Environmental Impacts of the Space Industry in Earth’s Atmosphere: An Analysis on Rocket Emissions and Ozone

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Abstract

Ozone has been a research topic for a few decades, specifically its depletion in the stratosphere and its production in the troposphere. The space industry burns multiple types of fuel to project spacecrafts possibly contributing to the ozone concerns in both areas of the atmosphere. Data consisting of Cocoa Beach’s daily ozone levels from the Florida Department of Environmental Protection’s Office of Air Monitoring were used to discover if ozone levels were significantly higher when rockets were launched from Kennedy Space Center from the years 1994 to 2019. After performing a hypothesis test on the ozone levels for those years, there was no evidence in the results to show that rocket launch days had significantly high ozone levels. Furthermore, it is likely that rocket launches do not affect the overall ozone for a specific day, but that does not show the industry has no impact. These results further emphasize why there are no regulations on the industry even though there is a profusion of articles stating the industry’s negative effect. The effects of the industry are likely long-term effects, but there are other contributors that make it difficult to identify the impact strictly from the rocket industry.

Introduction

• Ozone is an element that lies in the stratosphere of the Earth’s atmosphere that is vital to protecting the Earth from harmful rays.
• In the stratosphere, ozone is important and protects the Earth.
• In the troposphere, ozone can harm air quality and cause health problems for people.
• Rockets produce exhaust that contains elements known to be a catalyst to ozone production.
• Solid Rocket Fuels were used in the shuttle program and are planned to be used on NASA’s new Space Launch System(OMS) program.
• This type of fuel release aluminum Oxides, Nitrogen Oxides, and Hydroxyl Chlorides (Braunung, 2008).
• Ozone is an element that lies in the stratosphere of the Earth’s atmosphere that is vital to protecting the Earth from harmful rays.
• In the stratosphere, ozone is important and protects the Earth.

Methods & Data

• Data is collected from Florida Department of Environmental Protection’s Office of Air Monitoring.
• T-Test on a Normal Distribution
• Curve Fitting
• T-Test on a Normal Distribution
• Curve Fitting

Analysis

Results

• For the rocket launch days to have significant values compared to the rest of the year, the P-value needs to be relatively low and close to 0.05 or absolute values of all the t-Stat values and if it is less than the critical value.

Discussion

• This research aimed to find a correlation between rocket launch dates and the ozone levels of those dates. The main results of the T-Test proved that the ozone levels on rocket launch dates were not significant compared to the ozone levels for the rest of the year. The lack of significance is beneficial to know that there are no immediate ozone level concerns due to rocket launches from this study.

• Table 2 shows the rocket emissions that NASA currently monitors. Current studies on carbon soot state it is the second-largest contributor to global temperature increase (Pacific Northwest, 2015). Carbon soot is becoming a large contributor to the environment, and a Falcon 9 releases about 30 metric tonnes of it, but it is included in the particle matter and does not contain its own category for its environmental effect. NASA is an administration that is involved in the analysis of the environmental impacts of SpaceX’s rockets, and NASA has conducted research that has found that black carbon soot has damaging effects on the environment as well as travels in the atmosphere to different locations (Dunbar, 2005).

• Further research needs to be conducted on the long-term effects of the space industry. As important as it is to know that the space industry does not have an immediate negative effect on the Earth’s ozone level, there has been enough data to conduct long-term analyses? Greater consideration in the emission rocket launches produced is valuable to keep our planet safe before humans move onto a new planet and destroy that planet’s environment.

References

FDEP Office of Air Monitoring. (2007). Air Quality Index(AQI) that determines how healthy the air is.


Table 1: T-Stat Results

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Figure 1: Ozone Level for 2010-2019

Curve Fitting
• As shown in the figure above, there is a seasonal fluctuation of the ozone levels. To counteract this a curve is fitted to Standardization
• A standard metric for measuring spikes in the level must be created by subtracting the estimated point on the fitted curve
• T-Test on a Normal Distribution
• Now that the data is standardized, there is a normal distribution of data causing any spikes in the data to be significantly out of range compared to the critical value.

Figure 2: Ozone Level Trends for 2015

Data is collected from Florida Department of Environmental Protection’s Office of Air Monitoring.

Figure 3: Ozone Level for 2010-2019

Table 2: Rocket Emissions

<table>
<thead>
<tr>
<th>Rocket</th>
<th>Mass (Max) kg</th>
<th>Carbon Soot (Max)</th>
<th>Carbon Monoxide (Max) g/h</th>
<th>Methane (Max) kg</th>
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<tr>
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Figure 4: Bell Curve Normal Distribution of Residuals