Dynamics of PM2.5 and Ozone Pollution in NYC area

HIRES Students: Alexus Lee and Jendy DeLeon
Mentors: Dingdong Li and Yonghua Wu

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NOAA-CREST CENTER FOR EARTH SYSTEM SCIENCES AND REMOTE SENSING TECHNOLOGIES

CUNY THE CITY UNIVERSITY OF NEW YORK

The City College of New York

Background

WHAT IS PM2.5 ?

PM stands for airborne particulate matter; it's a mixture of many different chemicals. The particles are less than and equal to 2.5 microns in diameter [1].

WHAT IS OZONE

Ozone (O3) is a highly reactive greenhouse gas composed of three oxygen atoms. The chemical formula for Ozone is O_3 [2].

HOW DOES PM2.5 FORM?

PM2.5 is formed as a result of burning fuel and chemical reactions that take place in the atmosphere.

HOW DOES OZONE FORM?

Ozone is formed by the photochemical reactions between sunlight, volatile organic compounds (VOC) and nitrogen oxides (NOx) which are emitted by automobile tailpipes and smokestacks [2].

WHAT ARE THE MAJOR EMISSION SOURCES OF PM2.5?

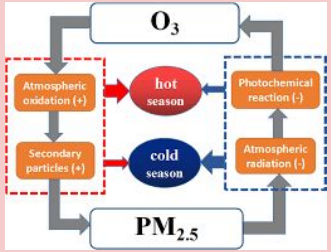
PM2. 5 include direct emissions from combustion of fuels such as gasoline, oil and diesel as well as wood combustion [3-9].

...OF OZONE?

Ozone's precursors (NOx, VOCs, etc) are emitted by cars, power plants, industrial boilers, refineries, chemical plants, and other biogenic sources [3-9].

Objectives

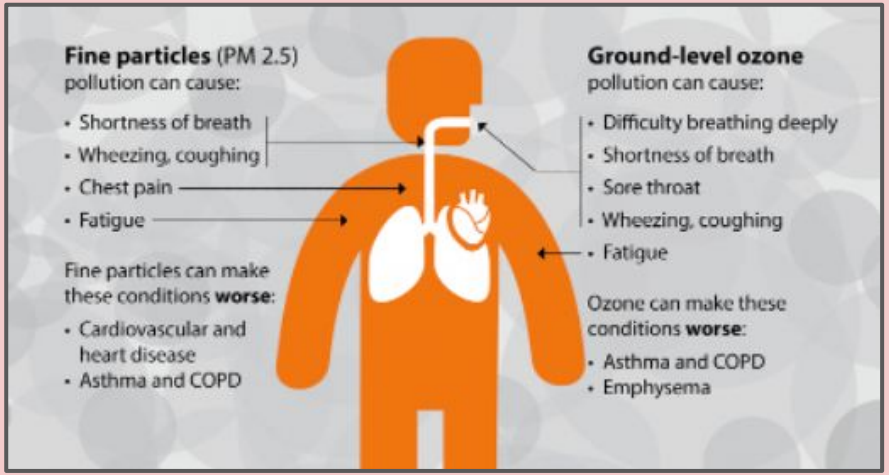
1. Study the yearly trend of PM2.5 and Ozone in NYC
2. Study the seasonal variation/characteristics of PM2.5 and Ozone.
3. Study the diurnal dynamics of PM2.5 and Ozone.
4. What factors impact PM2.5 and Ozone levels?



