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Investigating the Fluctuation of Atmospheric Temperature, Humidity, and CO_2 Levels Trends in a Daily Cycle

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Abstract

This research aimed to investigate the daily oscillations of pivotal atmospheric parameters—temperature, humidity, and carbon dioxide (CO_2) levels. The investigation is significant in comprehending Earth's climate dynamics and their repercussions on environmental processes. This study amalgamated primary data from an experiment with secondary research from diverse sources, employing statistical and analytical techniques to dissect these patterns. The findings revealed the intricate interplay of natural and anthropogenic influences on diurnal atmospheric variations, underscoring the imperative of sustained vigilance and research in this domain. Potential applications of these findings include improvements in weather forecasting, climate modeling, and environmental policy formulation.

Keywords: Identity, Gender, Socioeconomic class, Education, Politics

1. Introduction

The Earth's atmosphere is in a perpetual state of flux, undergoing continuous alterations in its composition and attributes (Boudreau et al., 2023; National Centre for Atmospheric Science; Tso, 2021). Temperature, humidity, and CO_2 levels stand as central parameters shaping global climate and weather patterns. Unraveling the diurnal variations of these parameters yields profound insights into the underlying mechanisms governing Earth's environment.

This research paper embarks on a comprehensive exploration of diurnal temperature, humidity, and CO_2 level trends, unraveling the drivers behind these oscillations and their potential implications. To achieve this, data from an array of sources were harnessed and bolstered by statistical and analytical methodologies to dissect these patterns.

2. Materials and Methods

2.1 Data collection

Data for this study were procured via an experiment employing the ESP32 Microprocessor, SCD30 CO_2 Sensor, and SHT40 Temperature and Humidity Sensor. Situated in an open-air location in a garden on the 18th floor of an apartment complex in Cau Giay, Hanoi, Vietnam, untainted by artificial interference, these sensors were operative for 24 hours. This location was chosen due to its representativeness of typical urban atmospheric conditions, paired with various biological organisms simulating natural photosynthesis and respiration cycles. Data acquisition and presentation were facilitated through the Adafruit IO platform via Wi-Fi connectivity.

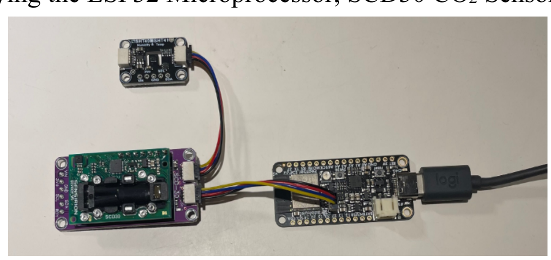

Figure 1. ESP32, SCD30, and SHT40 setup

Figure 2. Microcontroller and sensors in a protective box

Figure 3. Data collection environment

2.2 Data analysis

The collected data underwent meticulous analysis intended to delineate daily cycles and trends in atmospheric temperature, humidity, and CO_2 levels. Statistics from the Adafruit IO platform were plotted on graphs to visualize the trends in atmospheric temperature, humidity, and CO_2 levels over the 24-hour period. The graphs were manually examined to identify patterns and fluctuations. Trend lines were drawn visually to highlight the general direction of changes over time. This approach allowed for an intuitive understanding of the diurnal cycles and the relationships between the different atmospheric parameters.

3. Results

3.1 Daily Temperature Variations

The temporal temperature dynamics disclosed through our analysis offer profound insights into the diurnal thermal profile. Our findings substantiate the occurrence of a discernible nocturnal cooling trend, contributing to a cooler nighttime and dawn atmospheric environment. This phenomenon aligns with the expected nighttime temperature decrease attributed to reduced solar radiation and the absence of direct sunlight during the nocturnal hours (The Pennsylvania State University).

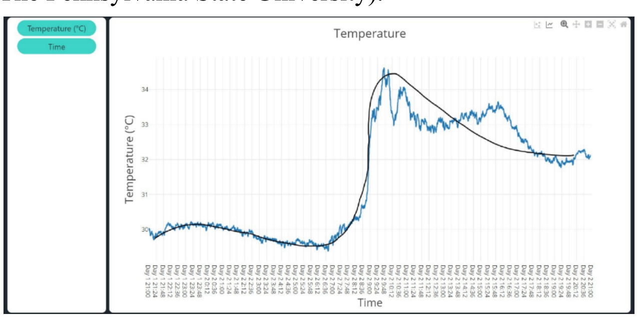

Figure 4. Collected temperature data across 24 hours

As dawn breaks and daylight ensues, temperatures undergo a rapid and marked elevation, ultimately peaking around noon. This upswing can be attributed to the intensification of solar radiation, a paramount driver of diurnal temperature fluctuations during daylight hours (University of California Regents). The zenith of temperature, occurring approximately at 10 AM, correlates with the solar zenith, underscoring its pivotal role in modulating daily temperature patterns.

Additionally, our data illustrate a gradual temperature decline as the day progresses into the afternoon and subsequently towards the culmination of the observed period at 9 PM on the second day. This progressive cooling is likely due to diminishing solar radiation and the resurgence of nocturnal cooling effects.

3.2 Daily Humidity Variations

The data suggest that humidity undergoes diurnal fluctuations, with higher values during the evening and nighttime compared to morning hours. Specifically, we observed a substantial drop in humidity levels, commencing at approximately 70% around 9 PM on the first day and reaching a nadir just above 45% around 12 PM at midday on the second day. Subsequently, as the afternoon progressed into the evening, we noted a gradual and consistent rise in humidity levels, culminating at 9 PM on the second day.

