Intra-city variability of fine particulate matter during the COVID-19 lockdown: A case study from Park City, Utah

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Project Sponsors

- Sustainability Office of Park City, Utah
- Global Change and Sustainability Center
- Nexus Center

Impacts of Air Pollution

- Poor air quality in Park City, Utah is a concern
  - Air pollution paired with mountain topography can lead to extended episodes of atmospheric inversions
- Urban air quality is increasingly studied due to a range of social (Mendoza et al, 2020), economic (Graff et al, 2013), and health impacts (Pirozzi et al., 2018)
- Emerging research also suggests that COVID-19 incidence rates may be associated with air pollution exposure (Sahoo et al., 2020)

Pollution Downturn Events

- Since the SARS-CoV-19 pandemic began, non-medical interventions (NMIs) (e.g. lockdowns, stay-at-home orders, mask mandates) have been used
- A co-benefit of NMI policies has been a substantial drop in the concentration of primary pollutants
  - Estimated decreases range from 10-43% (Sharma et al., 2020)
- Pollution downturn events are rare
  - Do such events change the composition of air quality locally?
  - Do changes have long-term policy implications?
  - How will such changes impact adaptation planning and low carbon transitions worldwide?

Research Aims

- To trace the changing emissions patterns during the pandemic in a mid-sized, high-altitude city to isolate the effects of human behavior on air pollution patterns.

- To use high quality, research grade sensors to compare pollution patterns found before, during, and after the pandemic lockdown period using direct measurements.

- To compare emissions levels in both commercial and residential settings over similar time periods of the pandemic to understand how each setting may be uniquely impacted by pollution downturn events.

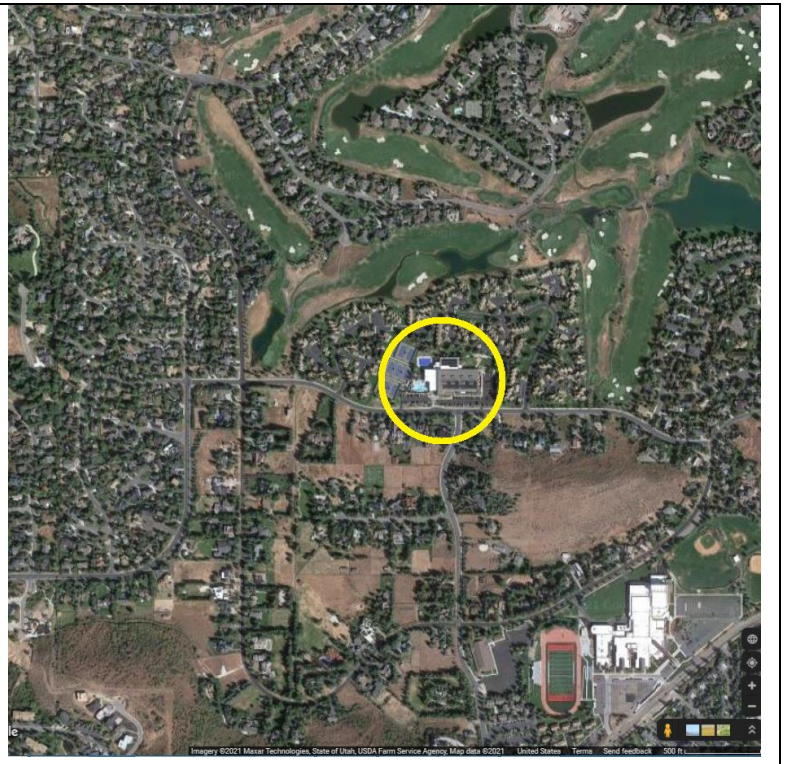
RESEARCH METHODS

Methods

- A physical exposure model was used to compare diurnally averaged $PM_{2.5}$ levels measured with research grade sensors with high measurement frequency to study pollution downturn
- Study Periods
  - Pre-Lockdown: February 3 – March 15
  - Lockdown: March 16 – April 26
  - Easing: May 1 – June 11
  - Reopening: June 12 – July 23
- Data was aggregated to an hourly scale and sorted by day type (e.g. weekday or weekend)
- Using the median values for each study period, site, and day type, we compared the diurnal patterns and calculated the percent change across study periods

Instrumentation

a)



b)

Figure 1. Location of air quality sensors (yellow circle): a) Commercial and b) Residential. Maps courtesy of Google Maps.

RESULTS

Hypothesis 1 (Commercial Location): The Lockdown period decreased pollutant concentrations and the Easing and Reopening periods resulted in increased pollution.

