Changes in atmospheric aerosols before and after the COVID-19 global shutdown

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Abstract

The COVID-19 virus was first detected in Wuhan, China and its genesis was traced to infected bats, passed through an intermediate host to humans. COVID-19 or "Coronavirus" reached approximately 4 million confirmed cases in the United States by July 2020. The spread of this virus has affected both social and economic affairs on a global scale with more than 15 million confirmed cases worldwide in July 2020. The pandemic has proven a global public health and socio-economic crisis. In addition, the shelter-in-place orders provide an unprecedented opportunity for examining the resulting reduction in greenhouse gases and aerosols on the atmosphere. The Sentinel-5P satellite has shown distinct changes in atmospheric aerosols over the COVID-19 epicenter in Wuhan. After Texas, U.S. established similar shelter-in-place orders to prevent the spread of the virus, the state's industrial activity experienced an economic slowdown. This paper quantifies the changes in atmospheric aerosols associated with the COVID-19 slowdown over major cities in Texas and compares it to similar changes in Wuhan, China using satellite imagery.

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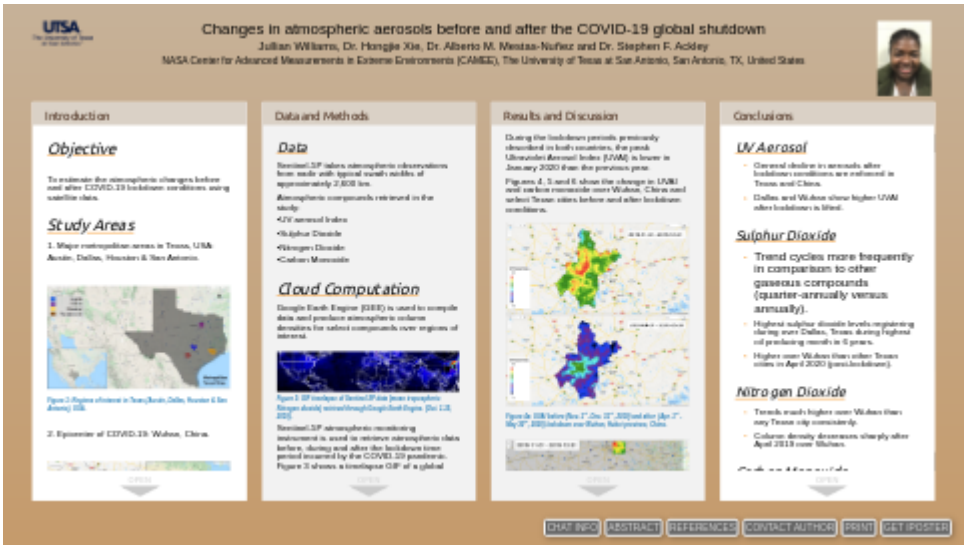

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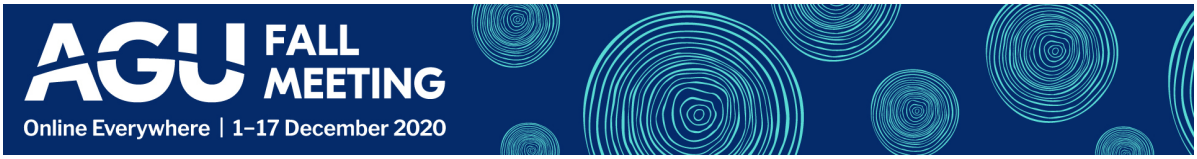

INTRODUCTION

Objective

To estimate the atmospheric changes before and after COVID-19 lockdown conditions using satellite data.

Study Areas

1. Major metropolitan areas in Texas, USA:

Austin, Dallas, Houston & San Antonio.

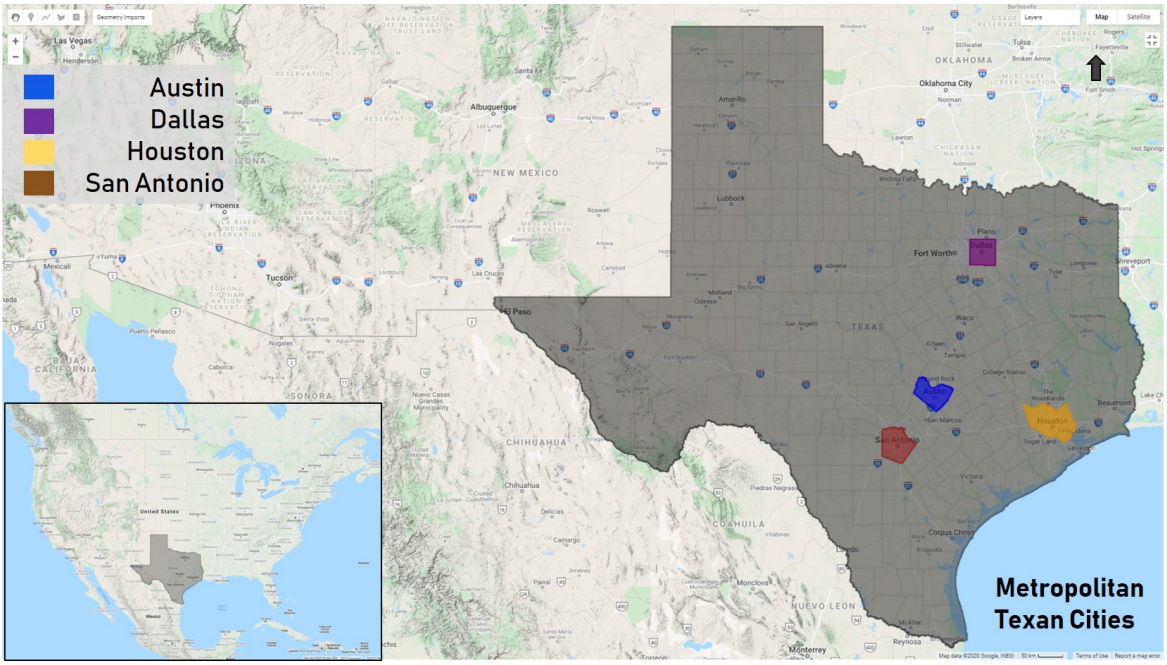

Figure 1: Regions of interest in Texas (Austin, Dallas, Houston & San Antonio), USA.

