Abstract

Lunar eclipses temporarily alter atmospheric conditions, yet their specific impact on local climate remains underexplored. This study examines the effects of lunar eclipses on temperature fluctuations and CO_2 levels in Bogotá, Colombia. By analyzing historical eclipse data and climate records, we observed a noticeable temperature decrease of one to three degrees Celsius during total lunar eclipses, which is likely caused by reduced atmospheric heating. However, CO_2 concentrations remained relatively stable, with minor variations attributed to human activity rather than the eclipse itself. Based on past trends, we predict that during the total lunar eclipse on March 13, 2025, Bogotá will experience a temperature drop to approximately eight degrees Celsius, with CO_2 levels reaching around 423 ppm. These findings contribute to a better understanding of how astronomical events interact with atmospheric conditions, providing insight into short-term climate variations.

Analysis of Lunar Eclipse Data: Predicting changes in atmospheric conditions

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Introduction

My personal interest in astronomy began at a young age when my older brother introduced me to the Moon through his telescope. Watching space-related films, such as Apollo 11, further fueled my curiosity about celestial events. Inspired by these experiences, I wanted to investigate how lunar eclipses might impact local atmospheric conditions, particularly in a high-altitude city like Bogotá, where temperature fluctuations may be more pronounced.

The movement of astronomical objects influences Earth's environment in various ways, from tides to atmospheric changes. One such event, a lunar eclipse, occurs when the Earth aligns between the Sun and the Moon, casting a shadow that temporarily blocks direct sunlight from reaching the lunar surface. While solar eclipses are well known for causing abrupt temperature drops due to the absence of solar radiation, the atmospheric effects of lunar eclipses have been less studied. This research seeks to determine whether a lunar eclipse can influence atmospheric conditions in Bogotá, specifically focusing on temperature fluctuations and CO_2 levels.

This study examines past data on lunar eclipses to identify patterns in temperature and CO_2 levels. By understanding how these events influence atmospheric conditions, we aim to assess whether similar effects can be expected during the upcoming lunar eclipse on March 14, 2025. The hypothesis suggests that Bogotá will experience a temperature decrease of approximately two to three degrees Celsius during the eclipse, while CO_2 levels will remain largely unchanged, with only slight fluctuations due to human activity.

Research Question and Hypothesis

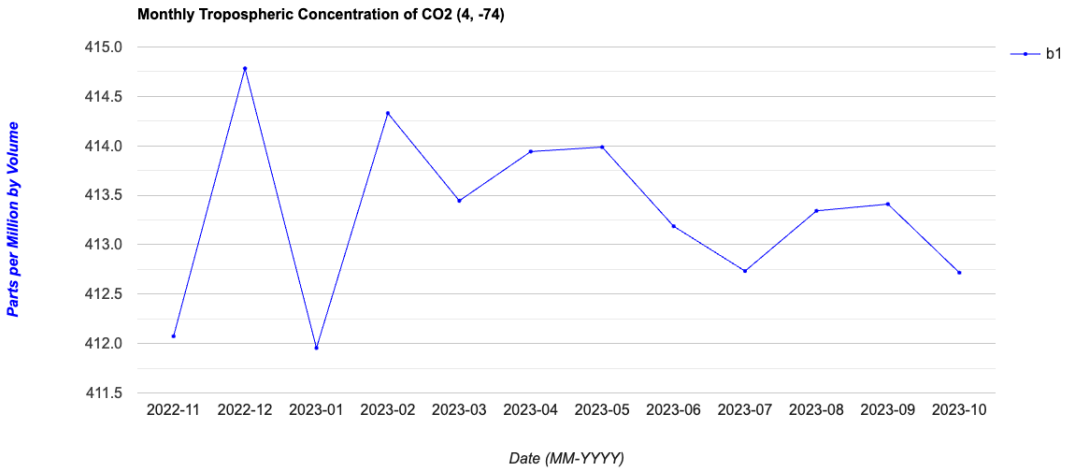
- What are some similar atmospheric conditions caused by eclipses?
- How do eclipses affect energy production of PV cells?
- How does an eclipse affect the physiological state of people?

To test the above questions, I formulated the following hypothesis. On March 14 the eclipse is going to start at 10pm and finish at 5am. There's going to be a decrease in temperature of about 2-3 C of the habitual one. The CO_2 is not going to be affected although there might be an increase at 4am due to human activity/transportation. We based this hypothesis on the normal temperatures in Bogota and the fact that whenever there's a total lunar eclipse the temperature decreases about 2-3 C, also it will be that low because March is a rainy season.

