Localized Variabilities in Traffic-related Air Pollutant Concentrations Revealed Using Compact Sensor Networks

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Presented by Eric Morris

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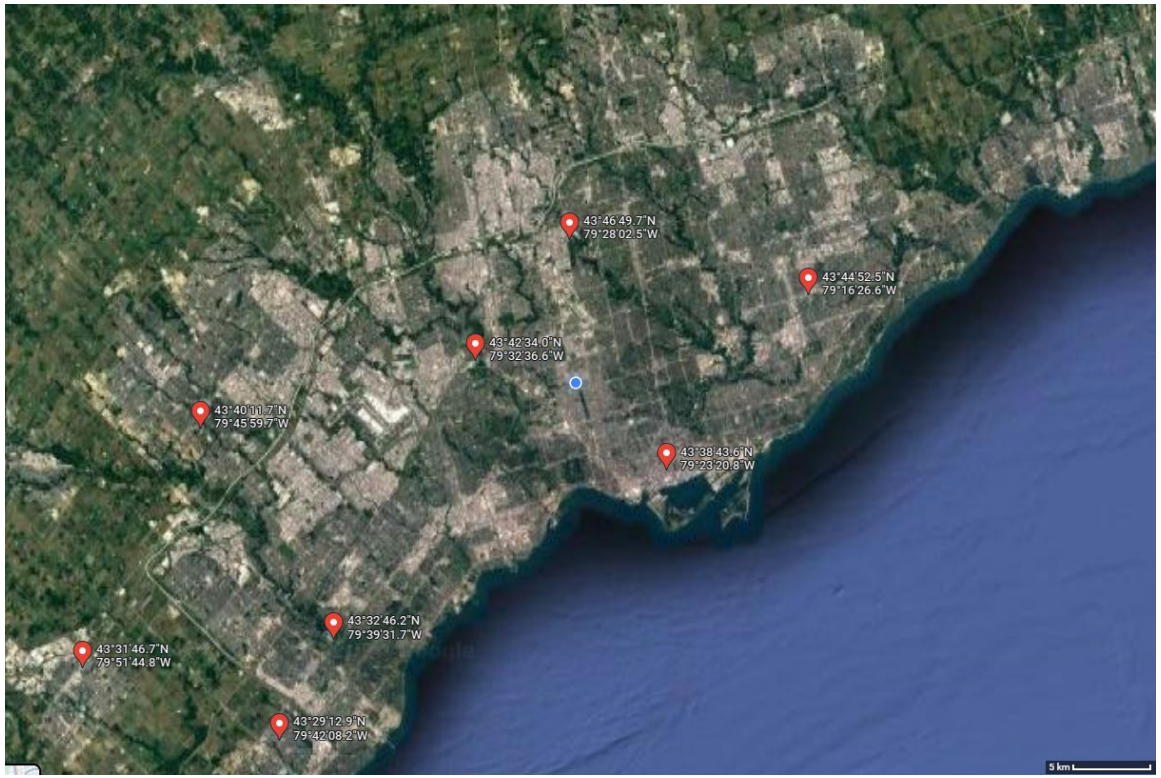
The Problem with TRAP

TRAP defined: NO, NO_2, CO, CO_2, VOC, and PM (including BC)

- TRAP known to exacerbate asthma; moderate to high association with mortality due to cardiovascular/circulatory disease, lung cancer[1]; suggested links to neurotoxicity and neurodevelopmental disorders[3-4]
- Health impacts of TRAP are difficult to study for 3 reasons:
  1. None are specific to vehicular traffic
  2. Some diminish rapidly with distance from roadways, others have regional scale impacts
  3. All vary significantly with time (diurnally and seasonally)

The Limitations of Conventional AQMs

- Standard AQMs provide reliable, highly accurate TRAP data, but are limited by:
  - High CAPEX and OPEX
  - Large footprint
  - Operational requirements (power, shelter, etc.)
  - Requirement for specialized personnel for installation and maintenance
- Spatially dense air quality monitoring is therefore impractical
- Large data gaps exist in intervening areas



Compact, low-cost air quality sensors are needed to fill data gaps

Addressing the Challenge with AirSENCE

- Developed along with the Southern Ontario Centre for Atmospheric Aerosol Research (SOCAAR) at the University of Toronto
- Measures gas pollutants (e.g., NO_X, CO, O_3, CO_2, SO_2) and particulates (PM_1, $PM_{2.5}$, PM_{10}) at 1-min resolution
- Optional environmental sensor add-ons (wind, noise, rainfall, light)
- Dedicated on-device processor with over-the-air updates
- Currently operating in 21 countries

Application 1
Traffic Monitor Co-location Study

TeachingCity Oshawa Project Summary

Project Goal:

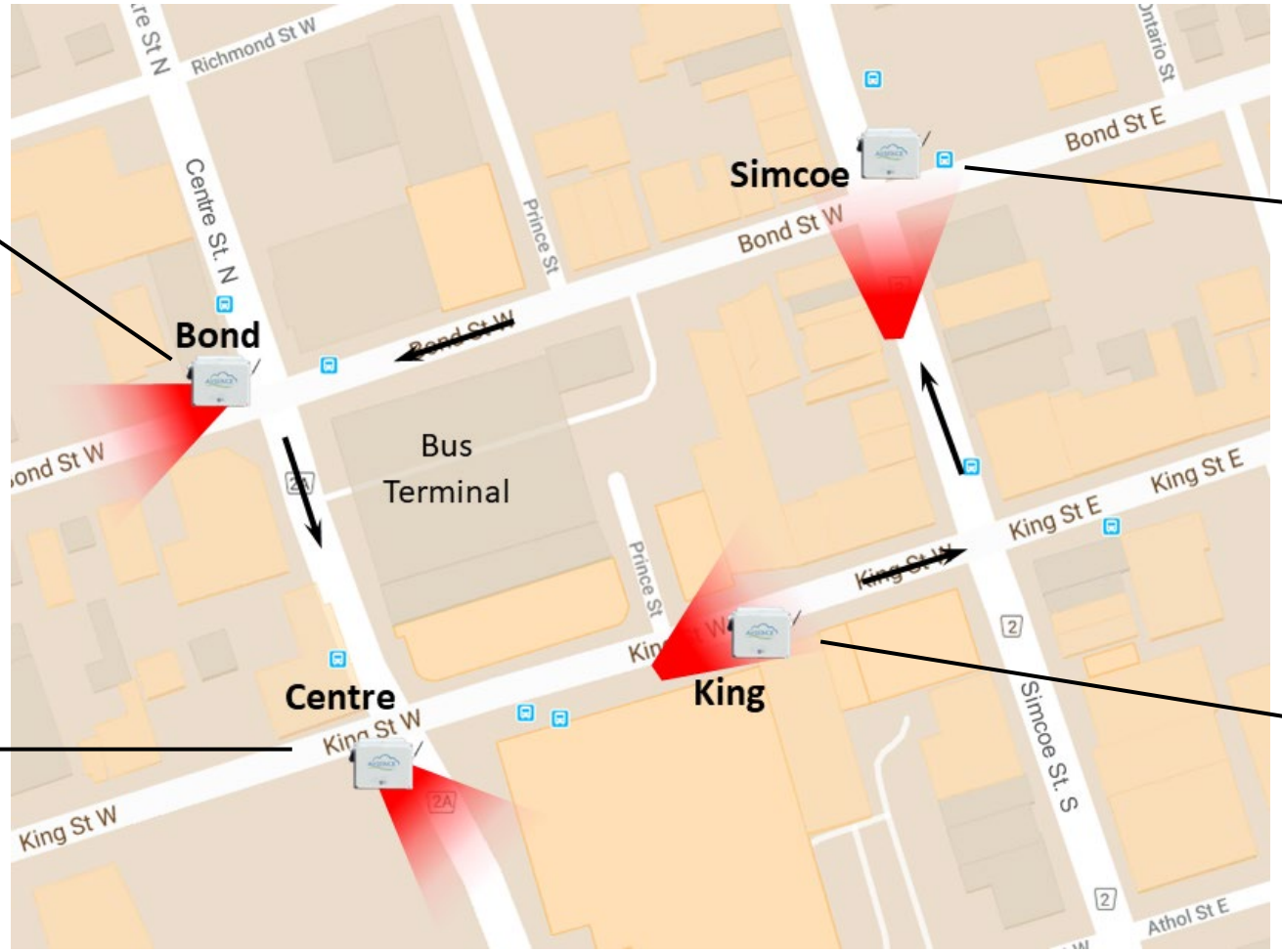
- To improve the City of Oshawa's understanding of the relationship between air quality and traffic movement in the Downtown Core
- Assess impact of traffic priorities on air quality and traffic patterns
- Improve downtown pedestrian experience