2. Epicenter of COVID-19: Wuhan, China.

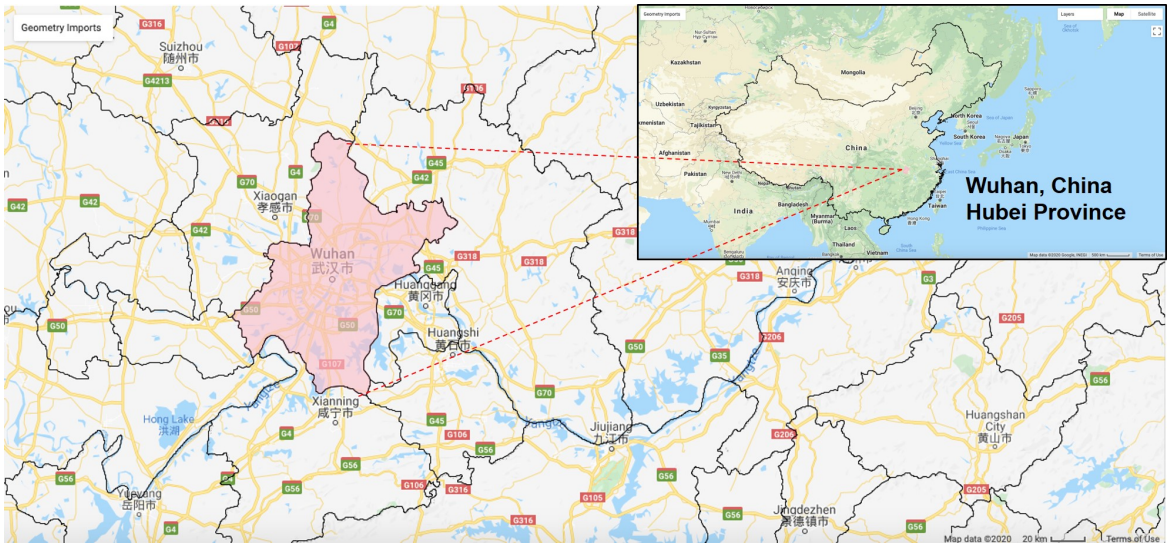

Figure 2: Region of interest in Wuhan, Hubei Province, China.

DATA AND METHODS

Data

Sentinel-5P takes atmospheric observations from nadir with typical swath widths of approximately 2,600 km.

Atmospheric compounds retrieved in the study:

•UV aerosol Index

•Sulphur Dioxide

•Nitrogen Dioxide

•Carbon Monoxide

Cloud Computation

Google Earth Engine (GEE) is used to compile data and produce atmospheric column densities for select compounds over regions of interest.

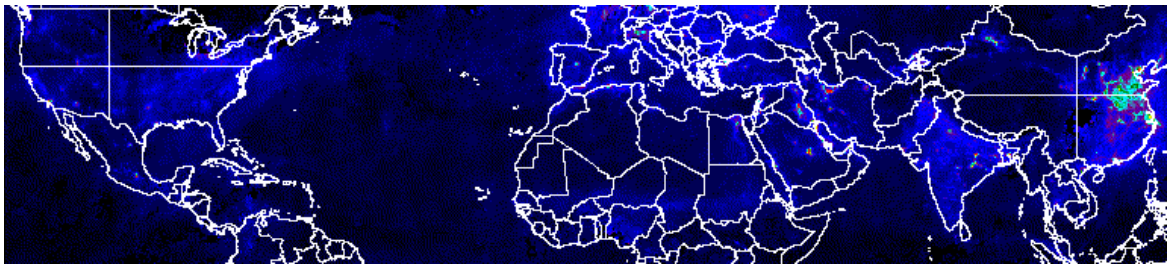

Figure 3: GIF timelapse of Sentinel-5P data (mean tropospheric Nitrogen dioxide) retrieval through Google Earth Engine. (Oct. 1-15, 2019).

Sentinel-5P atmospheric monitoring instrument is used to retrieve atmospheric data before, during and after the lockdown time period incurred by the COVID-19 pandemic. Figure 3 shows a timelapse GIF of a global retrieval of tropospheric nitrogen dioxide prevalence through Google Earth Engine.

To achieve the atmospheric trends, the forementioned regions of interests are first outlined. From this, the vertical column density of each compound is extracted for analysis. The data is then examined for missing entries and are removed. The data is then compiled for the monthly mean of each compound for the respective region.

RESULTS AND DISCUSSION

During the lockdown periods previously described in both countries, the peak Ultraviolet Aerosol Index (UVAI) is lower in January 2020 than the previous year.

Figures 4, 5 and 6 show the change in UVAI and carbon monoxide over Wuhan, China and select Texan cities before and after lockdown conditions.

