HARC

Impacts on Air Quality

COVID-19 Research: Ground Level Ozone

INTRODUCTION

The purpose of this analysis is to examine how ozone concentrations have changed during the COVID-19 pandemic, when stay at home orders to protect public health caused transportation to dramatically decrease. The analysis begins in Harris County and compares these results to trends observed in Texas cities and counties as well as other major cities across the US.

The change in ozone concentration in each region is compared to a historic six-year trend averaged over the same time period for that region. This comparison helps distinguish local conditions of atmospheric chemistry and meteorology that typically drive ozone concentrations for that region from any changes in emissions sources that may occur during the COVID-19 response.

HEALTH IMPACTS OF OZONE POLLUTION

Ozone is a respiratory irritant that can lead to throat irritation and coughing, cause difficulty breathing and shortness of breath; exacerbate the frequency and intensity of asthma attacks; and can even exacerbate lung infections and cause lung damage. Children and the elderly are especially sensitive to these health effects. Ozone can also affect the growth of vegetation and trees and reduce crop yields.

COVID-19: Greater Houston Ozone Levels and Mobility

- **During the COVID-19 response, ozone concentrations in Greater Houston decreased relative to normal conditions, owing to decreased NOx and VOC emissions from mobile sources.**
- **For ozone, there is an overall decrease during weekdays of 16%, with an even greater decrease on Saturdays.**

As the average distance traveled decreased during the COVID-19 response (March 11 to April 13, 2020; see Figure 1), mobile sources of NOx and VOC emissions also decreased and the chemical reactions that form ground-level ozone likely became less efficient. To examine the impact of reduced road traffic throughout the week on ozone formation, ozone concentrations are compared before and during the COVID-19 response (Figure 2). Monday through Friday, there was an average 16% reduction (or around 7 ppb) in ozone concentration compared to historical trends during the same time period.

COVID-19: Demonstrating the Weekend Effect with Decreased Mobility

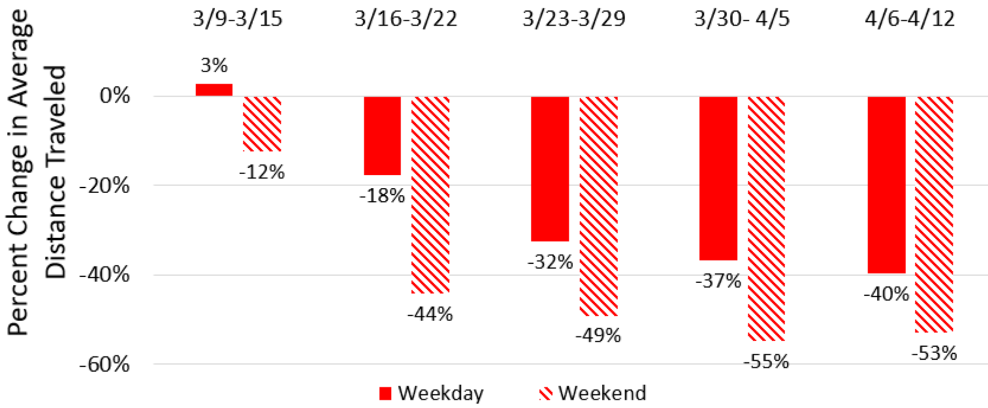


Figure 1. Change in average distance traveled in Harris County shown by week of the COVID-19 response, with greater reductions consistently achieved on weekends than weekdays.

