Traffic-related air pollution near roadways: Discerning local impacts from background

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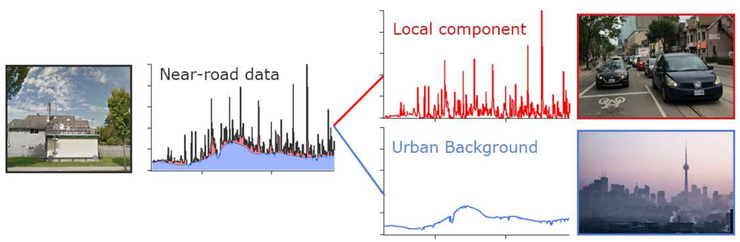
Near-road Measurements

- Air pollutant measurements near roadways are heavily influenced by traffic.
- Quantifying the amount traffic contributes to these concentrations is challenging.



Canadian Monitoring Initiative

- Six air quality stations were deployed throughout Ontario and Vancouver.
- Measurements taken continuously between 2015 – 2017.

NR-VAN: Located 6 m from Clark Drive, a major roadway experiencing 33,100 vehicles per day across four southbound and three northbound lanes.

BG-VAN: Situated on the property of Sunny Hill Children's Hospital.

NR-TOR-1: Positioned 10 m from Highway 401, with over 400,000 vehicles per day.

NR-TOR-2: Located on the University of Toronto campus in downtown Toronto.

BG-TOR-1: Located on the property of Environment Canada, Downsview.

BG-TOR-2: Located on the southernmost point of Toronto Islands.

Background Subtraction Methods

Method 1: Site Differences

- Near-road pollutant concentrations occurring as a result of traffic were estimated based on differences between near-road and background station pairs (i.e., NR-VAN and BG-VAN, NR-TOR-1 and BG-TOR-1, and NR-TOR-2 and BG-TOR-2).

Method 2: Downwind/Upwind Differences

- For each near-road station, excess pollutant concentrations were determined based on differences between measurements taken downwind and upwind of the road.

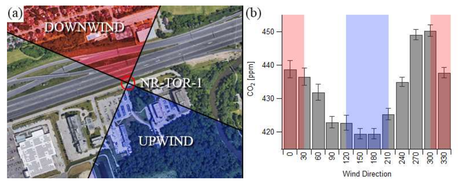
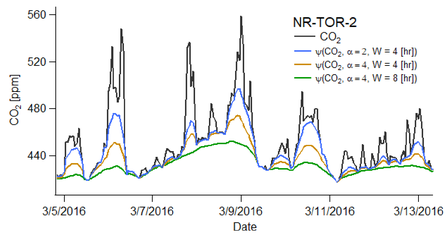


Figure 1.
Satellite image of the NR-TOR-1 site, along with upwind (blue) and downwind (red) quadrant definitions (left). Average CO_2 concentrations as a function of wind direction. Error bars are 95% confidence intervals on the mean (right).

Method 3: Baseline Inference

- Excess concentrations at each near-road station were approximated based on baseline inference using time-series analysis. This inferred baseline is intended to reasonably approximate concentrations measured at nearby background stations.

Figure 2.
Method 3 applied to hourly CO_2 concentrations (black) measured at NR-TOR-2. The effect of varying the input parameters α and W on the resulting baseline are shown in blue, orange, and green. See DOI ref. for details.



Method Comparison

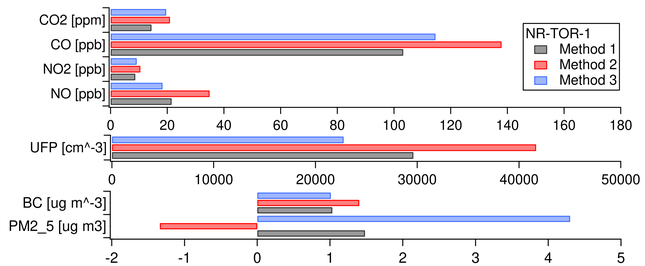


Figure 3.
A comparison of local concentrations determined using each method for each pollutant measured in this study at the Highway 401 station, NR-TOR-1.

Effect of Meteorology on Local Concentrations

- Local traffic-related concentrations, as determined using Method 3, were compared with meteorological data from NR-TOR-1 and NR-VAN.
- Concentrations were normalized with respect to mean values for comparability amongst all pollutants.

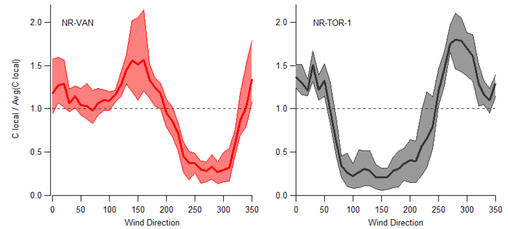


Figure 4.
Normalized local pollutant concentrations determined using method 3 as a function of wind direction at NR-VAN (left) and NR-TOR-1 (right). Solid lines are average trends amongst all pollutants, and shaded areas are ranges of variability between the pollutants.

- Wind speed relation regressed against the function: $\frac{C_{L,3}}{\bar{C}_{L,3}} = \frac{c_1}{WS^{c_2}}$

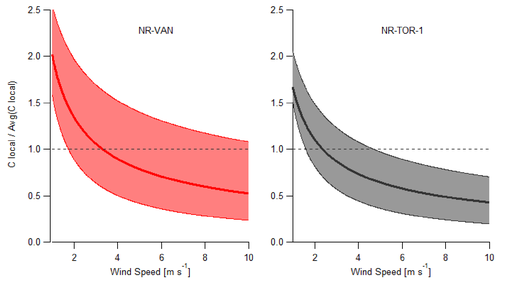


Figure 5.
Normalized local pollutant concentrations determined using method 3 as a function of wind speed at NR-VAN (left) and NR-TOR-1 (right). Solid lines are average trends amongst all pollutants, and shaded areas are ranges of variability between the pollutants.

Conclusions

- Local pollutant concentrations were up to six times higher when the monitoring station was directly downwind of the road, compared with the upwind case.
- Pollutant concentrations decreased by a factor of four with increasing wind speeds from 4 to 40 km hr^{-1} (c_2 ~ 0.5-0.6).
- Method 3 (baseline inference) was shown to reliably predict background concentrations (except $PM_{2.5}$), whereas downwind/upwind analysis over-predicted the influence of traffic.

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