Our interpretation of these observations implies a direct correlation between humidity and the solar radiation cycle. Notably, the lowest humidity levels were recorded at midday, coinciding with the zenith of solar radiation intensity. This alignment suggests that solar radiation significantly influences atmospheric moisture content, as it reaches its peak intensity during midday and gradually wanes as evening approaches (Mackintosh).

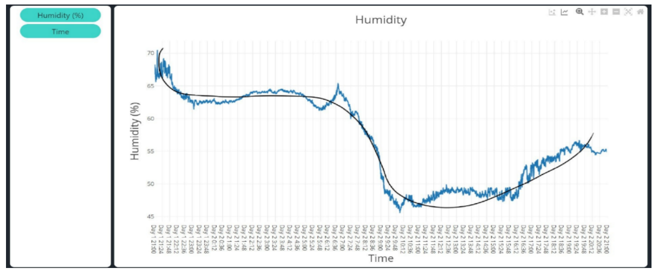

Figure 5. Collected humidity data across 24 hours

This finding aligns with established meteorological principles where solar radiation's impact on temperature and, consequently, humidity is well-documented. As solar radiation heats the Earth's surface, it engenders heightened evaporation rates, decreasing relative humidity. Conversely, as the day progresses into the evening, solar radiation diminishes, allowing temperatures and humidity to gradually recover (National Weather Service; Vattay and Harnos, 1994).

3.3 Daily CO_2 Levels Variations

In our endeavor to comprehensively grasp the dynamic fluctuations in atmospheric carbon dioxide (CO_2) levels over 24 hours, our study encountered a substantial challenge: the scarcity of conditions conducive to precise and accurate data measurement. Notwithstanding these limitations, valuable insights were garnered through the utilization of data provided by the European Centre for Medium-Range Weather Forecasts (ECMWF).

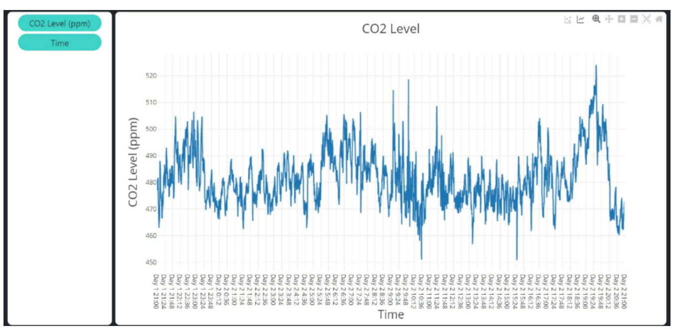

Figure 6. Collected CO_2 level data across 24 hours

ECMWF's data helped illuminate the intricate diurnal patterns of CO_2 concentrations within Earth's atmosphere, intricately intertwined with the natural carbon cycle. Over the day, the delicate equilibrium between photosynthesis and respiration becomes discernible. Daylight hours witness active terrestrial vegetation engaging in photosynthesis, characterized by the assimilation of carbon dioxide from the atmosphere. Consequently, this biological activity leads to a discernible reduction in atmospheric CO_2 levels (Copernicus Atmosphere Monitoring Service, 2019).

Conversely, as the sun sets and nighttime prevails, the equilibrium of this carbon exchange undergoes a transformative shift. Plants, with reduced or suspended photosynthetic activity, initiate respiration, releasing stored carbon dioxide back into the surrounding air. This nocturnal phase underscores the intricate dynamics of nature's carbon cycle (Alexandre et al., 2012).

4. Discussion

The results of this study provide a detailed understanding of the diurnal fluctuations in atmospheric temperature, humidity, and CO_2 levels. The correlation between solar radiation and these parameters underscores the importance of solar radiation in influencing daily atmospheric conditions.

The implications of these findings are significant for weather forecasting, climate modeling, and environmental policy. A thorough understanding of these daily fluctuations is essential for advancing climate science and formulating policies aimed at mitigating climate change.

5. Limitations

This study was conducted over a single 24-hour period without replication, limiting the ability to generalize the observations. Future research should include repeated experiments to confirm the findings and provide a more robust understanding of daily atmospheric variations. Moreover, the manual analysis of the collected data, instead of using computational methods, may reduce the accuracy of the identified trends.

6. Implications and Future Research

The findings from this research have significant implications for climate science, environmental policies, and daily weather forecasting. Understanding the diurnal fluctuations in temperature, humidity, and CO_2 levels can enhance the accuracy of weather predictions and climate models. These insights can inform policies aimed at mitigating the adverse effects of climate change by providing a clearer understanding of atmospheric dynamics.

Future research should focus on replicating this study over longer periods and in different geographic locations to validate and expand upon these findings. Additionally, incorporating more advanced and precise sensors could improve data accuracy, leading to more robust conclusions. It would also be beneficial to investigate other atmospheric parameters, such as wind speed and atmospheric pressure, to gain a more comprehensive understanding of Earth's atmospheric processes.

7. Conclusion

This research paper delves into the diurnal fluctuations of atmospheric temperature, humidity, and CO_2 levels, elucidating the factors instigating these variations and their ramifications for climate and environmental processes. Leveraging data from diverse sources and employing robust statistical methodologies, we unearth invaluable insights into the dynamics of our planet's atmosphere. Profoundly understanding these daily fluctuations is indispensable for the advancement of climate science and the formulation of environmental policies aimed at mitigating climate change.

Future research in this domain should prioritize the refinement of our comprehension regarding the complex interplay between natural and anthropogenic elements influencing daily atmospheric variations. Additionally, the ongoing monitoring and collection of data will remain pivotal in tracking changes in these patterns over time, particularly within the context of ongoing climate change.

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