Comparing Air Quality in Coastal and Inland areas: A Case Study in Long Island and Albany NY, and a Deeper Look onto the Effect of Dispersion from Canada's 2023 Wildfires

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Abstract

The ocean stands as a critical and significant feature of the earth, and plays a crucial role in a majority of weather-related phenomena. Thus, we examined the differences in air qualities between two regions depending on their proximity to the ocean using many factors to conclude if the ocean also plays a role in filtering air quality as well as the certain reason why the ocean has this effect. Furthermore, the wildfire's originating in Northern Canada had an unproportionately high impact on the air quality in New York and so the impact the wildfires had on the primary research objective was also studied. We analyzed a multitude of factors including wind speed, wind direction and particulate matter 2.5 to determine a conclusion to both research objectives. PurpleAir sensors were used to carefully gather Particulate matter 2.5 data over the selected time frames of March-May 2023 and June 4-10. The former set of dates was used to demonstrate the standard trend of comparisons between the air qualities in coastal and inland cities, and the latter was the week used to gather data for the wildfires. Wind speed data was obtained from NOAA in the same time frames. Sky color was gathered from GLOBE sites, and wind direction from weather underground.

Keywords: Atmospheric sciences• Climatology (Global Change) • Environmental sciences• Informatics •Oceanography

Introduction

The data was then graphed and analyzed. We concluded that the coastal region had the better air quality because of certain factors. and in fact, the ocean does serve as a natural air filter. Moreover, the wildfires undermined this conclusion and both of the air qualities were equally poor regardless of coastal proximity. Our research aims to expand and confirm prior studies by looking deeper into the specific reasons why the ocean is considered an "air quality filter" and compare this consensus to the effects of the recent wildfires.

Research Question and Hypothesis

Originating in Northern Canada, the wildfires spread to the US, and had the largest effect on New York from June 4th through June 10th which we will be calling the "wildfire week" (Figure 1).

Figure 1: Photo taken in US school parking lot on June 9th 2023

The objectives for this project were to examine the difference in air qualities between two regions depending on their respective location. We also studied the impact of wind direction, speed, and pm 2.5 had on air quality in addition to the path of Canada's June 2023 wildfire spread. Lastly, we compared the effects Canada's wildfires had on inland and coastal regions.

Prior to recording data, it was hypothesized that the coastal region would have better air quality compared to the inland region and that the air quality of both regions would be hindered to the same extent by the wildfires in Canada, therefore the wildfires will have no effect on the comparison made on air quality.

Literature Review

Wildfire particle dispersion, over New York State specifically, can transport over long distances and affect air quality in downwind regions. Smoke Aerosols are projected to increase in the future, exacerbating the effects of wildfire particle dispersion. In a study conducted on the influences of smoke aerosols on PM 2.5 concentrations, a threefold increase in PM 2.5 concentration from (8.4 μg m^{-3} to 24.8 μg).

This study was additionally prompted by the danger of pollutants that affect air quality. With New York being one of the most highly populated states such as New York. It has been estimated that ambient concentrations of PM2.5 in NYC still contribute to more than 3000 deaths every year, 2000 hospital admissions for lung and heart conditions, and approximately 6000 emergency department visits for asthma.

Lastly, the report's focus on the ocean was influenced by a study on the effect of the sea breeze on temporal climate in polluted areas. It was found that in the coastal-source cases, a circulation behind the sea breeze front was responsible for maintaining high concentration zone, just behind the front so that the product is not dispersed throughout the region, resulting in better air quality.

We planned to observe this trend of air quality compared between coastal and inland areas further with a greater number of factors, as well as compare these trends to the effects of a recent harmful wildfire dispersion [1-5].

Research Methods and Materials

For our study areas, we chose Long Island and Albany. Long Island, as you can see on the map, is bordering the ocean, is a coastal region, and Albany is landlocked and is the mainland region for this project. Furthermore, Long Island is more densely populated, so if the prediction that the air quality is better, the ocean's effect on air quality would great enough offset the difference in population in the two regions.

