

Supplementary information
**Rigorous quantification of the statistical significance of COVID-19
lockdown effect on air quality: The case from ground-based
measurements in Ontario, Canada**

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Table S1. Timeline of COVID-19 related restrictions in Ontario (ON), Canada, Michigan (MI), and Ohio (OH) in the U.S. Shaded rows refer to U.S. states.

Date in 2020	Province/State	Event
Mar-17	ON	State of emergency in Ontario while ordering some business to be closed, including daycares, bars and restaurants, theatres and private schools
Mar-22	OH	State-wide stay at home order and in effect until May 1, then extended to May 29.
Mar-23	MI	State-wide stay at home order.
	ON	Closure of all non-essential businesses across the province for 14 days.
Apr-09	MI	Statewide stay at home order extended.
Apr-24	MI	Non-essential retailers can reopen provided they follow strict guidelines or meet certain criteria.
May-4	OH	Manufacturing, construction and distribution can reopen.
May-11	MI	Manufacturers to return to work.
May-15	OH	Various businesses are allowed to open provided they follow strict guidelines or meet certain criteria.
May-19	ON	Various businesses are allowed to open provided they follow strict guidelines or meet certain criteria (this continues throughout the month)
May-26	OH	Further opening of businesses, including recreational facilities and activities.
Jun-01	MI	Stay at home order rescinded and entire state moved to Phase 4 of reopening.
Jun-08	ON	Some regions start Phase 2 re-opening.
Jun-15	ON	Durham, Halton, Haldimand-Norfolk, Hamilton, Lambton, Niagara, and York health regions enter Stage 2.
Jun-19	MI	Final stay at home order expires.
Jun-24	ON	Peel and Toronto enter Stage 2.
Jun-25	ON	Most of Windsor-Essex enter Stage 2, excluding Kingsville and Leamington.
Aug-12	ON	All regions in Ontario in Stage 3.
Oct-10	ON	Some restrictions re-implemented in Ottawa, Peel, and Toronto regions.
Oct-19	ON	Some restrictions re-implemented in York region.
Nov-17	OH	Formal announcement on state-wide "slow down".
Nov-18	MI	Orders the closure of several businesses and public services, including high schools and universities, for three weeks.
Dec-07	MI	Partial shutdown on businesses extended
Dec-10	OH	'Slow down' extended into January
Dec-26	ON	Province-wide lockdown

As Ontario eased restrictions and more people returned to work, the services that they rely on (e.g., public transportation, childcare) needed to be made available. As a result, traffic and industrial activity slowly increased from Stage 1 to 2 through to Stage 3. For more detailed information on allowable activities in Stage 2 and 3, see the following links:

<https://www.ontario.ca/page/framework-reopening-our-province-stage-2>

<https://www.ontario.ca/page/framework-reopening-our-province-stage-3>

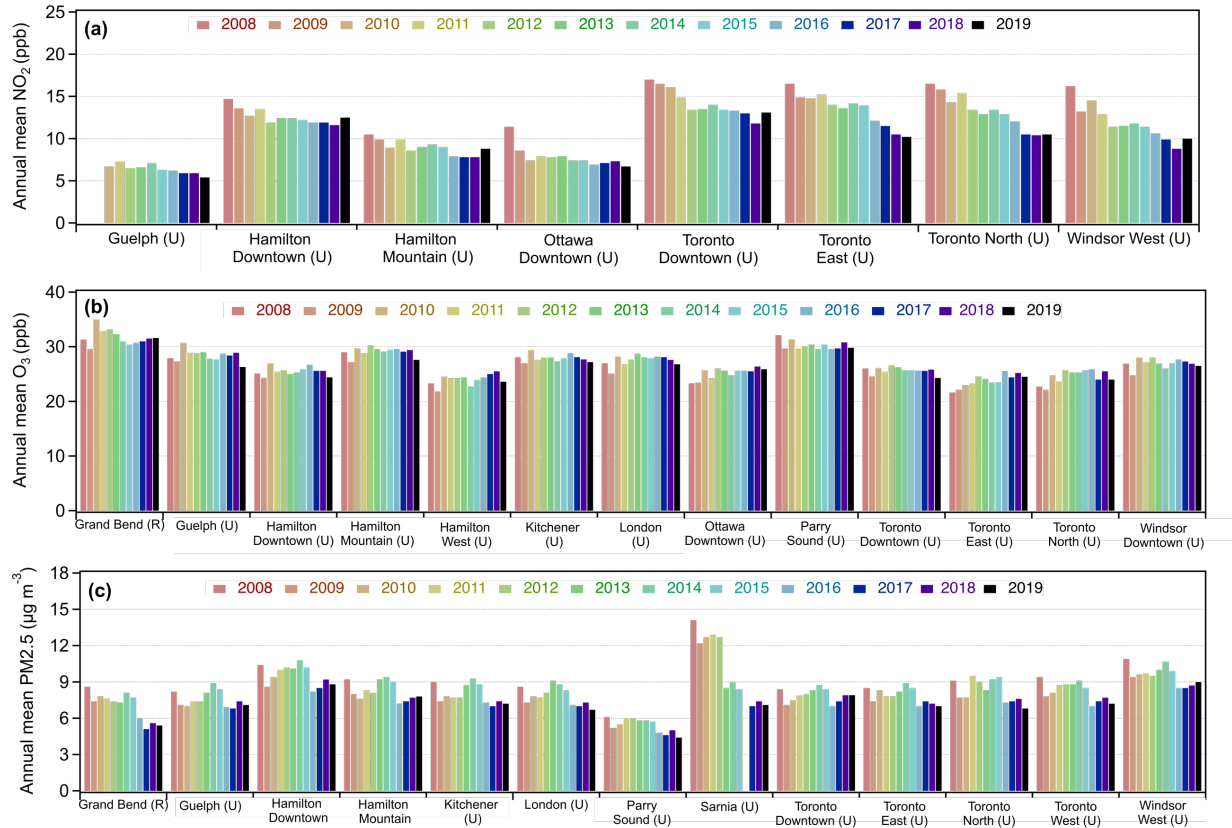
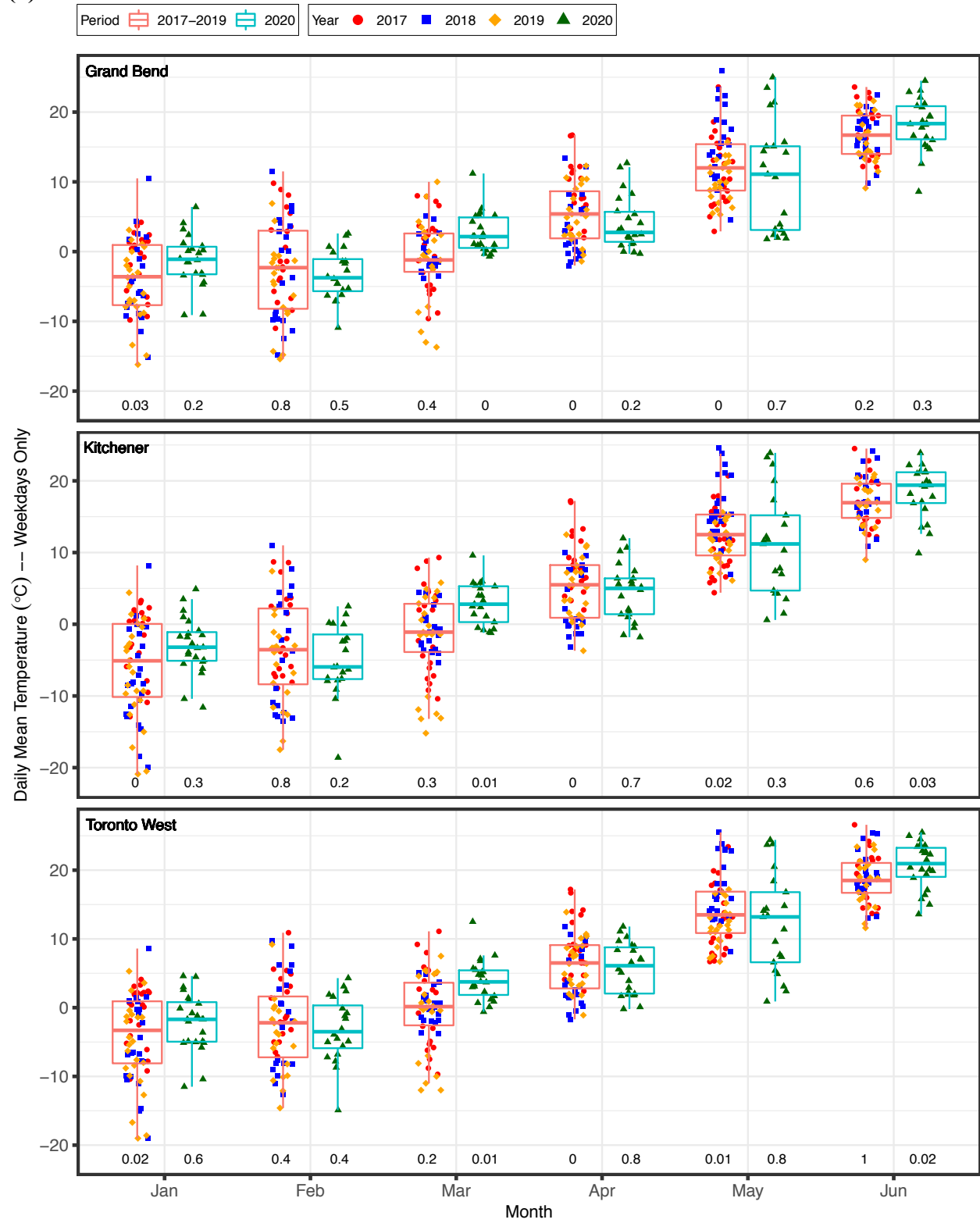


Figure S1: Eleven-year trends in air quality pollutant levels reported by MECP in selected cities in Southern Ontario. The population of these cities is listed in Table 1: (a) annual mean of NO₂ levels, (b) annual mean of O₃ levels, and (c) annual mean in PM_{2.5} levels. Similar data for more cities are shown in Figure 1.