COVID-19 provided an unprecedented opportunity to analyze effects of emergency protocols on traffic volume and air pollutant levels

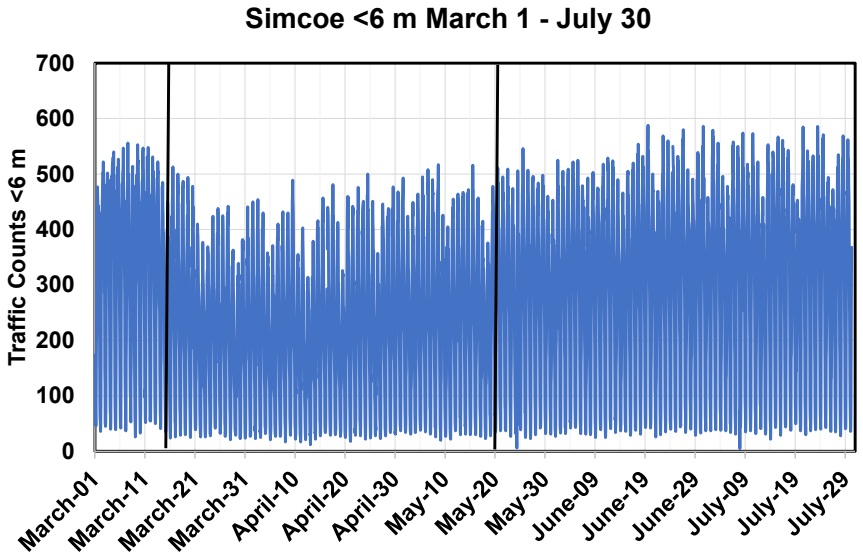
TeachingCity Oshawa

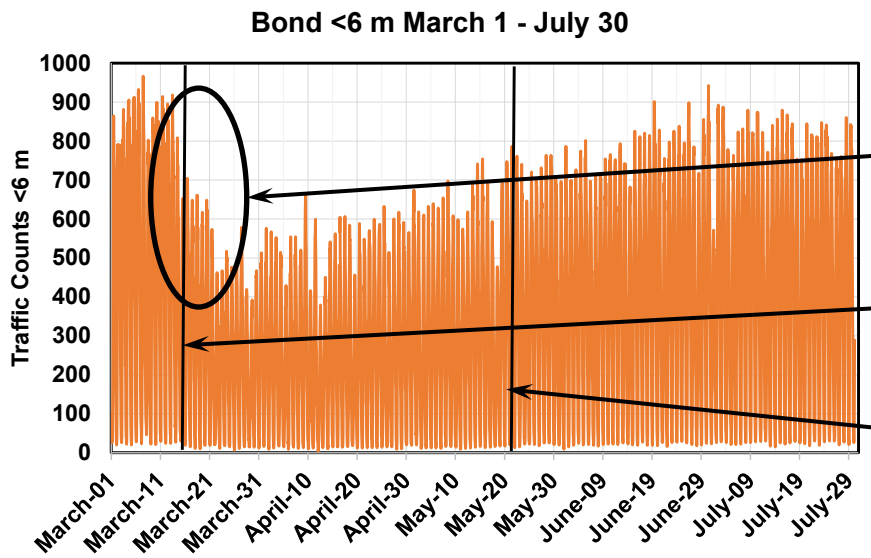
Sensor Deployment in Oshawa

Four AirSENCE™ and Northline Black CAT sensors installed in May 2019



Impact of COVID-19: Traffic Volume

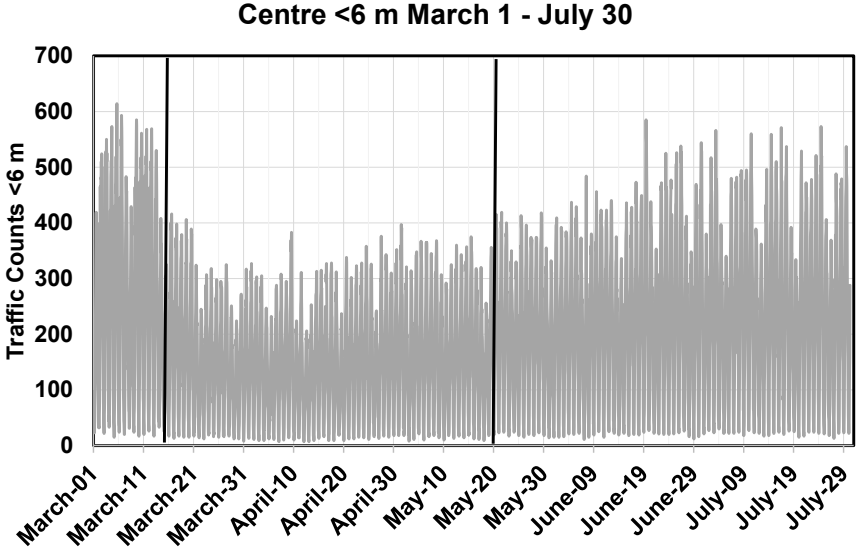


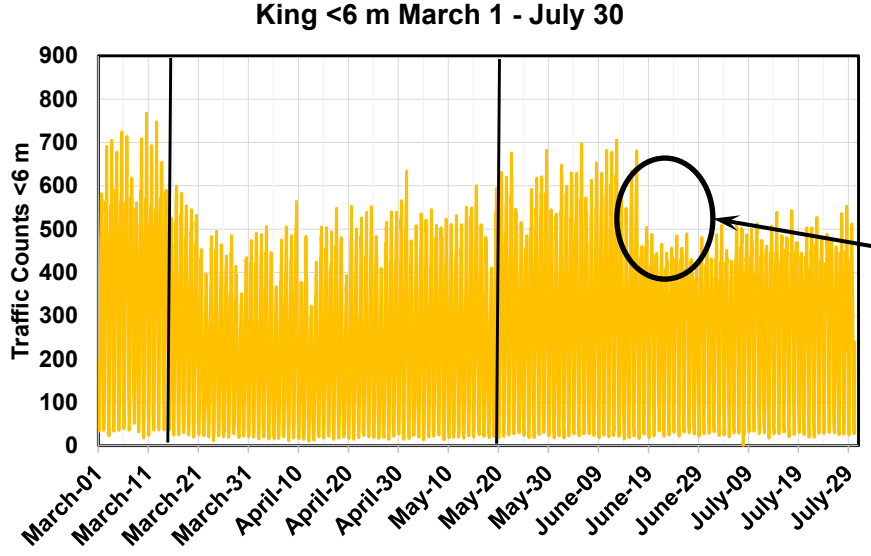


Mid-March reduction in traffic

Start of “Post-COVID” period

End of “Post-COVID” period



