Monthly NO_2 Supplementary Methods Documentation
April 2020

1. Considerations for Data Users

Annual and monthly NO_2 estimates have been derived by applying year-specific adjustment factors based on ratios derived from NO2 levels measured by National Air Pollution Surveillance (NAPS) monitors to the results of a land use regression (LUR) model developed by Dr. Perry Hystad circa 2006[1].

See the following s documents for more details on how annual estimates were made for years other than 2006:
For 1984 to 2012: http://canue.ca/wp-content/uploads/2018/03/NO2-Supplementary-Methods-Documentation.pdf
For 2013 to 2016:
https://www.canuedata.ca/docs/Annual_NO2_Supplementary_Methods_Documentation_2013_2016.pdf
This document details the process for producing year-specific monthly adjustment factors.

2. Establishing monthly trends in NO_2 concentrations over time

Measured NO_2 data from National Air Pollution Surveillance monitoring stations from 1985 to 2016 were analyzed by CANUE staff.

We first looked at monthly trends by station type, as defined by NAPS. These were calculated by separating stations located in commercial/industrial , natural, regional and residential settings into groups. We did not consider stations in proximity to point sources as these may not exhibit typical trends, or several stations in very close proximity to major expressways as these may not be representive of many other near road sites. The long-term monthly average and annual average was calculated for each station, and the ratio of the monthly average/annual average produced (Figure 1). The temporal pattern and magnitude of the ratios were very similar between stations in commercial-industrial, natural, and residential settings. Regional stations, which are sited away from major influences on NO_2 levels, showed the most variation month-to-month, but also had the lowest measured levels and therefore more extreme ratios will have lower impact on the adjusted concentration estimates.

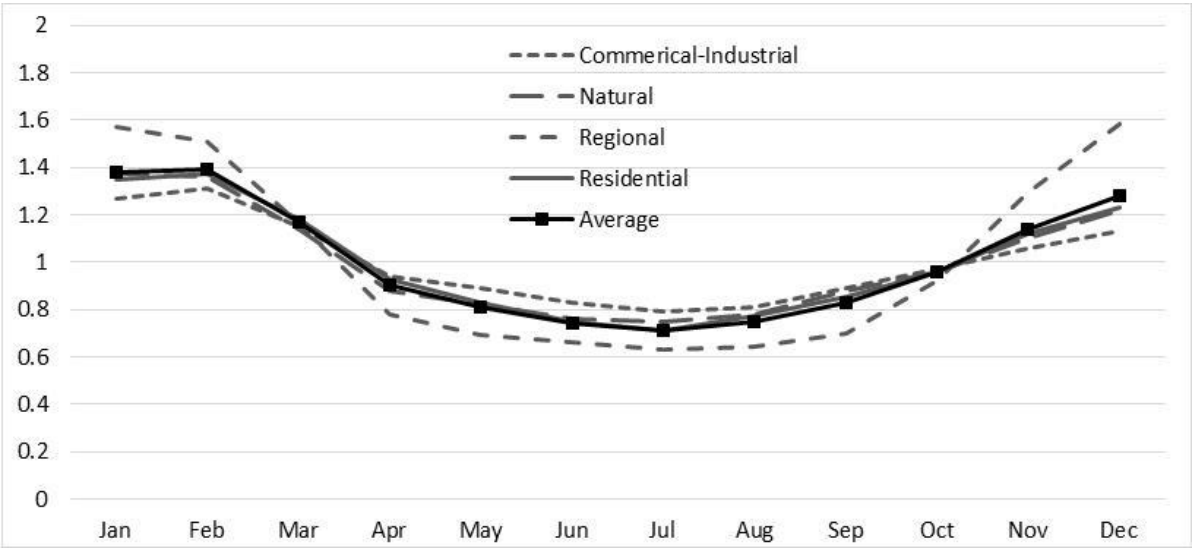

Figure 1. Long-term Monthly Ratios by Station Type.

