Exploring the Effect of the Solar Eclipse on Wind Speed and Direction in Texas using a Comparative Diurnal Analysis

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Introduction

- A solar eclipse is a rare celestial event where the moon temporarily blocks the Sun, leading to a brief period of darkness.
- The sudden reduction in solar radiation during an eclipse causes rapid changes in temperature and other atmospheric conditions.
- These changes provide a unique opportunity to study the Earth's atmospheric response to abrupt changes in solar radiation.
- One specific area of interest is "eclipse wind," where changes in solar radiation can alter wind speed and direction.
- Understanding eclipse wind helps in studying how rapid changes in solar radiation affect weather patterns and atmospheric dynamics.

Research Questions

1. What is the Effect of Solar Eclipse on Wind Speed and Direction Along the Path of Totality in Texas?
    a. Explored a specific phenomena called *eclipse wind*
    b. Used a **Comparative Diurnal Analysis** of Eclipse Wind

Data Sources Used

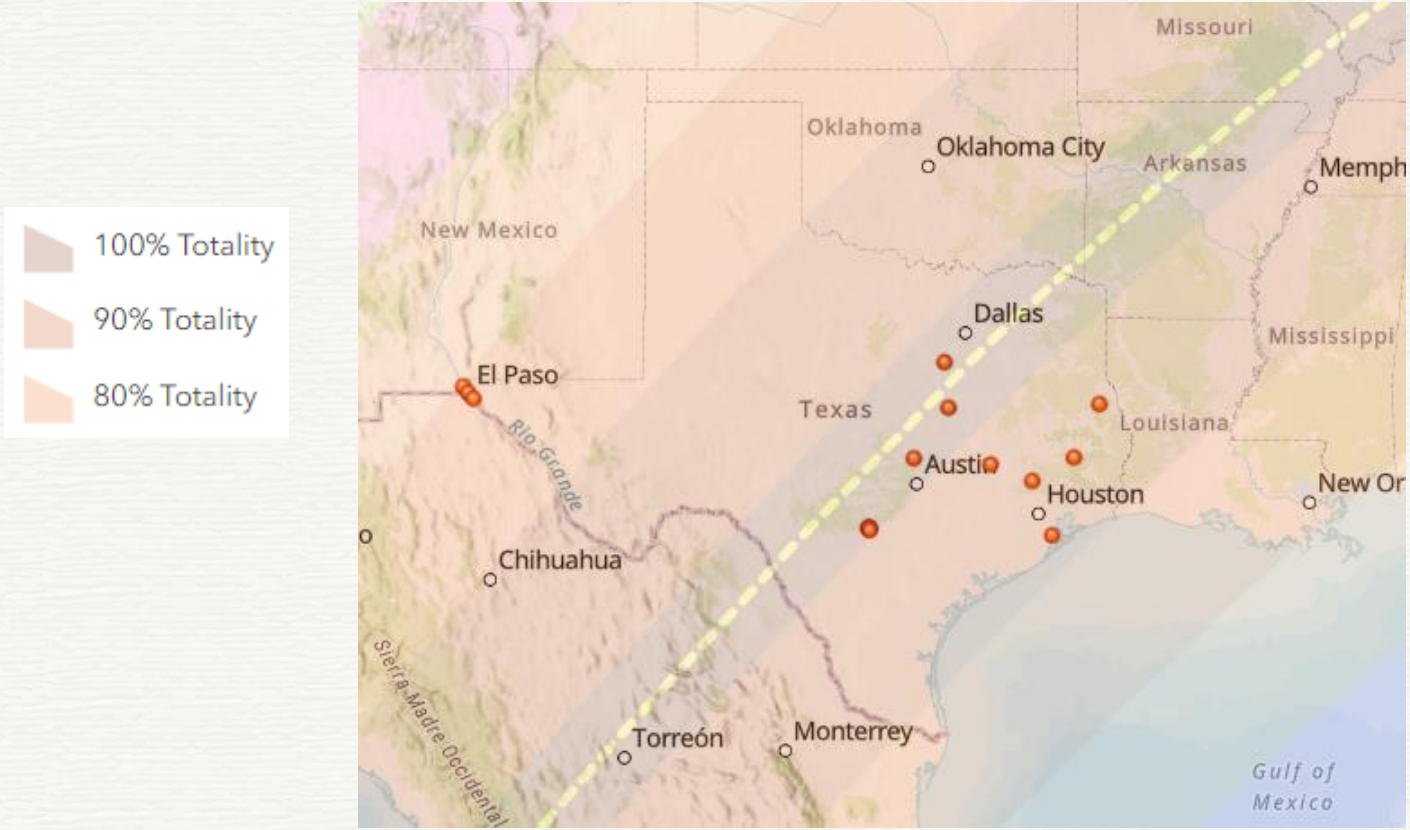
About GLOBE:

- GLOBE (Global Learning and Observations to Benefit the Environment) is an international science and education program promoting Earth science understanding through data collection and research.

Data Overview:

- Collected 9118 data points over 9 days (4 before, 4 after the solar eclipse, and the eclipse day).
- Collected data includes wind speed and direction.

Diagram of the Site Locations



Methodology

Data Collection

- **Wind speed** and **direction**
- **Data-Rich** Locations (in path of totality)
- Choose **8 surrounding days** to aggregate

Data Preparation

- Data Cleaning (remove **null** and **NaN values**)
- Standardize timezone (**UTC → CST**)
- Statistically removed **outliers**
- Isolated data to 1) Solar Eclipse Event (SEE) 2) Diurnal Average Days

Data Visualization

Graphed the **average wind speed** and **direction** of the average diurnal variation against the solar eclipse

matplotlib

NumPy

pandas

Statistical Testing

Performed **t-tests** on the average diurnal variation vs. the SEE

$$t = \frac{\bar{x} - \mu}{s/\sqrt{n}}$$

Data Analysis

Performed **t-tests** on the average diurnal variation vs. the SEE

python™

SciPy

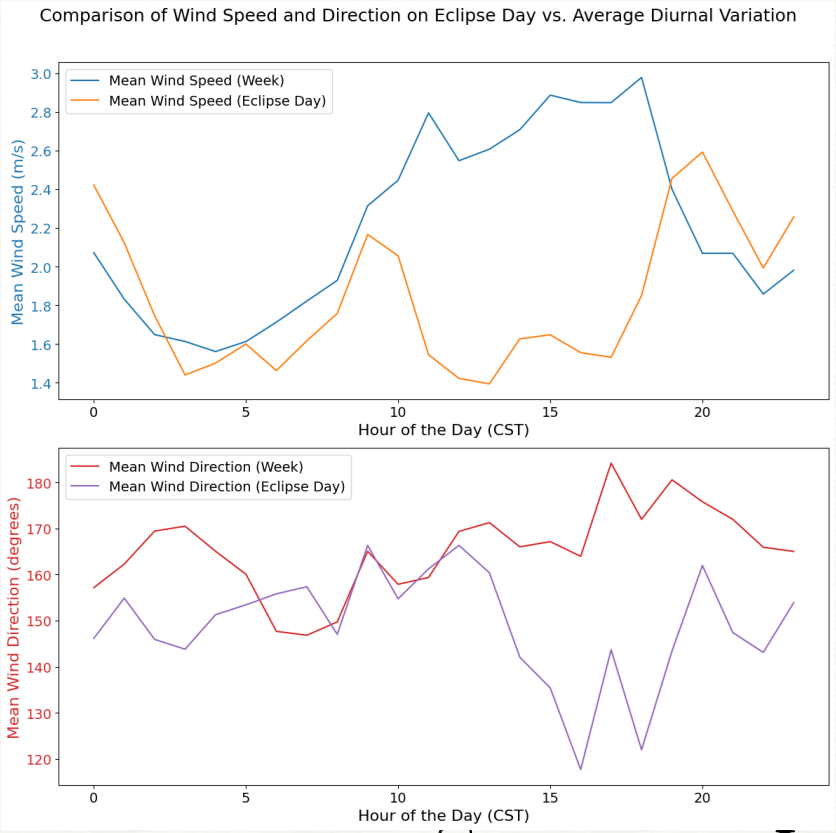
Resulting Data

Top Graph:

- Mean wind speed on eclipse day (orange) vs. weekly average (blue).
- Afternoon shows significant differences (0.4 to 1.4 m/s).

