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Quantifying urban, industrial, and background changes in NO_2 during the COVID-19 lockdown period based on TROPOMI satellite observations

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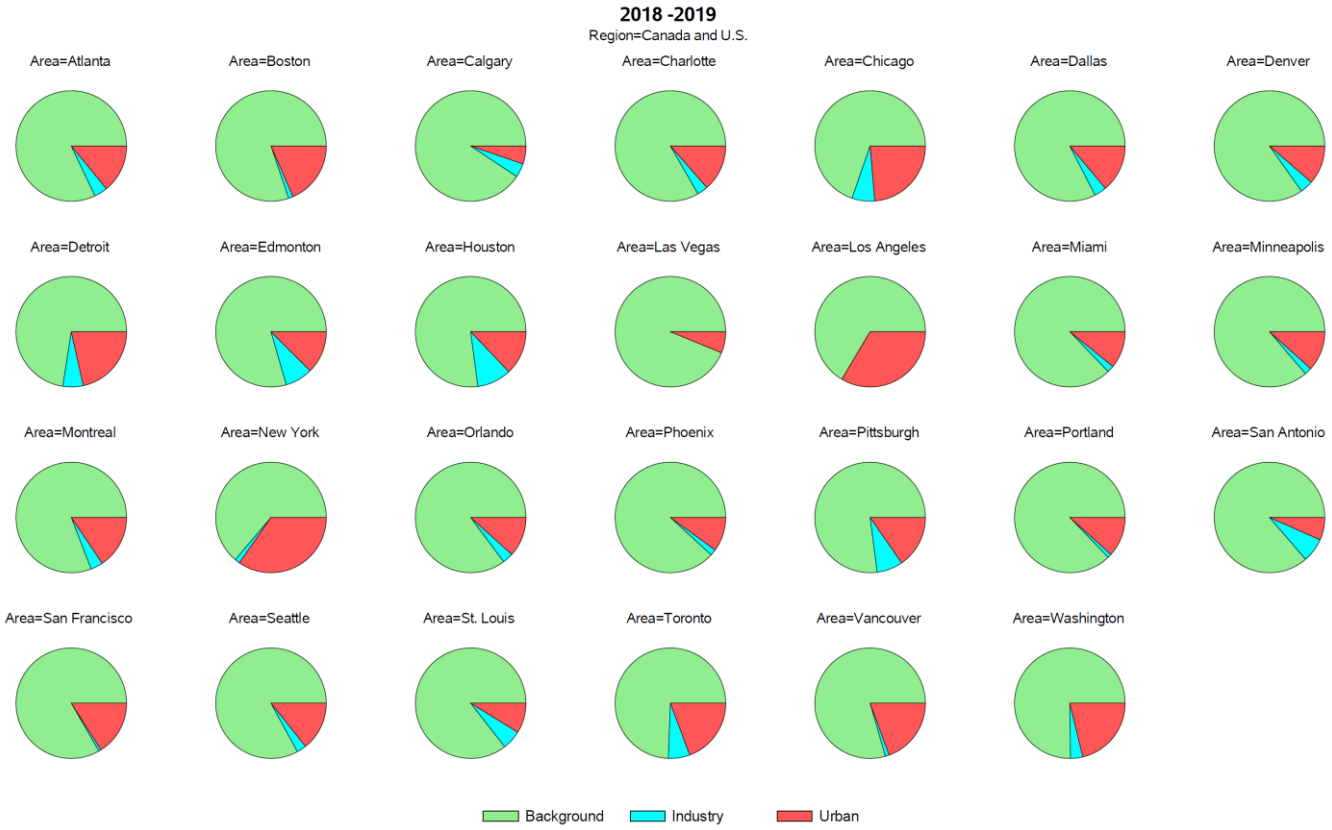

Figure S1. Relative contribution of the three components (background, urban, and industrial) components to the total tropospheric NO_2 mass for all 27 Canadian and U.S. areas for March 16 – June 15 (average for 2018-2019). The contribution from industrial sources and cities are responsible for less than a third of total NO_2 mass of the analysed 3° by 4° urban areas.