We will set this experiment up by first collecting PurpleAir pm 2.5 data and compare the difference between the two locations to answer our first question- How does the air quality near the coast differ from the air quality inland? Next, we will answer our second research question- How do past trends compare to the recent effects of the wildfires in Canada? - by collecting GLOBE data to show sky color and visibility on average for the entire USA and our specific study area. We also used wind direction data from NOAA to study the movement of Canada's wildfires, how far it spreads, and the effects it has on air quality. Lastly, we also used wind speed data from NOAA to study the strength of particle dispersion away from the region, which, used in tandem with wind direction, is an accurate indicator of air quality, as the more pollutants dispersed away from an area, the better the air quality in that specific area.

Results

Sky color is one of the qualitative factors that can aid in comparing air quality. The lighter colors in this map represent a milky sky or worse air quality, whereas the darker colors represent a blue sky and better air quality (Figure 2).

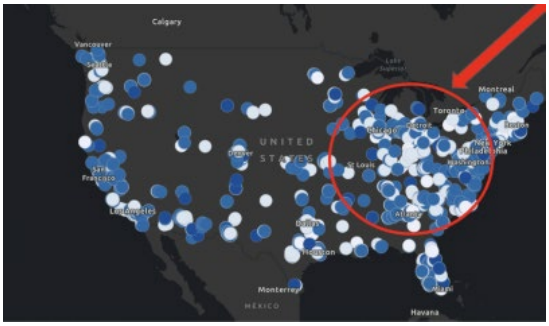


Figure 2: Sky Color Map with GLOBE data of United States

At the start of this process, we looked at how sky color in coastal regions compared to inland for the entirety of the US. In the northeast area, highlighted by the red circle, we can see that there is a greater frequency of sites that have reported a milky sky color inland, compared to along the coast. This sparked our interest and led us to explore this same phenomenon in our study area (Figure 3).

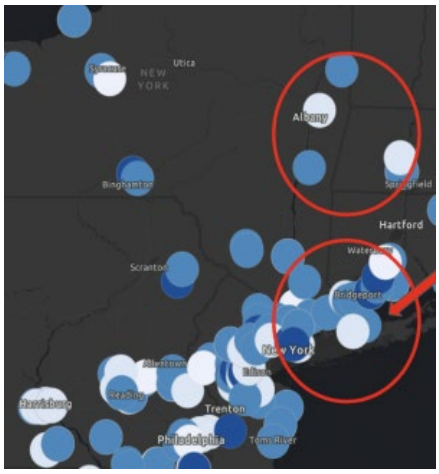


Figure 3: Sky Color Map with GLOBE data of Albany and Long Island March-May 2023

These maps was created using data from March-May 2023, which preceded the wildfire week and is the timespan for the standard trend for the rest of the factors. In the right map, we can see the same thing, with a greater number of sites reporting milky skies near Albany and inland, compared to along the coast.

The standard trend graph on the left shows that on average, Albany had lower wind speed, which is shown in blue, meaning that the pollutants in the air are less dispersed and the air quality is worse over the region. This wind speed graph on the right shows the hourly wind speed data from June 4-10. Compared to the standard trend, the wind speed during the wildfire week was much weaker contributing to a slower dispersion of particulate matter, and Long Island doesn't maintain a better air quality in this week (Figure 4 a and b).