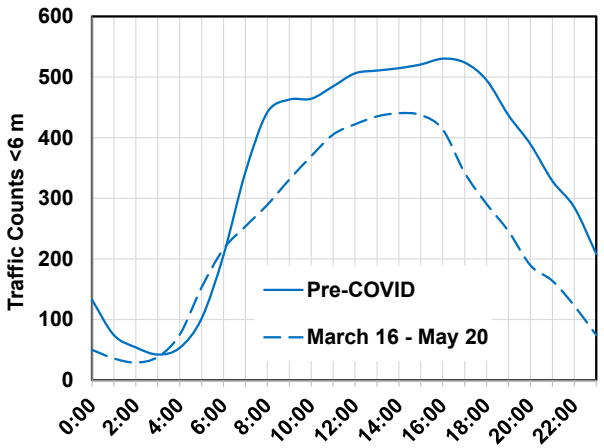


Mid-June reduction in traffic (King only)

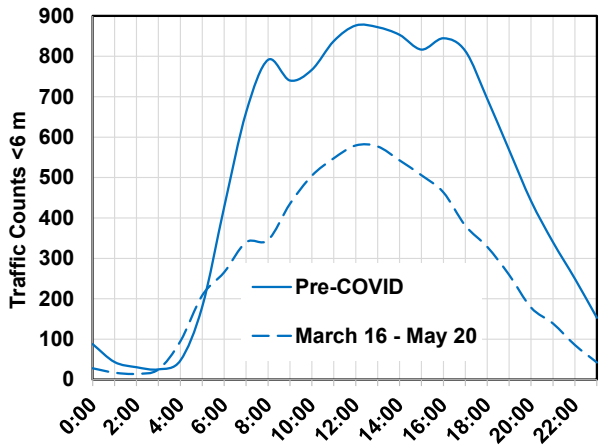
Impact of COVID-19: Traffic Volume (continued)

Small Vehicles

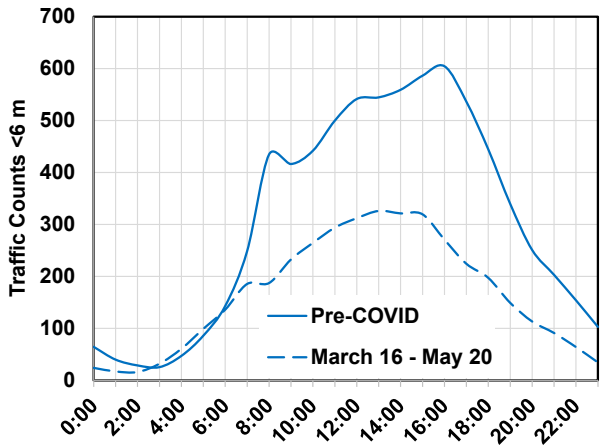
Simcoe <6 m (-26.1%)



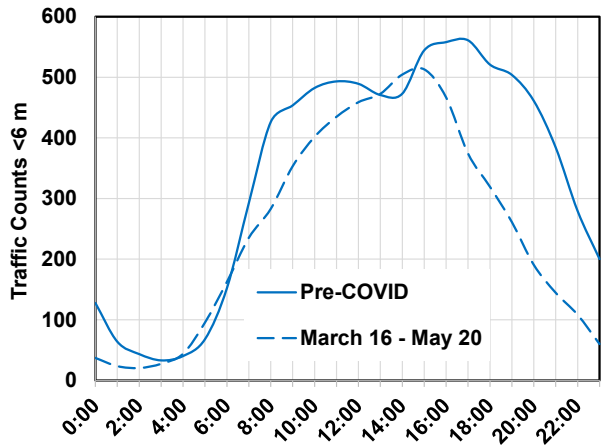
Bond <6 m (-38.5%)



Centre <6 m (-39.1%)

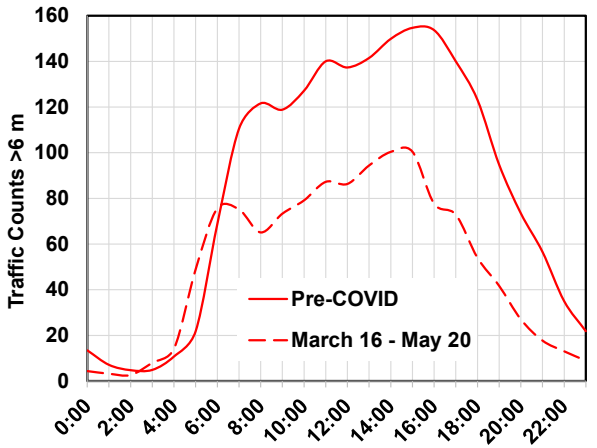


King <6 m (-27.1%)

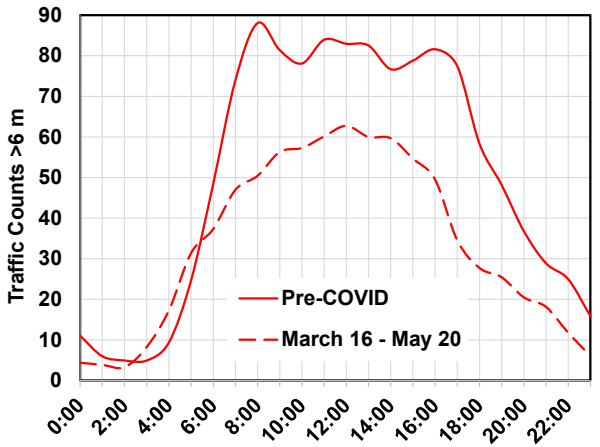


Large Vehicles

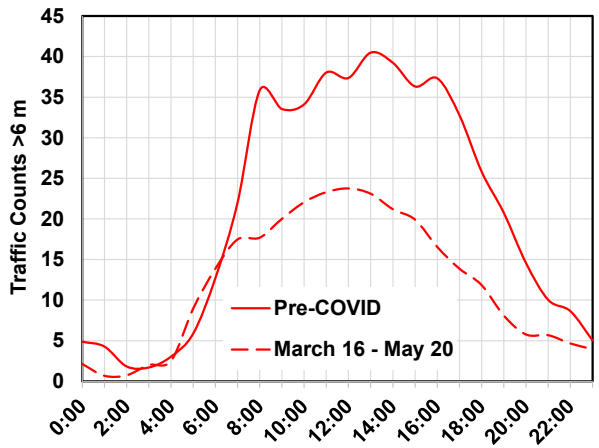
Simcoe >6 m (-30.5%)



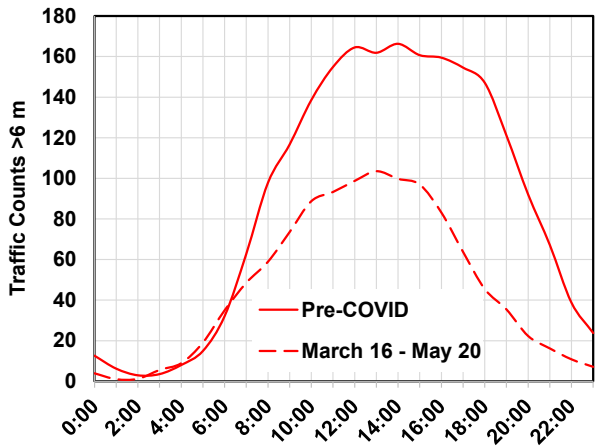
Bond >6 m (-26.3%)



