How does cloud coverage affect PM 2.5 measurements?

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1/28/21

Abstract:

Our research question is: how does cloud coverage affect PM 2.5 measurements? Our objective was to observe 15-20 days of december to not only find the correlation between air quality and cloud coverage but as well we're as how air pollution affects New York on the whole.The methods that we used for our research were the Purple Air website (PM2.5) , and the GLOBE Observer app. When using the globe observer app we submitted our own observations and got paired with a satellite nearby. With these tools, we were able to collect all of the data that we needed to prove our hypothesis. We all just set up a certain time throughout the days to collect our data, and try to be accurate as possible. Our hypothesis ended up being partially accepted. There was in fact a correlation between cloud coverage and PM 2.5, however not the kind we predicted. The result we found in this experiment was the greater the cloud coverage, the lower the PM 2.5 values was, as shown in our data. The best example of this was on December 18th when the cloud coverage was very overcast (95-100%) the air quality was worse(8-22). Our results also showed that the cloud coverage tracked by satellites was also overcast (100.1%)

Key Words: cloud coverage, aerosol, PM 2.5

Research Question: how does cloud coverage affect PM 2.5 measurements?

Hypothesis: We think that air quality and cloud coverage are connected because we noticed that at night time when there are less clouds, the air quality was worse. Now this could mean that there is absolutely no correlation between the two, but some “coincidences” are a bit too hard to ignore.

Introduction and Review of Literature:

We have taken data regarding cloud coverage and air quality. We used the PurpleAir protocol along with the GLOBE observer program. But before we were even able to dive into our project, we had to do some background research. We read many articles regarding air pollution, cloud visibility, cloud opacity and aerosols. Now you might be wondering what each of these things are, so I’ll break it down for you. Cloud opacity describes how much light passes through clouds, and through which you can even see. In most cases, the opacity of clouds will vary from cloud edge to cloud center, or from one cloud to another. Air pollution is a type of environmental pollution that affects the air and is usually caused by smoke or other harmful gases, mainly oxides of carbon, sulphur and nitrogen. Cloud coverage is the fraction or percentage of sky that is covered by clouds. But what you might not know is how the two are connected. The total number of particles in the sky can block incoming sunlight, which can usually be displayed in the world's most polluted cities. Aerosols are any small particle or liquid droplet suspended into the atmosphere. This research helped us come to somewhat of a conclusion that pollution and aerosols will play a big part in our data results. Pollution not only affects air quality levels but also how much sunlight can peer through clouds. But we were still left with one overall question, what’s the connection between cloud coverage and air quality (PM 2.5)?

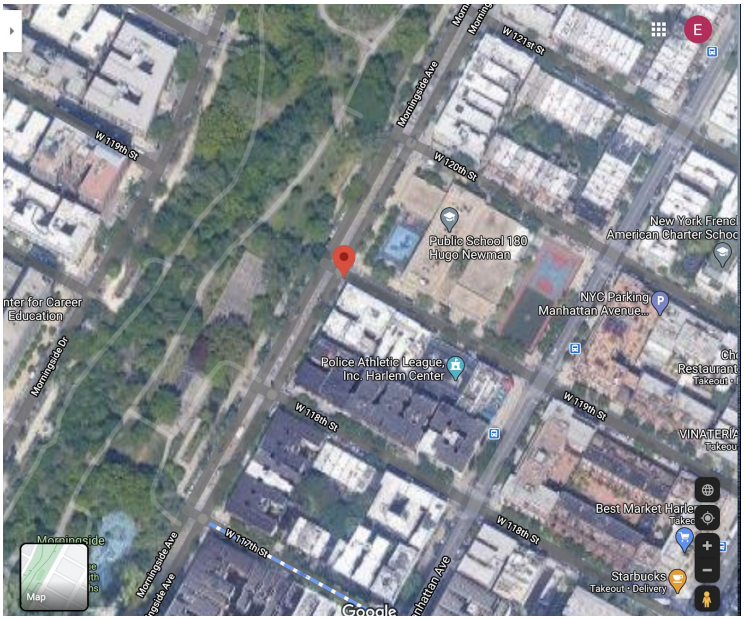
Procedure:

1. Go to your particular spot and get your data for your research.
2. If you're doing the Purple air protocol you want to make sure that you're taking a picture with a full view of the sky.
3. If you're doing the GLOBE Observer App, then observe the clouds and the sky then check the boxes on what you see to receive your data from the satellites.
4. Try to get the data for the air quality around the same time each day
5. Then record your data on your file/doc to be used for later.
6. Melany- Air Quality (PM 2.5) and take pictures at around 4:15 each day
7. Ben- Air Quality (PM 2.5) and take pictures at around 10:00 each day
8. Evan- GLOBE Observer Cloud Coverage 8 am
9. Julia- GLOBE Observer Cloud Coverage 5 pm

Manhattan Study Sites: Harlem, Upper West Side, Lower East Side

Study Site 1: 40.807493, -73.956731

Manhattan, New York has a very special type of climate one day it could be really cold in the middle of December, and the next day it could be warm with temperatures as high as 62°F. Our land cover includes an urban infrastructure and multiple rivers around the island.



