Evaluating the Coastal Environmental Impacts from the COVID-19 Shutdown in New York City

2021 Summer Research Virtual Symposium
August 9, 2021

HIRES students funding was supported by The Pinkerton Foundation

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

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Introduction

- The Coronavirus Disease 2019 (COVID-19) is a respiratory infectious disease from Wuhan, China that was declared a global pandemic by the World Health Organization on March 13, 2020 (Cucinotta et al., 2020)
- The shutdown led to numerous positive and negative environmental impacts regarding water quality and air pollution in urban and coastal areas.
- Numerous studies focusing on evaluating the urban air quality during the COVID-19 lockdown have documented significant reductions in air pollutants concentrations worldwide, associated with reduced emissions from anthropogenic activities, mainly from reduced vehicle activity (Hernández-Paniagua et al., 2021)
- Human activities in the ocean have been radically altered by the COVID-19 pandemic, with reports of port restrictions and changes in consumption patterns impacting multiple maritime sectors, most notably fisheries, passenger ferries and cruise ships (March et al. 2021)

Research Objectives

- To evaluate if there were any changes in air pollution levels and water quality in New York City before and after the Covid-19 shutdown.
- To measure tropospheric Nitrogen Dioxide (NO_2) levels and Colored Dissolved Organic Matter (CDOM) concentrations using satellite data.
- To observe if there's a correlation between air pollution and water quality during the years 2019 - 2021.

NO_2 - Nitrogen Dioxide

- A chemical composition of 1 nitrogen atom and 2 oxygen atoms.
- Primarily enters the atmosphere from the burning of fossil fuels within factories, as well as from vehicle emissions (The Sources and Solutions: Fossil Fuel)

CDOM - Colored Dissolved Organic Matter

- defined as the photoactive fraction of dissolved organic matters in water (Brando and Dekker, 2003).
  - This organic matter is primarily derived from the decomposition products of plant material, bacteria and algae (USGS).
- Very high concentrations of CDOM impedes biological activity (Slonecker et al., 2016).

Hypothesis

- We hypothesize that due to the COVID-19 shutdown both CDOM and NO_2 data will have a close relationship with each other since the lockdown, as discussed in the introduction, could cause a reduction in anthropogenic activity in both, land and sea.
- We believe that a reduction of human interaction with the environment will definitely cause a reduction in NO_2 and CDOM concentration.

Area of Study

- We chose New York City as the study area because it was one of the major cities hit by the COVID -19 outbreak. It is also one of the busiest port cities in the world (American Association of Port Authorities). Additionally, NYC is ranked as one of the most polluted cities in the United States(Culliton 2020), mainly because of population density.

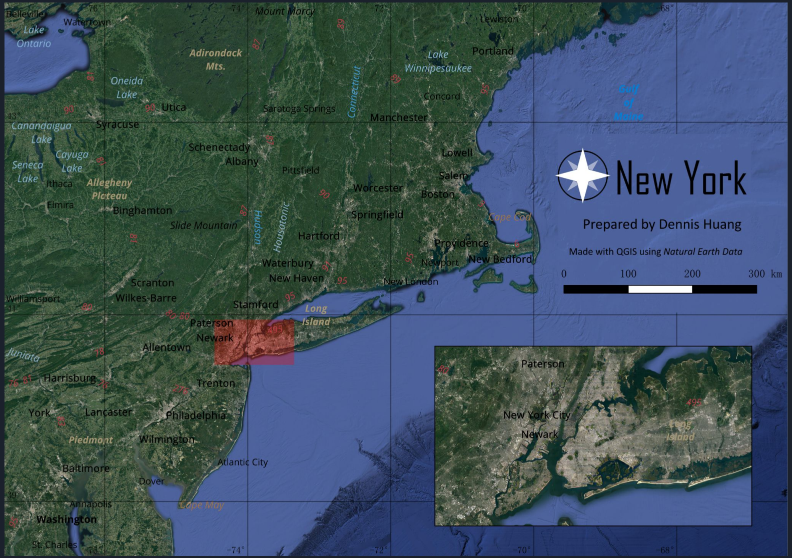


Figure 1. Greater NYC Area

Study site for NO_2 - New York City

Area of Study

- We also decided to pick SI due to its high fossil fuel usage. In addition, its central location relative to the other boroughs, will also provide us with a more accurate result.
- **The northside of Staten Island has been characterized as having the highest annual weighted average number of high ozone days of all boroughs during the year of 2020. (How Staten Island's air pollution served as a dangerous antecedent to the COVID-19 outbreak.)**