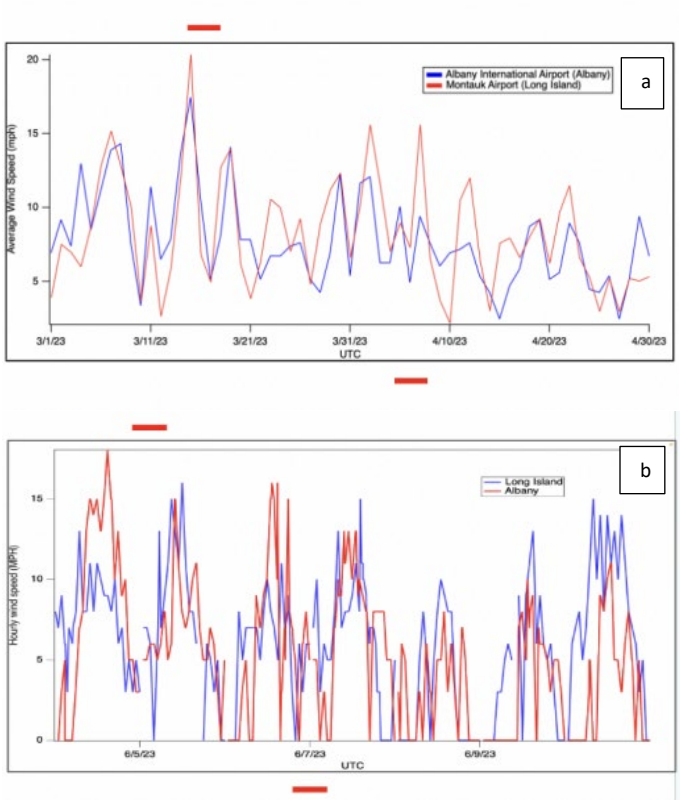
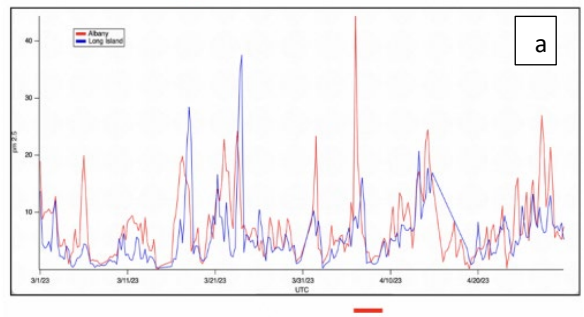


Figure 4: Comparison of Average wind speed from NOAA(a)Standard trend (March-May2023) (b)Wildfire week (June 4-10 2023)

Particulate matter 2.5 is one of the more dangerous effects of bad air quality and high concentrations of it is an important indicator of poor air quality. During the standard trend timespan, Albany, which is in red had higher concentrations of pm 2.5 compared to Long Island which is in blue, signifying worse air quality in Albany.

The y-axis scale for the standard trend is 0 to 40 while the scale for the wildfire week is 0 to 400. This goes to show just how poor the air quality was in these areas during the week.
During the wildfire week, Long Island's Pm 2.5 measurement, according to PurpleAir, was nearly twice as high as Albany's. Long Island reached a whopping 400 micrograms per cubic meter of air whereas Albany's peaked at approximately 275 (Figure 5 a and b).



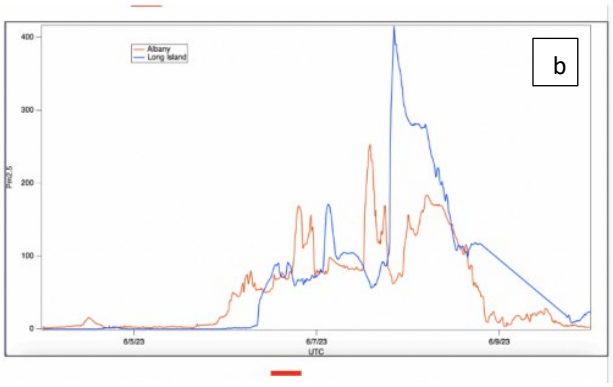


Figure 5: Comparison of pm 2.5 levels from 4 PurpleAir Sensors; 2 in each region. (a) Standard trend (March-May2023) (b) Wildfire week (June 4-10 2023) Average pm 2.5 measurement combined: 60.44 $\mu g/m^3$

The charts shown represent the mean wind direction for June 6,7, and 8. These three days were impactful because they were the worst days during the wildfire week. The chart on the left displays the most recurring wind direction for Albany being West. The chart on the right shows the frequent wind direction for Long Island being North West. To better visualize, this map exhibits the course the wind traveled throughout June 6-8 (Figure 6).