Study Site 2:

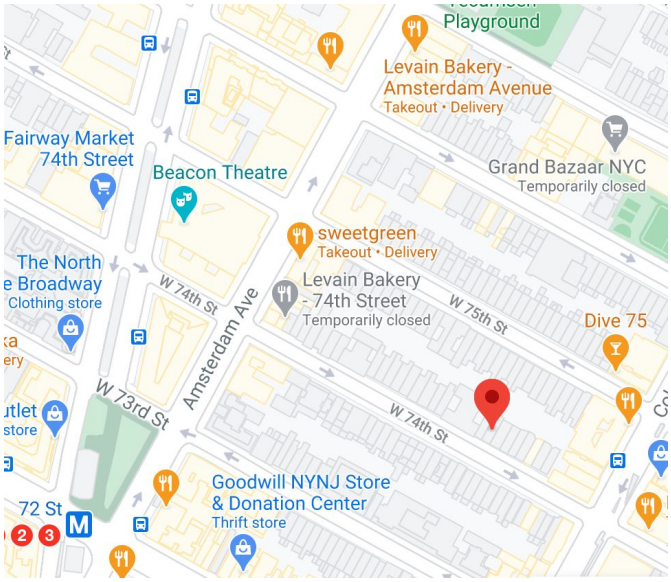
40°42'36.0"N 74°00'35.3"W

Manhattan, New York

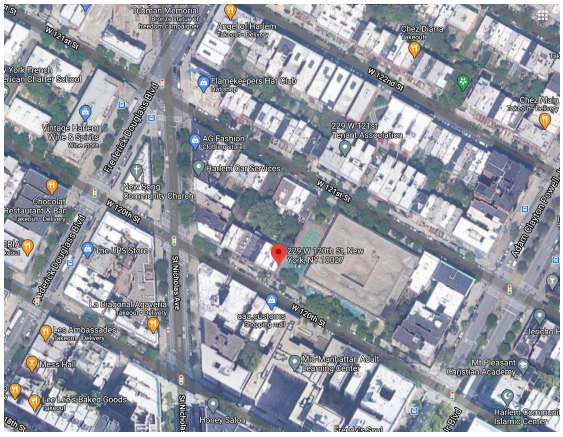
Humid subtropical climate. Winter. It can be 11 °F one day then 68 °F the next. In the middle of the city so not next to any river.

Study Site 3:

40.779324, -73.979229



Study Site 4:
West 120th St., between St Nicholas and Adam Clayton Powel
40.80655186754874, -73.95204131561435



New York is very unpredictable. One day it could be 65°F degrees and the next it could be 30°F. Our land contains many large urban structures and is surrounded by rivers.

Results:

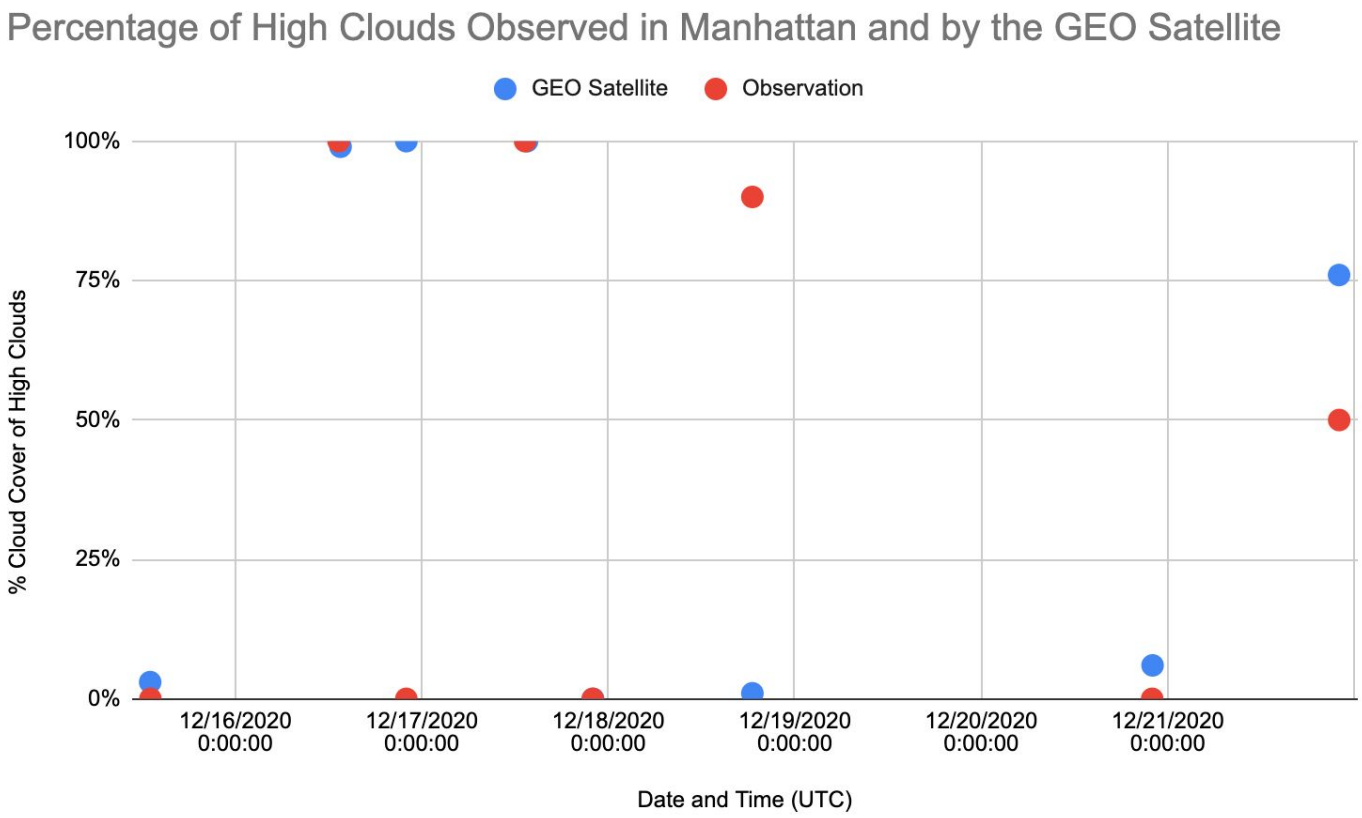


Figure 1. I've observed on this graph that the high clouds are not as high of a percentage as we observed, the GEO satellite observed that the percentage was low most days.