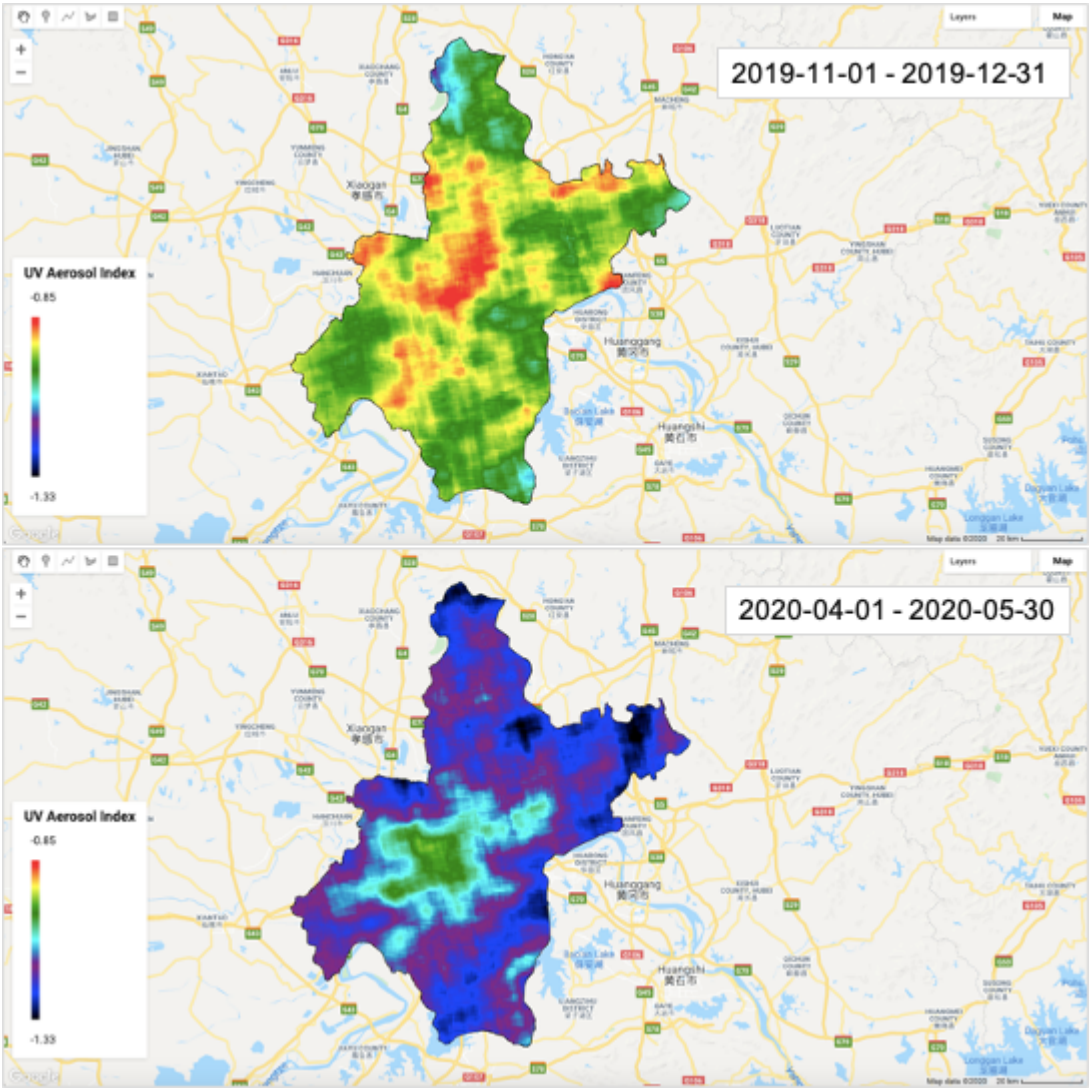

Figure 4a: UVAI before (Nov. 1st- Dec. 31st, 2019) and after (Apr. 1st - May 30th, 2020) lockdown over Wuhan, Hubei province, China.

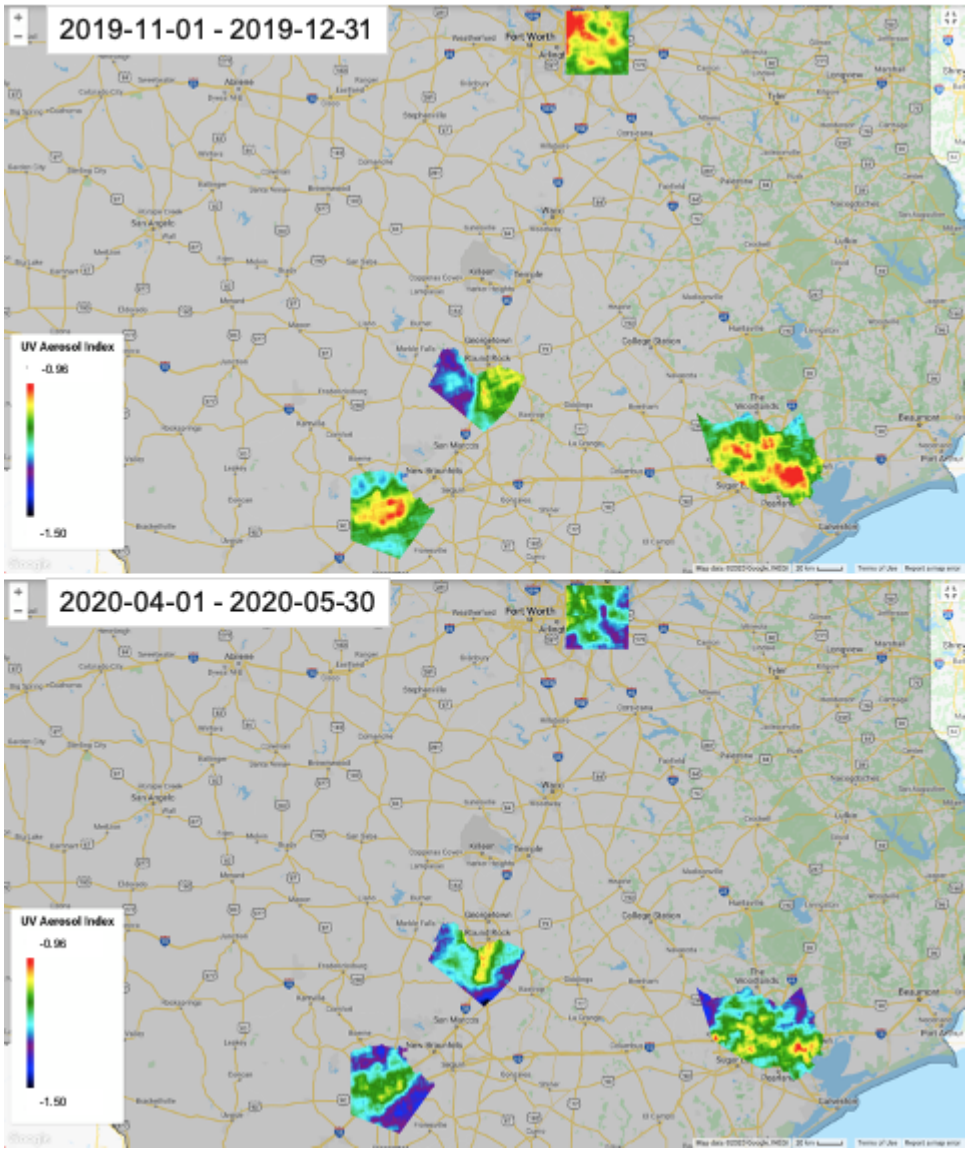

Figure 4b: UVAI before (Nov. 1st- Dec. 31st, 2019) and after (Apr. 1st - May 30th, 2020) lockdown over major metropolitan cities in Texas (refer to: 'study areas').