Centre >6 m (-37.3%)

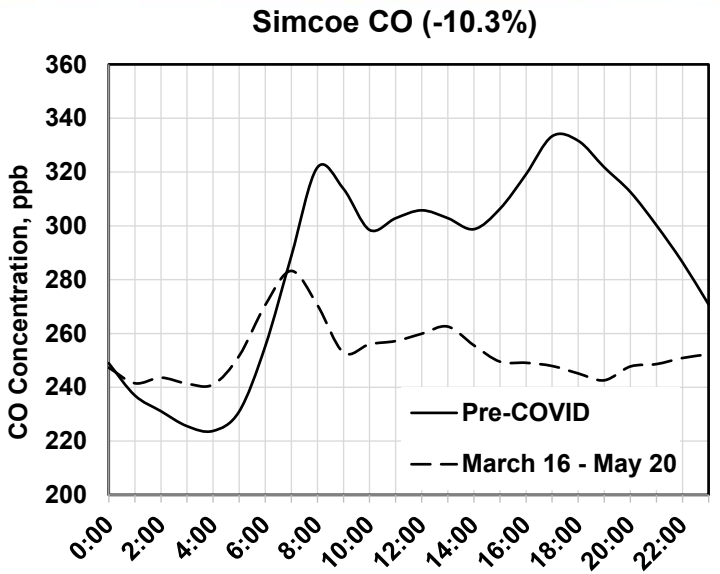


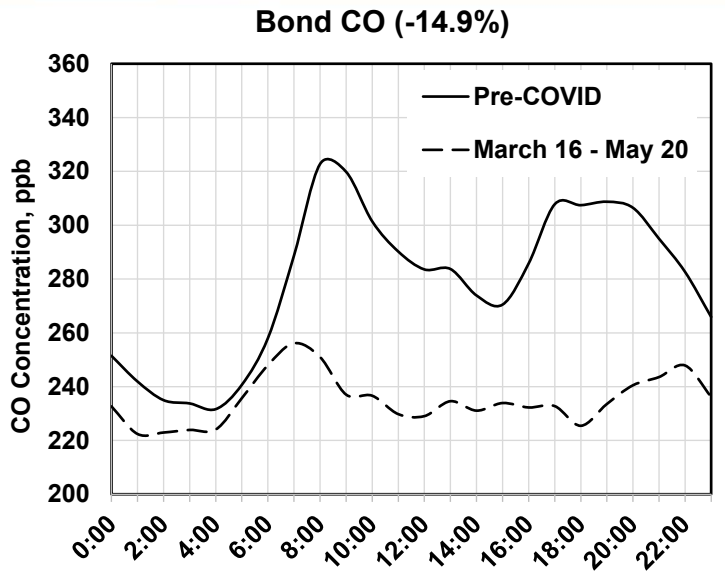
King >6 m (-40.7%)

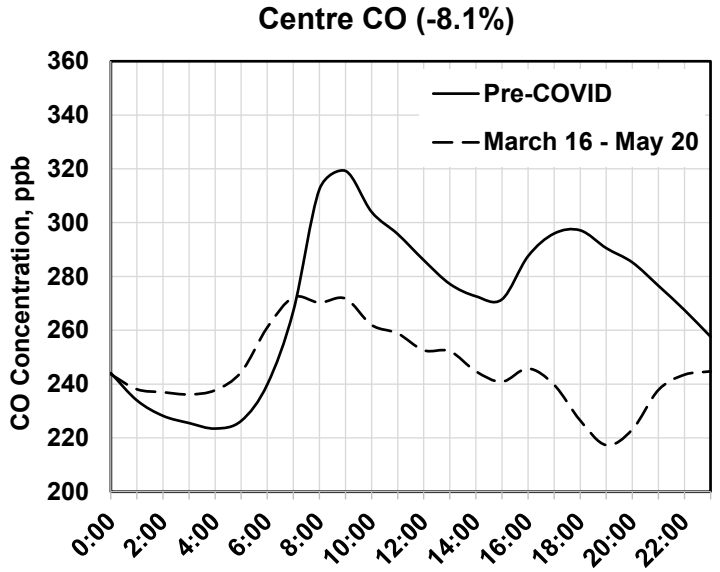


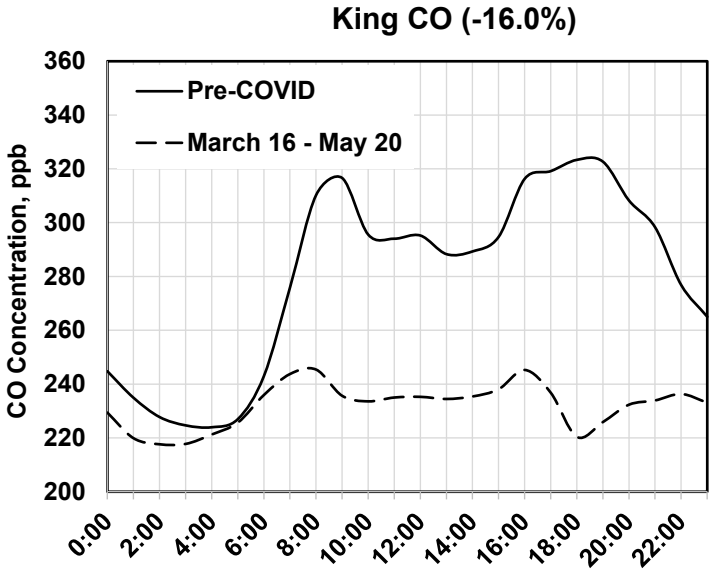
Impact of COVID-19: Carbon Monoxide

- Primarily from gasoline combustion (small vehicles)
- Significant decrease observed at each location, expected with traffic reduction
- High background CO level unaffected by local traffic
  - ➢ % reductions not as great as those for traffic