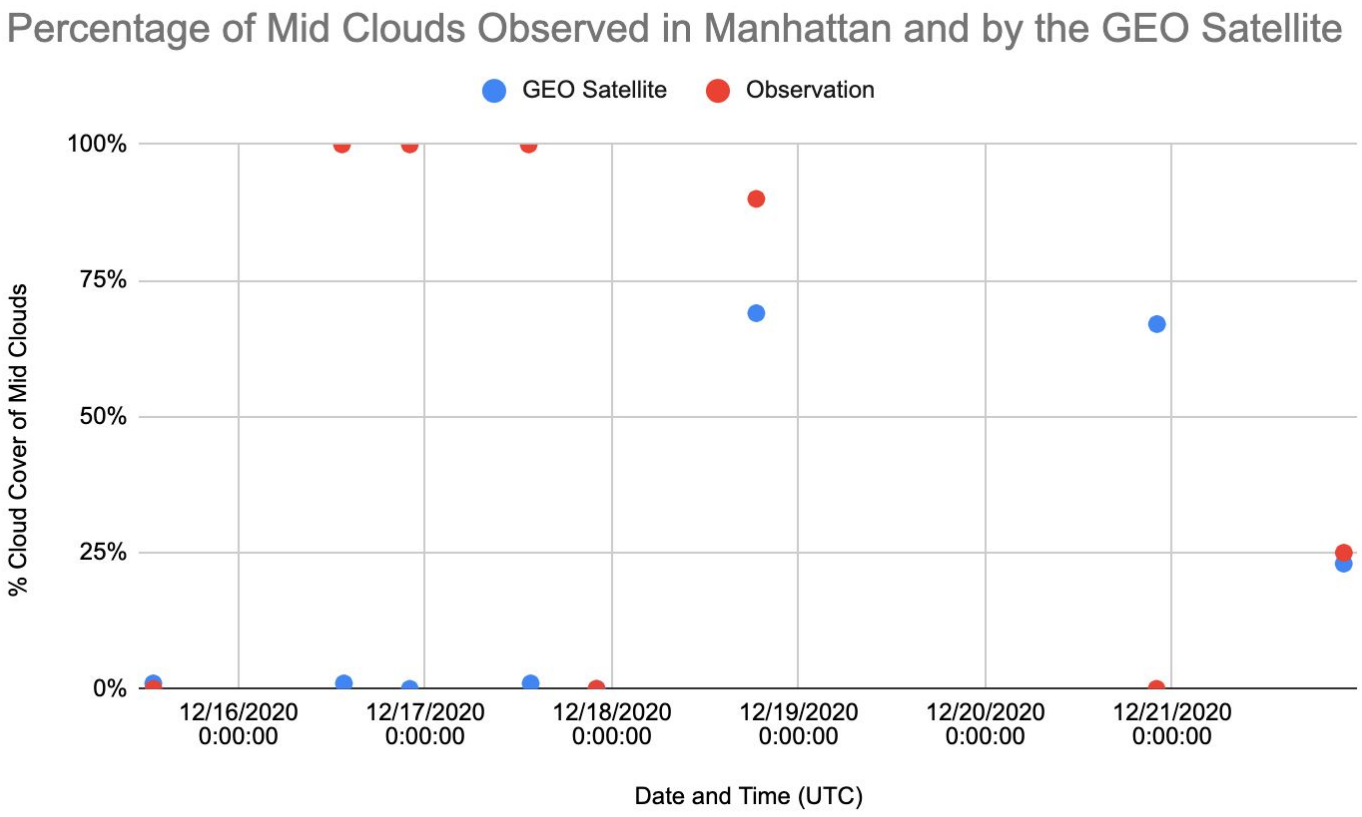


Figure 2. I observed that these mid level clouds are very low with what the satellite caught than what we observed.