Figure 2.
Map of Staten Island, New York

Study site for CDOM New York Bay / Staten Island

Methodology for OMI Aura: NO_2

OMI Aura Satellite:

- To study the chemistry & dynamics of Earth's atmosphere.
- Observes solar backscatter radiation.
- Ultraviolet spectrometer aboard the NASA Aura spacecraft.

1. Collected Ozone Monitoring Instrument (OMI) Aura level 3 data daily from NASA Goddard Earth Sciences Data and Information Center (GES DISC) to compare NO_2 levels from March 2019 to March 2021 (2 years and 30 days).
2. Extracted NO_2 latitude and longitude values from tropospheric data (NetCDF files) by programming in Python and Octave/MATLAB.
3. NO_2 Data plots were created using Matplotlib and formatted using pandas/NumPy packages.
4. Created visualization maps/time series graphs utilizing NASA Giovanni.

Methodology for CDOM (Landsat 8)

- Satellite launched in 2013
- Inclined at 98.2 degrees
- Data for every 16 days
- 9 spectral bands at 30 m resolution

1. Used USGS Earth Explorer to download Landsat 8-OLI Collection 1-Level 2 images
   a. Downloaded 6 satellite images from the years 2016 - 2021(Jan - June timeframe)
2. Unzipped the satellite images and opened Band 3 and Band 4 Geotiff files in QGIS.
3. Extracted lat and long for desired area of study by clipping raster mask and zooming into specific area of study (Staten Island/New York Bay)
4. Imported CDOM algorithm [5.20*(Band3/Band4) ^(-2.76) (Kutser et al., 2005) into raster calculator and created plot of CDOM concentrations.
5. Chose a specific point in the Bay to compare monthly CDOM concentrations.

Figure 3. Landsat 8 Natural Color Image of Lower New York/ New Jersey
Path:13 Row: 32