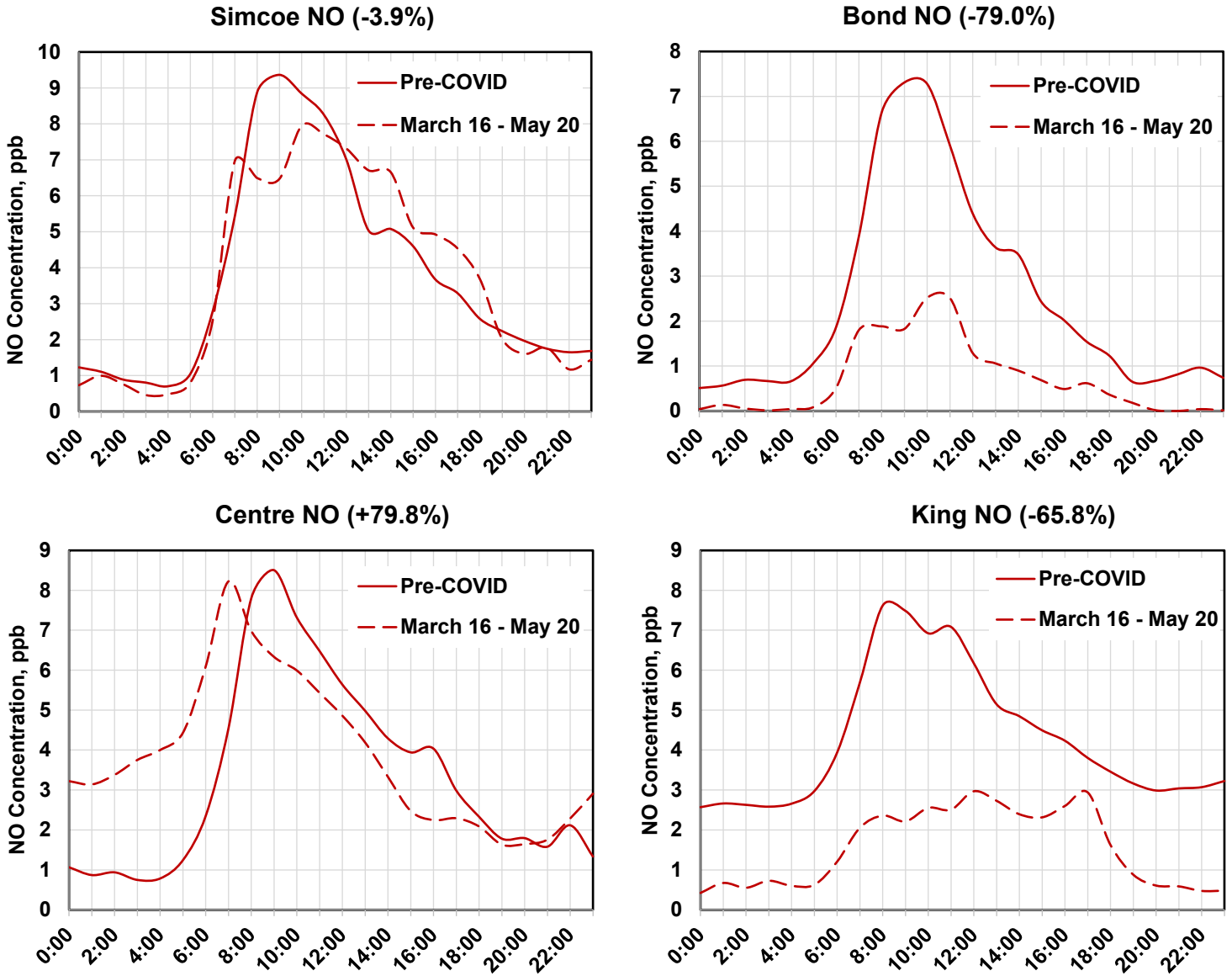




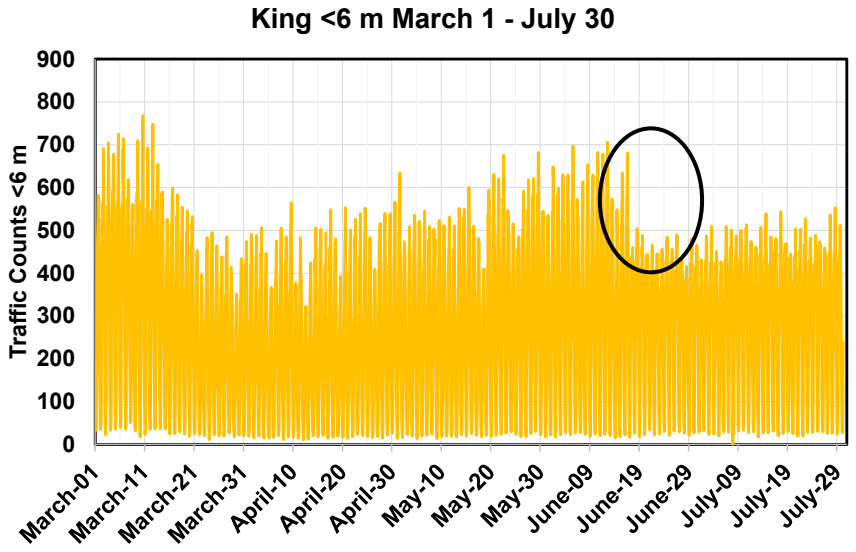


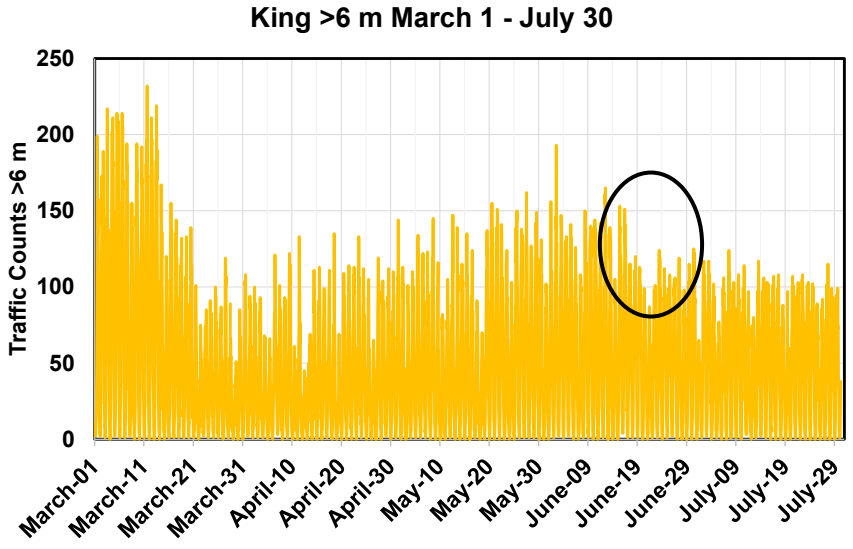


COVID-19 Impact: Nitric Oxide

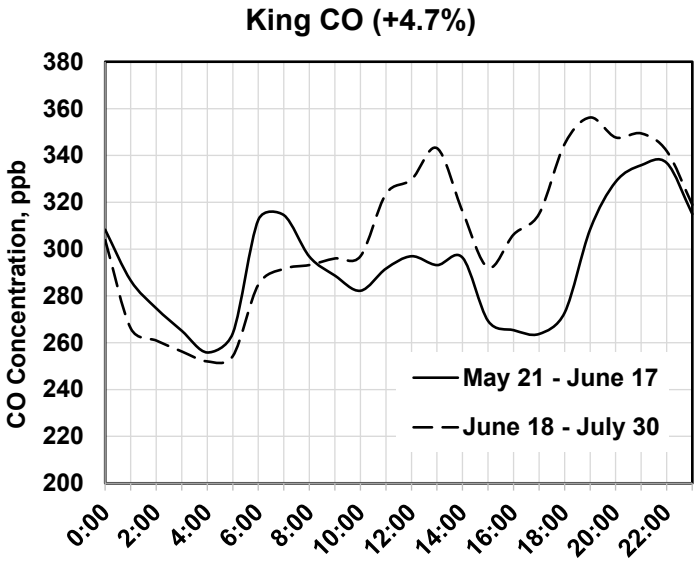


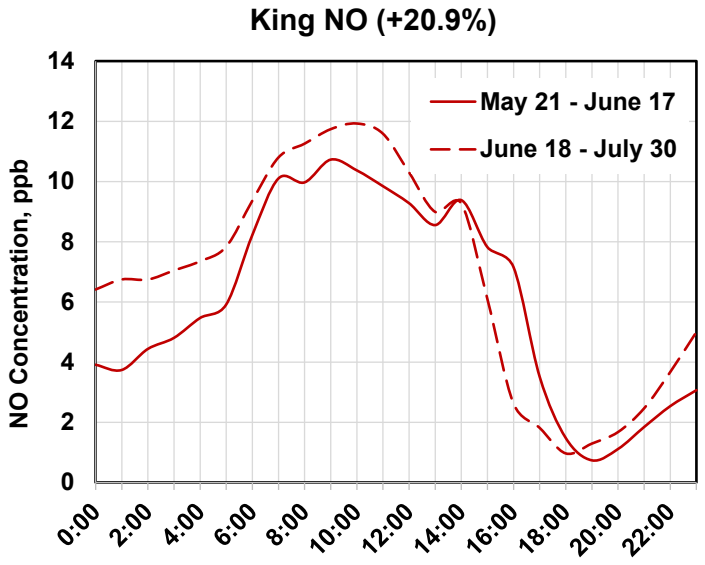
- Primarily from diesel combustion (large vehicles)
- Large decrease observed at Bond and King, not at Simcoe and Centre
- Simcoe and Centre replaced on April 23rd; difference possibly due to variations in calibration, operating near detection limit
- E.P. Taylor supports trends seen at Bond and King

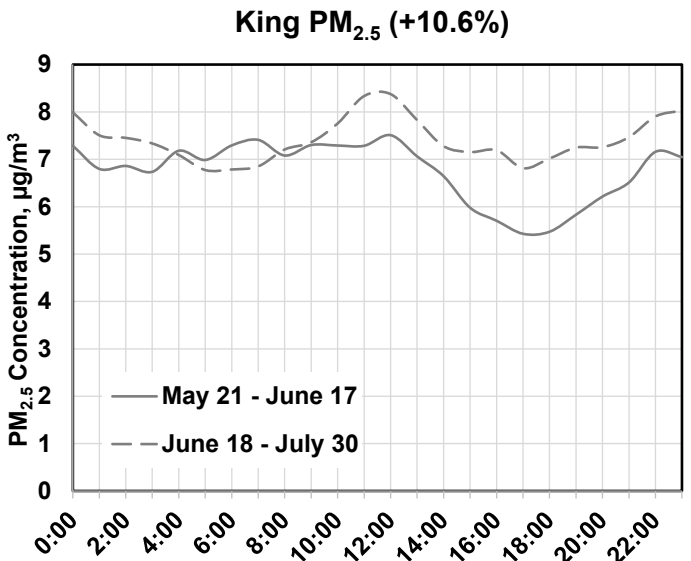

King <6 m March 1 - July 30
Traffic Counts <6 m
900
800
700
600
500
400
300
200
100
0
March-01
March-11