Materials and Methods

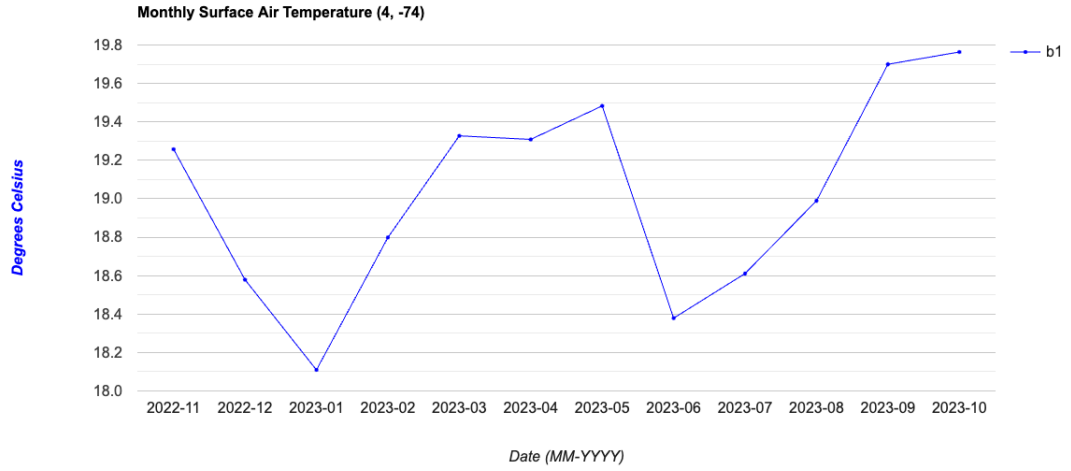
1. We compiled a table of past months of lunar eclipses. We focused on dry and rainy seasons. For example, we chose months that had exceptionally high or exceptionally low rainfall.
2. We then researched the change in carbon dioxide levels since 2022.
3. We then researched the change in temperature in Bogota during dry and rainy seasons.
4. We then investigated the change in temperature during lunar eclipses.
5. Based on the analysis of the data mentioned above, we made predictions about future atmospheric conditions during lunar eclipses.

Data Summary



-Figure 1. Relationship between months with eclipses and average surface CO_2.

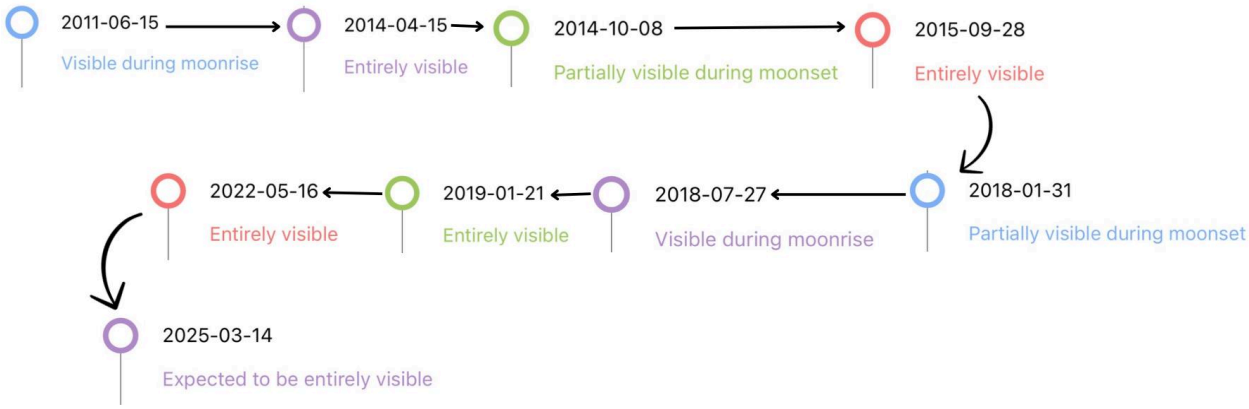
This figure shows the change in carbon dioxide levels from November 2022 to October 2023 in Bogota, Colombia. From November 2022 to December 2022 the CO_2 concentration drastically increased from 412 ppm to 414 ppm. The level then sharply decreased to precious levels. In February it increased again to over 414 ppm. The levels then gradually fluctuated while decreasing to 412.5 ppm on October 20, 2023.



-Figure 2. Relationship between months with eclipses and average surface temperature.