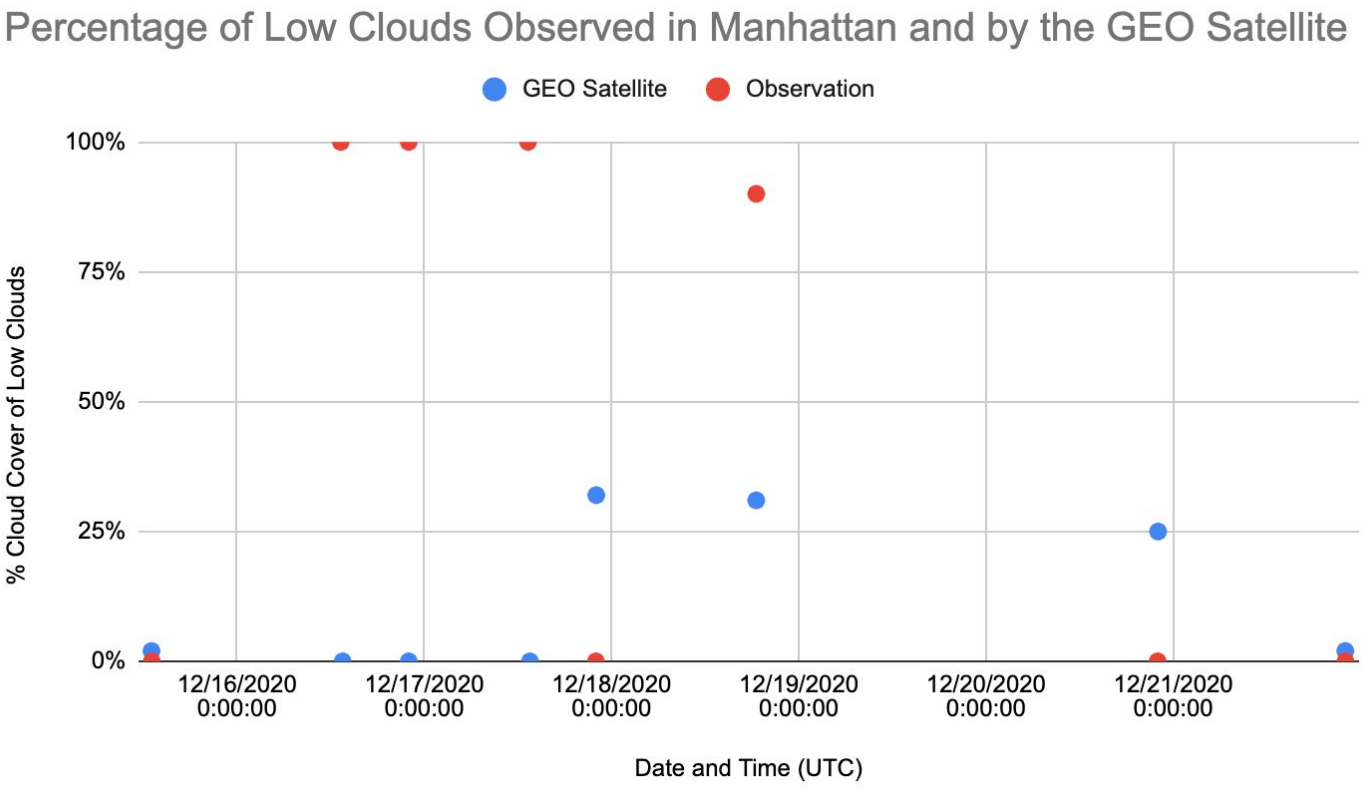


Figure 3. I observed that the percentage of these low clouds are also very low as what the satellite caught, compared to

what we observed on these days.

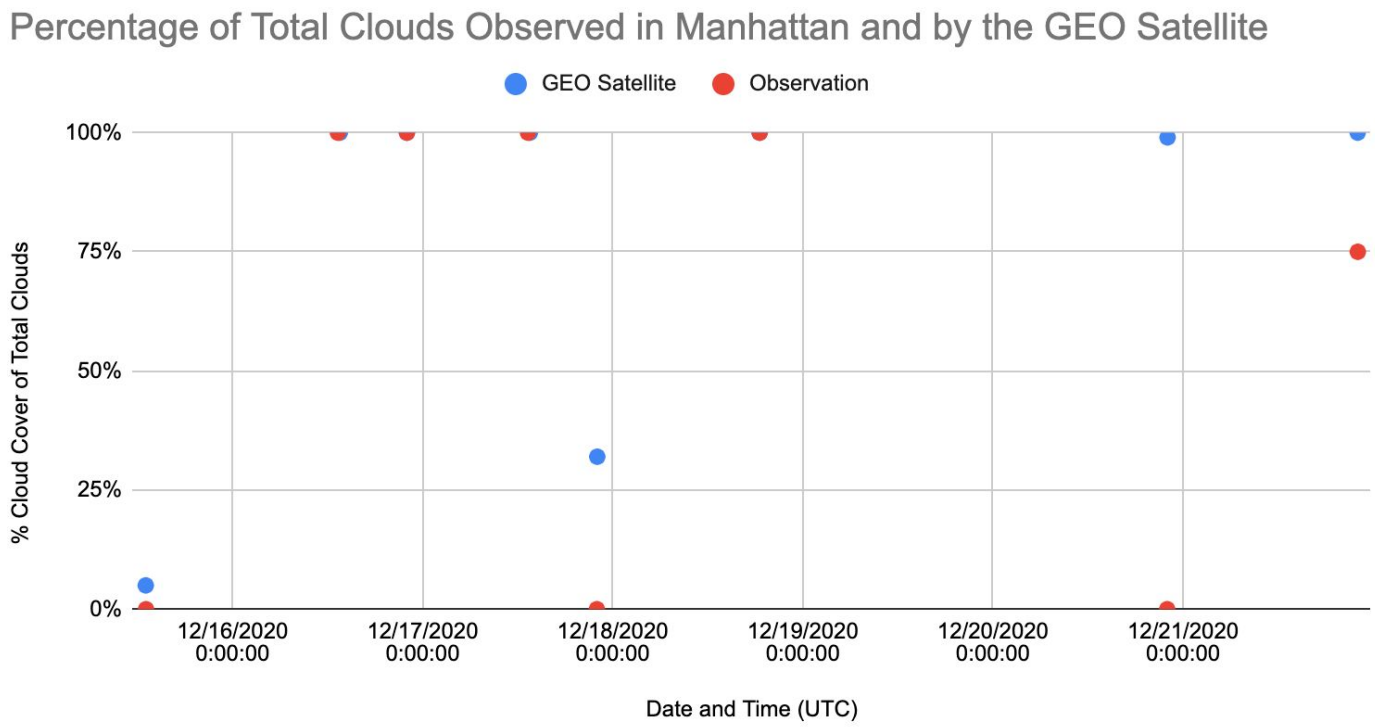


Figure 4. I observed that the percentage of the total cloud cover was pretty standard based on all of their percentages averaged on these days.