March-21
March-31
April-10
April-20
April-30
May-10
May-20
May-30
June-09
June-19
June-29
July-09
July-19
July-29


King >6 m March 1 - July 30
Traffic Counts >6 m
250
200
150
100
50
0
March-01
March-11
March-21
March-31
April-10
April-20
April-30
May-10
May-20
May-30
June-09
June-19
June-29
July-09
July-19
July-29


Traffic reduction starting in mid-June caused by channelization of King Street for sidewalk improvement project east of Simcoe
Toby's







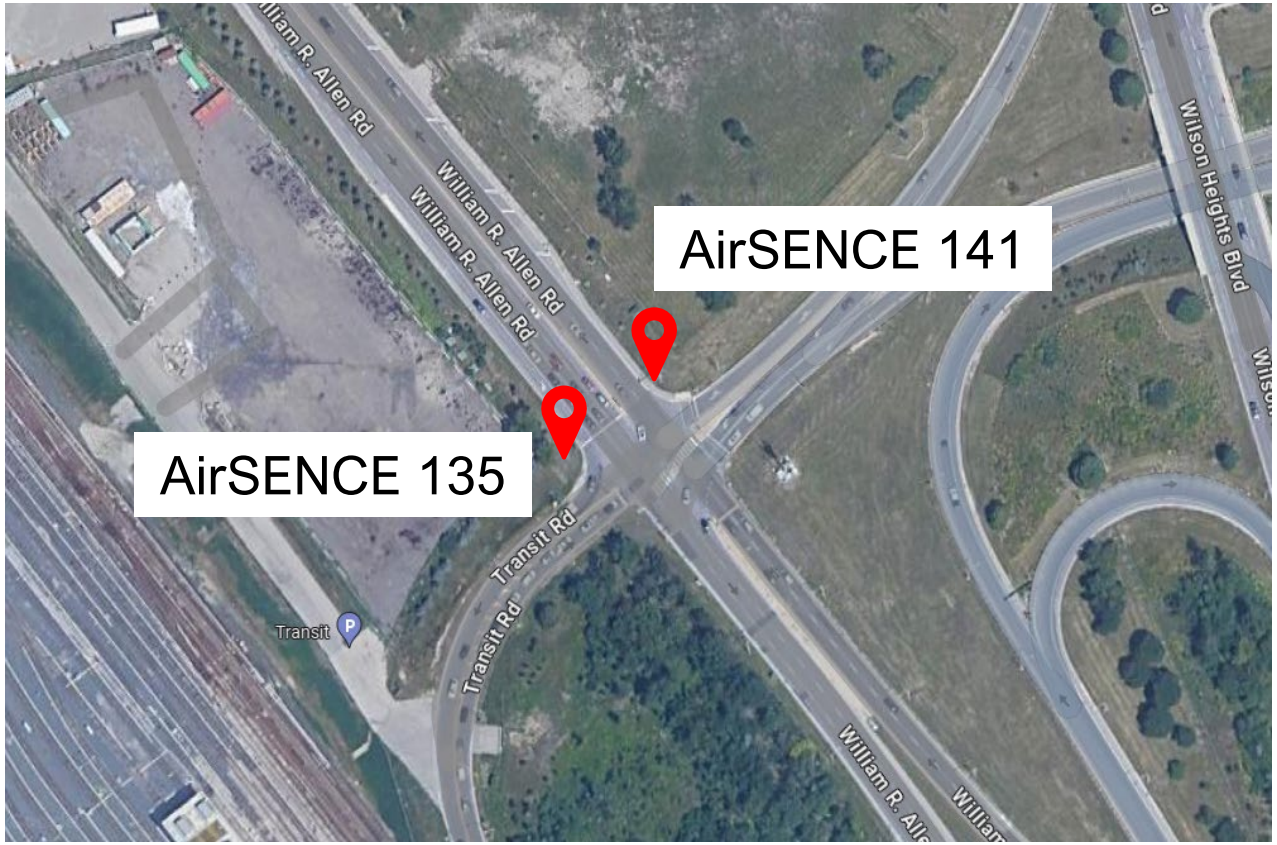
- Increase in CO, NO, and $PM_{2.5}$ observed
- Roadwork reduces overall traffic volume, creates additional emissions
- Pollutant levels reduced during morning rush hour, but increased during work day