Next, we looked at the trend in monthly ratios over time. Figure 2a and 2b show slightly decreasing trends in monthly ratios in warmer months, and relatively flat or slightly increasing trends in colder months over time. For this reason, we concluded that year specific monthly ratios were necessary.

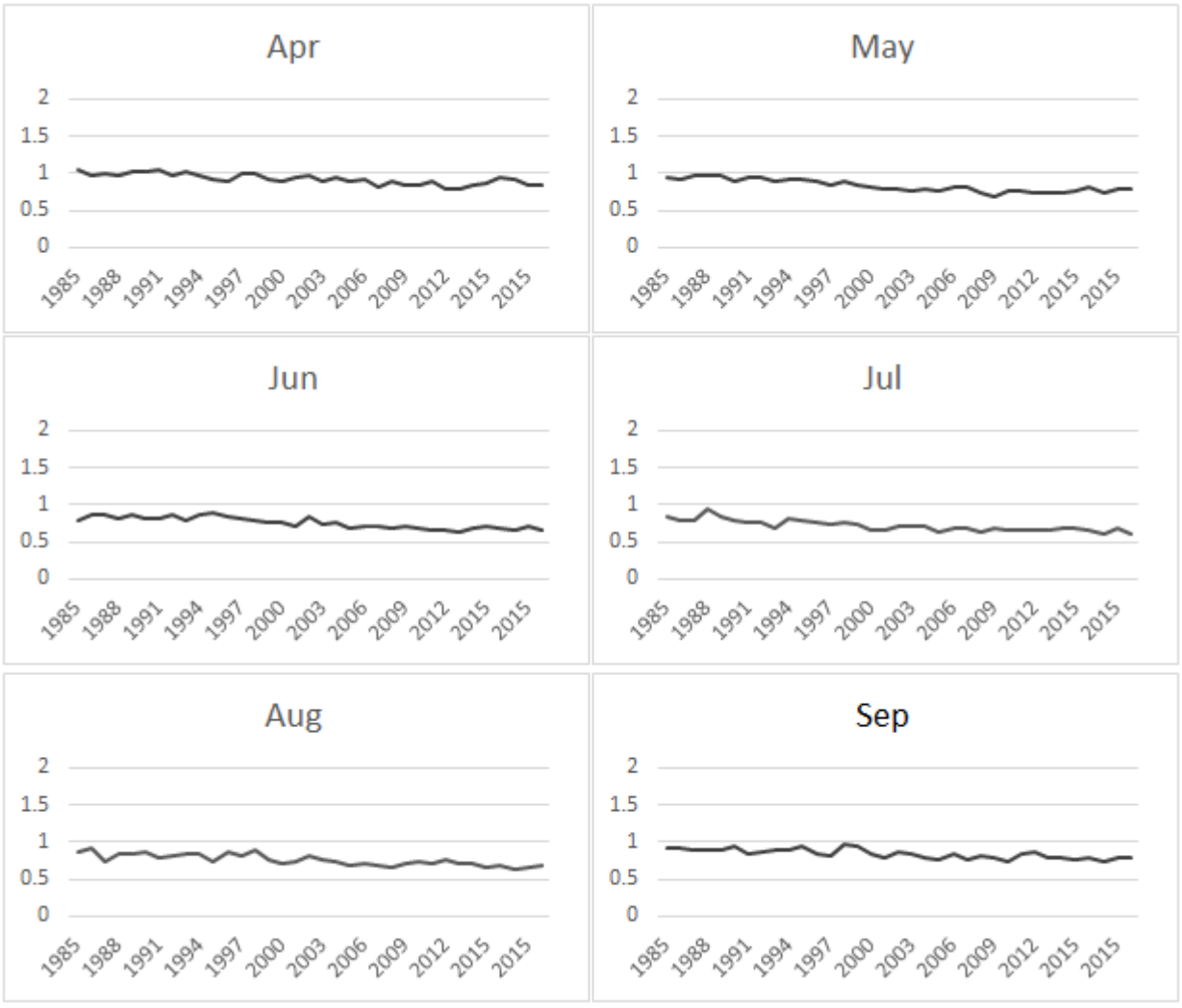