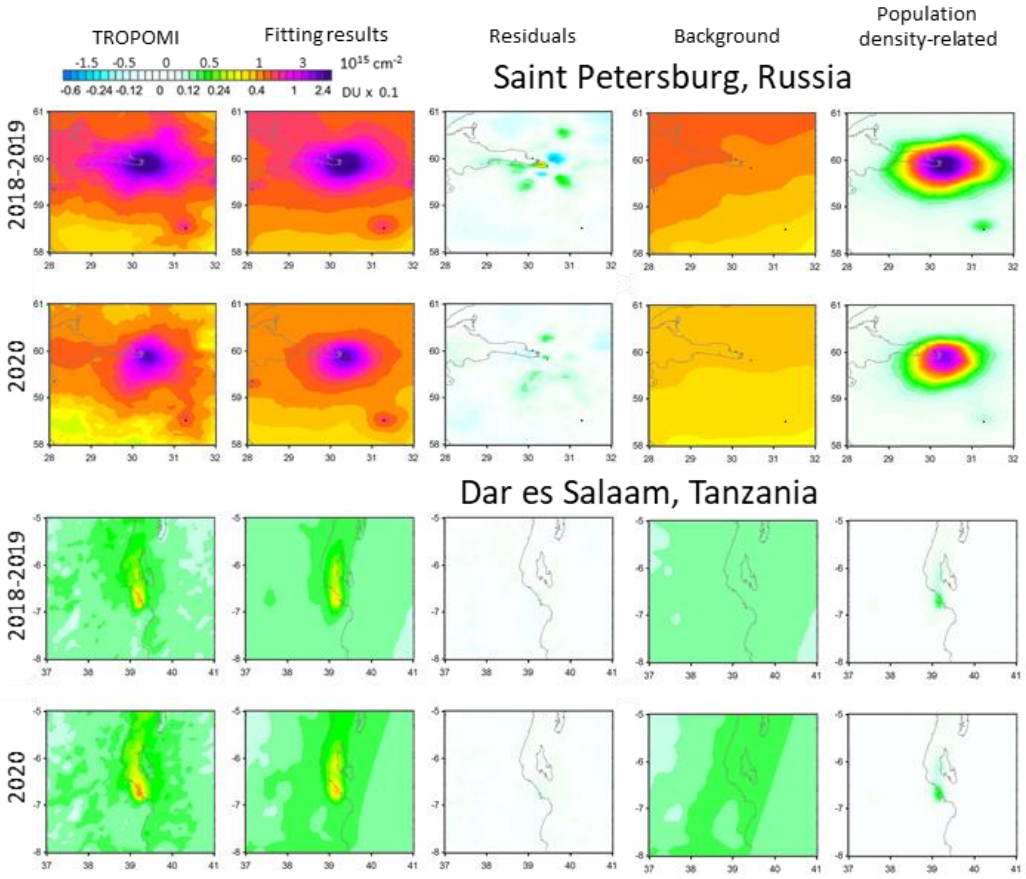

Figure S2. Similar to Figure 6 columns a-e, for Saint Petersburg, and Dar es Salaam, cities with similar population of about 6 million people, but very different NO_2 "footprint". There are no large industrial sources in these two areas.

Table S1. The standard deviations of the random errors and interannual variability for background, urban and industrial components for Europe-1 in percent. The random errors are calculated as the averages of estimates for individual years. The interannual variability are the standard deviations calculated from three years (2018, 2019, and 2021). Interannual variability of the industrial component is calculated for regions with estimated total emissions greater than 1 kt yr^{-1}.

	Random Error (%)			Interannual Variability (%)		
Area	**Background**	**Urban**	**Industrial**	**Background**	**Urban**	**Industrial**
Barcelona	0.17	0.70	1.83	2.6	7.8	13.6
Brussels	0.36	0.90	1.47	7.2	5.9	8.3
Dublin	0.29	1.71		9.9	6.8	
Lisbon	0.16	0.76	4.07	6.7	17.4	24.5
London	0.25	0.79	2.89	6.6	13.2	11.0
Lyon	0.23	1.81	5.61	6.9	14.9	32.0
Madrid	0.20	0.39	6.50	1.3	14.8	20.8
Manchester	0.39	0.58	2.28	14.3	7.6	22.0
Marseille	0.20	1.52	1.96	3.8	5.5	10.3
Milan	0.37	0.62	7.21	7.8	12	43.4
Naples	0.16	0.42	4.82	2.4	7	69.0
Nice	0.18	1.15	2.93	3.7	11.3	23.0
Paris	0.20	0.61	5.77	6.7	26.5	83.8
Rome	0.15	0.68	7.06	1.3	7.5	4.8
Sevilla	0.16	1.79	2.39	3.5	25.8	20.3
Average	0.23	0.96	4.06	5.6	12.3	27.6

Table S2. The standard deviations of the random errors and interannual variability for background, urban and industrial components for Europe-2 in percent. The random errors are calculated as the averages of estimates for individual years. The interannual variability are the standard deviations calculated from three years (2018, 2019, and 2021). Interannual variability of the industrial component is calculated for regions with estimated total emissions greater than 1 kt yr^{-1}.