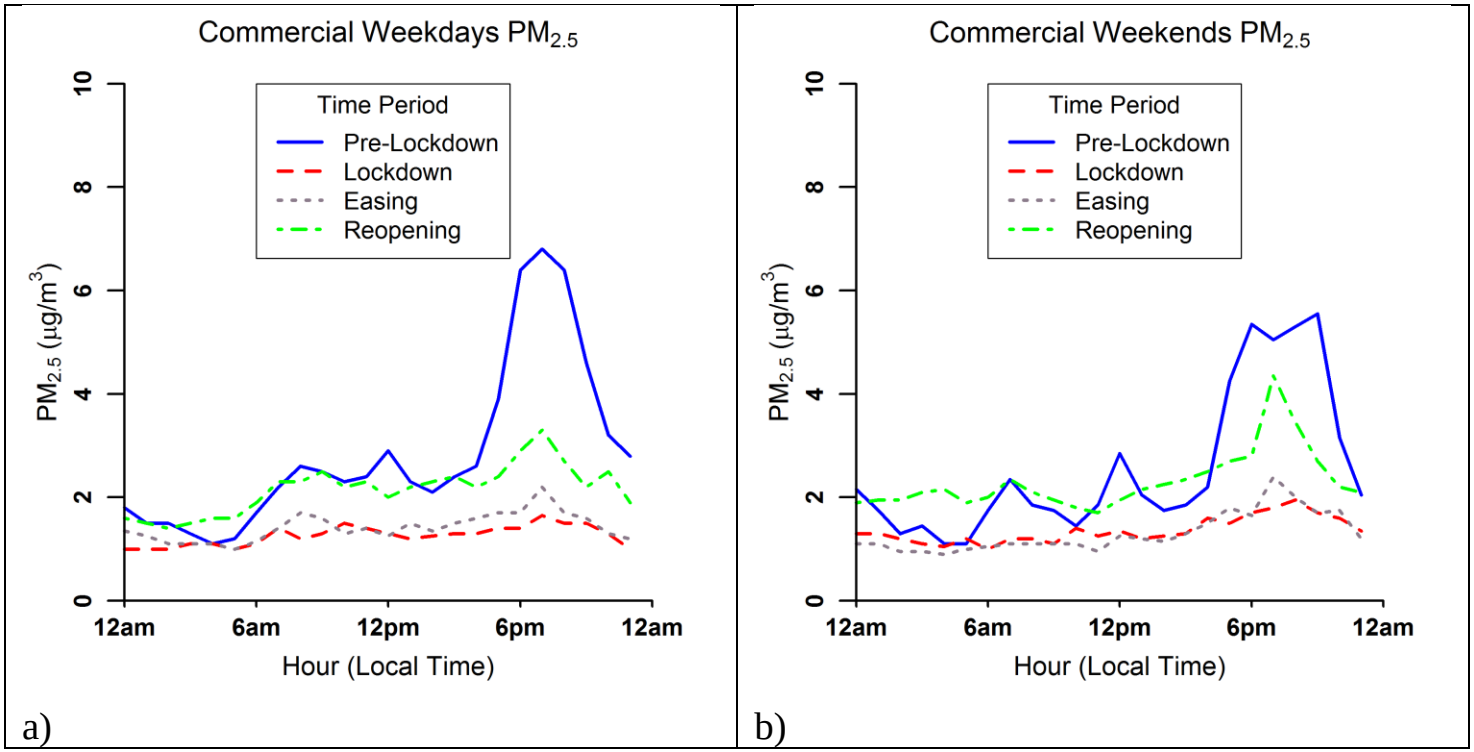


Figure 3. Median hourly (local time) $PM_{2.5}$ readings for study periods at the Commercial site: a) weekdays and b) weekends.

Hypothesis 1 (Residential Location): The Lockdown period decreased pollutant concentrations and the Easing and Reopening periods resulted in increased pollution.