(a)



...Figure S2(b) next page/

(b)

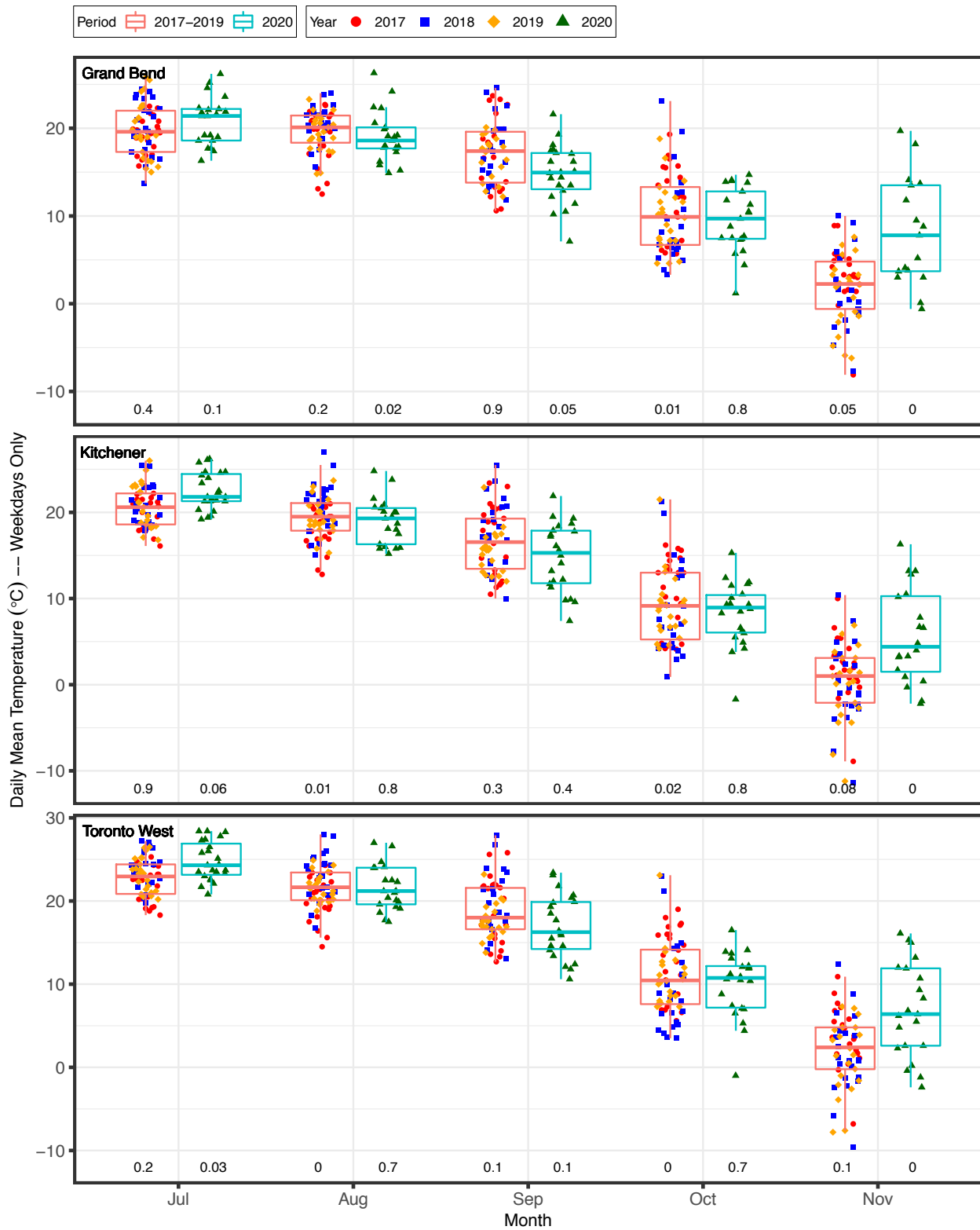
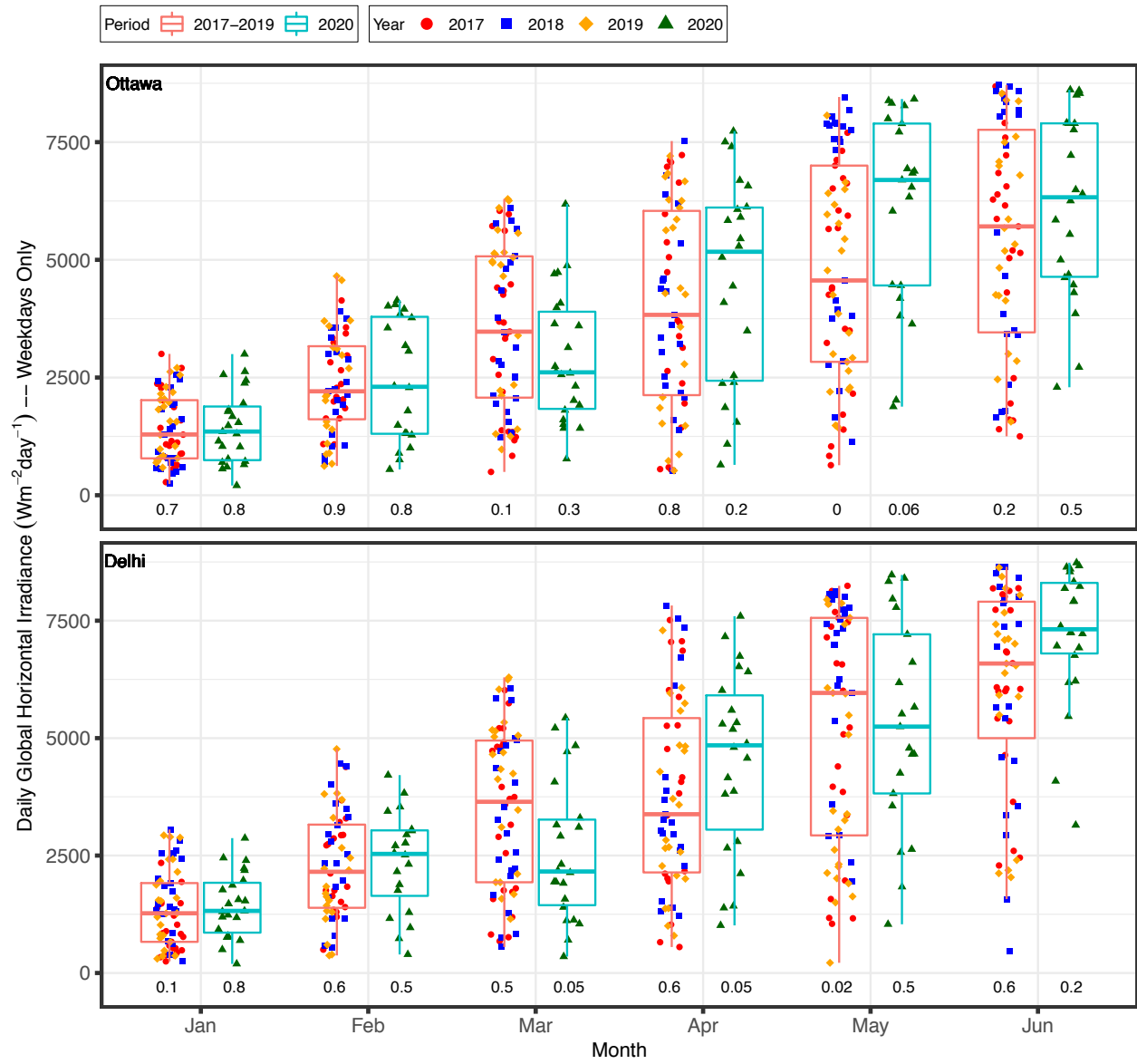


Figure S2. Box plots for the daily mean temperature per month over the 2017-2019 and 2020 periods for selected AQ stations in Southern Ontario, (a) Jan-Jun, and (b) July-Nov. Number below each data box corresponds to the calculated p-value. See text for details.

(a)



...Figure 3(b) next page/

(b)

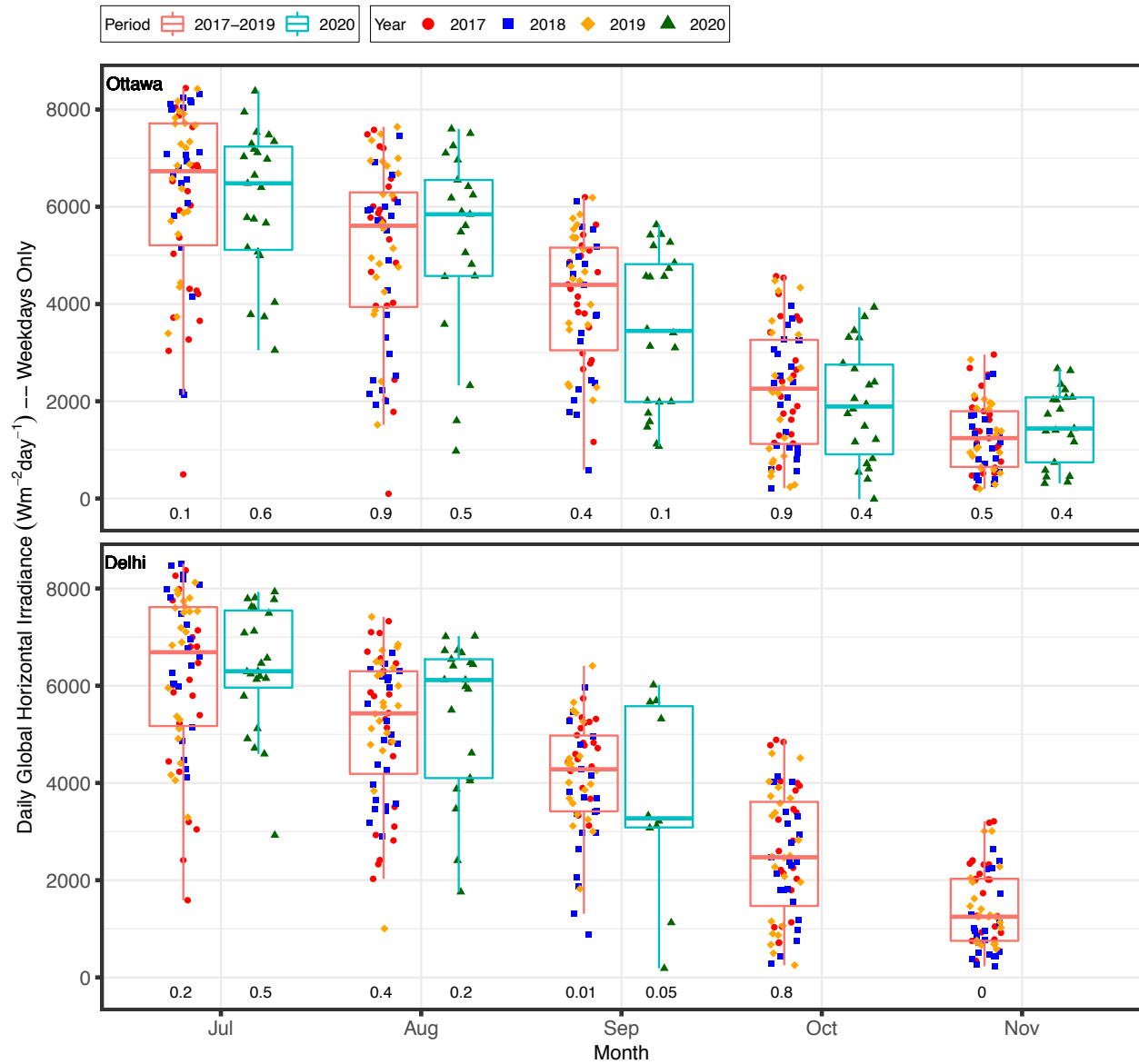


Figure S3. Daily (i.e., sum of hourly) solar global horizontal irradiance (GHI) in Ottawa, ON (top) and Delhi, ON (bottom) per month, as a function of year, (a) Jan-Jun, and (b) July-Nov. Values of GHI were converted from the measured radiation field 1(RF1). RF1 is a legacy term used by ECCC for solar radiation observations. It generally refers to the global solar radiation on a horizontal surface for an hour in energy units (MJ m^{-2}). Number below each data box corresponds to the calculated p-value. See text for details. The sensor at the Delhi station went down in October and November, hence no data available for these two months.