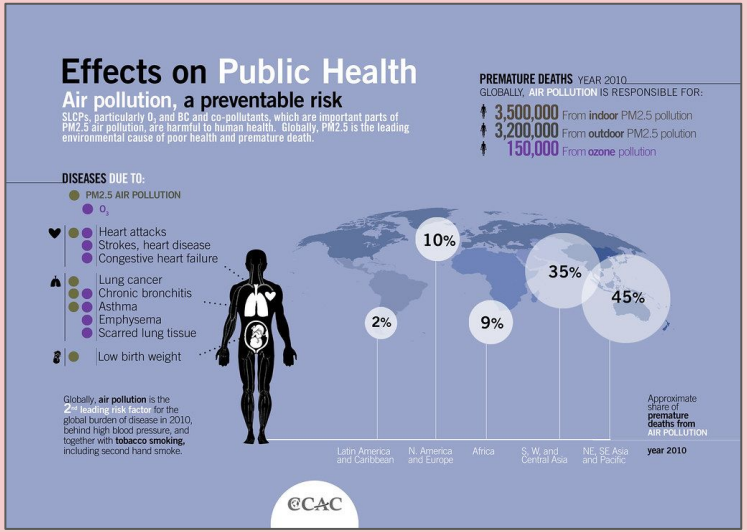
Societal Significance

1. HEALTH IMPACT

PM2.5 and **Ozone** are two types of major air pollutants in US and long-term exposure to PM2.5 and ozone aggravates various lung,cardiovascular diseases and asthma, etc. [3-6].

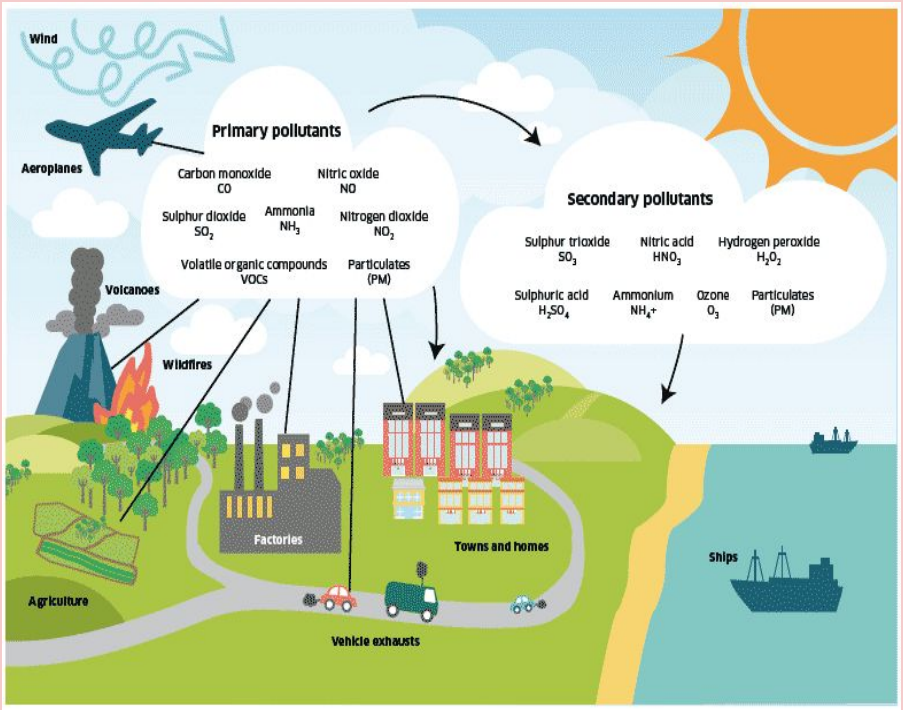


Source: https://www.pca.state.mn.us/air



Source: https://www.grida.no/resources/7544

Environmental Significance



Source: https://www.gov.scot/publications/cleaner-air-scotland-road-healthier-future/pages/6/

2. ENVIRONMENTAL IMPACT

-High levels of **PM2.5** can also impact the environment, resulting in changes to the climate and droughts because they can absorb and scatter solar radiation directly and affect clouds/precipitation [11-14].