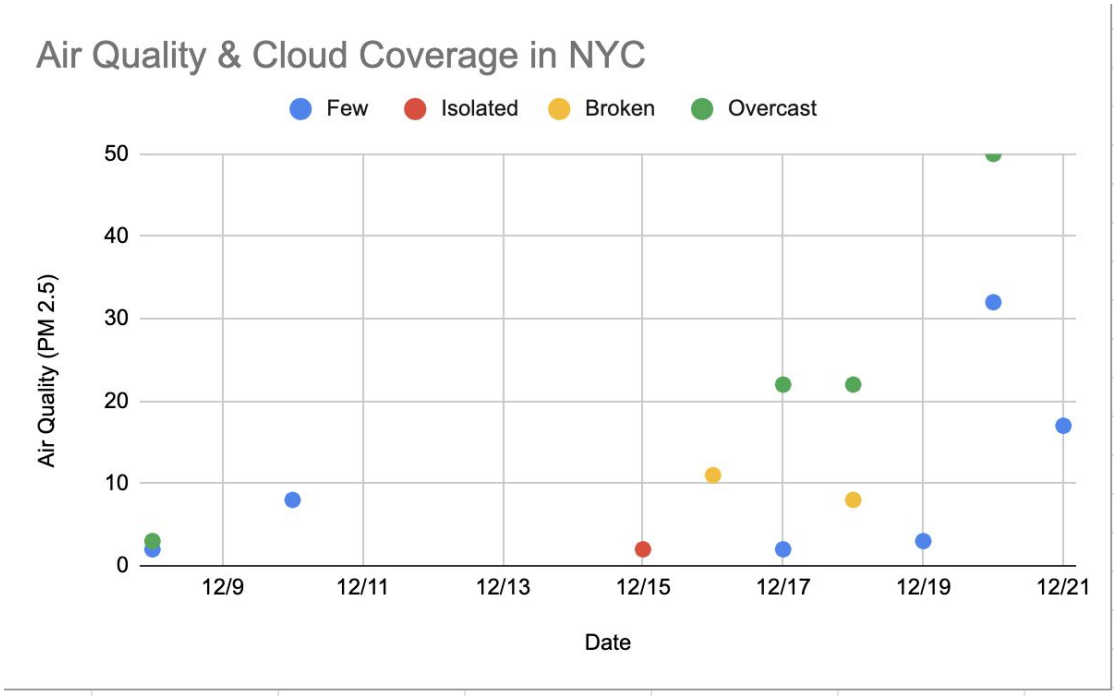


Figure 5. PM 2.5 vs Cloud Coverage

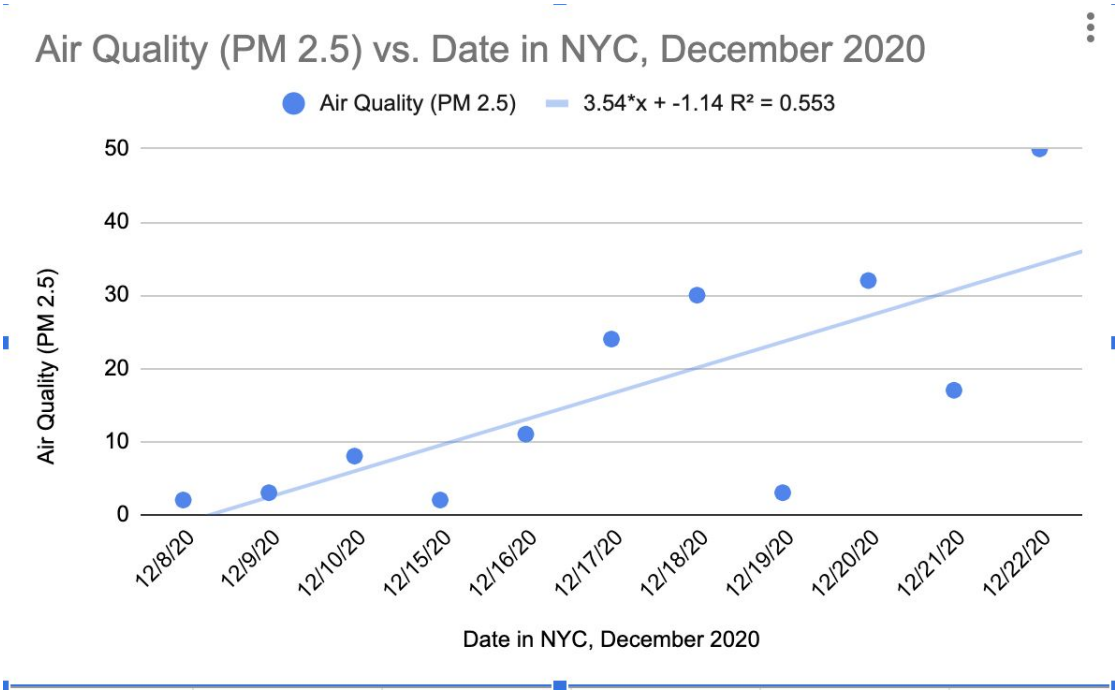


Figure 6: After recording all the data and creating a data table, we found that the average air quality was 16.9 PM 2.5 PM and the average cloud coverage was about 55.32%. There is also a noticeable positive trendline in our data of about a 3.54 slope.