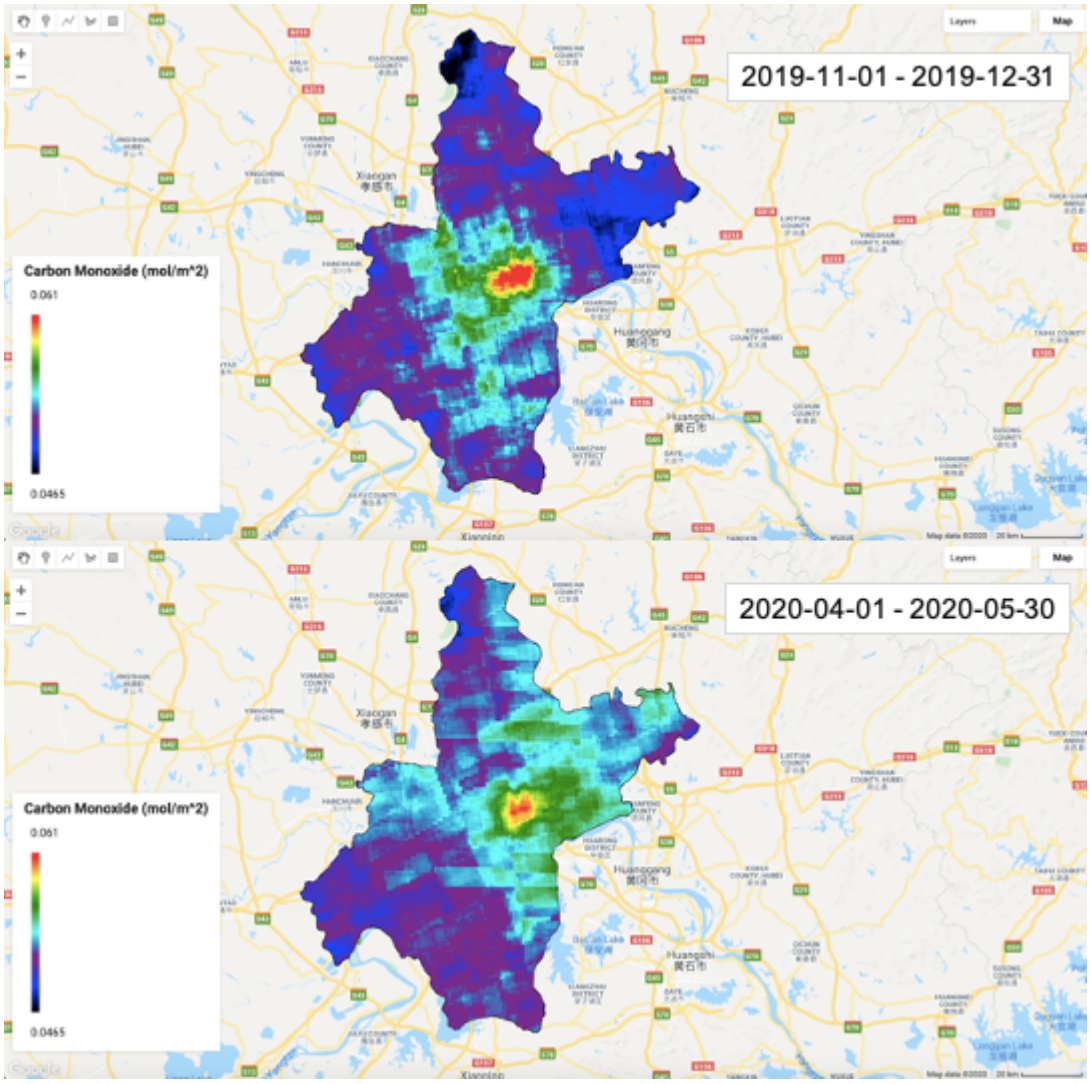

Figure 5a: Carbon monoxide (Nov. 1st- Dec. 31st, 2019) and after (Apr. 1st - May 30th, 2020) lockdown over Wuhan, Hubei province, China.