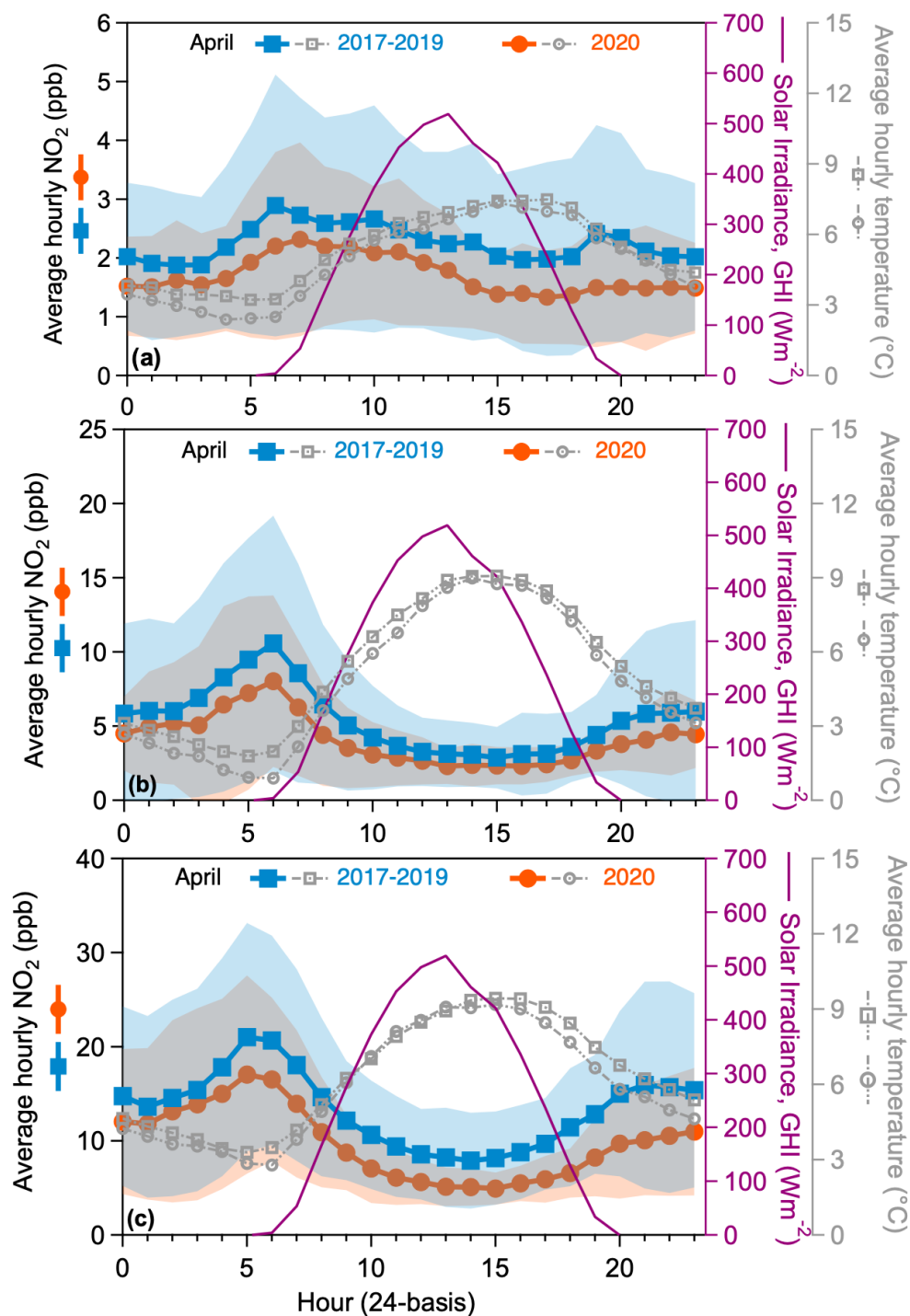
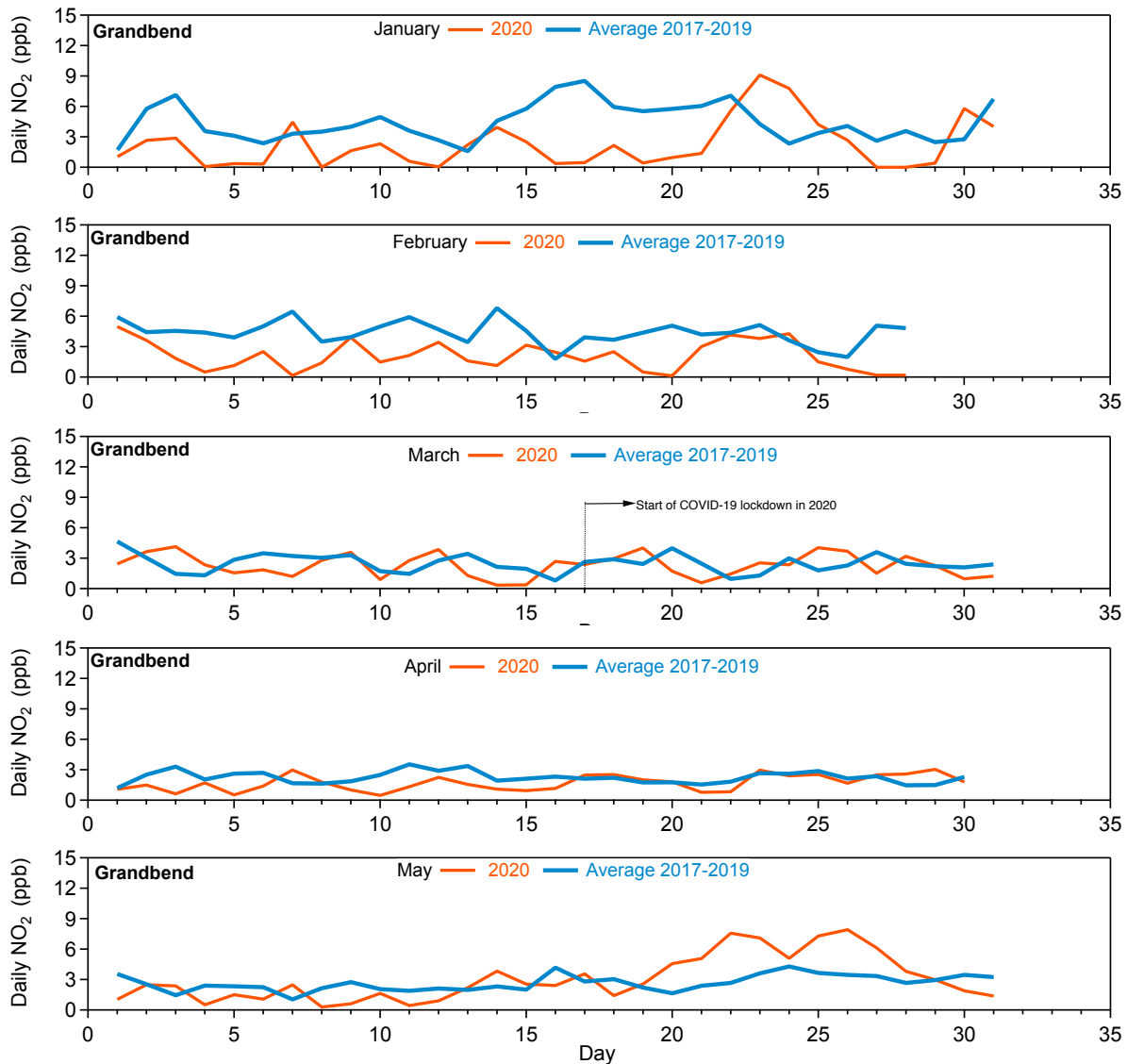


Figure S4. Diurnal levels of NO₂ (left axis) in April over 2017-2019 and 2020 for selected AQ stations in Southern Ontario: (a) Grand bend (rural), (b) Kitchener (urban), and (c) Toronto West (urban). The right axes show the average hourly solar irradiance, GHI, in April 2017-2019 at Delhi, ON, which is the closest irradiance observation station to the three locations, and average hourly temperature for each location in April 2017-2019 and 2020. The shaded areas represent the standard deviation, $\pm 1 \sigma$.

(A)



(B)

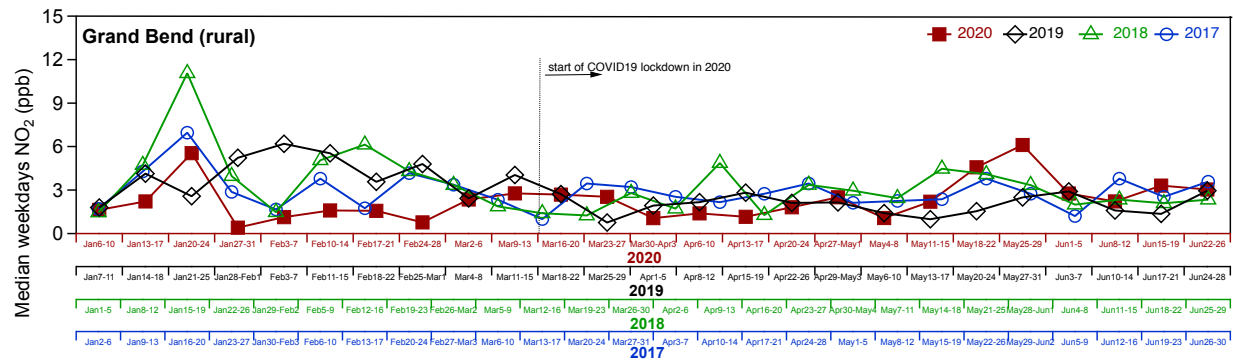


Figure S5. (A) Daily NO₂ levels in Jan-May from the average data over 2017-2019 and for 2020. (B) Median of weekdays of NO₂ levels from January to June per year over 2017-2020.