COVID-19: Harris County Ozone Levels

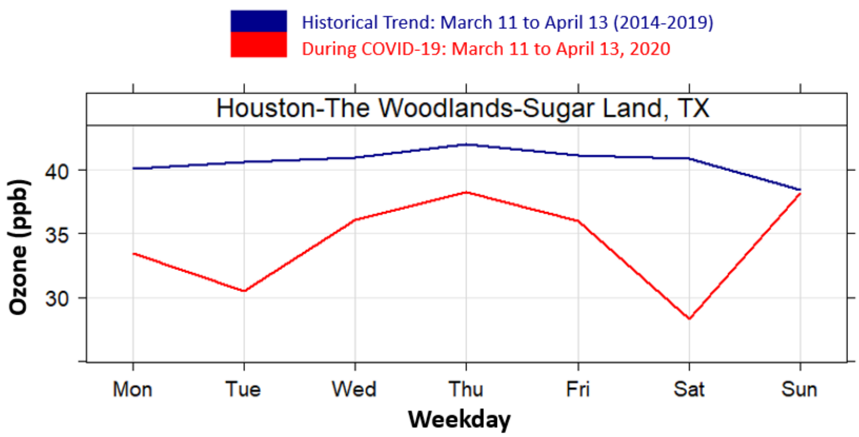


Figure 2. Weekday averages of ground-level ozone concentrations in the Greater Houston region during the COVID-19 response (red lines; March 11 to April 13, 2020) compared to historical trends (blue lines; March 11 to April 13, 2014-2019).

When concentrations of NOx and certain VOCs are low, ozone formation is less efficient and delayed. Since mobility decreased to a greater extent during the weekends of the COVID-19 response (Figure 1), the initial drop in NOx emissions leads to a drop in ozone concentration on Saturdays. After this initial short-term decrease on Saturdays, there is an observed increase in ozone concentrations on Sundays. This phenomenon is known as the ozone weekday/weekend effect.

OZONE CHEMISTRY 101

Ground-level ozone is a secondary air pollutant formed by the chemical reaction between volatile organic compounds (VOCs) and nitrogen oxides (NOx) in the presence of sunlight. High concentrations of ozone can be caused by elevated emissions of VOCs and NOx, especially when there is abundant sunlight and heat to facilitate photochemical processes associated with ozone formation. However, ozone can be removed from the air by directly reacting with other byproducts of ozone formation, through dry deposition to the land and ocean surface, or from unfavorable weather conditions (breezy and cloudy). Because of the complexity of the chemical reactions and changing weather patterns that produce and consume ozone, it may take a few weeks for ground-level ozone concentrations to stabilize and begin to show declines.

COVID-19: Comparison of Changing Ozone Levels and Mobility Across Texas

- **Across Texas, greater decreases in mobility resulted in greater decreases in ozone concentration.**
- **For most counties in Texas, there was a net decrease in ozone concentration during the COVID-19 time-period.**

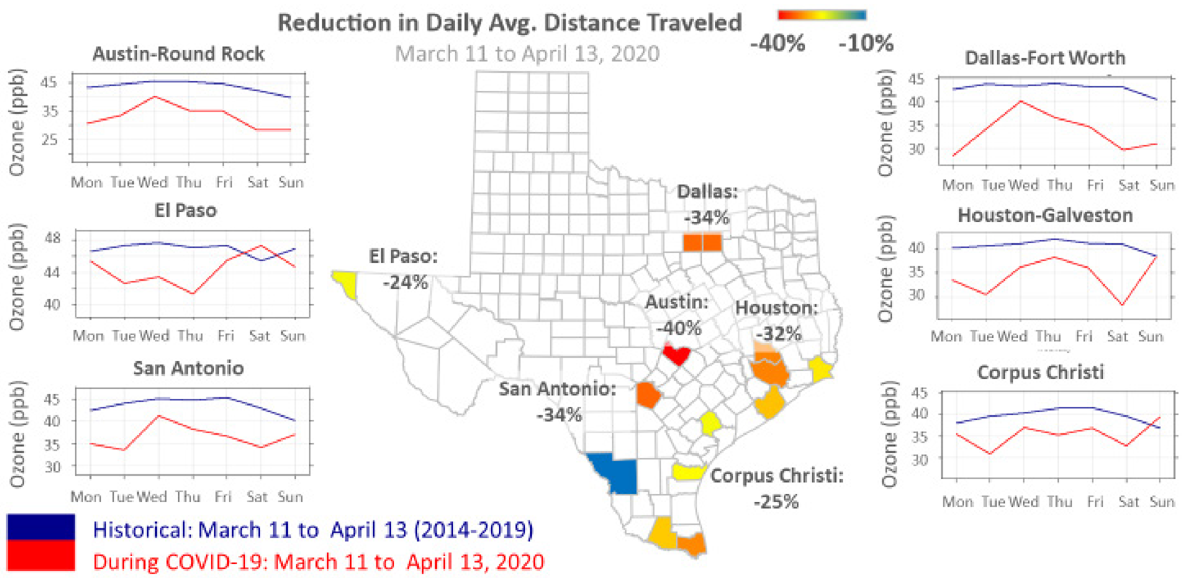


Figure 3. Weekday averages of ground-level ozone concentrations in selected Texas metropolitan areas during the COVID-19 response (red lines; March 11 to April 13, 2020) compared to historical trends (blue lines; March 11 to April 13, 2014-2019). The map shows the average percent reduction in distance traveled during the response period for selected Texas counties.

