to 6:08pm on the 22nd of August, 2021.

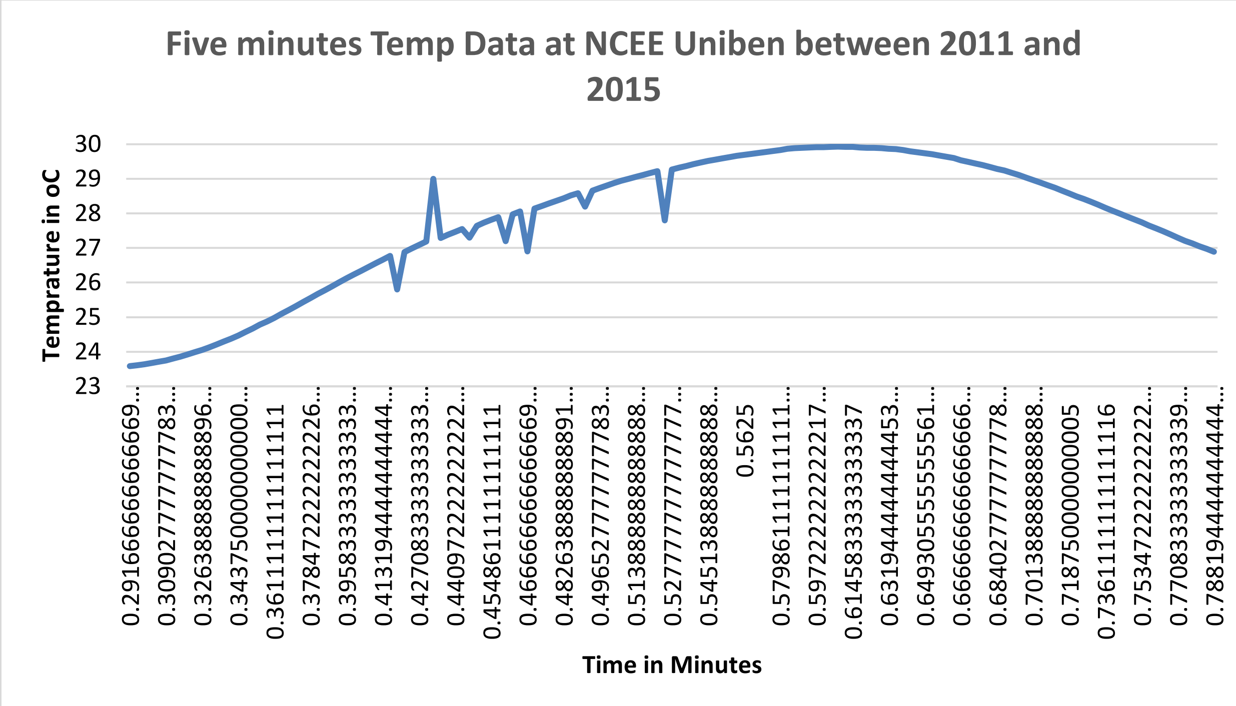


Figure 3: Graph showing Five minutes, average Temperature Data at NCEE UNIBEN between 2011 and 2015.

Time Interval am	20/07/2021 Average Temp. recorded	Average Difference in Temp.	01/08/2021 Average Temp. recorded	Average Difference in Temp.	19/08/2021 Average Temp. recorded	Average Difference in Temp.
8.30 – 8.35	26.644 – 26.711	0.067	28.182 – 28.218	0.036	26.426 – 26.515	0.089
8.35 – 8.40	26.711 – 26.701	-0.010	28.218 – 28.166	-0.052	26.515 – 26.428	-0.087
840 – 8.45	26.701 – 26.717	0.016	28.166 – 28.285	0.119	26.428 – 26.471	0.043
8.45 – 8.50	26.717 – 26.732	0.015	28.285 – 28.269	-0.301	26.471 – 26.432	-0.039
8.50 – 8.55	26.732 – 26.835	0,118	28.269 – 28.280	0.011	26.432 – 26.464	0.032
8.55 – 9.00	26.835 – 26.856	0.021	28.280 – 28.357	0.077	26.464 – 26.485	0.021
9.00 – 9.05	26.856 – 26.815	=0.041	28.357 – 28.352	-0.005	26.485 – 26.501	0.016
9.05 – 9.10	26.815 – 26.804	-0.011	28.352 – 28.398	0.046	26.501 – 26.494	-0.007
9.10 – 9.15	26.804 – 26.846	0.042	28.398 – 28.424	0.026	26.494 – 26.451	-0.043
9.15 – 9.20	26.846 – 26.908	0.062	28.424 – 28.403	-0.021	26.451 – 26.512	0.061
9.20 – 9.25	26.908 – 26.892	-0.016	28.403 – 28.409	0.006	26.512 – 26.518	0.006
9.25 – 9.30	26.892 --26.908	0.016	28.409-28.548	0.139	26.518 – 26.502	-0.016
9.30 – 9.35	26.908– 26.928	0.020	28.548 – 28.599	0.051	26.502 – 26.514	0.012
9.35 – 9.40	26.928 – 26.897	-0.031	28.599 – 28.414	-0.185	26.514 – 26.518	0.004
9.40 – 9.45	26.897 – 26.975	0.078	28.414 – 28.651	0.237	26.518 – 26.523	0.005
9.45 – 9.50	26.975 – 26.913	-0.062	28.651 – 28.692	0.041	26.523 – 26.510	-0.013
9.50 – 9.55	26.913 – 26.928	0.015	28.692 – 28.703	0.011	26.451 – 26.512	0.061
9.55 – 10.00	26.928 – 27.026	0.098	28.703 – 28.692	-0.011	26.510 – 26.521	0.011
10.00 – 10.05	27.026 – 27.248	0.222	28.692 – 28.620	-0.072	26.521 – 26.532	0.011
10.05 – 10.10	27.248 – 27.294	0.046	28.620 – 28.692	0.072	26.532 – 26.539	0.007
10.10 – 10.15	27.294 – 27.330	0.036	28.692 – 28.744	0.052	26.539 – 26.541	0.002
10.15 – 10.20	27.330 – 27.320	-0.010	28.744 – 28.759	0.015	26.541 – 26.579	0.038
10.20 – 10.25	27.320 – 27.392	0.072	28.759 – 28.723	-0.029	26.579 – 26.582	0.003