Results

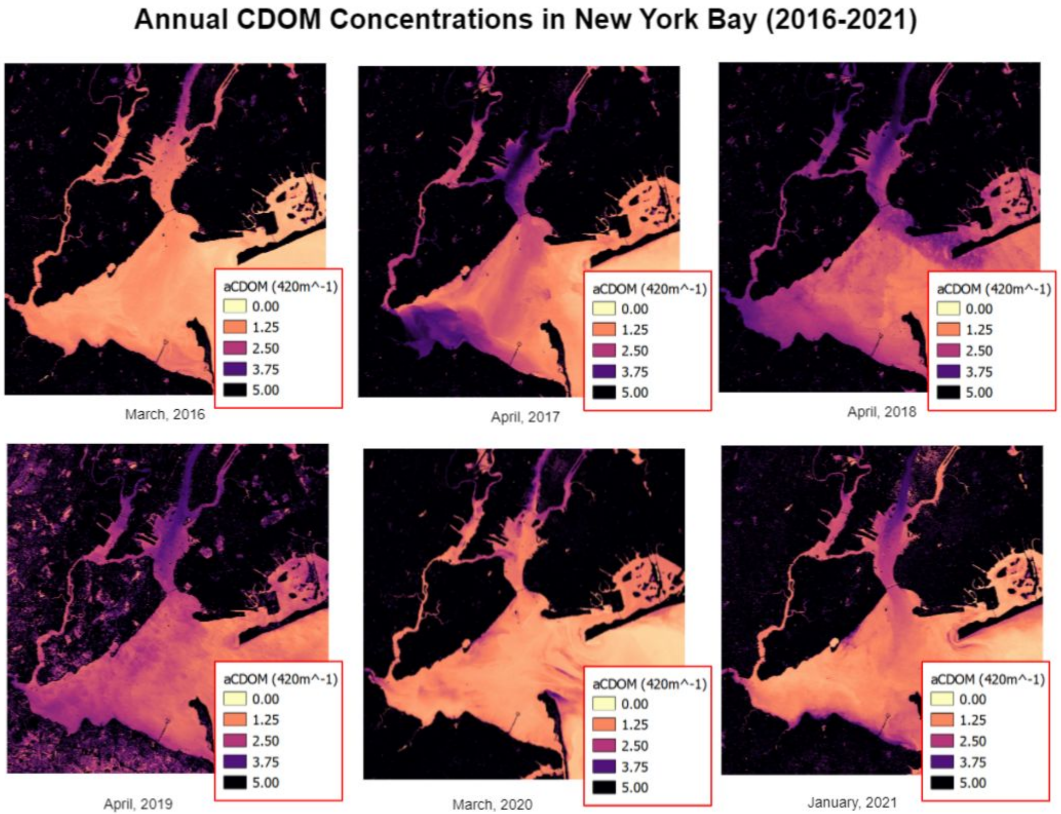
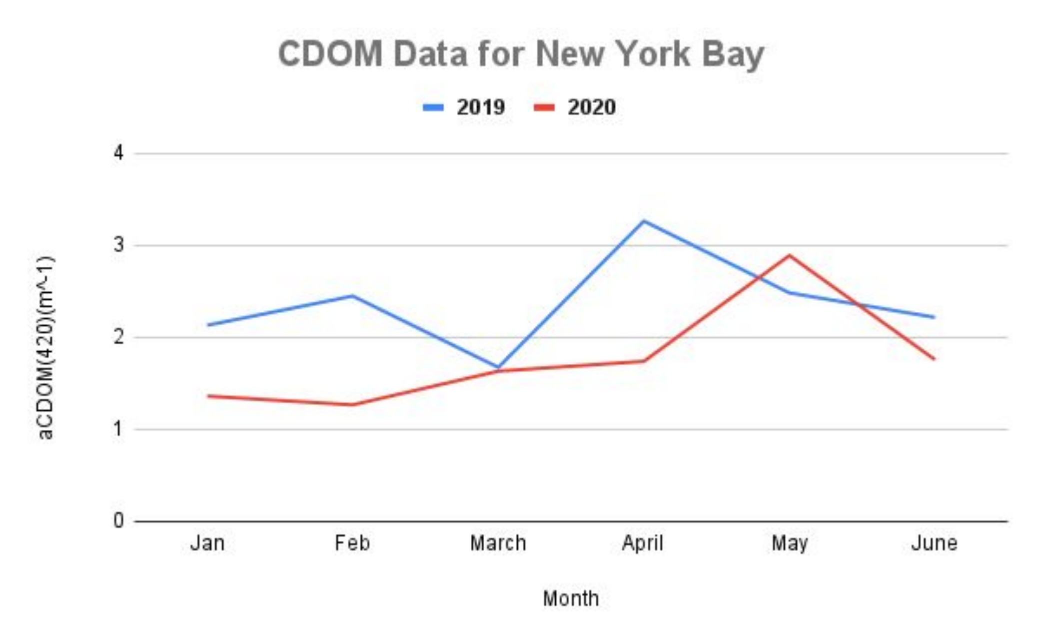


Figure 4. CDOM Concentrations in New York Bay, (2016-2021)

Dark purple indicates high CDOM concentrations
Light orange and yellow indicates lowest concentrations
Black indicates land