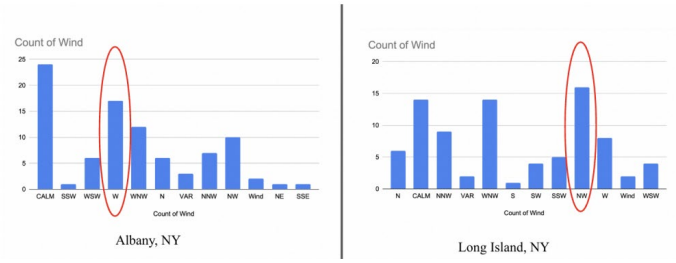


Figure 6: Comparison of most frequent wind direction of Wildfire Week from Weather Underground

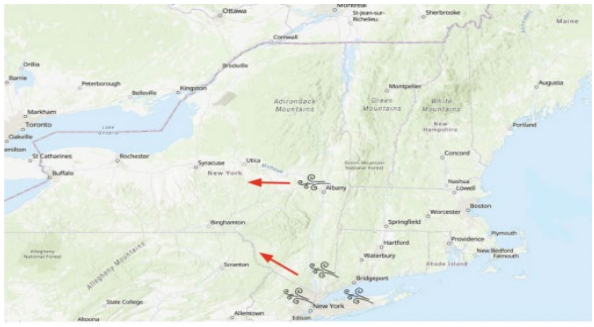


Figure 7: Map created in ArcGIS on most frequent Wildfire Week wind direction

This map shows wind direction data collected over the course of the two months to show the standard trend, and a majority of the arrows are pointing northwest or the direction of Albany, meaning that the pollutants in the air are traveling from nyc and long island to the inland areas. This factor can also explain why Albnay could have a worse air quality as the wind is carrying more of the pollutants towards it (Figure 8).

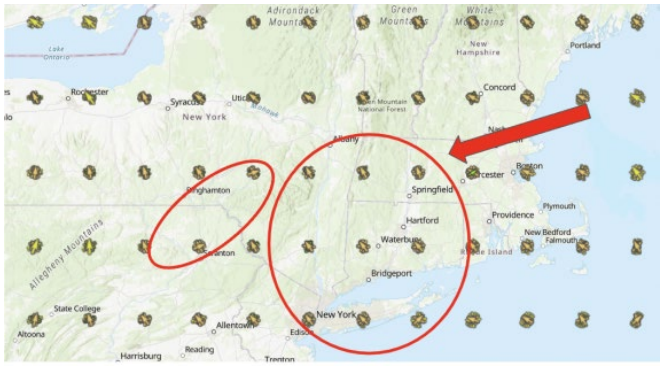


Figure 8: Map created in ArcGIS on wind direction data over March-May 2023

Conclusion

To answer the research questions, we can conclude that the air quality near the coast is better than the air quality inland, based on the factors observed. Moreover, this trend operated conversely during the wildfire week. Additionally, we found that wind direction had a substantial impact on the spread of wildfires and can explain why Long Island's air quality was more greatly hindered during the wildfire week.

After this project, we recognized that being situated near a large body of water will result in better air quality, and a rise in the atmospheric CO_2 could cause the large bodies of water to begin to evaporate, meaning that populations located on the coast could lose this benefit in air quality. This is why it is important to preserve our bodies of water as it also preserves the quality of the air we breathe.

Discussion

Our future steps, if time permits, include looking deeper into why Long Island was more profoundly impacted by the wildfires, and what other factors cause coastal regions to have better air quality than inland regions. Additionally, we plan to expand this research by adding more coastal and inland cities to make a more versatile closure to our questions. Lastly, we could continue to research how to mitigate the effects of global warming and the reducing CO_2 emissions rate.

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