TRACKING ATMOSPHERIC GREENHOUSE GASES IN TORONTO, CANADA

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[2]University of Toronto, Canada

Environment and Climate Change Canada
Environnement et Changement climatique Canada

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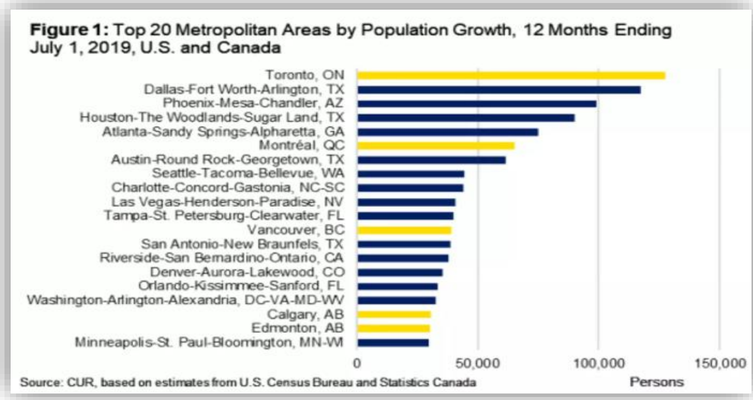
Outline

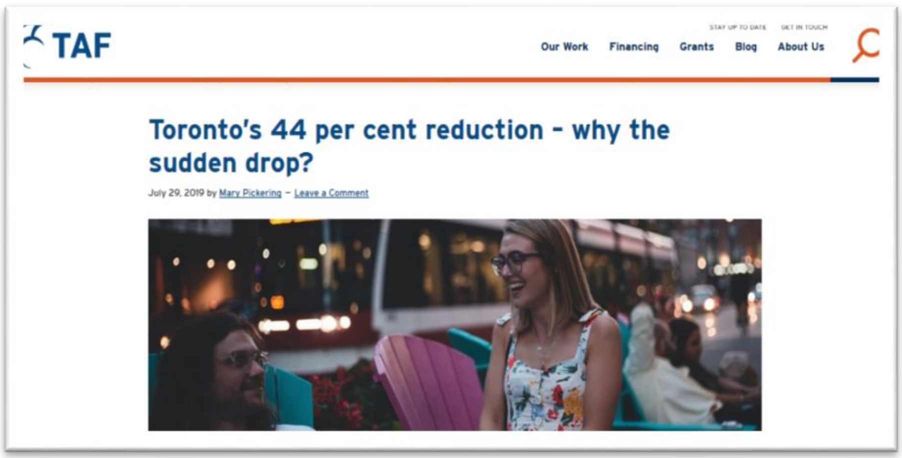
- Introduction to the program
- Methane in the Greater Toronto Area (GTA)
- Atmospheric greenhouse gases during COVID shutdown

Introduction to the program – The Greater Toronto Area

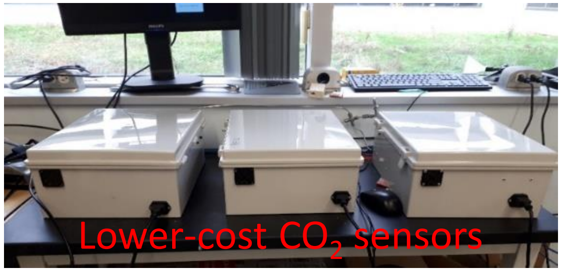
In 2018 about 7 Million people lived in the Greater Toronto Area and the population is predicted to **rise to 8.5 Million in 2030** – it is the fastest growing metropolitan area in US&CA, while **pursuing ambitious mitigation goals**.

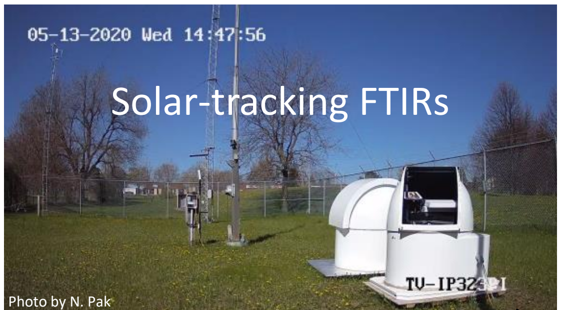
Transform TO emission reduction targets compared to 1990
-30% in 2020
-65% in 2030
-80% in 2050