Figure 2a. Trend in monthly ratios in warmer months

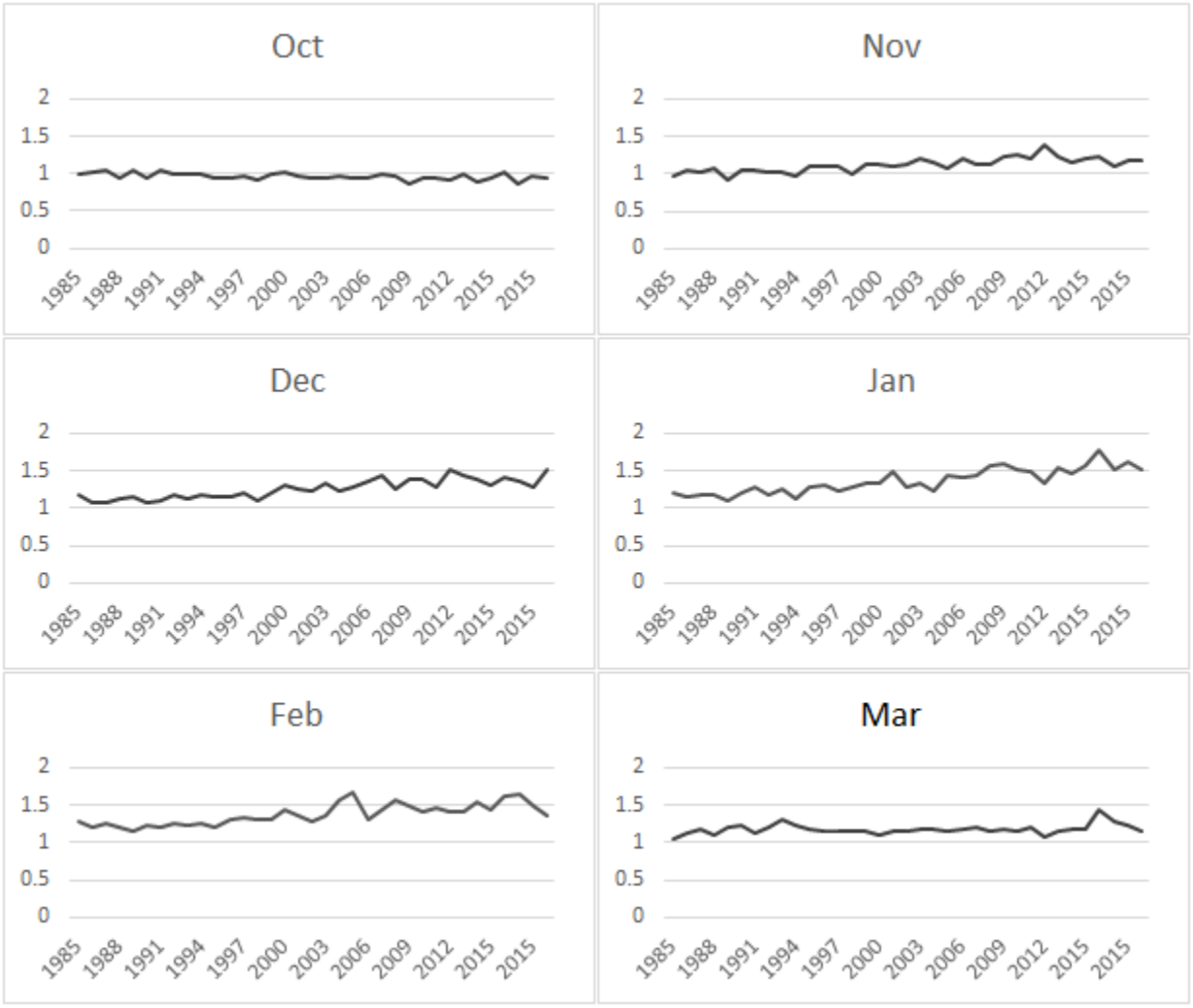

Figure 2a. Trend in monthly ratios in colder months

3. Calculating monthly factors

The monthly factors (ratios) were derived from National Air Pollution Surveillance monitoring stations classified as population exposure and regional background.