Bottom Graph:

- Mean wind direction on eclipse day (purple) vs. weekly average (red).
- Variations from 10 am to 1 pm (10 to 30 degrees).



Data Analysis - Wind Speed

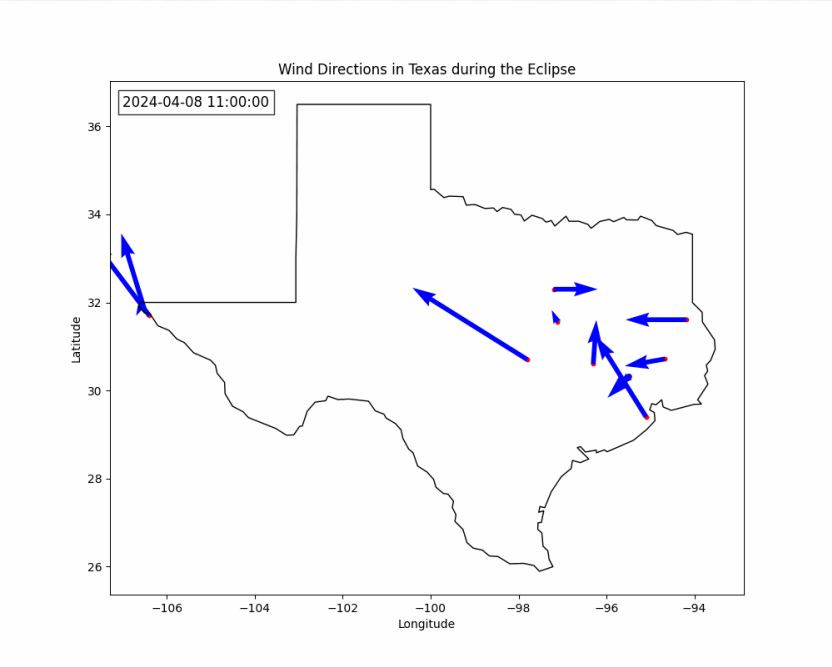
Results of T-testing:

Wind Speed:

- T-Statistic: 20.30
- P-Value: 1.02e-84

Wind Speed:

- The t-statistic for wind speed is 20.30 → the high value indicates **statistically significant** differences in the diurnal variation of eclipse wind before and during the solar eclipse.
- The p-value is 1.02e-84 < typical significance level of 0.05 → we can **reject the null hypothesis** that there is no difference between the two time periods.



Representation of Aggregated Wind Speed and Direction Data's progression throughout the day.

Data Analysis - Wind Direction

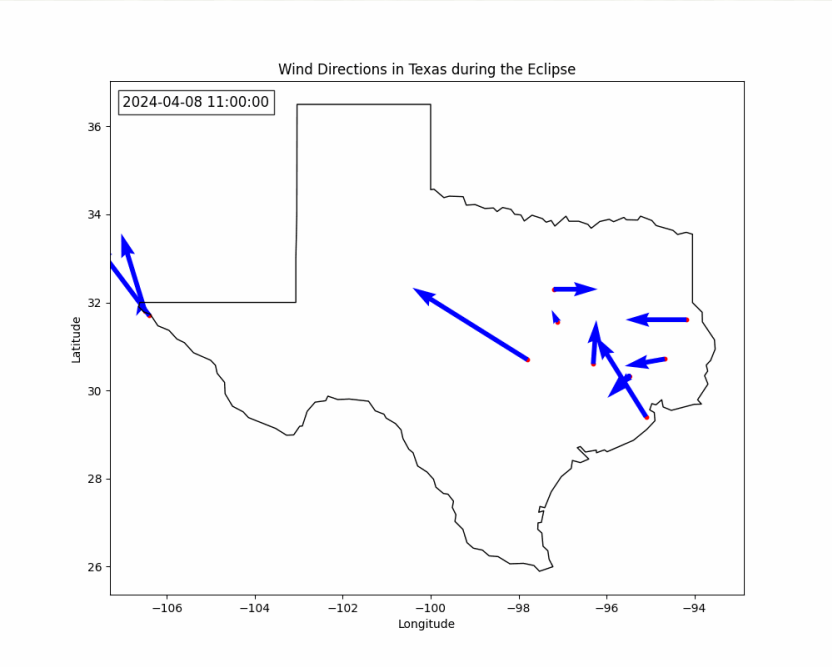
Results of T-testing:

Wind Direction:

- T-Statistic: 11.80
- P-Value: 3.91e-31

Wind Direction:

- The t-statistic for wind direction is 11.80 → the high value indicates **statistically significant** differences in the diurnal variation of eclipse wind before and during the solar eclipse.
- The p-value is 3.91e-31 < typical significance level of 0.05 → we can **reject the null hypothesis** that there is no difference between the two time periods.



Representation of Aggregated Wind Speed and Direction Data's progression throughout the day.

Conclusion

- Key Findings:
  - Wind Speed:
    - Observed a significant change in wind speed on the eclipse day compared to the typical week.
    - T-test results showed a statistically significant difference (T-statistic = 20.30, p-value = 1.02e-84).
  - Wind Direction:
    - Notable changes in wind direction were recorded during the eclipse.
    - T-test results also indicated a significant difference (T-statistic = 11.80, p-value = 3.91e-31).

Conclusion (cont.)

- Significance of Findings:
  - The decrease in wind speed and the shifts in wind direction are consistent with the expected cooling effect of the eclipse, leading to stabilization of the atmospheric boundary layer.
  - Understanding these changes can help improve weather prediction models and contribute to the broader field of atmospheric science.
  - The observed changes in wind patterns provide valuable insights into the transient effects of solar eclipses on local weather conditions.

Abstract

This study investigates the impact of the 8 April 2024 total solar eclipse on wind patterns across Texas. Solar eclipses cause rapid changes in solar radiation, significantly affecting weather conditions. Data were sourced from the GLOBE Program using the GLOBE Atmosphere protocols, encompassing 9118 observations from 15 sites over eight days surrounding the eclipse. The analysis focuses on wind speed and direction, key variables influenced by the eclipse-induced changes in solar radiation.

Using comparative diurnal analysis, we compared the mean wind speed and direction on the eclipse day with the average diurnal variation from the surrounding week. Statistical analyses, including T-tests, revealed significant deviations in wind speed and direction during the eclipse, particularly in the afternoon. The results showed that mean wind speed on the eclipse day varied significantly from the weekly average, with differences ranging from -0.4 m/s to -1.4 m/s. Wind direction also exhibited notable changes, especially between 10 AM and 1 PM CST, correlating with the period of maximum eclipse.

Our findings indicate that the eclipse caused a temporary but significant disruption in local wind patterns. The decrease in wind speed and the shifts in wind direction are consistent with the expected cooling effect of the eclipse, leading to stabilization of the atmospheric boundary layer. This study underscores the importance of solar eclipses as natural experiments for understanding atmospheric processes. The observed changes in wind patterns provide valuable insights into the transient effects of solar eclipses on local weather conditions, contributing to improved predictive weather models and enhancing our understanding of atmospheric dynamics during such rare events.

This research highlights the significance of solar eclipses as natural experiments for studying atmospheric processes, offering valuable insights into how transient events like solar eclipses influence wind patterns and contributing to improved predictive weather models.

My Experience with NASA SEES

Name: Bill Xu

I really enjoyed the SEES camp because I learned so much. I gained practical experience in data analysis, especially in studying wind patterns during the solar eclipse. The hands-on activities and projects enhanced my understanding of atmospheric science, and I appreciated the opportunity to work with advanced tools and software. Collaborating with mentors and peers deepened my knowledge and made the learning experience truly enriching.

My Experience with NASA SEES

The SEES program was truly an amazing experience. I got the chance to use significant datasets, such the GLOBE Observer Dataset, and even contribute to them with daily cloud cover and surface temperature data. The experience of working with like-minded interns as a part of the Solar Eclipse Impacts on Weather group was great; we were all driven to discover new relationships between solar eclipse events and our daily lives, and the culminating research project we completed really speaks to the dedication and excitement I had with this program. It was amazing!

Name: Saharsha Navani

Acknowledgements

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