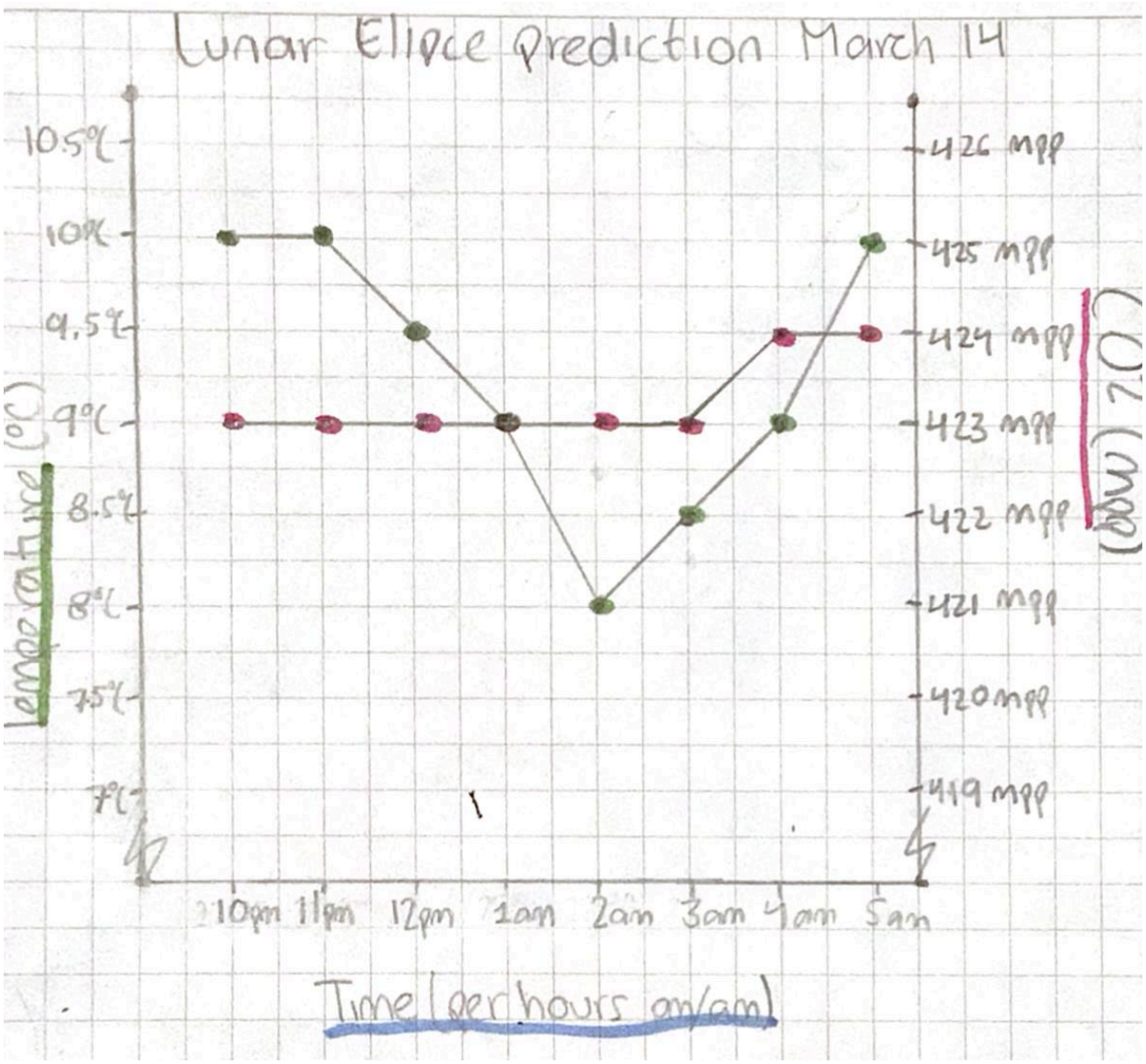
This graph shows the relationship between months with eclipses and average surface temperature. The data suggests that temperature varies throughout the year, with noticeable

fluctuations. There appears to be a decrease in temperature in some months where lunar eclipses occurred, potentially indicating a correlation between lunar events and atmospheric cooling. However, other factors, such as seasonal changes, may also influence these variations.



-Figure 3. Past lunar eclipses.

This timeline presents a historical record of past lunar eclipses, highlighting their visibility in Bogotá. It categorizes them based on whether they were entirely visible, partially visible, or only seen during moonrise or moonset. The inclusion of the upcoming eclipse on March 13, 2025, suggests an expectation of full visibility, making it a relevant event for further atmospheric analysis.



-Figure 4. Prediction of atmospheric conditions of lunar eclipse on March 13, 2025.