Satellite Matches:

Satellite		GEO	Your Observation
Universal Date/Time 2020-12-15		13:03	13:05
Latitude Range Longitude Range		40.49 to 41.13 -74.28 to -73.64	**Latitude 40.807600** **Longitude -73.956900**
Total Cloud Cover		Few 5.31%	**No Clouds Observed**
HIGH	Cloud Cover Cloud Altitude Cloud Phase Cloud Opacity	Few (3.03%) 7.43 (km) Ice 241.75 (K) Transparent	No Clouds Observed
MID	Cloud Cover Cloud Altitude Cloud Phase Cloud Opacity	Few (0.76%) 2.59 (km) Ice 260.83 (K) Transparent	No Clouds Observed
LOW	Cloud Cover Cloud Altitude Cloud Phase Cloud Opacity	Few (1.52%) 0.99 (km) Mixed 269.43 (K) Transparent	No Clouds Observed
Corresponding NASA Satellite Images. Click to view image --->		***GOES-16*** Visible  Infrared  GEO Tutorial	Sky Visibility : Clear Sky Color : Blue

Satellite		GEO	Your Observation
Universal Date/Time 2020-12-16		13:33	13:18
Latitude Range Longitude Range		40.49 to 41.13 -74.28 to -73.64	**Latitude 40.807500** **Longitude -73.956900**
Total Cloud Cover		Overcast 100.00%	**Overcast (>90%)**
HIGH	Cloud Cover Cloud Altitude Cloud Phase Cloud Opacity	Overcast 99.24% 8.54 (km) Mixed 237.55 (K) Opaque	Cirrostratus Overcast (>90%) Translucent
MID	Cloud Cover Cloud Altitude Cloud Phase Cloud Opacity	Few (0.76%) 5.96 (km) Water 252 (K) Translucent	Altostratus Overcast (>90%) Translucent
LOW	Cloud Cover Cloud Altitude Cloud Phase Cloud Opacity		Nimbostratus Cumulonimbus Stratus Stratocumulus Overcast (>90%) Translucent
Corresponding NASA		***GOES-16*** Visible Infrared	Sky Visibility : no report Sky Color : no report

Data & Research Day 2

North

Date/Time (UTC): **12/16/2020 22:01:00**

Data Source: **GLOBE Observer App**

Latitude/Longitude: **40.7788, -73.9796 (40° 46' 43.68", -73° 58' 46.56")**

Organization: **United States of America Citizen Science**

Site: **18TWL861147**

Total Sky

Cloud Cover: **Overcast (90-100%)**

High Level Clouds

Short Lived Contrails: **0**

Persistent Non-Spreading Contrails: **0**

Persistent Spreading Contrails: **0**

Mid Level Clouds

Cloud Types: **Altostratus**

Cloud Cover: **Overcast (90-100%)**

Opacity: **Opaque**

Low Level Clouds

Cloud Types: **Nimbostratus, Stratus**

Cloud Cover: **Overcast (90-100%)**

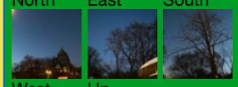
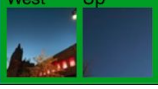
Opacity: **Opaque**

Surface Conditions: **Snow/Ice, Raining/Snowing**

NASA Cloud Observation and Satellite Match

Satellite		GEO	Your Observation
Universal Date/Time 2020-12-16		22:03	22:01
Latitude Range Longitude Range		40.46 to 41.1 -74.3 to -73.66	**Latitude 40.779500** **Longitude -73.978600**
Total Cloud Cover		Overcast 100.00%	**Overcast (>90%)**
HIGH	Cloud Cover Cloud Altitude Cloud Phase Cloud Opacity	Overcast 100.00% 12.31 (km) Ice 216.39 (K) Opaque	
MID	Cloud Cover Cloud Altitude Cloud Phase Cloud Opacity		Altostratus Overcast (>90%) Opaque
LOW	Cloud Cover Cloud Altitude Cloud Phase Cloud Opacity		Nimbostratus Stratus Overcast (>90%) Opaque
Corresponding NASA Satellite Images.		***GOES-16*** Visible Infrared	Sky Visibility : no report Sky Color : no report

NASA Cloud Observation and Satellite Match

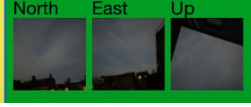
Satellite		GEO	Your Observation
Universal Date/Time 2020-12-17		22:03	22:00
Latitude Range Longitude Range		40.46 to 41.1 -74.29 to -73.65	**Latitude 40.779300** **Longitude -73.973800**
Total Cloud Cover		Scattered 31.75%	**No Clouds Observed**
HIGH	Cloud Cover Cloud Altitude Cloud Phase Cloud Opacity	No Clouds	No Clouds Observed
MID	Cloud Cover Cloud Altitude Cloud Phase Cloud Opacity	No Clouds	No Clouds Observed
LOW	Cloud Cover Cloud Altitude Cloud Phase Cloud Opacity	Scattered 31.75% 0.89 (km) Water 268.36 (K) Transparent	No Clouds Observed
Corresponding NASA Satellite Images. Click to view image --->		***GOES-16*** Visible  Infrared 	Sky Visibility : Unusually Clear Sky Color : Deep Blue North East South  West Up 