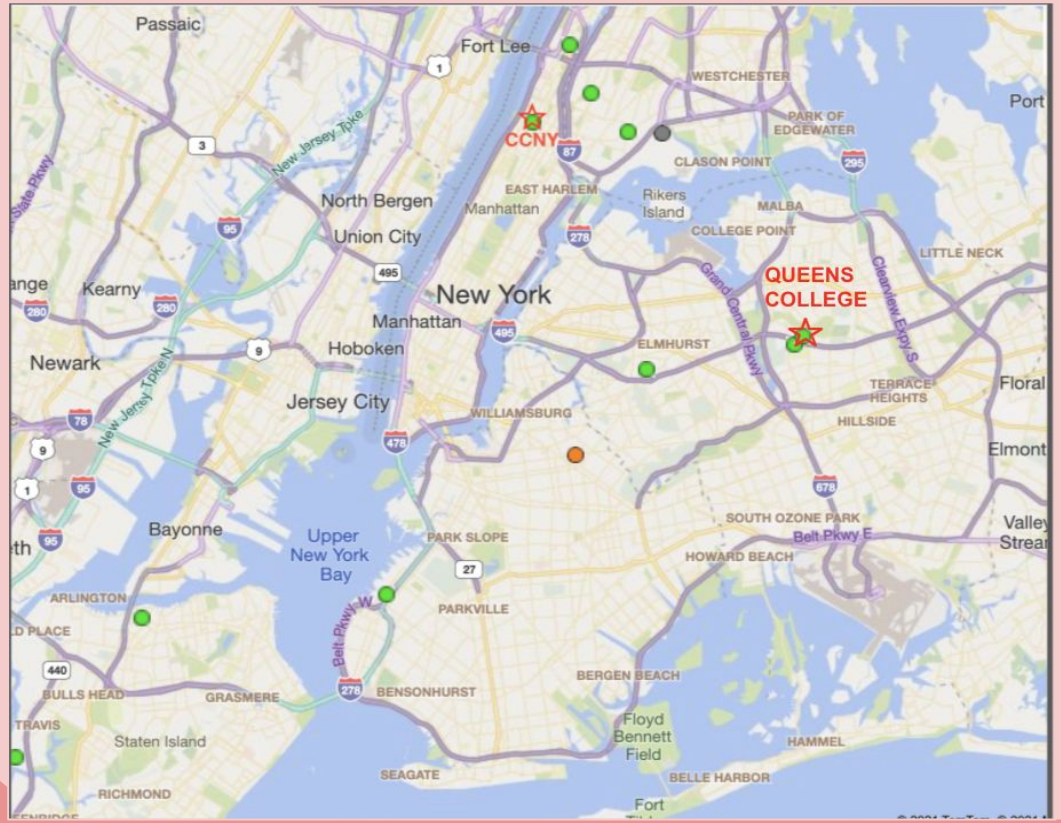
-Ground **Ozone** negatively affects vegetation by interfering with the process of photosynthesis. This affects entire ecosystems, possibly leading to the loss of species diversity [11-14].

Methodology

We used online databases like nyaqinow.net to find data and create graphs in Microsoft Excel based on Air Quality Trends in NYC.

- **PM2.5 and Ozone Graphs Data:**
  From CCNY air quality monitor station by nyaqinow.net in 2019 and 2020.
- **Temperature Graph Data:**
  From Queens College air quality and temperature monitor station by nyaqinow.net in 2019 and 2020.
- **Graph Creation:**
  Microsoft Excel Sheets and the usage of the ”Average” function in the application.