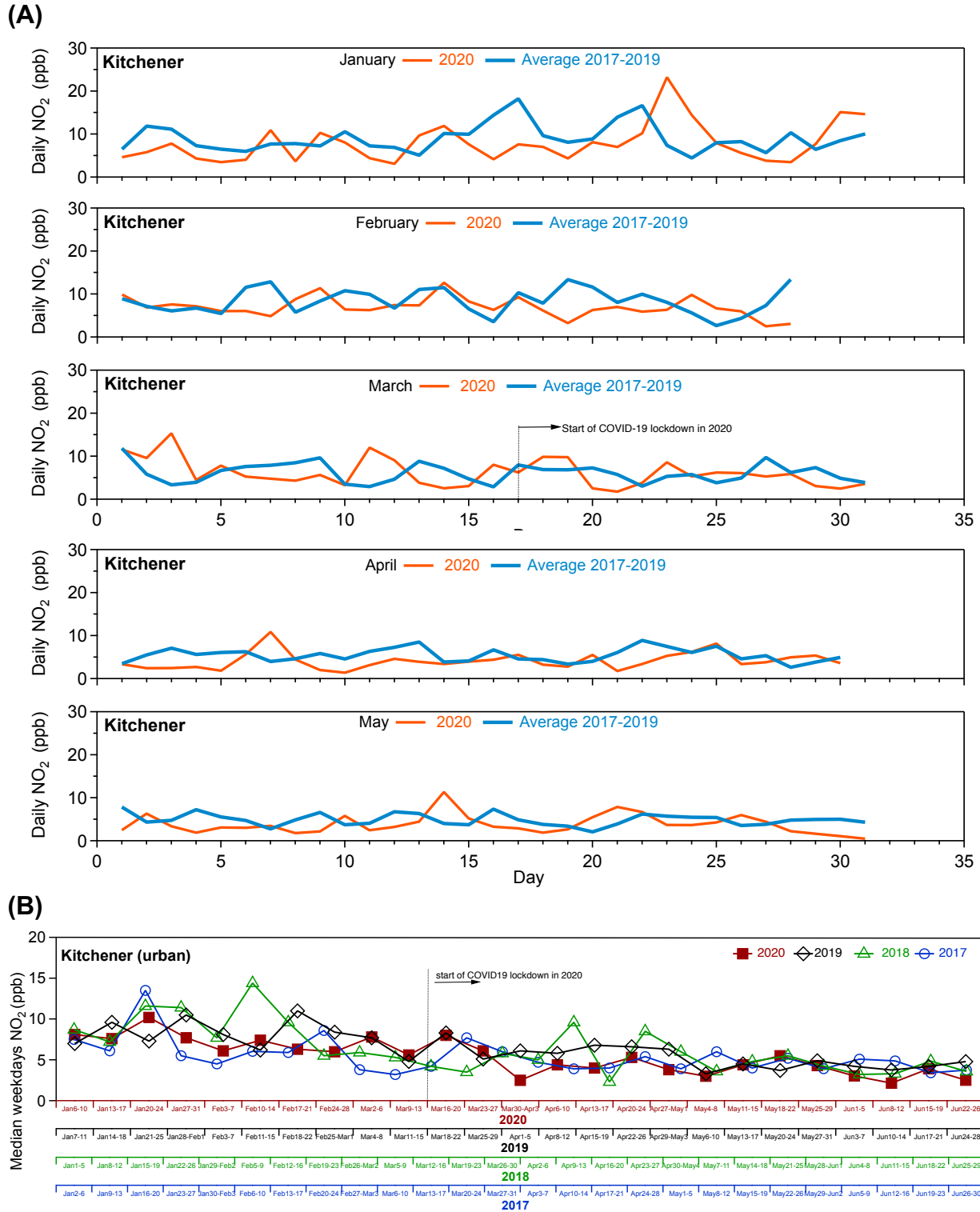
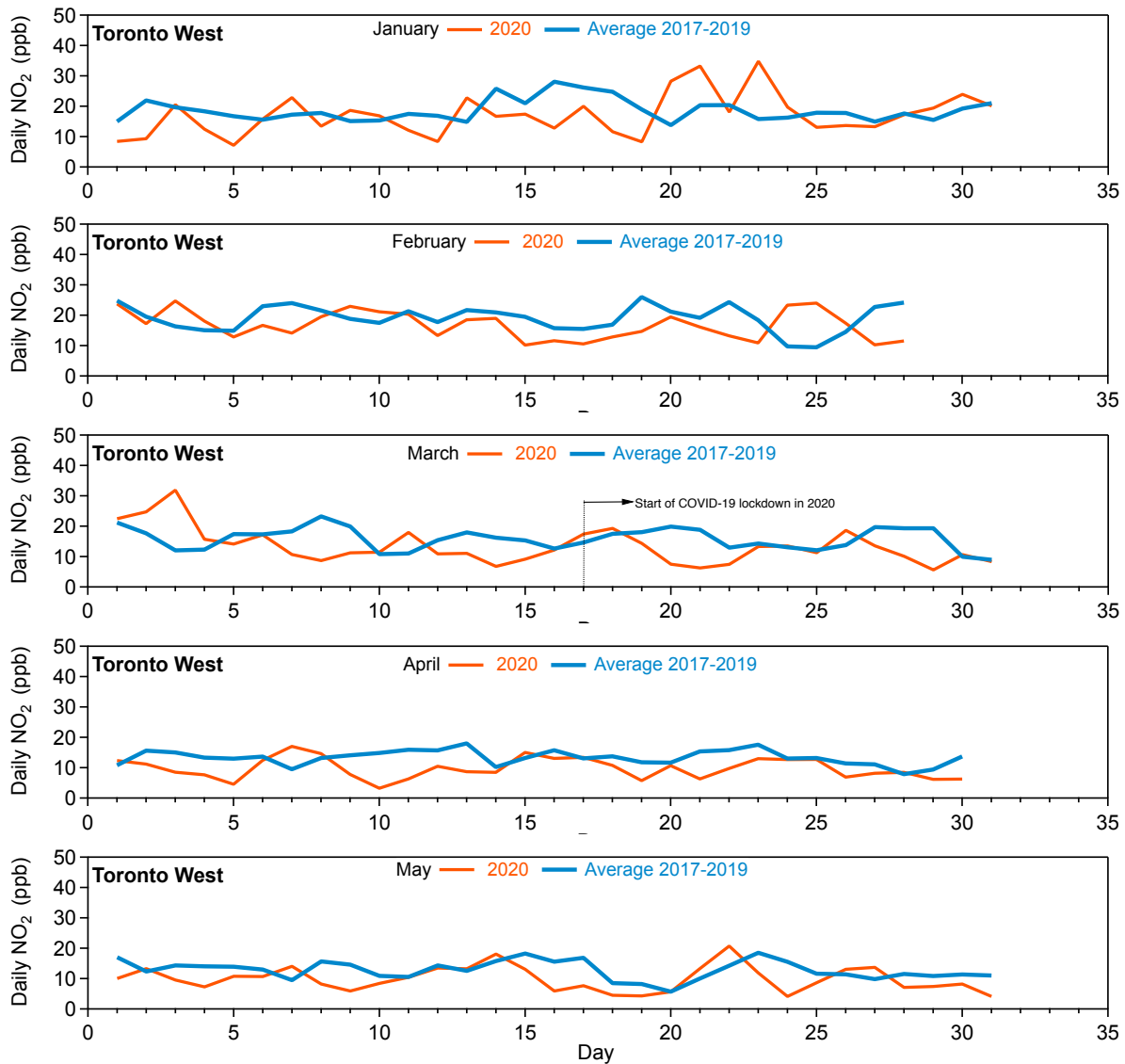


Figure S6. (A) Daily NO₂ levels in Jan-May from the average data over 2017-2019 and for 2020. (B) Median of weekdays of NO₂ levels from January to June per year over 2017-2020.

(A)



(B)

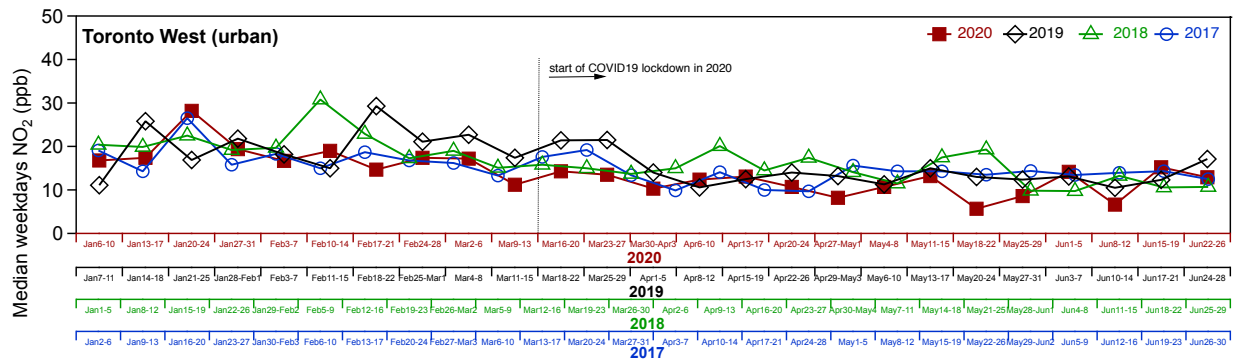


Figure S7. (A) Daily NO₂ levels in Jan-May from the average data over 2017-2019 and for 2020. **(B)** Median of weekdays of NO₂ levels from January to June per year over 2017-2020.

Table S2. Summary of p-values calculated from monthly median values of pollutant concentrations over 2017-2019 and 2020.