10.25 – 10.30	27.392 – 27.387	-0.005	28.723 – 28.625	-0.098	26.582 – 26.578	-0.004
10.30 – 10.35	27.387 – 27.330	-0.057	28.625 – 28.692	0.067	26.578 – 26.581	0.003
10.35 – 10.40	27.330 – 27.372	0.042	28.692 – 28.661	-0.031	26.581 – 26.725	0.114
10.40 – 10.45	27.372 – 27.389	0.017	28.661 – 28.785	0.124	26.725 – 26.831	0.106
10.45 – 10.50	27.389 – 27.403	0.014	28.785 – 28.734	-0.050	26.831 – 27.016	0.185
10.50 – 10.55	27.403 – 27.315	-0.088	28.734 – 28.796	0.042	27.016 – 26.843	-0. 173
10.55 – 11.00	27.315 – 27.284	-0.031	28.796 – 28.857	0.061	26.843 – 26.921	0.078
11.00 – 11.05	27.284 – 27.248	0.0336	28.857 – 28.894	0.037	26.921 – 26.843	-0.078
11.05 – 11.10	27.248 – 27.372	0.088	28.894 – 28.207	0,046	26.843 – 26.852	0.011
11.10 – 11.15	27.372 – 27.403	0.031	28.207 – 28.253	0.046	26.852 – 26.947	0.095
11.15 – 11.20	27.403 – 27.404	0.001	28.253 – 28.332	0.079	26.947 – 26.852	-0.087

Figure 3: Table showing minute by minute fluctuation of temperature with daily variation for three different days.

CONCLUSION

There is a need for measuring systems that can sense necessary data at quick intervals, transmit them to an available cost effective data base being, in the developing nations especially Nigeria. A combination of the Raspberry Pi 4 with the BME 280 sensor Real-time Data Collection System is a potable and easy to use system which gives a better improvement on the sensing of pressure, temperature and humidity weather parameters at a high frequency, for storage and analysis, it is a progressive way of collecting required atmospheric data and effective data base, due to the improvements on the Raspberry Pi 4B. The Raspberry Pi 4 B (a measure improvement) is the most recent version released in 2019 and modified in 2020; it is advisable for use considering the 8 GB memory. A Raspberry Pi does not include peripherals such as keyboards and mice but it now has a case, and some other accessories have been included in several official and unofficial bundles, after the second board type was released, the Raspberry Pi Foundation set up a new entity they named Raspberry Pi Trading, and installed Eben Upton as CEO, with the duty of developing technology. Wireless sensor networks can be introduced to this system for spatial analysis using Ethernet connection. For further improvement, researchers can add some features like machine learning since we have very large amount of data, as being done in advanced countries.

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APPENDIX

SAMPLE OF REAL TIME SENSOR READINGS on CORLYSIS DATA BASE ON 20-07-2021

meas_temp

Time	Pressure	Temperature	Humidity
2021-07-20T08:13:48.452012899Z	1004.851	26.510	86.58
2021-07-20T08:15:20.058495996Z	1004.937	26.546	86.66
2021-07-20T08:18:12.402835996Z	1004.945	26.552	87.03
2021-07-20T08:19:11.351479715Z	1004.847	26.541	86.82
2021-07-20T08:20:12.859816451Z	1004.955	26.541	87.05
2021-07-20T08:21:11.227684637Z	1004.902	26.541	86.83
2021-07-20T08:22:08.924125883Z	1004.925	26.572	86.79
2021-07-20T08:24:07.888682784Z	1004.993	26.598	86.99
2021-07-20T08:27:33.84726976Z	1004.940	26.598	86.80