CDOM Data Correlation to NYC Ferry Closure



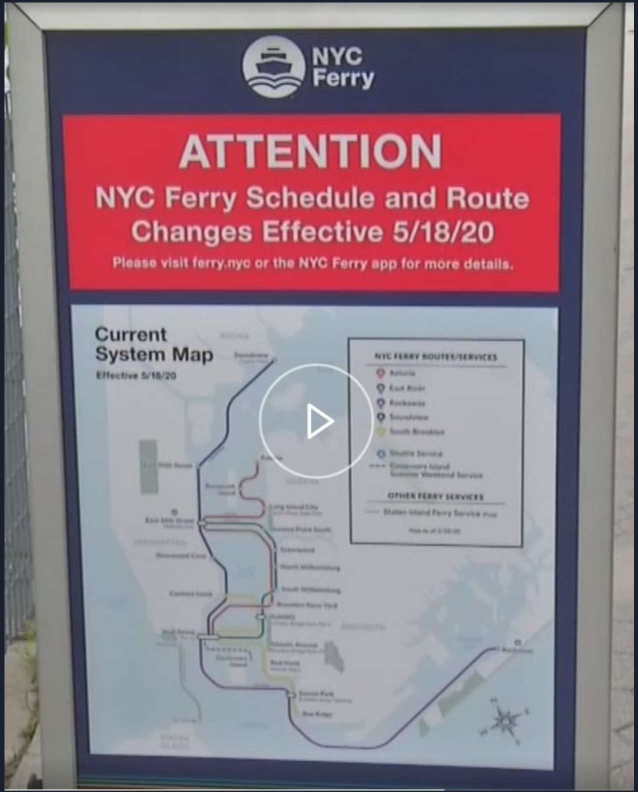


Figure 5. Line graphs of Monthly CDOM concentrations for years 2019 and 2020.

Results of NO_2 Levels Before & After COVID-19

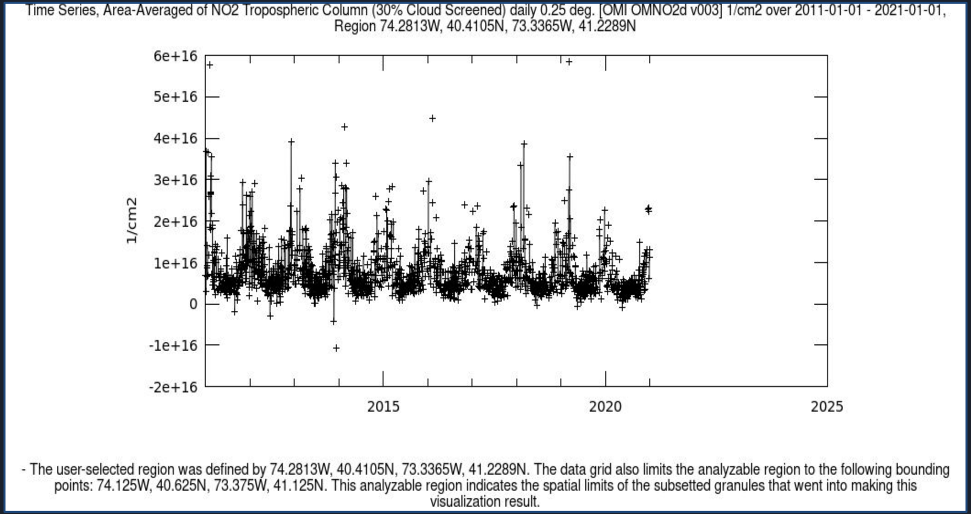
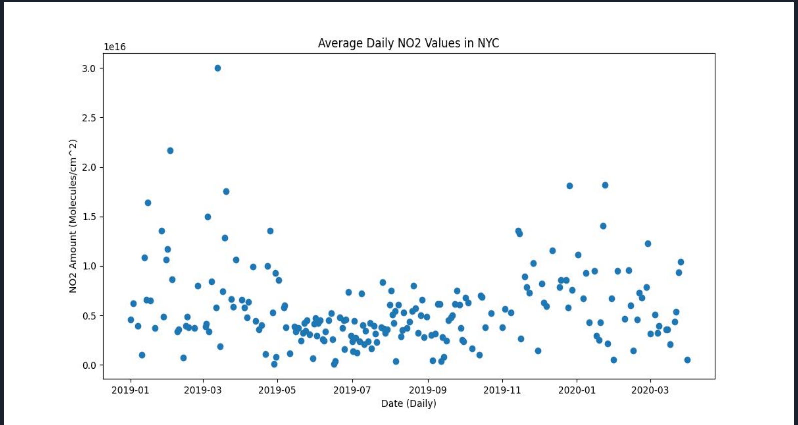


Figure 6.
Time Series, Area Averaged Graph of OMI Aura NO_2 levels from Jan 2011 - Jan 2021