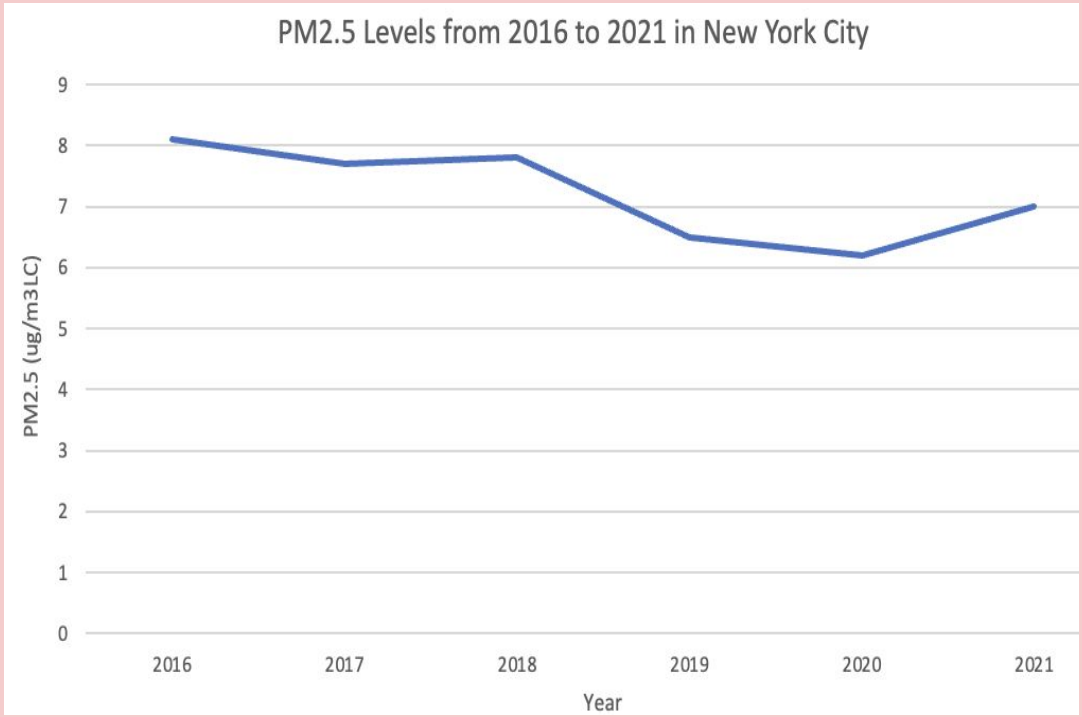
Air Quality and Temperature Stations



Map of New York City with CCNY and Queens College Stations [10].

Source: http://www.nyaqinow.net/

Results: Annual trend of PM2.5 in NYC

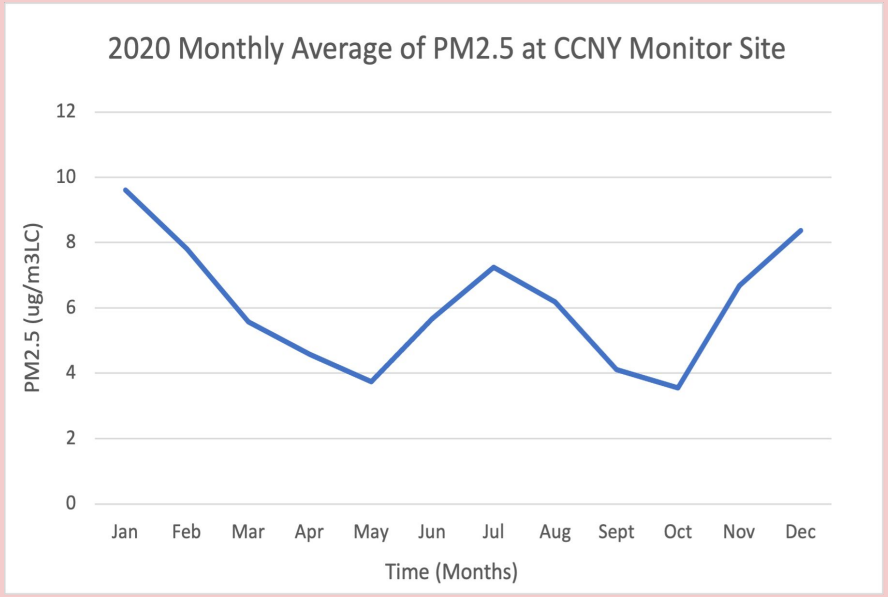


The annual PM2.5 shows a general trend of a decrease from 2016 to 2020.