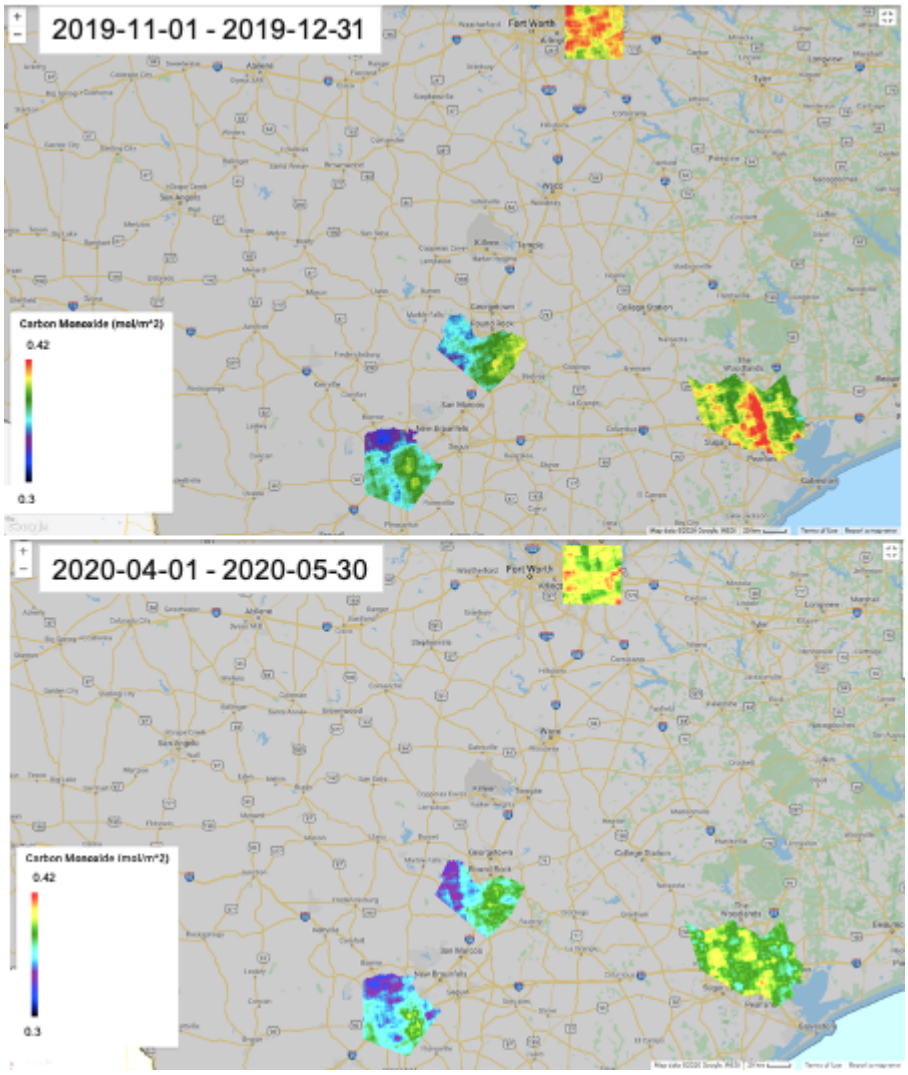

Figure 5b: Carbon monoxide (Nov. 1st- Dec. 31st, 2019) and after (Apr. 1st - May 30th, 2020) lockdown over major metropolitan cities in Texas (refer to: 'study areas').

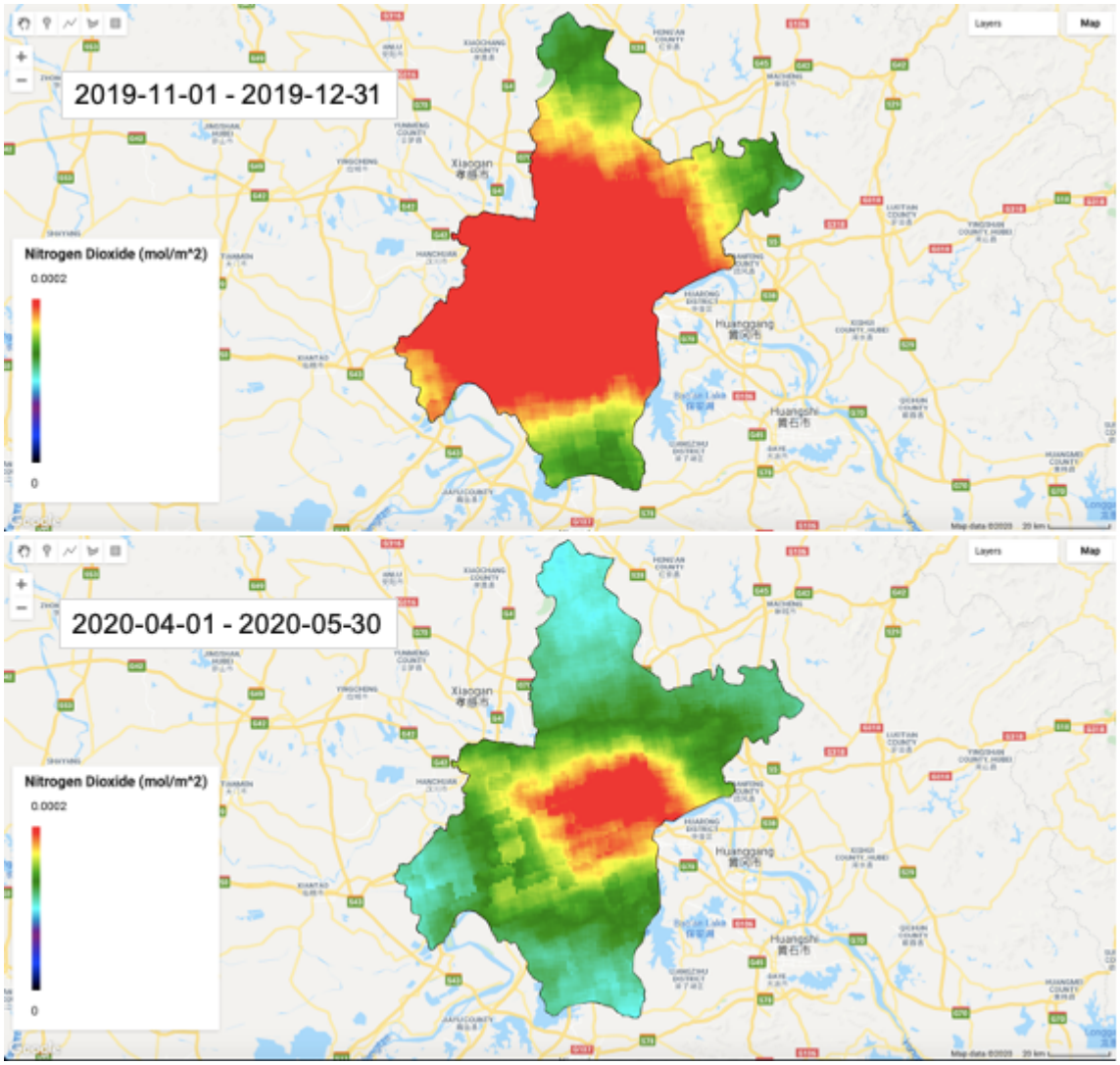

Figure 6a: Nitrogen dioxide (Nov. 1st- Dec. 31st, 2019) and after (Apr. 1st - May 30th, 2020) lockdown over Wuhan, Hubei province, China.