For 1985 – 2012, CANUE Staff used the below equations to calculate monthly NO_2 factors for all NAPS stations reporting a monthly average for at least 2 months in each quarter. First a monthly ratio was derived for each NAPS station for year Y using equation (1). This resulted in 12 distinct monthly ratios for year, Y, for station, x.

$$Monthly\ \mathrm{NO_2}\ ratio_{m,Y,x} = \frac{Average\ \mathrm{NO_2}\ level\ from\ NAPS\ station,x,for\ month,m,of\ year,Y}{Annual\ Average\ \mathrm{NO_2}\ level\ from\ NAPS\ station,x,for\ year,\ Y} \quad (1)$$

All NAPS stations' monthly NO_2 ratios from (i.e. the output from equation (1)) were then averaged to give a monthly NO_2 factor for the month of m during the year Y.

$$Monthly\ \mathrm{NO_2}\ \mathrm{factor}_{m,Y} = \frac{Monthly\ \mathrm{NO_2}\ ratio_{m,Y,x1} + Monthly\ \mathrm{NO_2}\ ratio_{m,Y,xn}}{number\ of\ NAPS\ stations} \quad (2)$$

Where x1 -> xn represents different NAPS stations.

When the data were updated for 2013 – 2016, a different method was employed, with the NAPS stations monthly concentrations being averaged first, and the ratio of the month to annual concencentrations being derived after. No missing data threshold was applied. See Table 1 for the final monthly NO_2 factors derived from 1984 to 2016.

Table 2 and Figure 3 provide a comparison of the ratios for three years when both methods were applied to the NAPS data. In general, the seasonal patterns of the ratios using either method are very similar. The largest differences are observed for 2013, particularly in January – April. Table 3 gives the estimated NO_2 (ppb) for quartile breaks in the distribution of estimated NO_2 in January of 2013, based on the application of the January ratios to the annual estaimted NO_2 for all postal codes (n = 843,072).

These different averaging methods produce slightly different ratios, however, the differences in the NO_2 estimations after application of the ratios is minimal, especially when the annual NO_2 estimates are low.