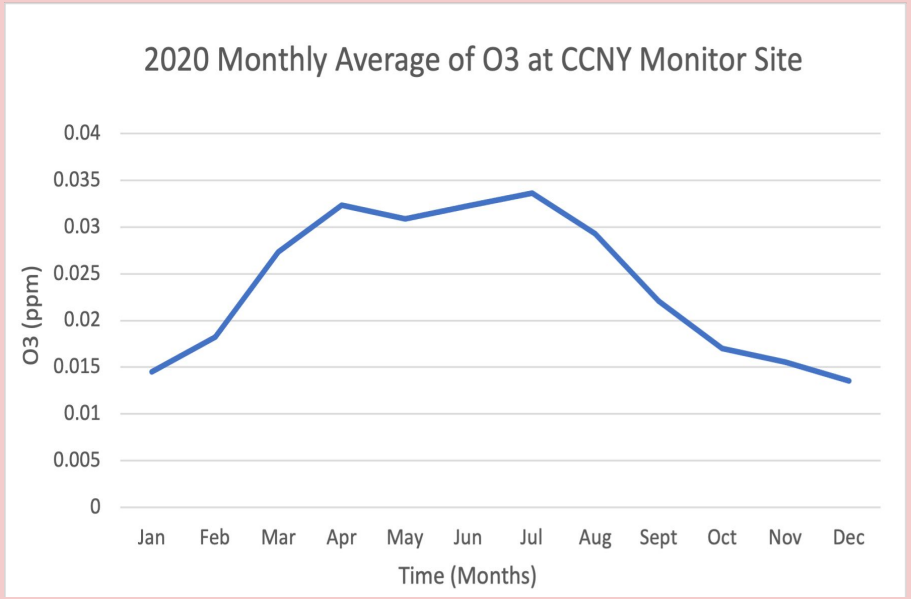
Lowest level PM2.5 likely related to the NYC Pandemic Lockdown and reduction of anthropogenic emissions.

A slow increase between 2020 and 2021 puts a pause on this pattern, possibly because of the recovery of in New York City.