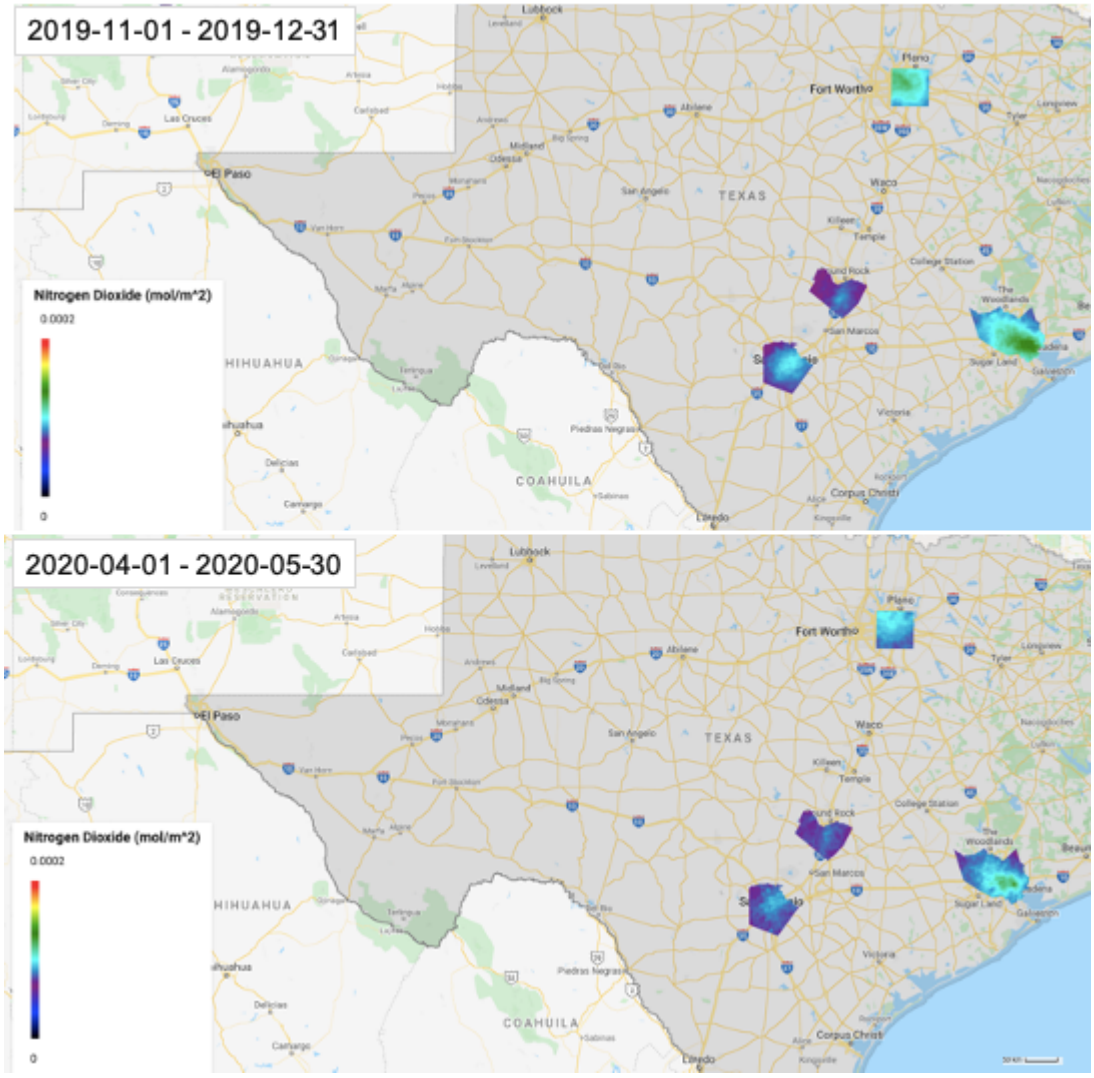

Figure 6b: Nitrogen dioxide (Nov. 1st- Dec. 31st, 2019) and after (Apr. 1st - May 30th, 2020) lockdown over major metropolitan cities in Texas (refer to: 'study areas').

Figure 7 shows the UVAI trends of Wuhan relative to the major Texan cities. There is a general reduction of UVAI since the pandemic compared to January-2019.

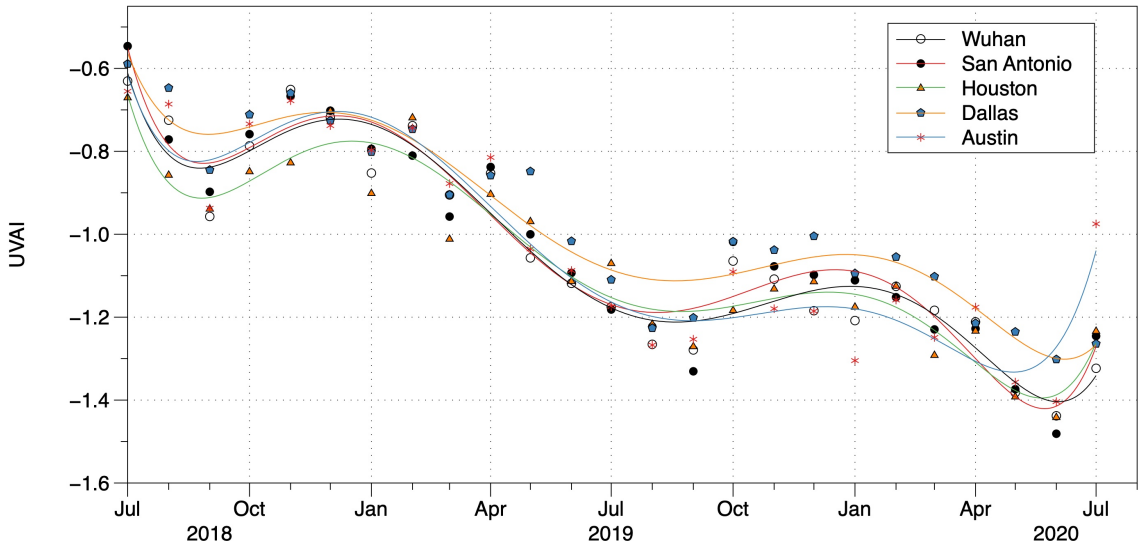

Figure 7: UVAI over the four major Texan cities: Austin, Dallas, Houston and San Antonio and Wuhan, China.