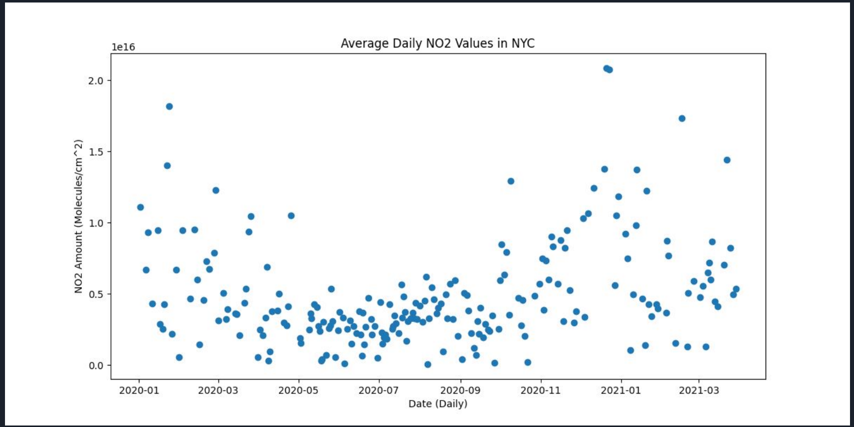
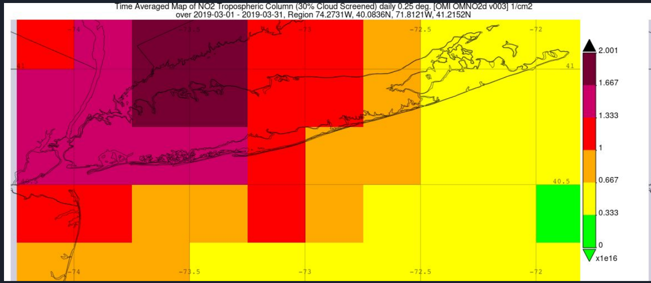
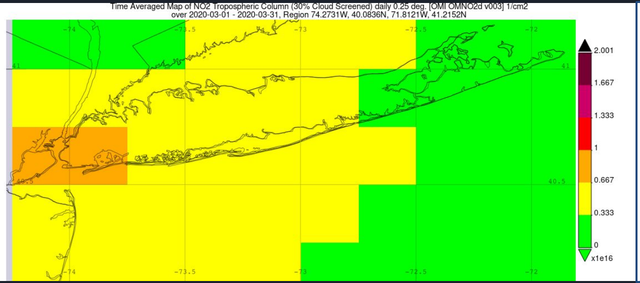


Figure 9-14. Time Averaged Maps of OMI Aura NO_2 levels from March 2019 - 2021 in NYC and Staten Island

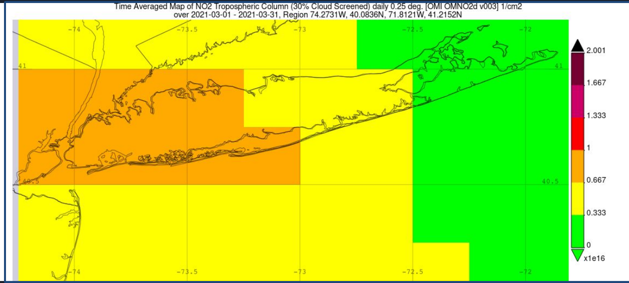
March 2019



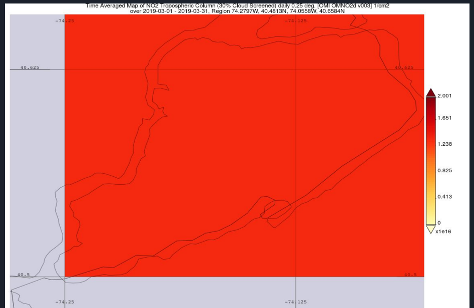
March 2020



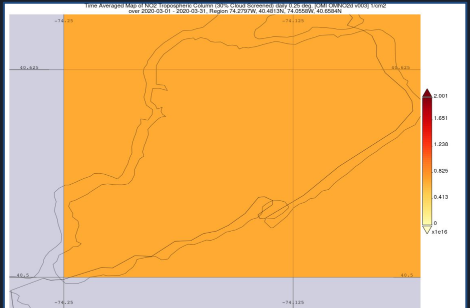
March 2021



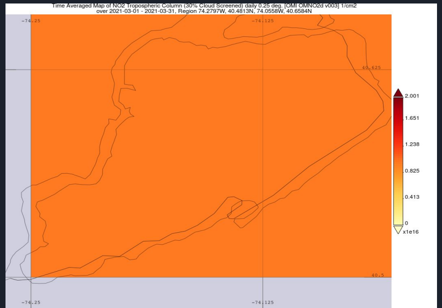
High



Low



Moderate (High)