Table 1. Monthly NO_2 factors derived from 1984 to 2016.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	1.19	1.28	1.06	1.06	0.94	0.80	0.84	0.87	0.91	0.99	0.97	1.18
1986	1.16	1.20	1.13	0.96	0.92	0.86	0.78	0.92	0.91	1.03	1.04	1.09
1987	1.18	1.26	1.17	0.99	0.97	0.87	0.80	0.75	0.88	1.06	1.03	1.07
1988	1.17	1.22	1.09	0.96	0.97	0.82	0.94	0.84	0.88	0.93	1.06	1.12
1989	1.10	1.16	1.19	1.03	0.98	0.87	0.85	0.84	0.88	1.04	0.92	1.15
1990	1.19	1.22	1.22	1.03	0.90	0.82	0.78	0.87	0.93	0.94	1.05	1.08
1991	1.29	1.19	1.13	1.05	0.95	0.82	0.76	0.79	0.85	1.04	1.04	1.11
1992	1.18	1.25	1.19	0.96	0.95	0.85	0.76	0.81	0.87	0.99	1.02	1.17
1993	1.26	1.23	1.30	1.01	0.88	0.78	0.68	0.83	0.90	1.01	1.02	1.14
1994	1.12	1.25	1.23	0.98	0.91	0.86	0.82	0.84	0.90	1.00	0.98	1.18
1995	1.27	1.20	1.17	0.91	0.92	0.90	0.79	0.74	0.94	0.93	1.09	1.15
1996	1.30	1.30	1.16	0.88	0.88	0.84	0.77	0.87	0.83	0.93	1.11	1.15
1997	1.24	1.32	1.16	1.01	0.84	0.81	0.73	0.81	0.83	0.96	1.10	1.20
1998	1.28	1.31	1.16	0.99	0.88	0.78	0.77	0.89	0.96	0.92	0.99	1.09
1999	1.32	1.32	1.15	0.91	0.85	0.77	0.72	0.77	0.95	1.00	1.13	1.20
2000	1.32	1.45	1.11	0.88	0.82	0.76	0.67	0.72	0.84	1.03	1.12	1.30
2001	1.50	1.37	1.15	0.95	0.80	0.72	0.67	0.73	0.78	0.96	1.11	1.25
2002	1.29	1.29	1.15	0.97	0.79	0.84	0.72	0.81	0.85	0.95	1.12	1.23
2003	1.34	1.37	1.17	0.88	0.77	0.75	0.71	0.76	0.84	0.93	1.20	1.33
2004	1.23	1.57	1.19	0.93	0.78	0.75	0.72	0.74	0.79	0.96	1.15	1.23
2005	1.45	1.68	1.16	0.88	0.77	0.70	0.63	0.69	0.77	0.95	1.07	1.28
2006	1.42	1.30	1.18	0.91	0.82	0.70	0.67	0.72	0.83	0.93	1.21	1.37
2007	1.43	1.43	1.20	0.82	0.82	0.71	0.69	0.67	0.76	0.98	1.14	1.44
2008	1.57	1.57	1.15	0.90	0.72	0.68	0.64	0.67	0.82	0.97	1.12	1.25
2009	1.59	1.50	1.19	0.85	0.69	0.71	0.69	0.71	0.78	0.86	1.22	1.39
2010	1.51	1.42	1.16	0.83	0.77	0.68	0.66	0.74	0.74	0.93	1.26	1.38
2011	1.50	1.47	1.22	0.89	0.75	0.66	0.65	0.70	0.85	0.94	1.21	1.28
2012	1.32	1.41	1.06	0.78	0.75	0.65	0.66	0.76	0.87	0.91	1.38	1.52
2013	1.76	1.63	1.44	0.94	0.80	0.68	0.66	0.69	0.78	1.03	1.22	1.40
2014	1.51	1.65	1.29	0.93	0.73	0.67	0.60	0.64	0.73	0.87	1.10	1.36
2015	1.62	1.48	1.22	0.84	0.78	0.70	0.67	0.65	0.80	0.96	1.19	1.28
2016	1.52	1.36	1.16	0.83	0.78	0.66	0.62	0.69	0.79	0.94	1.18	1.53

Table 2. Comparison of monthly NO_2 factors using each method
(Method A = average of monthly ratios Method B = ratio of averaged NO_2 concentration)

2013	J	F	M	A	M	J	J	A	S	O	N	D
Method A	1.55	1.4	1.14	0.79	0.73	0.63	0.66	0.7	0.78	0.98	1.22	1.45
Method B	1.76	1.63	1.44	0.94	0.80	0.68	0.66	0.69	0.78	1.03	1.22	1.40
Difference	-0.21	-0.23	-0.3	-0.15	-0.07	-0.05	0	0.01	0	-0.05	0	0.05
2014	J	F	M	A	M	J	J	A	S	O	N	D
Method A	1.46	1.54	1.19	0.84	0.73	0.68	0.68	0.72	0.79	0.9	1.15	1.39
Method B	1.51	1.65	1.29	0.93	0.73	0.67	0.60	0.64	0.73	0.87	1.10	1.36
Difference	-0.05	-0.11	-0.1	-0.09	0	0.01	0.08	0.08	0.06	0.03	0.05	0.03
2015	J	F	M	A	M	J	J	A	S	O	N	D
Method A	1.57	1.44	1.19	0.86	0.77	0.71	0.69	0.66	0.75	0.93	1.2	1.31
Method B	1.62	1.48	1.22	0.84	0.78	0.7	0.67	0.65	0.8	0.96	1.19	1.28
Difference	-0.05	-0.04	-0.03	0.02	-0.01	0.01	0.02	0.01	-0.05	-0.03	0.01	0.03