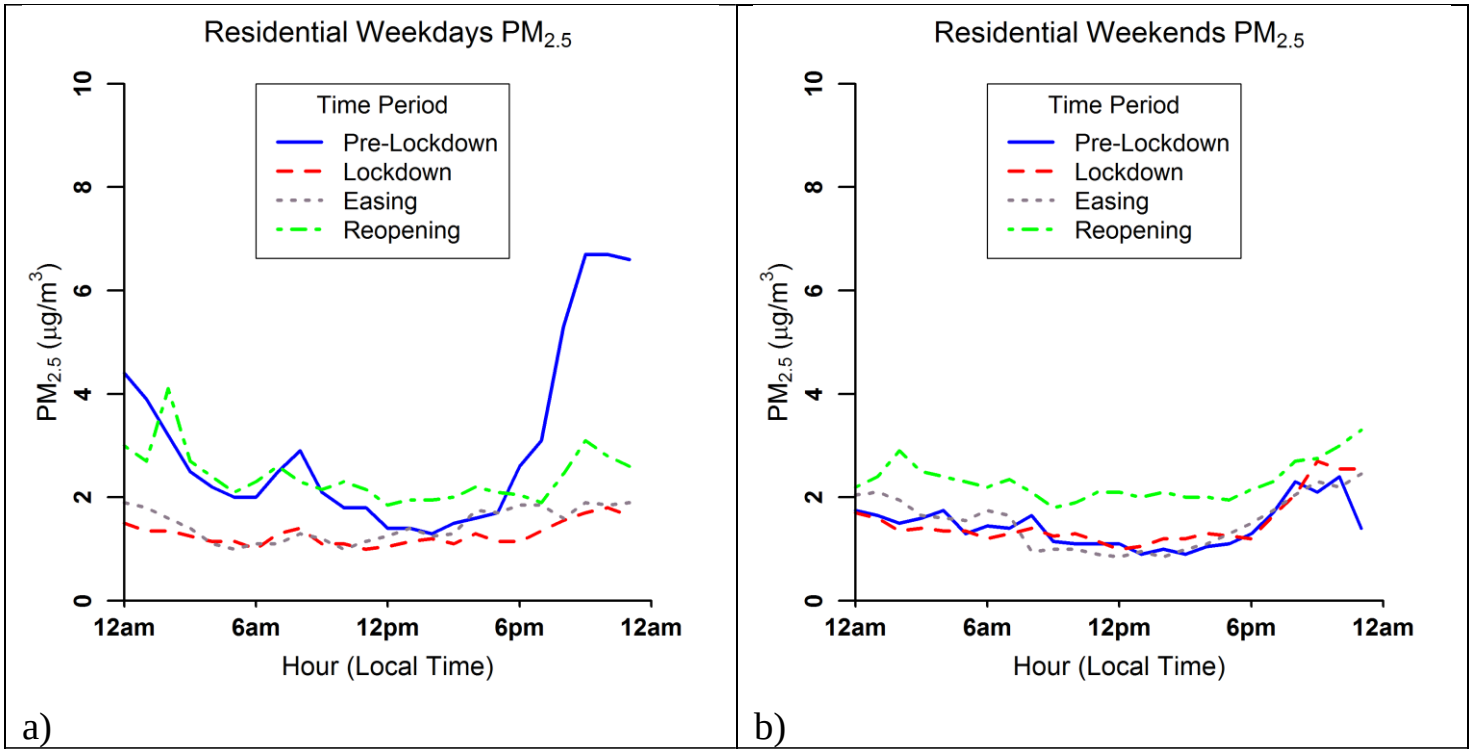


Figure 4. Median hourly $PM_{2.5}$ readings for study periods at the Residential site: a) weekdays and b) weekends.

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Hypothesis 2: The Lockdown period affected pollutant levels in commercial and residential areas differently.

	Commercial		Residential	
Time Period	**Weekdays**	**Weekends**	**Weekdays**	**Weekends**
Pre-Lockdown to Lockdown	-47 (8.24e-05)***	-36 (4.78e-04)***	-49 (8.86e-05)***	0 (0.655)
Lockdown to Easing	12 (0.024)*	-8 (0.568)	13 (0.027)*	-2 (0.908)
Lockdown to Reopening	70 (1.17e-09)***	70 (3.00e-08)***	82 (2.31e-11)***	61 (6.31e-08)***

Table 3. Percent difference (%) in median $PM_{2.5}$ values ($\mu g/m^3$) for each comparison time period and day of week type for both sites with p-value in parentheses (* = p≤ 0.05; *** = p ≤ 0.001)

Hypothesis 2 (Policy periods): The Lockdown period affected pollutant levels in commercial and residential areas differently.

	Commercial vs. Residential	
Time Period	**Weekdays**	**Weekends**
Pre-lockdown to Lockdown	0.846	2.09e-08***
Lockdown to Easing	0.716	0.216
Lockdown to Reopening	0.023*	0.241

Table 4. Resulting p-value comparing differences across time periods. (statistically significant results: * = p≤ 0.05; *** = p ≤ 0.001)

Findings

- Emissions were expected to decline during the Lockdown period, but this only occurred consistently in the commercial area
- The residential area showed this decline, but only during the Pre-lockdown period.
- Although meteorological conditions may have an effect on the Lockdown period, a return to Pre-Lockdown levels during the Reopening period shows the impact of climatic variables is minimal
- We found statistically significant differences by hour between the locations suggesting daily differences in emissions peaks between commercial and residential areas.
- We found emissions peaks and valleys to be quantitatively different for the commercial and residential sites across and within similar time periods and this varied uniquely for each location

Implications

- It is widely accepted that cities have consequential emissions exposure effects and these impacts can vary widely by neighborhood, but emissions reporting is generally aggregated to the city level (Giani et al., 2020).
  - Nuances in residential versus commercial areas are consequential for human health and public policy.
  - Calls for direct, high-quality measurement could be warranted
- This research has implications for energy policy and governance.
  - Relevant to low-income communities
  - Consequential to low-carbon energy transition policy and resiliency and adaptation planning
- Implications for COVID-19 recovery and climate change
  - Analyzing these patterns could improve the effectiveness of climate governance and reduce the cost of pandemic recovery

Conclusions

- Lockdowns due to the COVID-19 pandemic resulted in lower $PM_{2.5}$ pollution, but not at consistent levels in all locations
- Meteorological conditions had minimal impact on pollution measurements
- The commercial area showed a greater decrease of air pollution than residential
- Both commercial and residential areas experienced a similar rebound post lockdown
- Pollution increase, associated with reopening, took place two months after the lockdown ended
- These findings suggest that pollution downturn events are consequential for air quality, energy and public health policy

THANK YOU

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