	Random Error (%)			Interannual Variability (%)		
Area	**Background**	**Urban**	**Industrial**	**Background**	**Urban**	**Industrial**
Amsterdam	0.37	1.23	1.10	11.8	8.3	13.3
Athens	0.15	0.42	1.99	10	10.5	7.3
Belgrade	0.26	1.63	1.72	9.9	46.2	11.8
Berlin	0.24	2.18	1.76	1.1	10.4	12.1
Bucharest	0.19	1.02	4.23	9.1	11.7	40.5
Budapest	0.22	0.79	2.82	1.2	31.8	15.7
Cologne	0.45	1.10	1.51	2.2	10.2	9.3
Copenhagen	0.16	1.34	9.61	8.7	11.7	29.9
Hamburg	0.27	1.49	4.04	5.1	25.6	6.7
Helsinki	0.23	1.01	5.28	3.5	26.7	28.8
Munich	0.29	1.34	4.60	3.1	17.1	26.8
Nicosia	0.15	1.05	0.98	15.4	10.1	5.7
Oslo	0.28	1.31		13.2	10.3	
Prague	0.31	1.27	1.26	3.3	11.1	5.9
Riga	0.20	1.52		3.3	13.3	
Sofia	0.25	1.31	1.32	9.4	1.9	21.1
Stockholm	0.19	1.18		7.7	16.2	
Tirana	0.22	1.44	1.02	9.9	12.7	8.5
Vienna	0.24	1.15	6.61	2.8	18.1	38.0
Vilnius	0.24	1.77		2.5	20.7	
Warsaw	0.24	1.05	1.63	9	6	24.8
Zagreb	0.22	1.62		3.6	21.4	
Zurich	0.38	1.66	4.87	11.1	1.4	0.9
Average	0.25	1.30	3.13	6.8	15.4	17.1

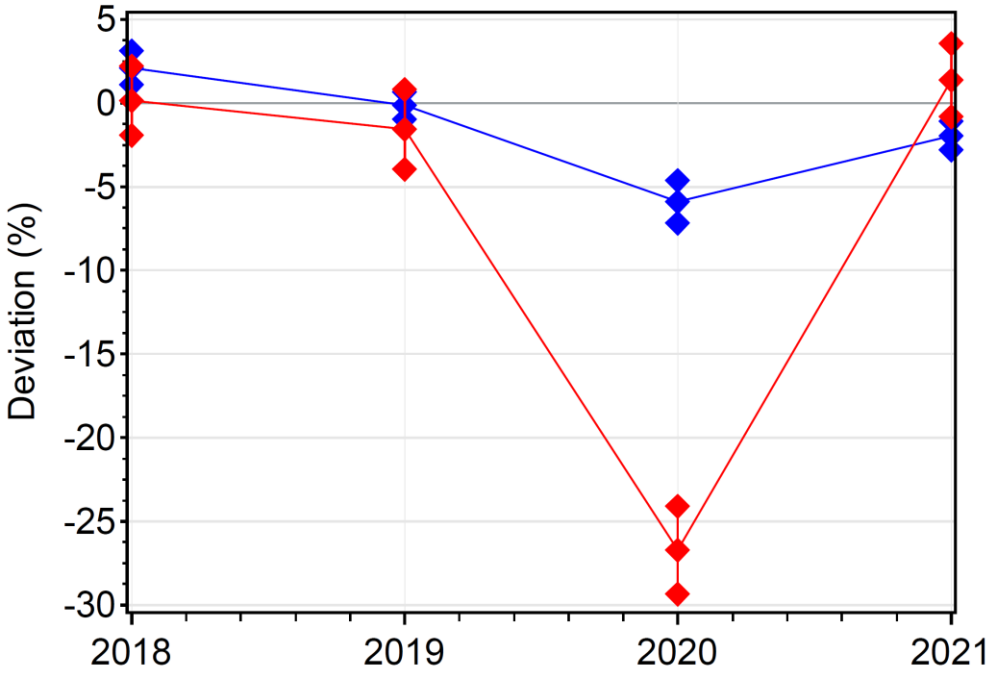

Figure S3. Deviations from the baseline level for averages of all individual areas excluding China for the background (blue) and urban (red) components. The baseline was calculated as the average of 2018, 2019, and 2021 values. The percent deviations were calculated for each area and then averaged. The error bars represent two standard errors of the mean.