Figures 8, 9 and 10 illustrate the gaseous compounds over the respective cities. The figures show that Wuhan has higher total nitrogen dioxide and carbon monoxide when compared with any of the Texan cities. Sulphur dioxides are highest over Dallas, Texas during the state's highest oil producing month for the past 6 years.

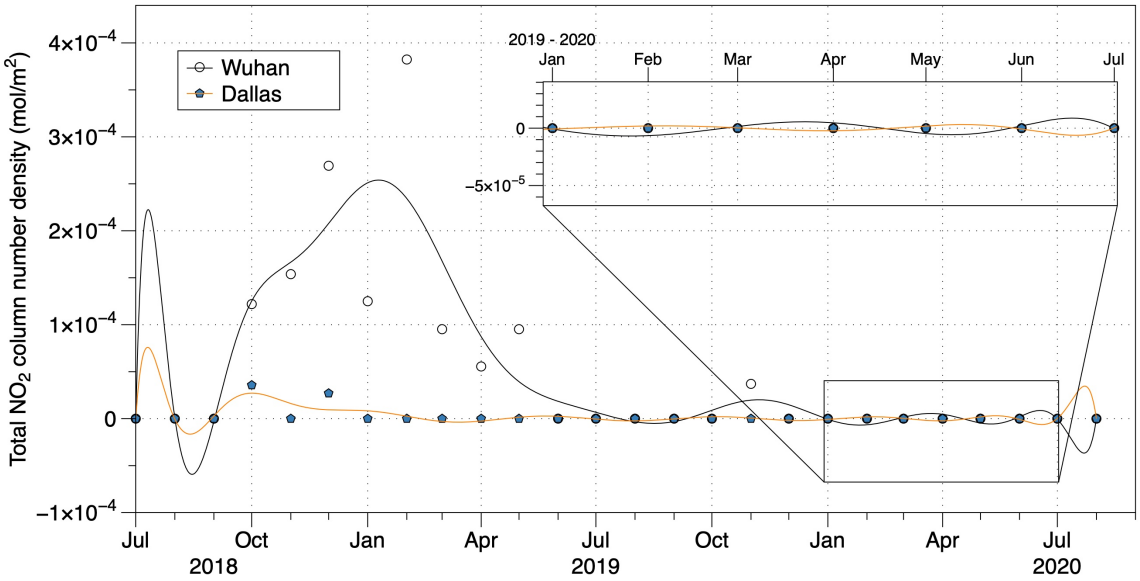

Figure 8: Nitrogen Dioxide over Dallas,Texas and Wuhan, China.

**Other Texan cities were negligble.*

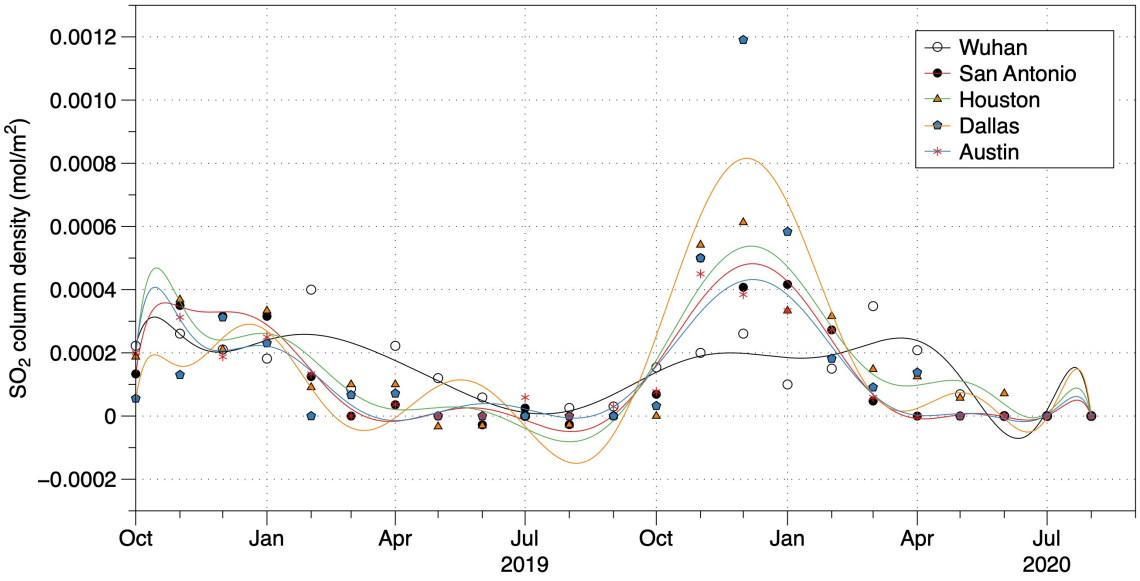

Figure 9: Sulphur Dioxide over the four major Texan cities: Austin, Dallas, Houston and San Antonio and Wuhan, China.