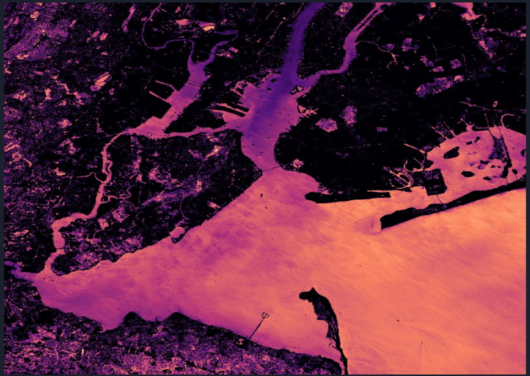


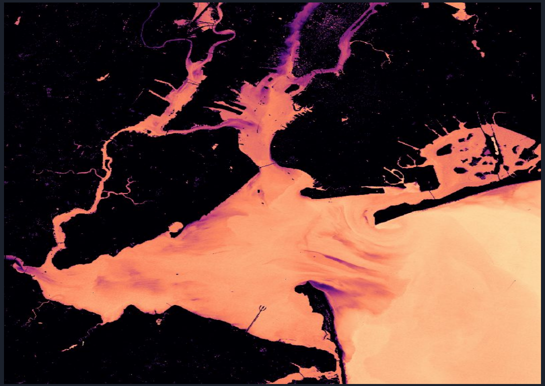
Results/Correlation Between NO_2 & CDOM Levels