Results: Monthly Variation

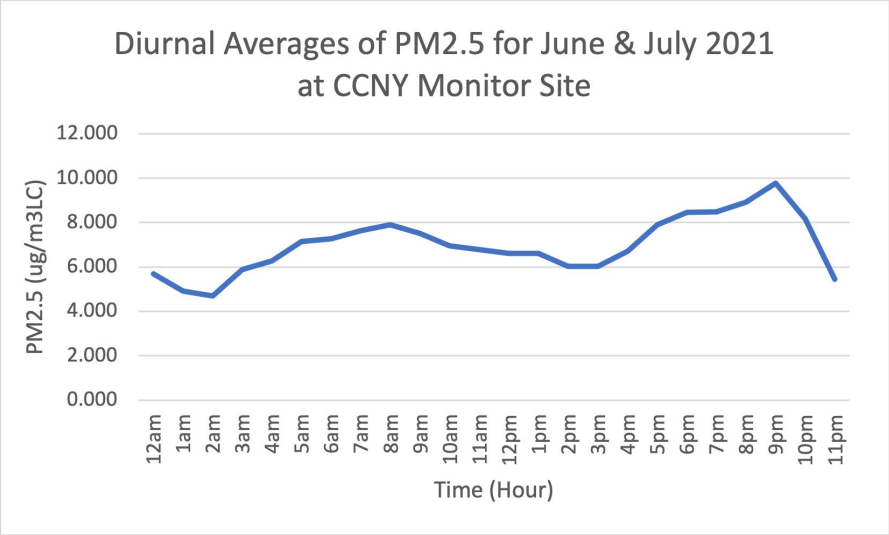


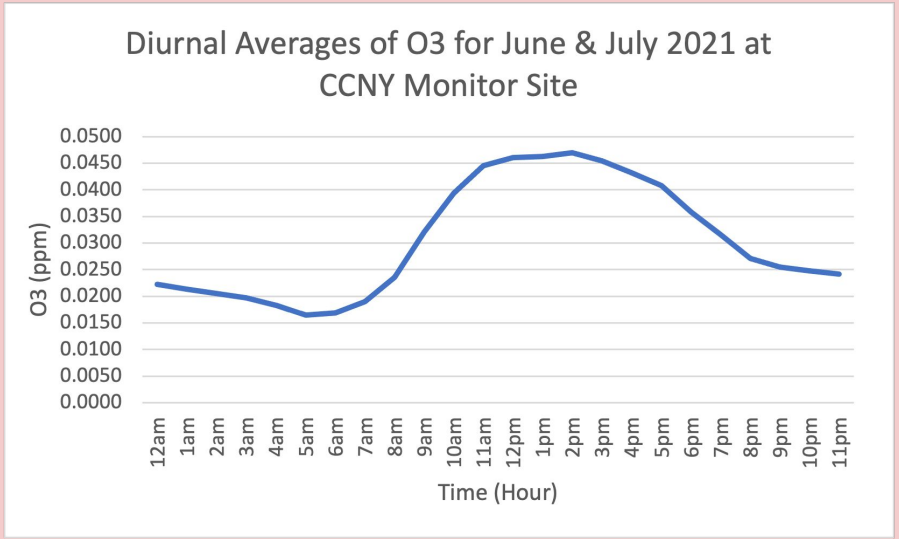
Higher PM2.5 in summer months probably due to more chemical production, wildfire smoke transport, local emissions, etc. Higher in Winter probably due to weak dilution of pollutants and local emissions under cold weather, etc.



Increase of O3 during the hotter months (Jun-Aug) as compared to the rest of the year. Stronger chemical production of O3 in summer due to strong sunlight, high temperature and emissions (NOx, VOCs) interaction.