AQ station name ^a R = Rural U = Urban	Pollutant																							
	NO ₂ (ppb)						CO (ppm)						O ₃ (ppb)						PM _{2.5} (µg m ⁻³)					
	p-values calculated from median ^b																							
	Apr		May		Jun		Apr		May		Jun		Apr		May		Jun		Apr		May		Jun	
17	20	17	20	17	20	17	20	17	20	17	20	17	20	17	20	17	20	17	20	17	20	17	20	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	
Grand Bend (R)	0.5	0.02	<u>0</u>	0.8	0.2	0.2	No measurements						<u>0</u>	0.8	0.4	0.9	0.9	0.2	0.1	0.6	<u>0</u>	0.7	<u>0.01</u>	0.2
Guelph (U)	<u>0.02</u>	0.04	0.2	0.1	1	0.8	No measurements						0.07	0.5	0	0.8	0.06	0.05	0.9	0.8	<u>0</u>	0.2	0.2	0.02
Hamilton Downtown (U)	0.8	0.08	0.1	0.6	0.2	0.2	0.5	0.01	0.5	0.7	0.1	0.4	0.1	0.2	0.04	0.5	1	0.02	0.8	0.7	0.1	0.3	0.1	0.7
Hamilton Mountain (U)	0.8	0.1	0.5	0.9	0.5	0.1	No measurements						0.2	0.1	<u>0.01</u>	0.7	0.6	0.03	0.6	0.2	<u>0.01</u>	0.4	<u>0.04</u>	0.3
Hamilton West (U)	0.3	0.2	0.5	0.1	<u>0.01</u>	0.3	No measurements						0.1	0.5	0.03	0.9	0.7	0.01	0.7	0.4	<u>0</u>	0.03	0.06	0.3
Kitchener (U)	<u>0.04</u>	0.08	1	0.04	1	0.13	No measurements						0.5	0.5	<u>0.01</u>	0.8	0.2	0.06	0.8	0.6	<u>0</u>	0.4	0.4	0.4
London (U)	<u>0.03</u>	0.01	0.2	0.02	0.4	0.02	No measurements						0.1	0.6	<u>0.01</u>	0.4	0.7	0.5	0.9	0.01	<u>0</u>	0.1	0.1	0.1
Ottawa Downtown (U)	0.07	0.2	0.05	0.2	0.6	0.1	0.1	0	0	0.01	<u>0.04</u>	0.3	0.09	0.6	<u>0.02</u>	0.4	0.8	0.02	0.5	0.3	<u>0</u>	0.03	0.2	0.05
Parry Sound (U)	0.3	0.6	0.1	0.6	0.9	0.4	No measurements						<u>0</u>	0.4	0	0.2	0.8	0.3	0.04	0.3	0	0.5	0.09	0
Sarnia (U)	0.1	0.02	<u>0.01</u>	0.1	0.07	0.6	No measurements						<u>0.01</u>	<u>0</u>	0.2	<u>0</u>	0.7	0.9	0.4	0.9	0.1	0.7	0.9	0.2
Toronto Downtown (U)	<u>0.01</u>	0.2	<u>0.01</u>	0.01	0.05	0.2	No measurements						0.1	0.3	0.01	0	0.5	0.5	0.5	0.4	<u>0</u>	0.5	<u>0.03</u>	0.03

Toronto East (U)	<u>0.01</u>	<u>0.01</u>	0.2	0.1	<u>0</u>	0.2	No measurements					0.9	<u>0.02</u>	<u>0.04</u>	0.7	0.2	<u>0</u>	0.9	0.5	0.01	0.1	0.2	0.06	
Toronto North (U)	0.01	<u>0.04</u>	0.1	0.6	0.3	0.9	No measurements					0.9	<u>0.01</u>	0	0.9	<u>0.01</u>	<u>0</u>	0.9	0.9	0.01	0.2	0.4	0.8	
Toronto West (U)	0	<u>0.02</u>	0.3	0.06	0.1	0.2	0.3	<u>0</u>	0.3	0.1	0.01	0.8	1	<u>0.01</u>	0	0.9	0.5	<u>0.03</u>	0.9	0.8	0	0.2	0.4	0.9
Windsor Downtown (U)	<u>0</u>	0.1	0.1	<u>0.01</u>	0.2	0.1	<u>0.01</u>	<u>0.03</u>	<u>0.01</u>	<u>0.01</u>	0.5	0.1	0.1	0.3	<u>0</u>	0.6	0.7	0.3	0.2	0.4	0.3	<u>0.04</u>	0.6	1
Windsor West (U)	0.4	0.5	0.3	<u>0</u>	0.06	0.2	No measurements					0.08	0	0	0.2	0.7	0.2	0.3	<u>0.03</u>	0.2	0.9	0.9	0.08	

Notes. Values equal or below 0.05 (5%) are considered statistically significant (underlined) when comparing 2020 median pollutant data to those from the 2017-2019 data. In other words, if a p-value in the year “17-19” column is greater than 0.05, then that means that these years can be considered similar to each other (i.e., no statistically significant difference among years). If a p-value in the year “20” column is greater than 0.05, that means pollutant data in 2020 are similar to those collected for 2017-2019 (i.e., no statistically significant difference between 2020 and the previous three years). ^a See Table S1 for station type and Figure 1 for location. ^b See Methods section for details. See Figures S8-S10 for the association of p-values with weekdays median of pollutant concentrations.

Table S3. Grand Bend (rural)

Median O₃ (ppb)											
April				May				June			
2017	2018	2019	2020	2017	2018	2019	2020	2017	2018	2019	2020
34.3	40.3	37.1	37.0	35.8	37.0	33.9	35.8	34.0	33.7	35.0	37.7
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
31.1	34.5	31.5	29.8	30.8	32.4	29.3	24.6	26.6	22.7	26.9	26.5
October				November				December			
17	18	19	20	17	18	19	20	17	18	19	20
26.8	24.8	25.0	24.5	25.2	23.9	27.4	27.9	30.0	25.3	26.5	25.4

Median PM_{2.5} (µg m⁻³)											
April				May				June			
17	18	19	20	17	18	19	20	17	18	19	20
3.4	4.9	3.7	4.2	2.8	5.9	3.8	3.8	1.7	3.2	4.2	4.4
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
4.4	5.4	5.8	4.3	5.8	5.5	3.1	3.0	5.3	3.0	3.8	2.9
October				November				December			
17	18	19	20	17	18	19	20	17	18	19	20
3.4	3.8	3.3	3.0	4.8	4.8	3.9	4.5	3.8	6.1	6.8	5.0

Median NO₂ (ppb)											
April				May				June			
17	18	19	20	17	18	19	20	17	18	19	20
2.7	2.1	2.2	1.5	2.8	4.0	1.6	2.6	2.6	2.3	1.7	2.8
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
2.7	3.0	2.3	2.4	2.6	2.7	1.4	1.7	2.6	2.1	1.7	1.6
October				November				December			
17	18	19	20	17	18	19	20	17	18	19	20
3.0	2.4	1.8	1.7	4.2	2.8	3.1	2.9	3.1	4.2	2.4	3.0

Table S4. Guelph (urban)

Median O₃ (ppb)											
April				May				June			
2017	2018	2019	2020	2017	2018	2019	2020	2017	2018	2019	2020
34.4	36.3	32.4	35.0	34.1	36.8	28.5	33.0	30.4	33.9	29.1	35.1
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
28.6	32.5	28.6	26.0	28.8	27.3	27.0	23.8	23.1	20.9	22.0	22.6
October				November				December			
17	18	19	20	17	18	19	20	17	18	19	20
23.6	20.3	17.5	21.3	20.9	20.3	22.5	24.7	26.2	19.5	20.5	23.9

Median PM_{2.5} (µg m⁻³)											
April				May				June			
17	18	19	20	17	18	19	20	17	18	19	20
4.5	5.7	5.7	5.8	4.8	8.7	6.1	4.8	4.1	5.9	6.4	8.1
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
7.0	6.8	8.6	6.1	7.9	7.4	4.7	5.0	7.4	5.0	5.6	6.2
October				November				December			
17	18	19	20	17	18	19	20	17	18	19	20
5.5	4.1	5.7	5.5	7.0	4.0	4.7	7.8	5.4	8.8	6.4	6.8

Median NO₂ (ppb)											
April				May				June			
17	18	19	20	17	18	19	20	17	18	19	20
4.5	7.0	4.8	3.8	4.3	5.0	3.8	3.4	3.5	3.5	3.7	3.8
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
3.1	4.3			4.5	3.5			6.4	4.3		
October				November				December			
17	18	19	20	17	18	19	20	17	18	19	20
6.3	4.7			8.3	7.0			6.9	6.4		

Table S5. Hamilton Downtown (U)

Median O₃ (ppb)											
April				May				June			
2017	2018	2019	2020	2017	2018	2019	2020	2017	2018	2019	2020
29.4	33.1	28.2	32.7	29.7	32.8	25.6	29.1	28.0	27.5	27.4	34.2
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
27.0	31.8	28.4	29.3	27.5	31.3	25.0	23.5	19.9	19.6	22.1	24.3
October				November				December			
17	18	19	20	17	18	19	20	17	18	19	20
21.5	18.1	15.9	19.3	20.2	15.1	18.4	23.5	19.4	15.4	17.9	20.4

Median PM_{2.5} (µg m⁻³)											
April				May				June			
17	18	19	20	17	18	19	20	17	18	19	20
7.2	8.7	7.7	6.9	8.5	11.3	9.7	8.5	6.5	9.2	10.9	9.5
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
9.4	9.9	10.8	8.5	10.4	9.8	6.8	7.6	12.0	6.4	6.4	6.4
October				November				December			
17	18	19	20	17	18	19	20	17	18	19	20
6.9	5.5	6.3	4.4	8.1	8.0	7.4	8.4	6.1	9.6	7.1	7.5

Median NO₂ (ppb)											
April				May				June			
17	18	19	20	17	18	19	20	17	18	19	20
12.9	11.7	12.4	9.0	10.5	16.0	15.2	11.0	8.1	11.5	12.8	6.7
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
9.6	9.5	9.3	7.0	9.0	5.7	7.0	7.5	12.4	8.8	9.3	5.8
October				November				December			
17	18	19	20	17	18	19	20	17	18	19	20
10.9	10.1	12.1	8.9	11.7	13.5	12.4	11.1	14.2	13.3	15.2	11.3

Median CO (ppm)											
April				May				June			
17	18	19	20	17	18	19	20	17	18	19	20
0.24	0.25	0.27	0.20	0.22	0.24	0.27	0.23	0.18	0.24	0.25	0.19
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
0.20	0.23	0.20	0.20	0.22	0.22	0.20	0.20	0.25	0.23	0.21	0.19
October				November				December			
17	18	19	20	17	18	19	20	17	18	19	20
0.21	0.19	0.21	0.19	0.21	0.23	0.21	0.22	0.20	0.21	0.23	0.18

Table S6. Hamilton Mountain (U)