In most large cities, mobile sources such as cars and trucks account for the majority of NOx and a significant portion of VOC emissions, such that decreases in traffic result in lower production rates of ozone. This effect can be seen across Texas as greater decreases in mobility resulted in higher decreases in ground-level ozone concentration. For instance, Dallas, Austin, Houston, and San Antonio all experienced greater relative reductions in ozone concentration compared to El Paso and Corpus Christi, which had the lowest average reductions in mobility during the time period studied (around -25%). Austin had the largest reduction in mobility during the COVID period (-40%) whereas Dallas, Houston, and San Antonio all had similar reductions (-32% to -34%). Of these regions, Corpus Christi was also the last to implement a stay at home order (March 26) compared to the earliest, Dallas (March 23). The rest implemented their orders on March 24.

The different ozone patterns observed throughout the week are dependent on location and based on daily traffic patterns, the source and ratio of NOx and VOC emissions, and local weather conditions. For example, air quality in Houston is influenced by a combination of different industries, on- and off-road traffic, and long-range transport (due to proximity to the Gulf of Mexico); while Austin's ozone level is mostly influenced by road traffic.

Similarly, at the county level (Figure 4), reductions in ozone concentration are more pronounced in counties with higher population density (e.g., Travis) as a result of significant reductions in mobility and industrial shutdown. For the counties located at the state border (e.g., Orange at the Texas-Louisiana boundary, and Webb at the Texas-Mexico border), the impact of COVID-19 was minimal. This is due to the importance of other factors associated with their local air pollution, particularly pollution transport.

COVID-19: Comparison of Changing Ozone Levels Across Texas Counties

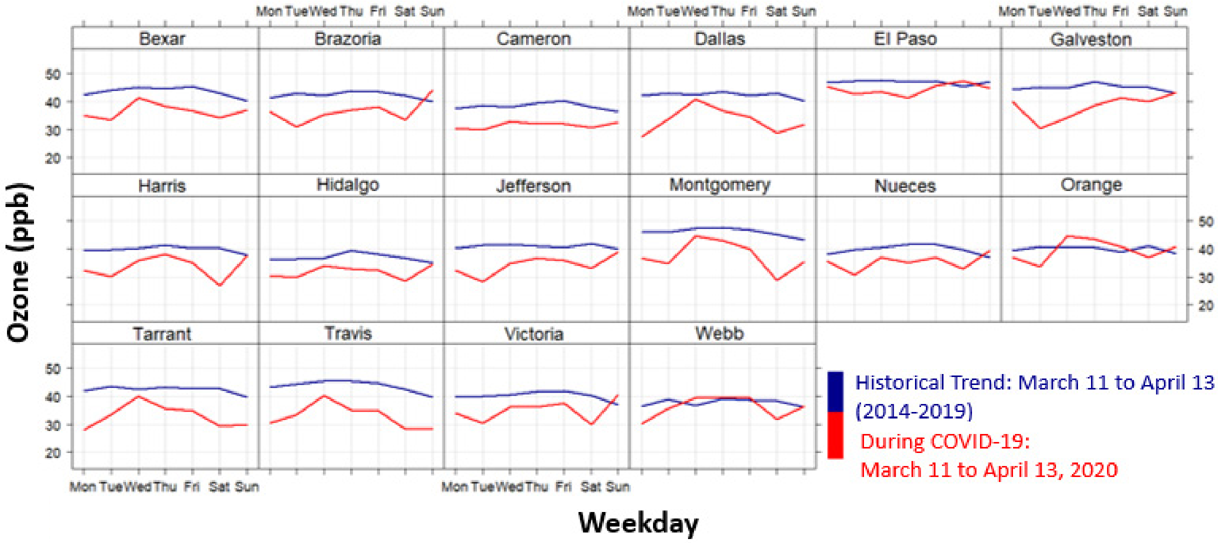


Figure 4. Weekday averages of ground-level ozone levels in selected Texas counties during COVID-19 response (red; March 11 to April 13, 2020) compared to historical trends (blue; March 11 to April 13, 2014-2019).