Results: Diurnal Variation

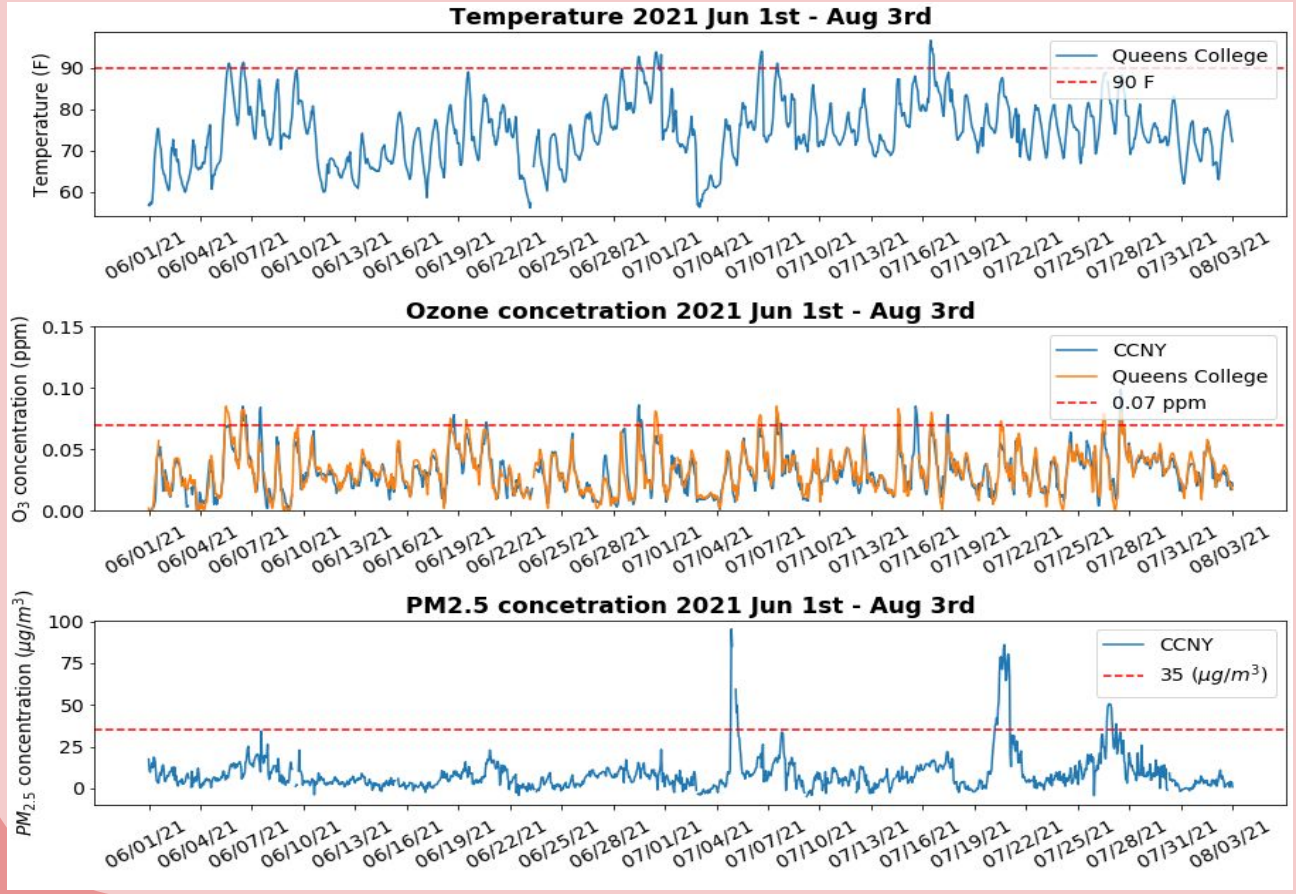




There are two peaks of PM2.5, one at 7am and the other at 9pm. This may be because of morning rush hour and people returning home at night that emit more particles.

There is a peak of Ozone at 2pm. Overall, we see an increase of Ozone levels from about 8am to 5pm. This is because those are the hours when the sunlight is usually strong and temperature is high.

Results: Daily Variation and Pollution Episodes



High O3 on the hot days (June 5-7, 29-30, July 6-7, & 16)

Large PM2.5 on July 4-5 due to the fireworks

Large PM2.5 on July 20-21 and 26 due to the wildfire smoke transport from the Northwest US and Canada (evidence from NOAA satellite and CCNY-lidar observations)

Conclusions:

- The annual average of PM2.5 shows a decrease trend during 2016-2020, particularly lowest level in 2020 that was probably due to the emission reduction and NYC Pandemic lockdown.
- In June-July, high-level of O3 episodes (>70 ppb) were indicated on the hot days in NYC area.
- PM2.5 shows very high levels on July 4-5 due to the fireworks, and on July 20 and 26 due to the wildfire smoke transport from the northwest US and Canada.
- With monthly average, the O3 are usually higher in summer due to strong chemical production.
- The PM2.5 indicates higher levels in winter and summer, respectively.
- By hourly average, the O3 are higher at noon time due to strong sunlight and high temperature. The PM2.5 is usually higher in the morning traffic rush hours and late night.

References

1. https://ww2.arb.ca.gov/resources/inhalable-particulate-matter-and-health
2. https://ozonewatch.gsfc.nasa.gov/facts/
3. https://www.epa.gov/ozone-pollution-and-your-patients-health/what-ozone
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Acknowledgements

to

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Dynamics of PM2.5 and Ozone Pollution in the NYC area

Alexus Lee[1,4], Jendy DeLeon[1,3], Dingdong Li[2]
1 - NOAA CREST HIRES Intern 2- The City College of New York
3- Manhattan Center for Science and Math 4- Hunter College High School

Background and Introduction:

- **What is PM2.5?** - PM stands for airborne particulate matter (a mixture of many different chemicals) less than 2.5 microns in diameter.
- **What is ozone?** - Tropospheric, or ground level ozone, is not emitted directly into the air, but is created by chemical reactions between oxides of nitrogen (NOx) and volatile organic compounds (VOC).

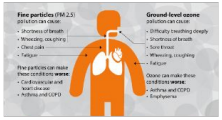
- **How do they form?**
  - **PM2.5** is formed as a result of burning fuel and chemical reactions that take place in the atmosphere.
  - **Ozone** forms in both the stratosphere and the troposphere in the earth's atmosphere. **Stratospheric ozone** is formed naturally by chemical reactions involving solar ultraviolet radiation (sunlight) and oxygen molecules. **Tropospheric ozone** is formed by the interaction of sunlight, particularly ultraviolet light, with hydrocarbons and nitrogen oxides, which are emitted by automobile tailpipes and smokestacks.

Objectives:

1. Study the yearly trend of PM2.5 and Ozone in NYC.
2. Study the seasonal variation/characteristics of PM2.5 and Ozone.
3. Study the diurnal dynamics of PM2.5 and Ozone.
4. What factors can impact the PM2.5 and Ozone?