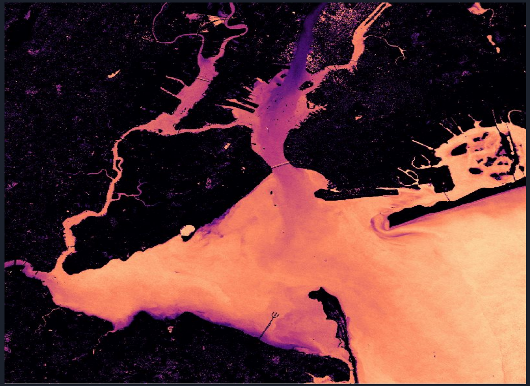
March 2019

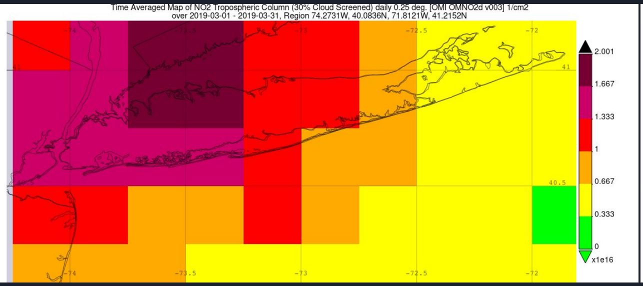
March 2020

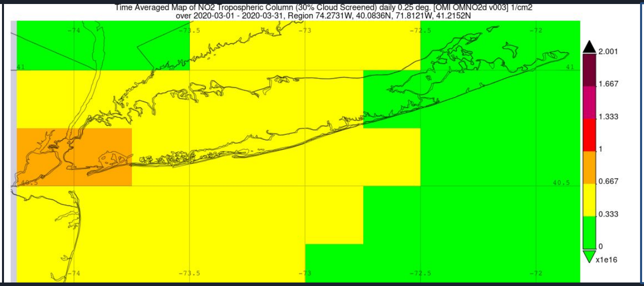
March 2021

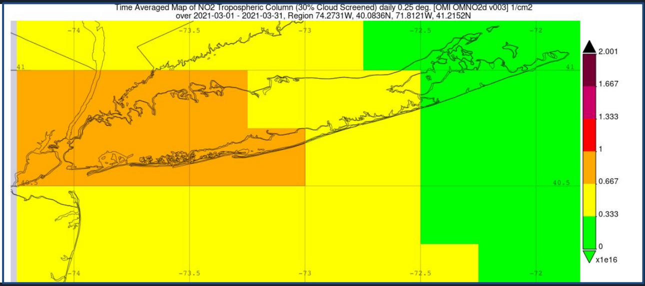










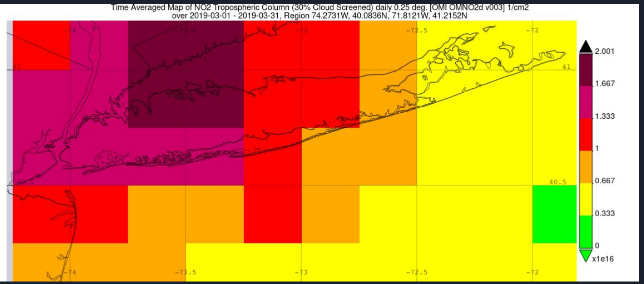


Conclusions/Discussion

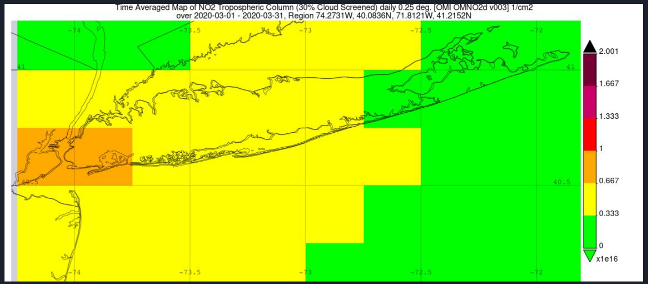
- Before the pandemic, NO_2 and CDOM levels were high but they started decreasing after the shutdown in NYC and Staten Island. After lockdown was lifted, the NO_2 and CDOM concentrations saw a slight increase again, perhaps due to the restart of anthropogenic activity outdoors.
- During 2019-2021, just by looking at the images, there appears to be a correlation between the two parameters, but more research and statistical analysis is needed to identify a correlation between NO_2 and CDOM levels.
- One reason why CDOM data may have been varied in New York Bay other than reduced boat traffic is due to sewage overflow. Approximately 60% of New York City has a combined sewer system (NYC Environmental Protection).
    - During heavy rainstorms, combined sewers receive higher than normal amounts of stormwater. So a mixture of this stormwater and untreated sewage could have flowed directly into local waterways, which could in turn have affected CDOM levels.

Future References/Discussion

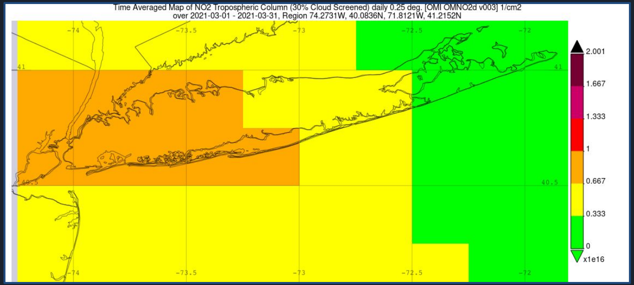
- Future research includes continuing yearly studies of NO_2 and CDOM concentrations around NYC to study comparisons between correlations and other natural disastrous events.
- We can also analyze wind currents to explain the decreasing NO_2 trend seen on the previous Time Average Maps and see if the NO_2 released by the Staten Island factories affected the other boroughs. This study may bring awareness of how a small island with factories could have a massive impact on the surrounding area.



March 2019



March 2020



March 2021

Citations

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Acknowledgements

This study is supported and monitored by The National Oceanic and Atmospheric Administration – Cooperative Science Center for Earth System Sciences and Remote Sensing Technologies under the Cooperative Agreement Grant #: NA16SEC4810008.

The authors would like to thank NOAA Educational Partnership Program with Minority Serving Institutions for funding Puja Roy and Sahib Mostafa and Pinkerton Foundation for fellowship support for Dennis Huang and Sebastian David and NOAA Center for Earth System Sciences and Remote Sensing Technologies.

The statements contained within the poster are not the opinions of the funding agency or the U.S. government, but reflect the author's opinions.