Traffic volumes do not always directly correlate with pollutant levels

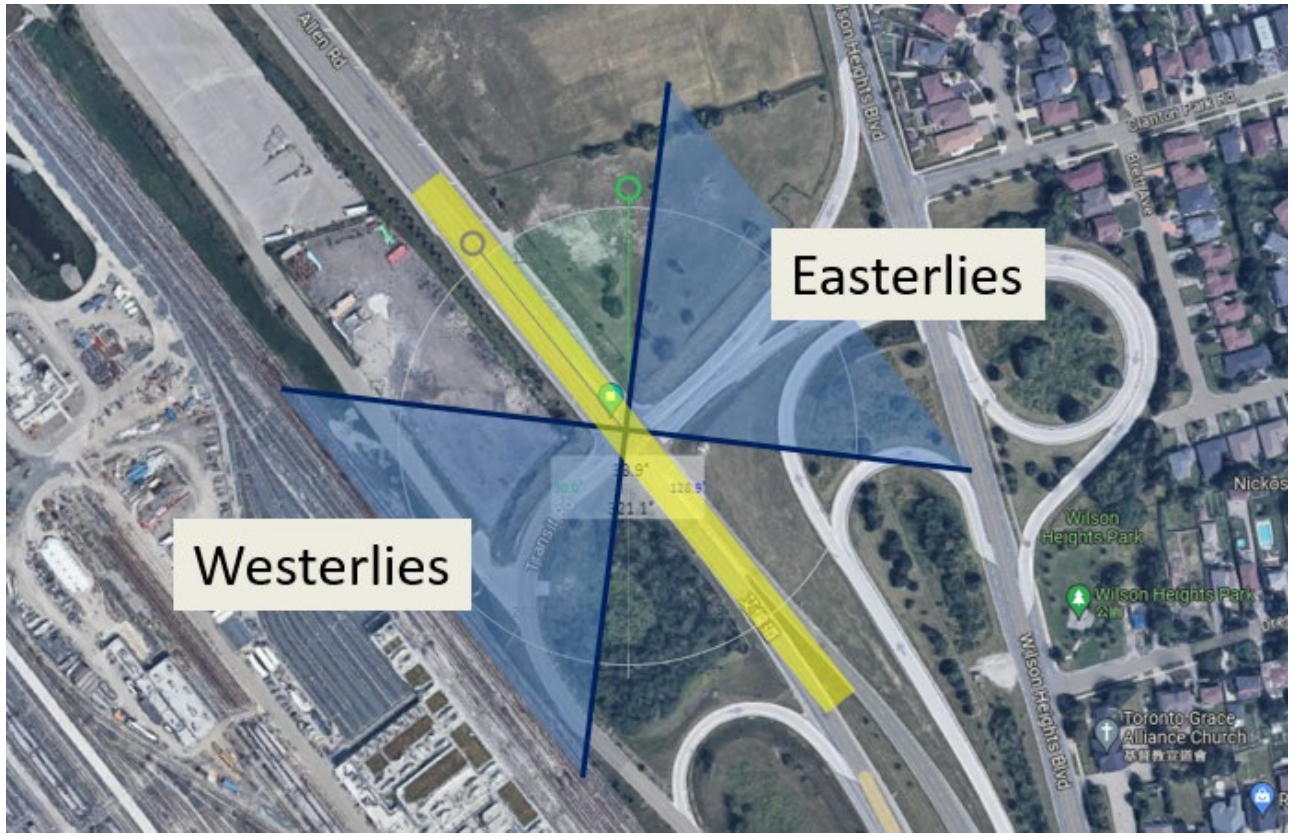
Application 2
Cross-road Wind Direction Study

Description of Study Site

- Allen Road: major north-south thoroughfare in Toronto
- One AirSENCE device placed at each side of road at key intersection, 27 m apart
- West side: AirSENCE device ID 135
- East side: AirSENCE device ID 141