Societal Impacts:

- **PM2.5** and **Ozone** are two types of major air pollutants in US and long-term exposure to PM2.5 and ozone aggravates various lung diseases.



(Source: adapted from https://www.pca.state.mn.us/air)

Environmental Impacts:

- High levels of **PM2.5** can also impact the environment. Particulate matter pollution contributes to climate change; particulate matter results in more droughts and it prevents heat from escaping the planet. PM pollution can also result in acid rain.
- Ground **Ozone** gas negatively affects vegetation by interfering with the process of photosynthesis. This affects entire ecosystems, possibly leading to the loss of species diversity.

Methodology:

We used online databases such as nyaqinow.com to find and create graphs in Microsoft Excel based on Air Quality Trends in NYC.

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Graphs & Images:

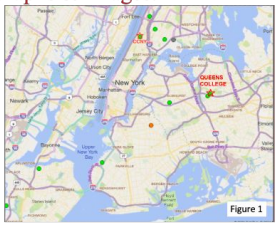

Figure 1

Figure 2

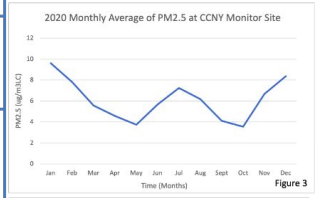

Figure 3

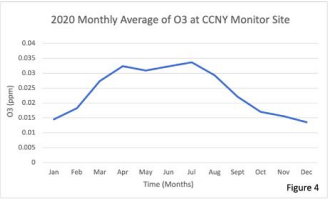

Figure 4

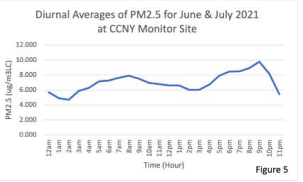

Figure 5

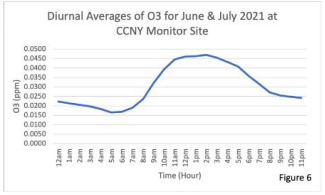

Figure 6

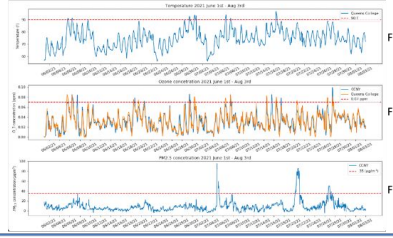
Figure 7

Figure 8

Figure 9

Results:

Fig.1: The map shows the locations of the CCNY and Queens College Air Quality and Temperature Monitoring Sites.
Fig.2: The annual PM2.5 shows a general trend of a decrease from 2016 to 2020. Lowest level PM2.5 likely related to the NYC Pandemic Lockdown and reduction of anthropogenic emissions. A slow increase between 2020 and 2021 puts a pause on this pattern, possibly because of the recovery of in New York City.
Fig.3: There are higher PM2.5 levels in summer months probably due to more chemical production, wildfire smoke transport, local emissions, etc. and there are higher PM2.5 levels in winter probably due to weak dilution of pollutants and local emissions under cold weather, etc.
Fig.4: There is an Increase of O3 during the hotter months (Jun-Aug) as compared to the rest of the year because Ozone production increases due to strong sunlight, high temperature and emissions (NOx, VOCs) interaction.
Fig.5: There are two peaks of PM2.5, one at 7am and the other at 9pm. This may be because of morning rush hour and people returning home at night that emit more particles.
Fig.6: There is a peak of Ozone at 2pm. Overall, we see an increase of Ozone levels from about 8am to 5pm. This is because those are the hours when the sunlight is usually strong, and the temperature is high.
Fig.7, 8, & 9: Higher Ozone levels on the hot days (June 5-7, 29-30, July 6-7, & 16). High levels of PM2.5 on July 4-5 due to the fireworks. Higher PM2.5l levels on July 20-21 and 26 due to the wildfire smoke transport from the Northwest US and Canada (evidence from NOAA satellite and CCNY-lidar observations).

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