Satellite		GEO	Your Observation
Universal Date/Time 2020-12-18		18:33	18:18
Latitude Range Longitude Range		40.49 to 41.13 -74.28 to -73.64	**Latitude 40.807500** **Longitude -73.956900**
Total Cloud Cover		Overcast 100.01%	**Overcast (>90%)**
HIGH	Cloud Cover Cloud Altitude Cloud Phase Cloud Opacity	Few (0.81%) 6.71 (km) Ice 242.57 (K) Transparent	 Cirrostratus Overcast (>90%) Opaque
MID	Cloud Cover Cloud Altitude Cloud Phase Cloud Opacity	Broken 68.55% 2.51 (km) Mixed 261 (K) Translucent	 Altocumulus Overcast (>90%) Opaque
LOW	Cloud Cover Cloud Altitude Cloud Phase Cloud Opacity	Scattered 30.65% 1.62 (km) Water 263.44 (K) Translucent	 Cumulonimbus Cumulus Overcast (>90%) Opaque
Corresponding NASA Satellite Images. Click to view image --->		***GOES-16*** Visible  Infrared  GEO Tutorial	Sky Visibility : no report Sky Color : no report

NASA Cloud Observation and Satellite Match

Satellite		GEO	Your Observation
Universal Date/Time 2020-12-20		22:03	22:00
Latitude Range Longitude Range		40.46 to 41.1 -74.3 to -73.66	**Latitude 40.776500** **Longitude -73.982200**
Total Cloud Cover		Overcast 99.15%	**No Clouds Observed**
HIGH	Cloud Cover Cloud Altitude Cloud Phase Cloud Opacity	Few (6.78%) 6.29 (km) Ice 251.26 (K) Translucent	No Clouds Observed
MID	Cloud Cover Cloud Altitude Cloud Phase Cloud Opacity	Broken 66.95% 4.46 (km) Mixed 256.67 (K) Translucent	No Clouds Observed
LOW	Cloud Cover Cloud Altitude Cloud Phase Cloud Opacity	Scattered 25.42% 1.34 (km) Water 267.4 (K) Translucent	No Clouds Observed
Corresponding NASA Satellite Images. Click to view image --->		***GOES-16*** Visible  Infrared  GEO Tutorial	Sky Visibility : Clear Sky Color : Blue

NASA Cloud Observation and Satellite Match

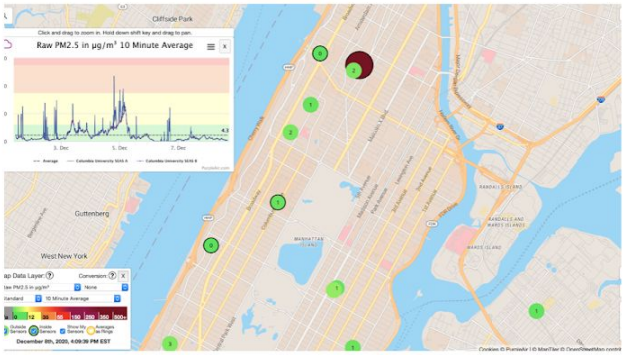
Satellite		GEO	Your Observation
Universal Date/Time 2020-12-21		22:03	22:04
Latitude Range Longitude Range		40.46 to 41.1 -74.3 to -73.66	**Latitude 40.779400** **Longitude -73.978500**
Total Cloud Cover		Overcast 100.00%	**Broken (50-90%)**
HIGH	Cloud Cover Cloud Altitude Cloud Phase Cloud Opacity	Broken 75.78% 7.11 (km) Ice 244.93 (K) Transparent	 Cirrocumulus Scattered (25-50%) Transparent
MID	Cloud Cover Cloud Altitude Cloud Phase Cloud Opacity	Isolated 22.66% 5.29 (km) Ice 254.37 (K) Transparent	 Altocumulus Isolated (10-25%) Transparent
LOW	Cloud Cover Cloud Altitude Cloud Phase Cloud Opacity	Few (1.56%) 1.1 (km) Water 269.48 (K) Translucent	
Corresponding NASA Satellite Images. Click to view image --->		***GOES-16*** Visible  Infrared  GEO Tutorial	Sky Visibility : no report Sky Color : no report North East Up 

Air Quality Story:

12/8/2020

West 120th St

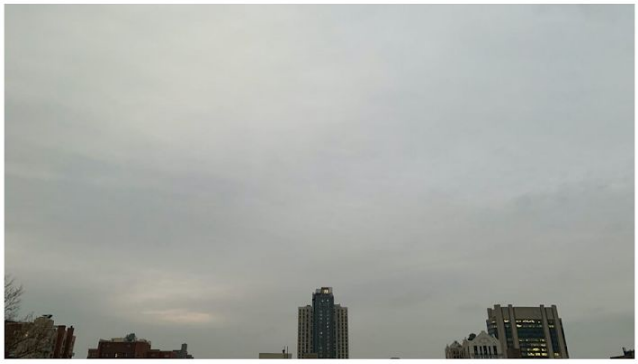
The sky is clear with very few pale blue low to mid level cumulus clouds. The air quality is good and safe to breath. This means Air quality is satisfactory, and air pollution poses little or no risk.