Median O₃ (ppb)											
April				May				June			
2017	2018	2019	2020	2017	2018	2019	2020	2017	2018	2019	2020
31.1	34.8	32.3	36.4	31.8	39.0	29.7	31.4	30.7	34.2	32.9	37.5
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
30.8	36.1	32.5	31.9	30.8	34.0	28.0	26.0	25.1	23.0	23.8	26.4
October				November				December			
17	18	19	20	17	18	19	20	17	18	19	20
25.4	22.7	18.4	21.0	23.4	18.7	19.5	27	24.8	16.6	20.8	23.7

Median PM_{2.5} (µg m⁻³)											
April				May				June			
17	18	19	20	17	18	19	20	17	18	19	20
6.6	6.1	7.5	5.4	5.7	10.2	8.6	6.3	5.0	6.3	9.1	7.8
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
7.7	7.0	7.9	7.3	8.3	8.5	5.2	6.9	8.3	4.5	5.0	5.1
October				November							
17	18	19	20	17	18	19	20	17	18	19	20
5.5	4.2	4.8	4.1	7.0	6.0	6.5	7.3	5.9	8.1	6.9	6.7

Median NO₂ (ppb)											
April				May				June			
17	18	19	20	17	18	19	20	17	18	19	20
8.6	8.5	9.0	6.3	6.7	7.9	9.1	7.5	5.9	6.0	7.4	4.3
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
6.5	4.8	5.0	4.5	6.0	4.5	4.5	5.4	10.3	4.6	6.9	4.3
October				November				December			
17	18	19	20	17	18	19	20	17	18	19	20
5.0	5.7	9.1	6.5	7.4	10.4	9.3	5.1	9.0	9.0	11.5	6.0

Table S7. Hamilton West (U)

Median O₃ (ppb)											
April				May				June			
2017	2018	2019	2020	2017	2018	2019	2020	2017	2018	2019	2020
28.0	33.5	29.1	31.8	28.9	33.8	25.6	28.3	27.4	24.6	25.3	33.8
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
24.8	29.3	26.5	27.1	23.8	29.7	21.8	20.8	19.3	19.3	17.4	23.0
October				November				December			
17	18	19	20	17	18	19	20	17	18	19	20
20.9	19.1	14.9	18.2	19.5	16.2	16.4	22.1	21.1	17.3	17.3	19.8

Median PM_{2.5} (µg m⁻³)											
April				May				June			
17	18	19	20	17	18	19	20	17	18	19	20
5.9	6.4	6.8	5.7	6.3	10.9	7.8	5.9	5.4	6.6	8.8	8.2
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
8.3	8.0	8.3	8.1	9.2	9.0	5.6	7.8	9.4	5.2	5.7	8.1
October				November							
17	18	19	20	17	18	19	20	17	18	19	20
5.9	5.3	5.4	6.1	6.5	6.0	6.2	8.9	5.3	9.2	7.6	5.8

Median NO₂ (ppb)											
April				May				June			
17	18	19	20	17	18	19	20	17	18	19	20
8.3	11.3	12.1	8.4	10.7	12.4	11.7	9.2	7.9	9.2	13.3	8.0
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
8.9	10.0	7.5	7.3	8.4	6.0	7.6	7.6	13.3	8.1	9.3	6.2
October				November				December			
17	18	19	20	17	18	19	20	17	18	19	20
9.2	9.5	10.3	8.8	13	12.2	11.3	9.7	12.6	12.3	12.0	10.8

Table S8. Kitchener (U)

Median O₃ (ppb)											
April				May				June			
2017	2018	2019	2020	2017	2018	2019	2020	2017	2018	2019	2020
33.7	35.8	34.5	33.9	33.3	38.3	31.0	32.5	29.9	33.3	31.1	34.6
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
29.5	32.2	29.1	26.9	30.1	26.5	27.9	25.5	24.0	19.6	22.5	24.2
October				November				December			
17	18	19	20	17	18	19	20	17	18	19	20
23.6	20.3	18.2	21.3	21.2	18.4	22.3	25.3	25.5	18.0	20.7	23.2

Median PM_{2.5} (µg m⁻³)											
April				May				June			
17	18	19	20	17	18	19	20	17	18	19	20
4.2	5.6	5.2	4.7	3.5	7.7	5.7	4.3	4.8	6.5	6.3	7.0
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
7.0	7.5	7.9	7.9	6.8	7.4	5.5	5.4	7.8	4.6	5.1	4.6
October				November				December			
17	18	19	20	17	18	19	20	17	18	19	20
5.6	5.1	4.3	4.2	7.1	4.5	7.0	7.4	5.8	8.8	8.5	6.3

Median NO₂ (ppb)											
April				May				June			
17	18	19	20	17	18	19	20	17	18	19	20
4.1	6.6	6.1	4.1	4.7	4.8	4.9	3.4	4.2	3.9	4.2	3.5
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
3.6	3.7	3.2	2.6	3.9	3.7	3.4	3.6	5.2	3.4	4.5	3.0
October				November				December			
17	18	19	20	17	18	19	20	17	18	19	20
5.7	5.1	6.4	3.7	8.0	7.6	6.6	5.5	8.6	8.7	7.5	5.9

Table S9. London (U)

Median O₃ (ppb)											
April				May				June			
2017	2018	2019	2020	2017	2018	2019	2020	2017	2018	2019	2020
31.9	35.5	34.0	34.5	32.9	36.2	29.9	31.4	30.9	33.7	31.7	33.4
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
29.2	28.6	26	29.9	32.7	28.5	25.7	22.0	23.2	18.6	23.4	24.5
October				November							
17	18	19	20	17	18	19	20	17	18	19	20
22.6	22.7	18.7	20.6	22.3	20.3	21.8	24.6	24.1	19.4	22.4	22.7

Median PM_{2.5} (µg m⁻³)											
April				May				June			
17	18	19	20	17	18	19	20	17	18	19	20
6.3	5.7	5.7	3.9	5.5	8.4	6.3	5.3	5.1	6.6	4.1	7.0
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
6.4	7.8	5.3	5.6	8.0	8.3	3.8	4.5	7.3	4.5	5.1	4.5
October				November				December			
17	18	19	20	17	18	19	20	17	18	19	20
5.4	4.7	4.8	4.9	6.3	4.6	4.6	6.9	4.4	7.6	6.9	6.0

Median NO₂ (ppb)											
April				May				June			
17	18	19	20	17	18	19	20	17	18	19	20
4.7	6.6	5.1	3.6	4.5	5.2	4.3	3.8	4.1	4.2	4.7	3.5
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
4.1	4.4	3.9	2.9	4.7	3.6	3.2	2.7	5.7	3.9	4.2	3.9
October				November							
17	18	19	20	17	18	19	20	17	18	19	20
5.5	4.9	4.6	4.2	7.0	5.6	8.0	5.5	5.3	8.7	6.4	5.5

Table S10. Ottawa Downtown (U)

Median O₃ (ppb)											
April				May				June			
2017	2018	2019	2020	2017	2018	2019	2020	2017	2018	2019	2020
32.1	35.8	34.2	34.6	28.4	35.4	29.7	32.7	24.6	25.7	25.5	29.8
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
23.4	29.1	25.4	23.1	21.9	24.8	25.1	17.9	22.0	20.2	19.5	18.7
October				November				December			
17	18	19	20	17	18	19	20	17	18	19	20
20.3	19.0	18	18.8	19.8	17.4	23.3	21.4	24.6	18.8	23.9	19.3

Median PM_{2.5} (µg m⁻³)											
April				May				June			
17	18	19	20	17	18	19	20	17	18	19	20
4.1	4.5	4.1	4.6	3.8	6.0	5.0	3.9	3.7	3.8	5.0	5.9
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
5.4	5.3	8.3	5.9	5.4	7.2	4.9	3.8	7.2	4.0	4.0	3.9
October				November							
17	18	19	20	17	18	19	20	17	18	19	20
4.2	3.7	4.3	4.6	4.9	3.8	4.3	6.7	4.6	6.3	5.1	4.9

Median NO₂ (ppb)											
April				May				June			
17	18	19	20	17	18	19	20	17	18	19	20
4.7	7.4	4.9	4.3	4.5	5.2	4.1	3.8	3.8	4.4	4.3	3.4
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
3.9	4.2	3.9	2.9	4.5	4.0	3.0	2.4	6.5	4.5	3.7	3.0
October				November				December			
17	18	19	20	17	18	19	20	17	18	19	20
6.4	4.7	6.3	5.2	11	7.9	7.7	9.8	8.6	12	7.8	6.6

Median CO (ppm)											
April				May				June			
17	18	19	20	17	18	19	20	17	18	19	20
0.19	0.20	0.18	0.215	0.17	0.20	0.16	0.15	0.14	0.16	0.17	0.15
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
0.16	0.16	0.16	0.15	0.19	0.2	0.16	0.16	0.23	0.17	0.17	0.17
October				November				Decemeber			
17	18	19	20	17	18	19	20	17	18	19	20
0.17	0.15	0.17	0.18	0.21	0.18	0.15	0.22	0.18	0.20	0.16	0.19

Table S11. Parry Sound (U)

Median O₃ (ppb)											
April				May				June			
2017	2018	2019	2020	2017	2018	2019	2020	2017	2018	2019	2020
34.7	40.8	36.7	38.4	31.9	38.6	29.6	35.5	28.5	29.2	26.9	32.0
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
24.2	32.3	30.2	25.6	23.6	29.1	24.3	20.8	22.0	20.1	21.5	24.5
October				November							
17	18	19	20	17	18	19	20	17	18	19	20
26.6	23.6	22.1	24.3	26.3	22.3	27.8	27.1	30.3	27.2	27.5	26.5

Median PM_{2.5} (µg m⁻³)											
April				May				June			
17	18	19	20	17	18	19	20	17	18	19	20
3.0	4.5	3.8	3.1	2.0	5.5	3.6	4.1	3.0	3.3	4.5	5.7
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
4.5	6.0	6.2	5.1	5.5	8.0	4.0	3.1	6.0	2.3	3.3	3.8
October				November							
17	18	19	20	17	18	19	20	17	18	19	20
4.1	2.0	2.1	1.6	4.3	1.4	1.2	4.1	2.3	4.3	4.1	2.9

Median NO₂ (ppb)											
April				May				June			
17	18	19	20	17	18	19	20	17	18	19	20
1.7	2.6	2.0	1.9	1.9	2.5	1.7	1.7	2.0	2.2	1.9	1.9
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
1.8	2.0	1.6	1.6	2.3	2.2	2.3	2.3	2.7	1.8	2.2	2.2
October				November				December			
17	18	19	20	17	18	19	20	17	18	19	20
1.7	2.1	1.9	1.9	2.5	2.0	2.1	2.1	3.5	2.8	2.4	2.4

Table S12. Sarnia (U)