COVID-19: Comparison of Changing Ozone Levels Across US Metros

- **While the magnitude of the impact varied by location, ground-level ozone concentrations generally decreased in major cities across the US during the COVID-19 response.**
- **Some regions require more time to observe significant improvements in air quality.**

Due to the complex nature of ozone formation in the atmosphere, the extent that local ozone concentrations decreased in response to changes in transportation emissions of ozone precursors varied by region (Figure 5). For example, in Houston and Los Angeles, the reduction in local ozone concentration was higher than New York and San Francisco. It is likely that more time may be needed for some parts of the country to observe additional improvements in air quality.

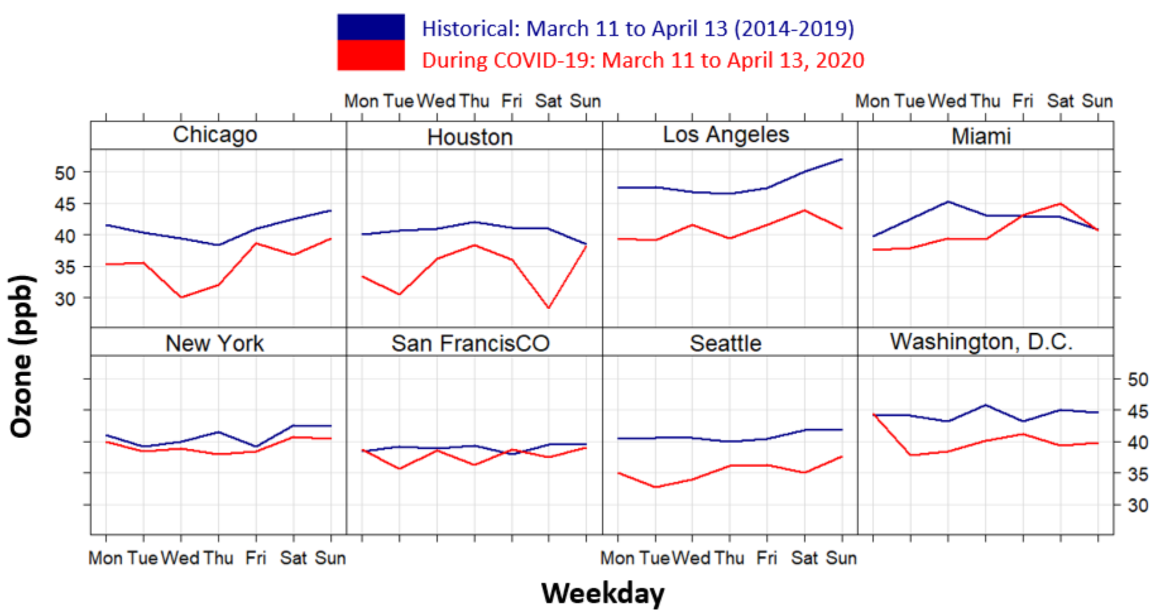


Figure 5. Weekday averages of ground-level ozone levels in selected US metros during COVID-19 response (red; March 11 to April 13, 2020) compared to historical trends (blue; March 11 to April 13, 2014-2019).

METHODOLOGY

Ozone analyses (see Figure 6) for the six Texas metro areas, 16 Texas counties, and seven additional US metro areas were made by averaging available data from ambient air quality monitored stations from EPA's AirNow network. Data for each station was averaged to calculate the maximum daily 8-hour average for ozone. As part of the National Ambient Air Quality Standards, the 2015 ground-level ozone standard is 70 parts per billion (ppb) for Maximum Daily Average Ozone Over An 8-Hour Period (MDA8). The COVID-19 response (March 11 to April 13, 2020) was compared to historical trends (the average concentration for the same day of the week during the same time period over the last six years; March 11 to April 13, 2014-2019).