This hand-drawn graph predicts atmospheric conditions for the lunar eclipse on March 13, 2025. It shows temperature decreasing around 2:00–3:00 AM before gradually rising again, aligning with past observations of temperature drops during total lunar eclipses. Meanwhile, CO_2 levels remain relatively stable, fluctuating slightly but without a clear pattern directly tied to the eclipse itself. This supports the hypothesis that lunar eclipses impact temperature but do not significantly alter CO_2 concentrations.

Analysis and Results

The data analysis highlights notable atmospheric variations during lunar eclipses, particularly in temperature fluctuations, while CO_2 levels exhibit more stable trends.

Figure 1 presents changes in carbon dioxide levels in Bogotá from November 2022 to October 2023. The data indicates a sharp increase in CO_2 concentrations from 412 ppm in November 2022 to 414 ppm in December 2022, followed by a rapid decline back to previous levels. Another spike occurred in February 2023, exceeding 414 ppm, before CO_2 levels gradually fluctuated and decreased to 412.5 ppm by October 20, 2023. These variations appear to be influenced more by seasonal patterns and human activity rather than lunar eclipses, as no direct correlation between eclipses and CO_2 concentration changes was observed.

Figure 2 demonstrates how average surface air temperatures varied across months with lunar eclipses. A notable trend is the temporary cooling effect observed during eclipse months, reinforcing the hypothesis that lunar eclipses contribute to short-term temperature drops due to reduced atmospheric heating at night. However, external factors such as seasonal shifts and weather conditions must also be considered when interpreting these fluctuations.

Figure 3 provides a timeline of past lunar eclipses in Bogotá, categorizing them based on visibility. This historical record helps establish trends in atmospheric conditions during these events and serves as a reference for predicting the impact of the upcoming lunar eclipse on March 13, 2025.

Figure 4 projects the expected atmospheric conditions during the 2025 eclipse, forecasting a temperature drop to around 8°C at its lowest point. The predicted cooling aligns with past eclipse-related trends, supporting the idea that lunar eclipses temporarily influence surface temperatures. Meanwhile, CO_2 levels are expected to remain stable, reinforcing the conclusion that lunar eclipses do not significantly impact atmospheric carbon dioxide concentrations.

Overall, the analysis confirms that lunar eclipses contribute to short-term temperature fluctuations but have minimal influence on CO_2 levels. Future research could expand on these findings by incorporating real-time atmospheric measurements and exploring regional variations in eclipse-related climate effects.

Conclusions

- Finally we concluded that during the total event, it will reach 8°C and ~423ppm.

LUNAR ECLIPSES TEMPERATURE DROPS

Lunar eclipses contribute to short-term temperature drops. The data suggests that during and shortly after lunar eclipses, surface air temperature tends to decrease. This cooling effect is likely due to the temporary reduction in atmospheric heating at night, although seasonal changes and other meteorological factors also play a role. The temperature drop during lunar eclipses is due to a reduction in atmospheric heating and moonlight intensity. However, CO_2 does not cause this drop directly—it mainly traps heat, contributing to overall warming. The observed anomaly in some eclipses might involve weather conditions like cloud cover, wind patterns, or additional cooling mechanisms amplified by high-altitude cities like Bogotá.

CO_2 LEVELS DURING ECLIPSES

CO_2 levels are not significantly affected by lunar eclipses. While fluctuations in atmospheric carbon dioxide concentrations were observed throughout the study period, they do not appear to be directly correlated with lunar eclipses. Instead, these variations are more likely influenced by seasonal cycles and human activity.

HISTORICAL DATA

Historical data helps predict future eclipse-related atmospheric trends. The timeline of past lunar eclipses provides valuable insights into recurring temperature patterns, which align with the predictions for the upcoming March 14, 2025, eclipse. The expected temperature decrease further supports the hypothesis that eclipses influence short-term atmospheric conditions. With the data of previous eclipses we were able to make a little prediction of the temperature and CO_2 (*'cause based on global atmospheric the CO_2 increases about 2.3 to 2.8 ppm annually since 2022, we also needed to take into account that Bogotá's average temperature is around 13°C (58°F) all year, with temperatures ranging from 10°C (50°F) to 18°C (64°F). The temperature can be influenced by the CO_2 levels or if it's on dry or rainy season.)*

COLOMBIA'S MONTHS AND CHANGE ON TEMPERATURE

Further research is needed to refine these observations. While this study identifies trends in temperature changes during lunar eclipses, additional real-time atmospheric data collection would enhance the accuracy of future predictions. Investigating other atmospheric parameters, such as humidity and wind patterns, could provide a more comprehensive understanding of eclipse-related climate effects.