Median O₃ (ppb)											
April				May				June			
2017	2018	2019	2020	2017	2018	2019	2020	2017	2018	2019	2020
33.7	38.4	36.3	30.3	35.7	37.9	34.6	29.9	34.5	35.3	36.4	35.1
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
32.3	37.1	36.2	31.6	31.1	32.5	29.6	25.1	25.1	21.8	25.6	26.1
October				November							
17	18	19	20	17	18	19	20	17	18	19	20
24.4	20.4	20.5	20.9	18.7	18.1	20.7	18.1	25.3	19.2	22.4	18.0

Median PM_{2.5} (µg m⁻³)											
April				May				June			
17	18	19	20	17	18	19	20	17	18	19	20
5.8	7.0	5.3	5.9	3.9	7.3	5.5	5.3	3.8	5.0	4.8	6.9
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
6.6	6.5	7.7	8.2	8.3	6.9	6.0	6.9	8.3	6.1	6.3	5.3
October				November							
17	18	19	20	17	18	19	20	17	18	19	20
5.7	4.5	4.3	4.7	7.7	4.8	5.2	7.3	5.5	8.2	9.0	6.2

Median NO₂ (ppb)											
April				May				June			
17	18	19	20	17	18	19	20	17	18	19	20
5.4	7.3	5.1	3.4	6.4	7.6	3.8	4.6	6.9	4.9	4.9	4.9
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
6.5	6.6	4.6	4.3	6.6	5.8	6.0	5.0	7.3	5.4	5.9	6.1
October				November							
17	18	19	20	17	18	19	20	17	18	19	20
9.0	6.5	5.6	6.0	9.7	6.5	9.0	9.9	9.0	10.8	8.5	6.7

Table S13. Toronto Downtown (U)

Median O₃ (ppb)											
April				May				June			
2017	2018	2019	2020	2017	2018	2019	2020	2017	2018	2019	2020
31.2	30.2	33.2	29.6	30.5	35.6	29.5	24.8	26.6	30.3	29.9	29.7
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
26.8	26.8	26.8	26.8	26.4	32.1	21.7	20.7	22.7	22.6	18.5	19.6
October				November				December			
17	18	19	20	17	18	19	20	17	18	19	20
21.3	18.4	15.4	16.4	19.1	14.0	17.1	20.8	18.6	13.0	16.1	6.3

Median PM_{2.5} (µg m⁻³)											
April				May				June			
17	18	19	20	17	18	19	20	17	18	19	20
5.0	6.1	5.9	6.1	4.5	8.3	6.6	6.0	5.6	6.6	8.5	8.8
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
7.6	9.3	9.6	6.5	10.3	10.6	7.7	6.2	13.1	5.8	7.0	5.4
October				November							
17	18	19	20	17	18	19	20	17	18	19	20
6.8	4.2	5.9	5.3	7.6	4.9	8.0	6.6	6.1	10.1	8.8	14.0

Median NO₂ (ppb)											
April				May				June			
17	18	19	20	17	18	19	20	17	18	19	20
10.1	12.3	8.2	12.1	10.2	12.0	8.5	14.2	11.0	9.1	13.1	12.7
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
12.3	9.6	14.7	9.7	9.9	9.1	12.5	8.8	14.6	8.5	13.7	8.1
October				November							
17	18	19	20	17	18	19	20	17	18	19	20
13.2	11.0	13.0	12.0	12.7	14.7	16.5	12.0	15.1	15.0	17.1	18.3

Table S14. Toronto East (U)

Median O₃ (ppb)											
April				May				June			
2017	2018	2019	2020	2017	2018	2019	2020	2017	2018	2019	2020
31.3	31.4	32.2	35.0	27.5	32.3	27.3	28.4	23.9	28.5	26.3	32.4
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
22.2	31.1	26.8	26.2	25.1	29.1	25.2	22.4	20.2	20.5	19.7	20.3
October				November				December			
17	18	19	20	17	18	19	20	17	18	19	20
19.4	17.3	16.8	17.8	17.4	15.1	19.1	22.5	19.8	14.6	18.5	19.5

Median PM_{2.5} (µg m⁻³)											
April				May				June			
17	18	19	20	17	18	19	20	17	18	19	20
5.1	5.1	5.5	4.9	5.0	8.5	5.8	4.8	5.8	5.3	6.8	7.6
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
8.5	7.3	6.8	6.3	8.0	7.8	5.8	6.2	11.2	3.9	5.4	4.3
October				November				December			
17	18	19	20	17	18	19	20	17	18	19	20
5.2	4.3	4.6	4.5	6.5	4.8	6.9	6.5	5.1	9.7	7.5	5.0

Median NO₂ (ppb)											
April				May				June			
17	18	19	20	17	18	19	20	17	18	19	20
6.9	9.9	7.9	6.0	9.1	8.2	6.7	6.5	10.9	7.2	8.9	7.7
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
10.2	8.2	8.0	5.5	9.5	8.0	6.9	6.1	13.1	6.4	8.3	6.6
October				November				December			
17	18	19	20	17	18	19	20	17	18	19	20
11.1	8.2	9.0	9.5	12.2	11.1	12.3	10.9	12.6	13.9	13.4	12.0

Table S15. Toronto North (U)

Median O₃ (ppb)											
April				May				June			
2017	2018	2019	2020	2017	2018	2019	2020	2017	2018	2019	2020
30.9	31.3	31.5	34.4	29.4	34.3	26.2	30.1	25.9	32.0	25.2	34.1
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
23.5	32.7	26.9	28.2	25.3	27.8	26.2	23.6	21.0	19.7	19.5	20.1
October				November							
17	18	19	20	17	18	19	20	17	18	19	20
19.0	16.4	16.3	18.9	14.0	15.0	19.8	20.8	20.3	14.6	16.3	20.3

Median PM_{2.5} (µg m⁻³)											
April				May				June			
17	18	19	20	17	18	19	20	17	18	19	20
5.3	5.4	5.8	5.4	5.8	9.1	5.6	4.9	5.5	6.4	7.1	6.3
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
7.3	7.6	8.2	5.8	8.1	7.9	5.0	5.4	10.5	4.2	4.6	4.0
October				November				December			
17	18	19	20	17	18	19	20	17	18	19	20
6.9	4.8	4.8	4.3	7.1	5.0	7.3	8.5	5.1	8.6	9.1	5.3

Median NO₂ (ppb)											
April				May				June			
17	18	19	20	17	18	19	20	17	18	19	20
6.7	11.4	10.7	6.4	8.1	9.1	7.2	7.6	8.6	6.6	8.2	7.5
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
8.7	6.4	8.1	5.1	7.8	7.5	5.4	5.6	11.3	6.2	7.5	6.8
October				November				December			
17	18	19	20	17	18	19	20	17	18	19	20
11.1	10.9	9.0	9.5	13.3	13.3	12.8	15.1	13.1	15.8	15.3	11.5

Table S16. Toronto West (U)

Median O₃ (ppb)											
April				May				June			
17	18	19	20	17	18	19	20	17	18	19	20
28.3	28.4	27.8	31.2	26.4	29.1	22.2	26.5	23.3	26.1	23.3	28.6
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
21.5	28.1	26.7	20.8	20.3	21.0	23.0	22.1	18.8	16.8	17.7	17.3
October				November				December			
17	18	19	20	17	18	19	20	17	18	19	20
15.8	13.7	14.2	14.9	15.1	11.1	15.4	17.9	14.5	12.8	14.8	15.9

Median PM_{2.5} (µg m⁻³)											
April				May				June			
17	18	19	20	17	18	19	20	17	18	19	20
4.9	5.4	5.3	5.4	5.1	9.8	6.1	5.0	6.1	6.6	7.0	6.6
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
8.1	8.1	7.6	6.3	8.0	9.7	6.3	5.7	10.8	5.3	6.3	5.7
October				November				December			
17	18	19	20	17	18	19	20	17	18	19	20
6.4	5.6	5.9	5.0	6.7	5.6	6.8	7.9	6.6	9.5	8.1	6.2

Median NO₂ (ppb)											
April				May				June			
17	18	19	20	17	18	19	20	17	18	19	20
10.9	17.4	12.8	10.9	14.3	14.1	12.4	11.4	13.4	10.9	13.4	11.1
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
12.7	12.1	11.4	8.7	11.8	11.5	11.3	9.1	17.8	9.3	13.6	10.2
October				November							

17	18	19	20	17	18	19	20	17	18	19	20
16.5	13.4	14.9	13.5	16.4	16.0	17.7	14.7	21.5	19.9	18.2	17.1

Median CO (ppm)											
April				May				June			
17	18	19	20	17	18	19	20	17	18	19	20
0.22	0.23	0.22	0.19	0.22	0.23	0.21	0.20	0.20	0.19	0.23	0.20
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
0.21	0.20	0.22	0.20	0.24	0.24	0.23	0.20	0.31	0.21	0.25	0.20
October				November							
17	18	19	20	17	18	19	20	17	18	19	20
0.25	0.20	0.21	0.22	0.23	0.23	0.21	0.25	0.25	0.25	0.23	0.22

Table S17. Windsor Downtown (U)

Median O₃ (ppb)											
April				May				June			
2017	2018	2019	2020	2017	2018	2019	2020	2017	2018	2019	2020
32.0	33.9	31.0	30.6	35.3	36.0	28.4	33.0	34.6	36.2	33.4	37.7
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
35.2	34.9	34.8	35.9	30.5	34.0	31.1	31.7	24.3	24.6	27.8	25.7
October				November				December			
17	18	19	20	17	18	19	20	17	18	19	20
21.4	20.0	20.4	20.1	17.9	17.5	16.4	23.3	16.9	13.9	17.5	20.3

Median PM_{2.5} (µg m⁻³)											
April				May				June			
17	18	19	20	17	18	19	20	17	18	19	20
5.5	6.5	5.6	6.3	5.5	7.3	6.2	4.7	6.3	7.7	6.8	7.0
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
8.0	8.6	8.0	8.0	8.3	9.0	6.3	5.3	8.0	6.3	6.2	6.5
October				November							
17	18	19	20	17	18	19	20	17	18	19	20
6.4	5.5	4.4	5.4	7.9	6.0	6.8	7.2	7.5	9.3	8.7	6.9

Median NO₂ (ppb)											
April				May				June			
17	18	19	20	17	18	19	20	17	18	19	20
8.1	11.4	8.9	8.1	7.6	9.9	9.3	6.4	8.9	7.7	9.1	7.6
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
7.9	7.3	8.5	6.7	9.4	8.0	8.4	7.7	11.5	7.7	7.9	8.0
October				November							
17	18	19	20	17	18	19	20	17	18	19	20
11.4	10.5	10.1	9.5	14.2	10.4	13.0	9.8	15.3	16.9	13.1	11.6