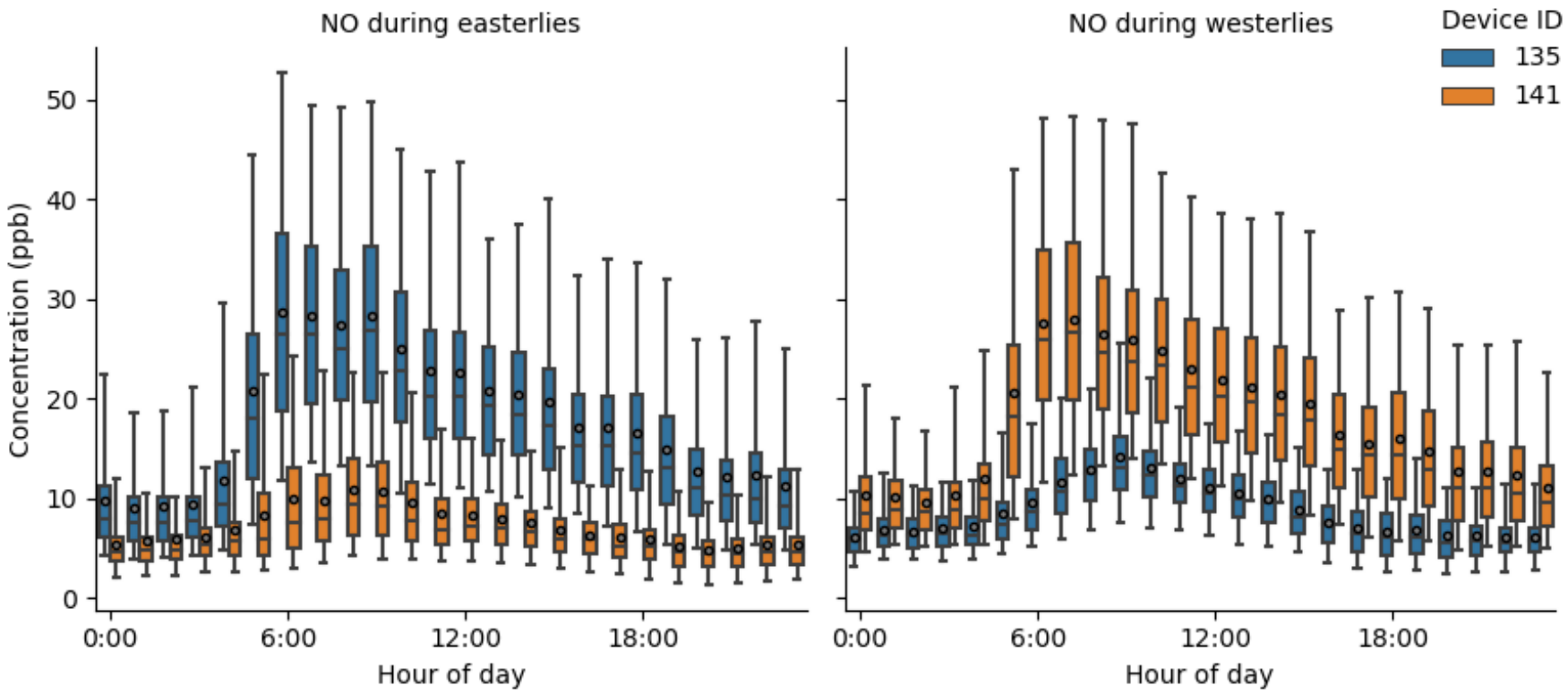


Context of Wind Direction



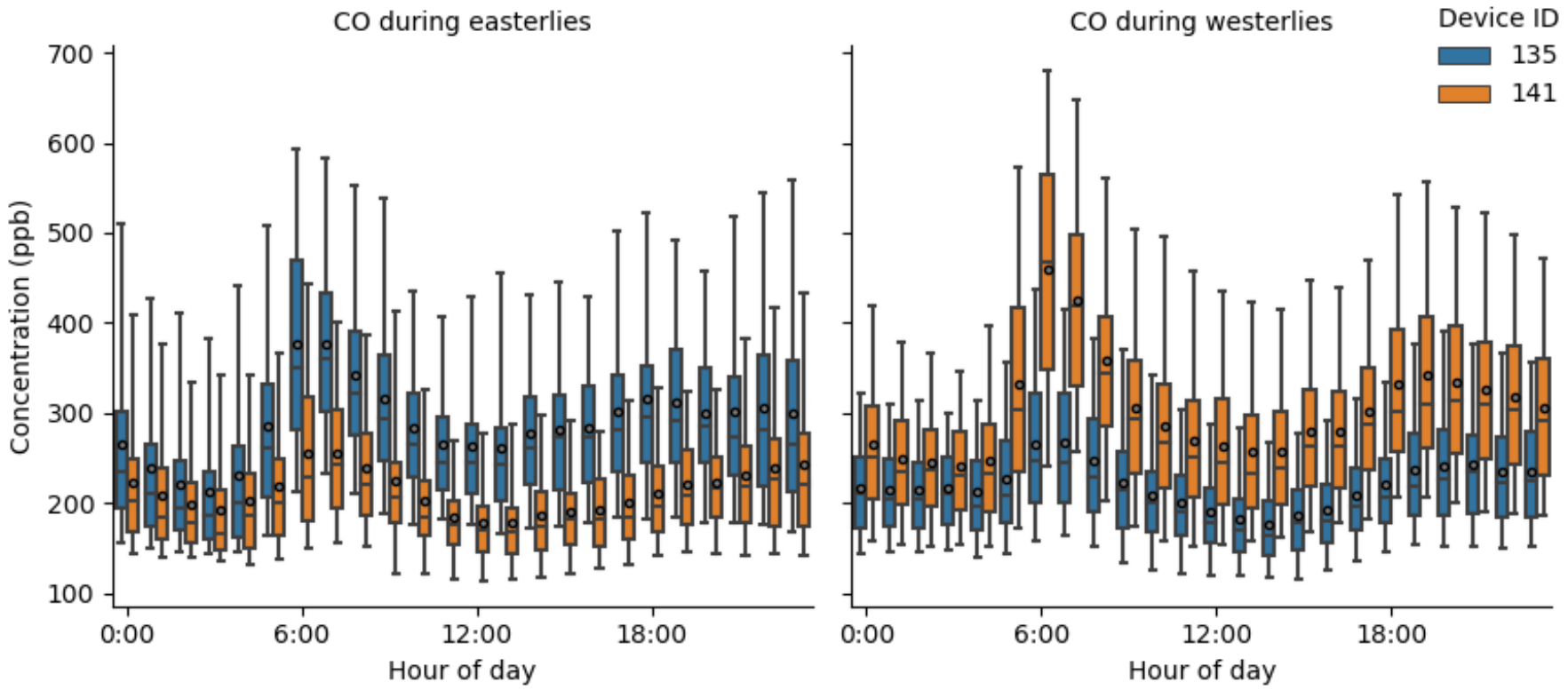
- “North” defined as road direction, -40° from true north
- “Easterly” and “westerly” winds defined as originating from ±45° from road-aligned east and west
- Wind data obtained from meteorological station at Pearson International Airport, ~15 km west

Influence of Wind Direction: Nitric Oxide



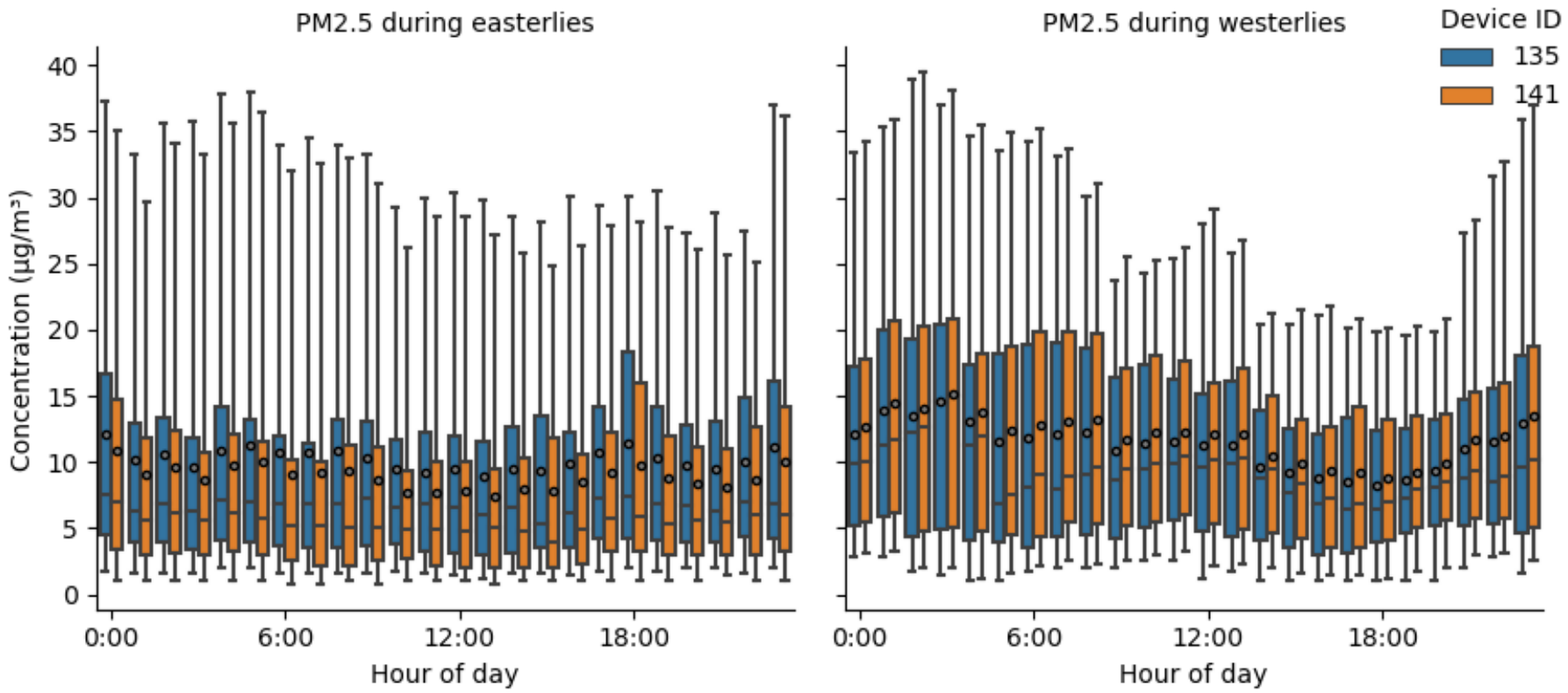
Difference in NO concentration effectively indicates contribution of road traffic

Influence of Wind Direction: Carbon Monoxide



East-west difference lower than that of NO; attributed to higher background levels of CO

Influence of Wind Direction: Fine Particulate



Absence of significant east-west difference indicates predominance of background PM contribution

Conclusions

Traffic monitoring co-location study

- Concentrations of TRAP showed strong correlation with traffic volume during initial COVID-19 lockdown period
- Road construction in June produced an inverse correlation: traffic ↓, TRAP ↑
- TRAP levels should not be assumed based on conventional indicators (i.e., traffic counts)

Cross-road wind direction study

- Analysis method separates background NO and CO from local traffic contribution
- Illustrates variability of TRAP hot spots with changing weather conditions

- Both studies highlight the utility of compact air quality monitors for public health alerting and urban planning
- Smart City infrastructure projects stand to benefit from real-time air quality data

THANK YOU!

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+1 (416) 923-4425

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AIRSENCE@AUGSIGNALS.COM

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