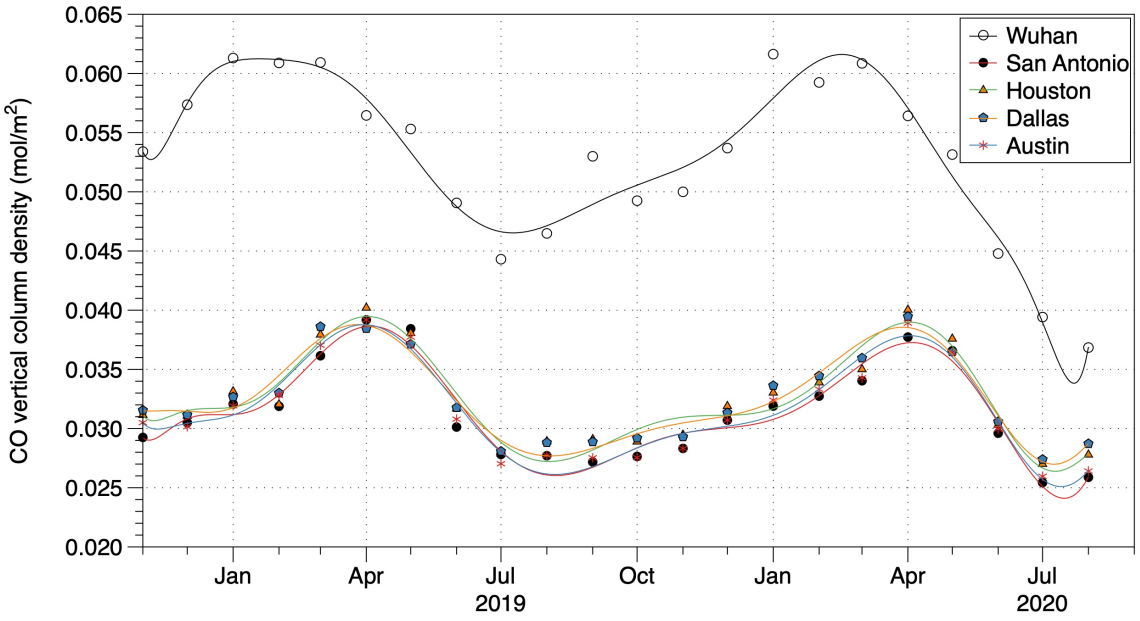

Figure 10: Carbon Monoxide over the four major Texan cities: Austin, Dallas, Houston and San Antonio and Wuhan, China.

Carbon monoxide is one compound that does not naturally occur in the atmosphere and is therefore a direct input from anthropogenic activity. Lockdown conditions can be reflected directly from the change in carbon monoxide as shown in Figures 10 and 11. While Texan cities maintain relatively lower levels of carbon monoxide during the time series, Wuhan shows a marked decrease in the compounds' levels after the lockdown time period.

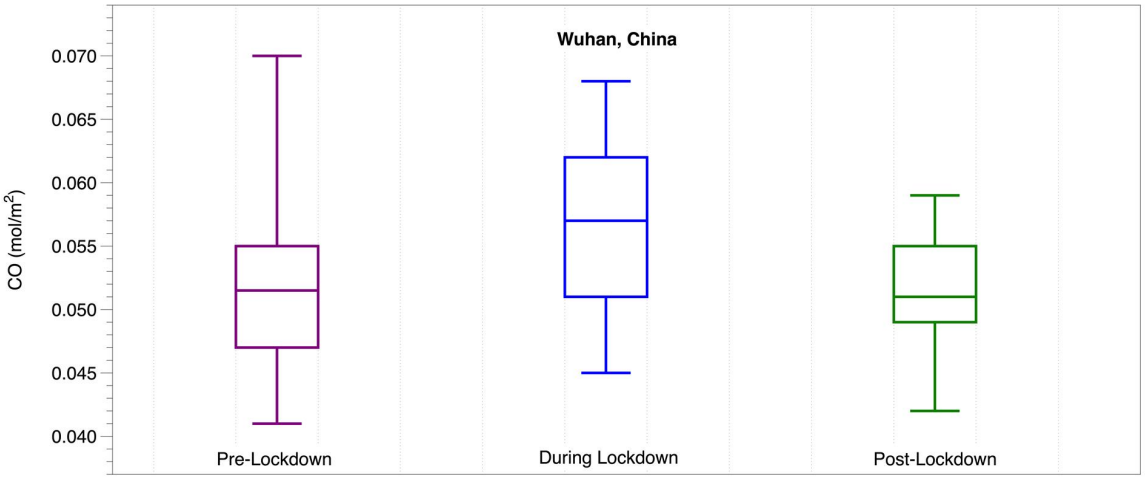

Figure 11: Carbon Monoxide column density before: (November 1st - December 31st, 2019), during: (January 23rd - April 8th, 2020) and after (April 9th - May 30th, 2020) lockdown conditions in Wuhan, China.

CONCLUSIONS

UV Aerosol

- General decline in aerosols after lockdown conditions are enforced in Texas and China.
- Dallas and Wuhan show higher UVAI after lockdown is lifted.

Sulphur Dioxide

- Trend cycles more frequently in comparison to other gaseous compounds (quarter-annually versus annually).
- Highest sulphur dioxide levels registering during over Dallas, Texas during highest oil producing month in 6 years.
- Higher over Wuhan than other Texan cities in April 2020 (post-lockdown).

Nitrogen Dioxide

- Trends much higher over Wuhan than any Texan city consistenly.
- Column density decreases sharply after April 2019 over Wuhan.

Carbon Monoxide

- Trends roughly 70% higher over Wuhan than Texan cities between Feburary and March 2020.
- Sharp decrease after lockdown conditions to meet levels within Texan cities.
- Lower limit of residence time of carbon monoxide over Wuhan within range of lockdown time period.

ABSTRACT

The COVID-19 virus was first detected in Wuhan, China and its genesis was traced to infected bats, passed through an intermediate host to humans. COVID-19 or “Coronavirus” reached approximately 4 million confirmed cases in the United States by July 2020. The spread of this virus has affected both social and economic affairs on a global scale with more than 15 million confirmed cases worldwide in July 2020. The pandemic has proven a global public health and socio-economic crisis. In addition, the shelter-in-place orders provide an unprecedented opportunity for examining the resulting reduction in greenhouse gases and aerosols on the atmosphere.

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