Median CO (ppm)											
April				May				June			
17	18	19	20	17	18	19	20	17	18	19	20
0.20	0.23	0.22	0.20	0.20	0.25	0.23	0.18	0.21	0.18	0.21	0.18
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
0.20	0.23	0.22	0.18	0.23	0.25	0.21	0.21	0.25	0.21	0.21	0.20
October				November							
17	18	19	20	17	18	19	20	17	18	19	20
0.24	0.21	0.20	0.21	0.24	0.22	0.20	0.22	0.24	0.29	0.23	0.21

Table S18. Windsor West (U)

Median O₃ (ppb)											
April				May				June			
2017	2018	2019	2020	2017	2018	2019	2020	2017	2018	2019	2020
31.2	34.4	33.8	29.6	33.9	36.8	29.1	29.5	33.3	34.6	34.1	36.7
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
34.3	34.2	34.4	32.8	30.6	32.3	30.3	28.8	23.6	22.0	26.8	24.0
October				November							
17	18	19	20	17	18	19	20	17	18	19	20
21.3	19.1	20.3	19.5	17.3	17.2	16.7	20.9	18.6	14.0	18.6	18.0

Median PM_{2.5} (µg m⁻³)											
April				May				June			
17	18	19	20	17	18	19	20	17	18	19	20
5.8	7.0	6.4	8.4	5.6	8.8	6.0	6.4	7.3	7.7	7.7	9.3
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
9.3	8.3	9.0	7.5	8.9	9.6	7.2	7.7	7.6	7.1	7.3	7.6
October				November							
17	18	19	20	17	18	19	20	17	18	19	20
7.0	6.5	7.4	7.2	9.3	5.5	9.7	7.2	7.8	10.5	11.8	8.8

Median NO₂ (ppb)											
April				May				June			
17	18	19	20	17	18	19	20	17	18	19	20
7.1	8.3	8.3	7.5	8.4	7.6	8.9	4.8	8.8	6.9	8.8	7.2
July				August				September			
17	18	19	20	17	18	19	20	17	18	19	20
7.2	6.6	7.3	6.6	9.7	5.6	8.0	8.0	9.5	7.5	8.3	7.0
October				November							
17	18	19	20	17	18	19	20	17	18	19	20
11.1	9.0	10.1	8.6	11.9	9.4	13.1	9.0	12.8	13.9	11.4	9.6

Table S19. Summary of the *extra percentage decrease* observed in 2020 relative to 2017-2019 calculated from the percentage in pollutant levels in 2020 and 2017-2019 relative to January of the same year(s). Figures S10, 3, 4d-f and 5d-f show graphical representation of this extra decrease for selected sites. The statistically significant values are highlighted in p-values below 0.05 listed in parentheses.

AQ station name ^a R = Rural U = Urban	Pollutant											
	NO ₂ (ppb)			CO (ppm)			O ₃ (ppb)			PM _{2.5} (µg m ⁻³)		
	COVID-19 related decrease (%) ^b											
	Apr	May	Jun	Apr	May	Jun	Apr	May	Jun	Apr	May	Jun
Grand Bend (R)	n.o. (0.02)	n.o.	n.o.	No measurements			3.2 (0)	4.2	n.o.	n.o.	n.o.	n.o.
Guelph (U)	14 (0.044)	13	n.o.	No measurements			n.o.	n.o.	n.o.	3.7	35	n.o. (0.02)
Hamilton Downtown (U)	30	14	28	16 (0.01)	n.o.	3	n.o.	n.o.	n.o. (0.02)	n.o.	11	n.o.
Hamilton Mountain (U)	9	n.o.	8	No measurements			n.o.	5	n.o. (0.03)	6	20	n.o.
Hamilton West (U)	33	35	21	No measurements			n.o.	n.o.	n.o. (0.01)	5	35 (0.03)	n.o.
Kitchener (U)	9	11 (0.04)	4	No measurements			6	5	n.o.	n.o.	12	n.o.
London (U)	18 (0.01)	10 (0.02)	8 (0.02)	No measurements			2	10	n.o.	16 (0.01)	5	n.o.
Ottawa Downtown (U)	3	2	3	12 (0)	7 (0.01)	0	n.o.	n.o.	n.o. (0.02)	n.o.	11 (0.03)	n.o.
Parry Sound (U)	10	14	n.o.	No measurements			n.o.	n.o.	n.o.	33	15	n.o. (0)
Sarnia (U)	20 (0.02)	10	n.o.	No measurements			24 (0)	30 (0)	4	n.o.	n.o.	n.o.
Toronto Downtown (U)	3	n.o. (0.01)	n.o.	No measurements			n.o.	14 (0)	n.o.	n.o.	13	n.o. (0.03)
Toronto East (U)	10 (0.01)	4	3	No measurements			n.o. (0.02)	8	n.o. (0)	0	9	n.o.
Toronto North (U)	11 (0.04)	n.o.	n.o.	No measurements			n.o. (0.01)	10	n.o. (0)	n.o.	16	n.o.
Toronto West (U)	13 (0.02)	9	7	12 (0)	4	n.o.	n.o. (0.01)	12	n.o. (0.03)	n.o.	1	n.o.
Windsor Downtown (U)	4	12 (0)	1	n.o. (0.03)	2 (0.01)	n.o.	4	n.o.	n.o.	n.o.	7 (0.04)	n.o.
Windsor West (U)	6	28 (0)	9	No measurements			19 (0)	12	n.o.	n.o. (0.03)	n.o.	n.o.

Notes. ^a See Table S2 for station type and Figure S1 for location. ^b % decrease in 2020 in a given month = (median in 2020 – median in 2017-2019)*100% / (median in 2017-2019). See Figure S10 for examples. ‘n.o.’ = no decrease observed, on the other hand, an increase was observed in pollutant level in 2020 relative to 2017-2019.

Table S20. Summary of Average Annual Daily Traffic (AADT) in the City of Kitchener in 2020 compared to previous year.

Intersection	Dates	Year	(a) Previous years AADT	(b) COVID (2020) AADT	(c) Difference, (a)-(b)	% Reduction of Volume %(c)/(a)
Data from Early May						
King Street & Bells Lane	May 2 - May 21	2014	2862	1551	1311	45.8%
Duke Street & Weber Street	May 2 - May 21	2014	5300	1675	3625	68.4%
Bingeman Street & Chapel Street	May 2 - May 21	2016	4443	1622	2821	63.5%
Duke Street West & Waterloo Street	May 2 - May 21	2010	843	163	680	80.7%
Young Street & Ontario Street	May 2 - May 21	2012	8220	3398	4822	58.7%
Water Street & David Street	May 2 - May 21	2019	8992	5393	3599	40.0%
Pandora Ave N & Fairview Avenue	May 2 - May 21	2019	10469	5419	5050	48.2%
East Avenue & Melrose Avenue	May 2 - May 21	2011	4359	1491	2868	65.8%
Aberdeen Road & Inwood Drive	May 2 - May 21	2018	5287	2437	2850	53.9%
St. Leger Street & Margaret Avenue	May 2 - May 21	2018	4105	2409	1696	41.3%
Rosemount Drive & Islington Avenue	May 2 - May 21	2017	10743	4299	6444	60.0%
Sub total 1.			65623	29857	35766	54.5%
Data from Late May - Early June						
McGarry Drive & Lorilee Cres	May 23 - Jun 5	2019	7310	2912	4398	60.2%
Warren Road & Stonybrook Drive	May 23 - Jun 5	2017	3407	1674	1733	50.9%
Wilderness Drive & Copper Leaf Street	May 23 - Jun 5	2018	7013	3786	3227	46.0%
Anvil Street & Tilt Drive	May 23 - Jun 5	2016	10220	5066	5154	50.4%

New Dundee Drive & Pieter Vos Drive	May 23 - Jun 5	2019	5195	3276	1919	36.9%
Windrush Trail & Winding Wood Crescent	May 23 - Jun 5	2018	4399	2632	1767	40.2%
Shelley Drive & Siebert Avenue	May 23 - Jun 5	2017	3993	2074	1919	48.1%
Ninth Avenue & Woodhaven Road	May 23 - Jun 5	2017	3173	2166	1007	31.7%
Sub total 2.			44710	23586	21124	47.2%

Additional information on Methods.

Statistical information.

The proposed median-based randomization test can be used not only to compare pre- and post-lockdown data, but also to measure the extent to which seasonal meteorology affects pollutant concentrations in a given month for the pre-lockdown reference years 2017-2019. That is, suppose that N_{2017} , N_{2018} , and N_{2019} are daily weekday pollutant concentrations recorded in a given month of these years. Let R_{obs} denote the range (max minus min) between the three respective medians in the actual data, and R_{rand} the corresponding statistic for a random permutation of the data. Then under H_0 that the data from all three years come from the same distribution, the p-value against H_0 is the probability that R_{rand} exceeds R_{obs} where each permutation of the data is equally likely. Indeed, the range statistic R_{obs} can be used to compare differences between two or more groups. For the two-group comparison between 2020 and the reference years 2017-2019, the range statistic R_{obs} and the absolute difference in medians Δ_{obs} are one and the same, as are their respective p-values.

It is worth noting that randomization tests such as ours do not necessarily rely on assumptions about iid sampling. Indeed, while classical significance tests must be interpreted in the context of repeated data collection, for the unique meteorological conditions underlying the comparison of 2020 data to reference years, such replications are conceptually infeasible — or at least not without modeling assumptions which cannot be verified with the small data samples available. In contrast, randomization tests have the ability to condition on the outcome of one-time events such as COVID-19, since the test probability $\Pr(\Delta_{\text{rand}} > \Delta_{\text{obs}})$ is determined entirely by the set of all random permutations, and not by a statistical model which may or may not have generated the data (Ludbrook and Dudley, 1998). When such a model can be reasonably argued to exist, randomization test probabilities coincide with classical test p-values — i.e., 5% of repeated experiments will have $p < 0.05$ when H_0 is true — provided that the data generation mechanism is iid. When it is not, randomization tests generally do not produce classical p-values.^{8,11} However, randomization p-values can be made asymptotically equivalent to classical ones under a wide range of non-iid settings, provided that the test statistic is subjected to an appropriate transformation. (Brunner and Munzel, 2000; Chung and Romano, 2013; Janssen, 1997; Neubert and Brunner, 2007) While we have not made such adjustments here due to the limited impact for small sample sizes (Chung and Romano, 2013), the connection to classical tests is highlighted for future large-sample air quality studies to enjoy the advantages of randomization tests for quantifying statistical significance.

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