Number of Stations Used in Ozone Analyses

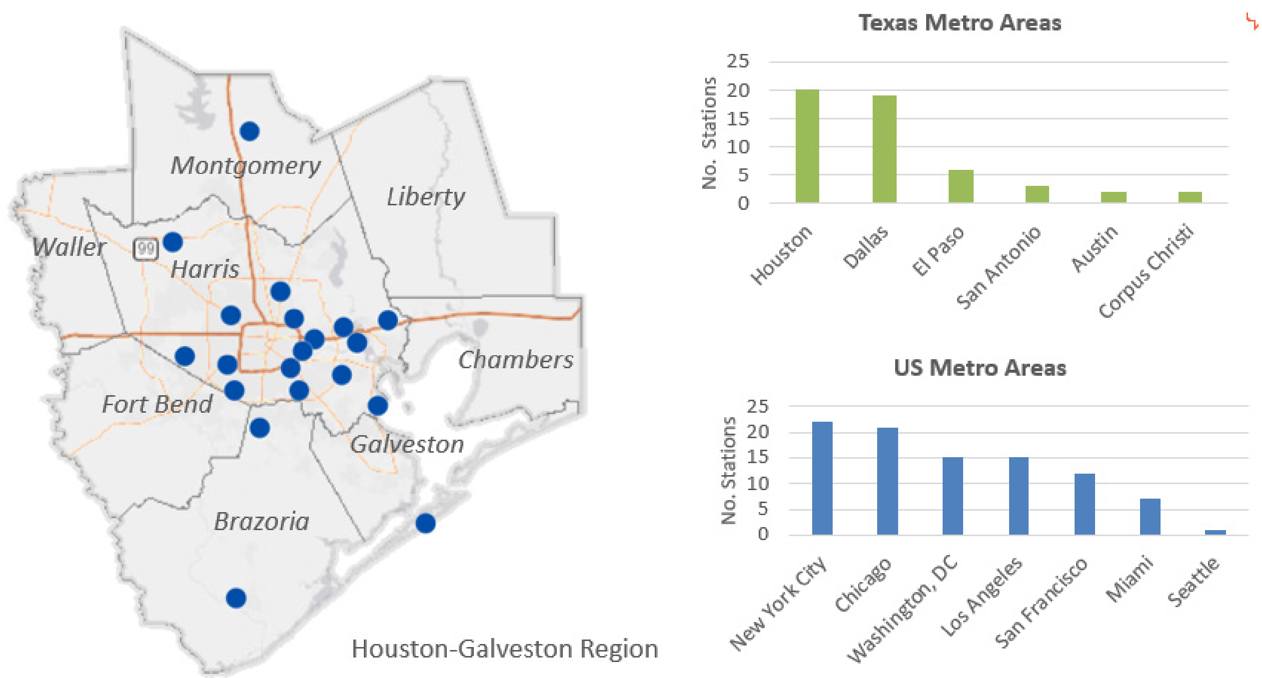
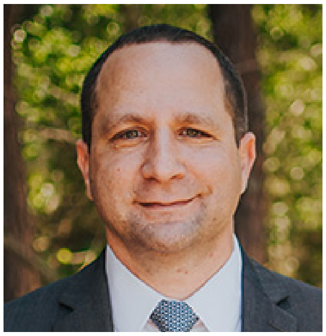


Figure 6. Number of EPA air monitoring stations averaged for each metro area in ozone analysis.

Mobility data shown in Figures 1 and 2 are derived from the Unacast COVID-19 Location Data Toolkit, which uses location intelligence from data collected through mobile applications, GPS, mobile device Bluetooth connections, and Wi-Fi connections to understand customer movement patterns. The change in average distance is compared to a baseline (average distance traveled for same day of week during non-COVID-19 time period for a specific county). Data were provided free of charge by Unacast through the Data for Good program.

Learn more about HARC and review the ongoing COVID-19 research at HARCresearch.org/covid19.

RESEARCH STAFF



Mustapha Beydoun, PhD
Vice President and
Chief Operating Officer

Ebrahim Eslami, PhD
Postdoctoral Research Scientist,
Air Quality

Meredith Jennings, PhD
Postdoctoral Research Scientist,
Community and Climate Resilience

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Houston Advanced Research Center
8801 Gosling Road
The Woodlands, Texas 77381

Mustapha Beydoung, PhD
mbeydoun@HARCresearch.org
281-364-6046

Ebrahim Eslami, PhD
eeslami@HARCresearch.org
281-364-6049

Meredith Jennings, PhD
mjennings@HARCresearch.org
281-364-6034

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