LUNAR ECLIPSES AND ATMOSPHERIC CONDITIONS

-Colombia, including Bogotá, experiences temperature changes throughout the year, even though it is located near the equator and lacks distinct seasons like summer or winter. These variations are typically subtle and influenced by the rainy and dry seasons rather than drastic seasonal temperature changes.

Bogotá's Temperature Changes Across Months:

- Dry Seasons (January–February, July–August):
    - Slightly warmer temperatures during the day (highs of 19–20°C).
    - Nights remain cool (lows of 6–8°C).
- Rainy Seasons (March–May, October–November):
    - Cloud cover and rain moderate daytime temperatures (highs of 17–19°C).
    - Nights can feel colder due to increased humidity.

Discussion

Bogotá's Climate: Bogotá is already cold, with average nighttime temperatures ranging from 7°C to 12°C, depending on the time of year. In March, temperatures can dip slightly due to local weather patterns or astronomical phenomena. For example, total lunar eclipses can lower surface temperatures temporarily, especially during the totality phase, due to the lack of direct moonlight and reduced atmospheric heating. Es changes in CO_2 are more gradual over months, with small daily fluctuations due to human activity, vegetation cycles, and weather.

Estimate for Temperature and CO_2 Levels: Before the Eclipse, the nighttime temperature in Bogotá is likely around 10°C (typical March average). Based on current global trends (rising ~2.5 ppm per year) and Bogotá's urban profile, CO_2 levels could be 423 ppm, extrapolated from recent averages.

During the Eclipse

Temperature Drop: During the eclipse, temperatures could dip by 1-2°C, reaching 8-9°C, especially during totality (1:26 AM - 2:31 AM). This drop occurs because the Earth's shadow blocks sunlight, reducing surface heating further in an already cold environment. Carbon dioxide levels will remain stable at 423 ppm, as CO_2 isn't directly affected by eclipses but fluctuates minimally due to nighttime cooling and local emissions.

After the Eclipse

After totality ends and the moonlight gradually returns, temperatures might slowly rise again to 10°C by early morning, as natural atmospheric patterns resume. CO_2 Levels could experience minor local variations that could cause a slight increase (from morning traffic or human activity), but it will likely stay close to 423-424 ppm.

Acknowledgments

I would like to express my deepest gratitude to NASA for providing valuable data and resources that made this research possible. Their commitment to space exploration and scientific discovery continues to inspire and advance our understanding of the universe.

A special thank you to my teacher, Matthew Reis, for his guidance, support, and expertise throughout this project. His encouragement and insights were instrumental in helping me analyze the data and refine my conclusions.

Finally, I would like to acknowledge everyone who contributed to this research, directly or indirectly, for their support and dedication to scientific inquiry.

Resources

- *NASA Eclipse web site*. (s. f.). https://eclipse.gsfc.nasa.gov/

CLIMATE/WEATHER

- *Bogotá, Colombia Weather History | Weather Underground*. (s. f.). https://www.wunderground.com/history/daily/co/bogot%C3%A1/SKBO
- *Bogotá climate, Weather by month, Average temperature (Colombia) - Weather Spark*. (s. f.). Weather Spark. https://weatherspark.com/y/23324/Average-Weather-in-Bogot%C3%A1-Colombia-Year-Round
- https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter11.pdf
- https://climateknowledgeportal.worldbank.org/sites/default/files/country-profiles/16698-WB_Colombia%20Country%20Profile-WEB.pdf
- https://www.ideam.gov.co

ECLIPSES

- *Eclipse Data Analysis - GLOBE Observer - GLOBE.gov*. (s. f.). https://observer.globe.gov/do-globe-observer/eclipse/data-analysis
- *Eclipse 2019 Data - GLOBE Observer - GLOBE.gov*. (s. f.). https://observer.globe.gov/get-data/eclipse-data/eclipse-2019-data
- Data, M. N. (s. f.). *My NASA data*. My NASA Data. https://mynasadata.larc.nasa.gov/
- *Eclipses in Colombia*. (s. f.). https://www.timeanddate.com/eclipse/in/colombia

- Aplin, K. L., Scott, C. J., & Gray, S. L. (2016). Atmospheric changes from solar eclipses. *Philosophical Transactions Of The Royal Society A Mathematical Physical And Engineering Sciences*, *374*(2077), 20150217. https://doi.org/10.1098/rsta.2015.0217