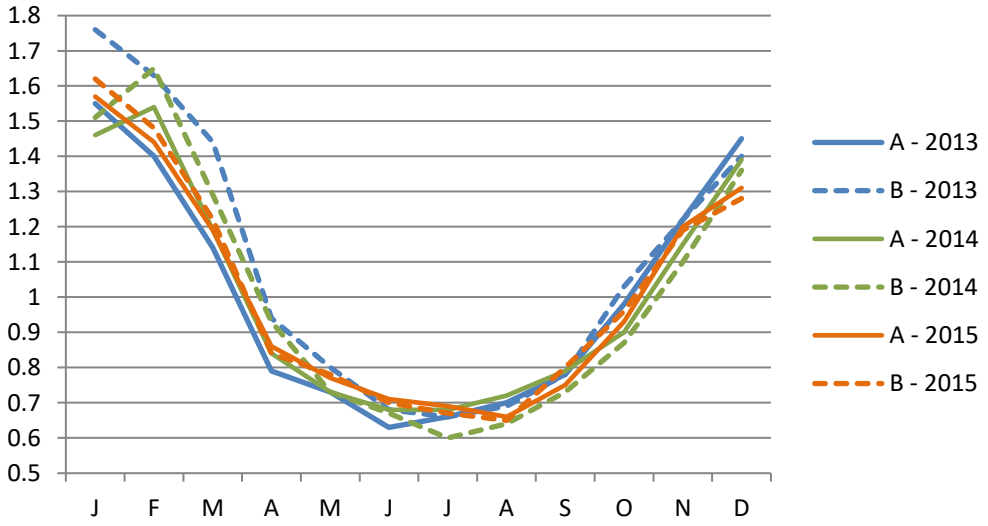

Figure 3. Comparison of final monthly ratios for 2013, 2014 and 2015 using each method
(Method A = average of monthly ratios Method B = ratio of averaged NO_2 concentration)

Table 3. Distribution of estimated NO_2 (ppb) for January 2013 using each method

	Minimum	25th percentile	50th percentile	75th percentile	Maximum
Method A	0	7.2	12.1	19.2	68.6

Method B	0	8.2	13.7	21.8	77.9

4. Applying the monthly factors

CANUE staff applied the monthly factors to the annual estimates for year, Y,to produce estimates of monthly average NO_2 (ppb) for every single-link DMTI Spatial Inc postal code location in use between 1984 and 2016,using equation (3)

$$Monthly\ \mathrm{NO_2}\ \text{estimate} = Monthly\ \mathrm{NO_2}\ \text{factor}_{m,Y}\ x\ Annual\ \mathrm{NO_2}\ estimate\ for\ year, Y \qquad (3)$$

This resulted in 12 monthly files containing NO_2 estimates for each year, and 384 monthly files for 1984 to 2016.

References

1. Hystad, P. *et al.* Creating National Air Pollution Models for Population Exposure Assessment in Canada. *Environ. Health Perspect.* **119,** 1123–1129 (2011).

2. Hystad, P., Brauer, M. & Cervantes, A. Refining the NAPS Monitor Classification: Extending it to Inform Population Exposure Assessment and Identifying High Traffic Air Pollution Locations in Vancouver. (2013).

3. Chen, H. *et al.* Back-extrapolation of estimates of exposure from current land-use regression models. *Atmos. Environ.* **44,** 4346–4354 (2010).

4. Beelen, R. *et al.* Effects of long-term exposure to air pollution on natural-cause mortality: an analysis of 22 European cohorts within the multicentre ESCAPE project. *The Lancet* **383,** 785–795 (2014).