12/8/2020

West 120th St

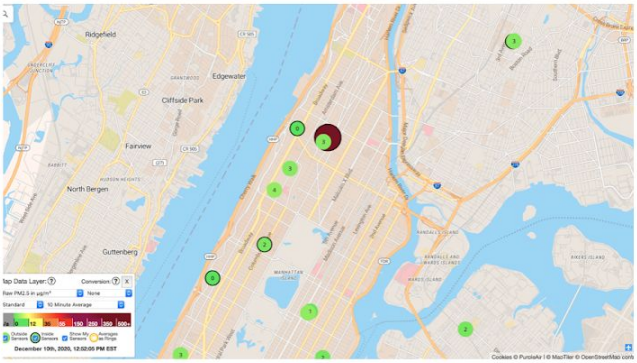
The map shows us the level of air quality within the neighrborhood/area the picture was taken in. On this day the air quality was 2.



12/9/2020

West 120th St

It was an overcast day (>90%) with some Altostratus clouds covering up our sun for most of the day and the amount of cloud capacity was very Opaque.



12/9/2020

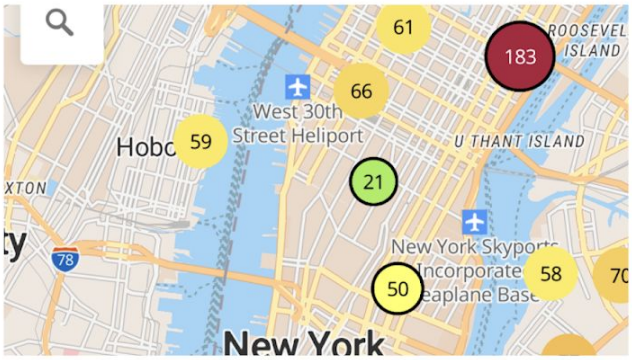
West 120th St

The air quality today was low in pollution just like the day prior so it is safe to go outside. Air quality is satisfactory, and air pollution poses little or no risk.

12/22/2020

Midtown, Madison Ave

The sky is very overcast with altostratus clouds in the sky. The air quality is moderate to unhealthy in some areas. This means members of sensitive groups may experience health effects. The general public is less likely to be affected.



12/22/2020

Midtown, Madison Ave

The air quality today was extremely high compared to other days. It reached 50.

Discussion:

Our results are showing how PM 2.5 measurements relate to cloud coverage. The cloud coverage does not impact how high the PM 2.5 values are daily. PM 2.5 depends on the amount of aerosols in the air but not the cloud cover. It could be really cloudy and have really low PM 2.5 values on the same day. The results of our experiment disprove our initial hypothesis, “we think that air quality (PM 2.5) and cloud coverage are connected because we noticed that at night time when there are less clouds, the air quality was worse.” The best example of this was on December 18th, 2020 when the cloud coverage was very overcast (95-100%) and the PM 2.5 values were higher and worse (8-22 PM 2.5).

Conclusion:

Our research question is: what is the connection between cloud coverage and PM 2.5 measurements? We have concluded that there is very little correlating between the two and that it depends on the aerosols in the air. Both cloud coverage and PM 2.5 values vary from the 8th - 21st and don’t display much of a pattern. From 12/8/2020 to 12/21/2020, we collected data each day. For PM 2.5 measurements, we would take a picture of the sky in our neighborhood and by using the purple air protocol we would see what the air quality level was at that time and then record it. For cloud coverage we would use the GLOBE Observe App to tell us the percentage and amount of clouds in the sky and then record it. By doing that we were surprised by how good it was during most days because we live in a large city called New York, and air pollution is extremely common and can cause many health issues. That’s why we chose the American Lung Association for our “I Make An Impact” work. We chose this organization to not only spread awareness on the consequences of poor air quality but to also connect it back to science and cloud coverage.

We, as a society, need to realize the connection between air pollution/air quality and aerosols. Certain types of aerosols are able to scatter or absorb sunlight which affects climate. The aerosols that are from air pollution are hazardous to human health. Avoid purchasing bundled or supersized aerosol sprays. Some improvements that could help better our methods are the way we organize them and instead of just saving it on a document or a google slide and totally forgetting about them. We could put them straight into the google spreadsheet so it will be easier for each of us to be able to find the data without scrolling through all of each other’s data.

Bibliography/Citations:

- “Air quality changes in New York City during the COVID-19 pandemic,”

- https://www.scientificamerican.com/article/how-does-air-pollution-affect-clouds/
- https://www.youtube.com/watch?v=R8YjREB5sw0
- https://www.scientificamerican.com/article/how-does-air-pollution-affect-clouds/

Acknowledgements:

Thank you to our teachers, the American Lung Association, PurpleAir, Globe Research Center, Angela Rizzi and Dr., Margaret Pippin, and other viewers.

Badge Descriptions/Justifications:

When we started our project, we selected four badges that we wanted to achieve. We chose; I make an Impact, I am a collaborator, I am a STEM professional, and, I am a storyteller. We believe that we attained these goals many times throughout this project. We made an impact by spreading awareness to younger kids in our community and others around the country through a presentation. We connected the American Lung Association to our project by connecting our data back to air pollution and its effects on human behavior and health. We also discovered that air quality and cloud coverage really have no correlation. We collaborated by working with each other within our group and supporting and helping each other along the way. We accepted feedback and collaborated with STEM professionals, Angela Rizzi and Dr. Margaret Pippin to better improve our project and create more sophisticated analyses. Lastly, we told a story but sharing not only each other's data but our own. We didn’t base it off of what professional scientists had already discovered. We based it off of what's out our window and what we as New Yorkers are exposed to every day.