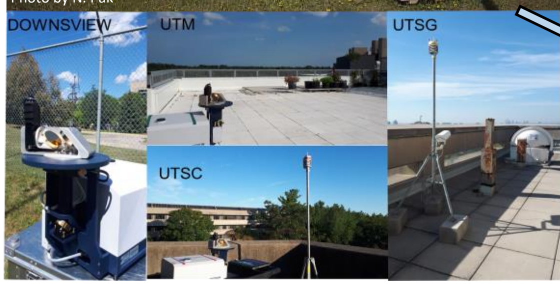




Introduction to the program – atmospheric observations







Mobile survey platforms

High-precision GHG instruments

In-situ sites are integrated in ECCC's national GHG monitoring network and ground-based remote sensing sites are maintained in collaboration with UoToronto

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IG3IS Integrated Global Greenhouse Gas Information System

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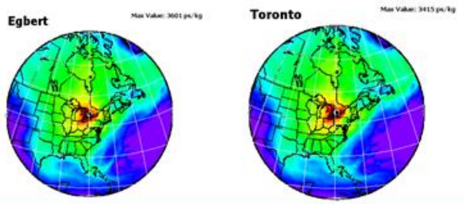
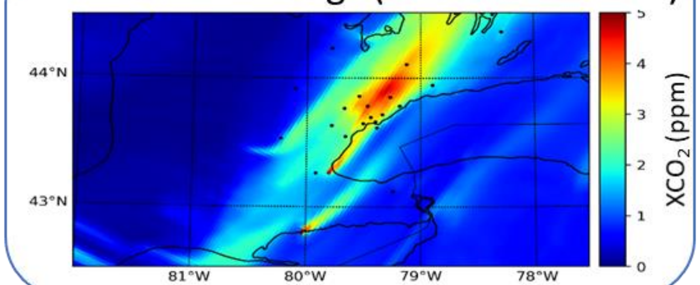
Introduction to the program – modelling tools

Atmospheric transport modelling ⟺ **Emission products (inventories/models)**

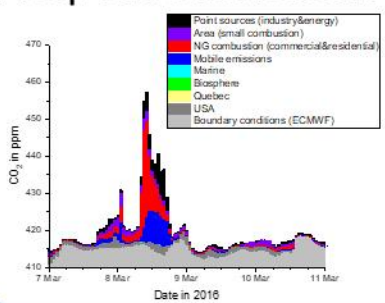
Footprints[1] (FLEXPART and STILT)

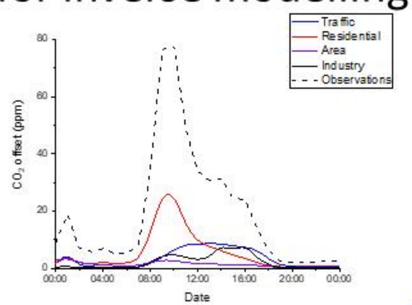


Eulerian modelling[2] (GEM-MACH-TEB)

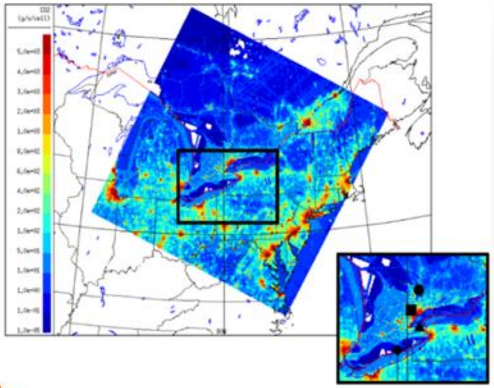


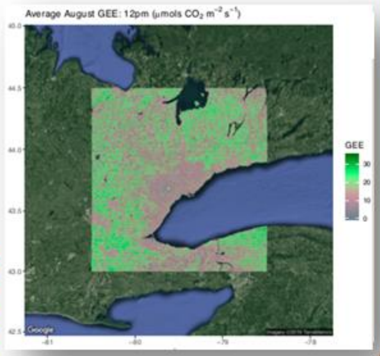
Response functions (for inverse modelling)



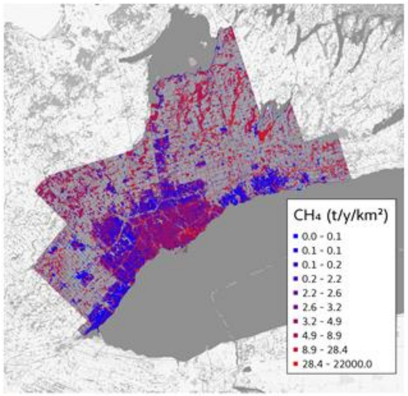


Fossil fuel[3] and biogenic[4] CO_2 fluxes





CH_4 emission map and sector information[5]



category	uoft	eccc	edgar
agricultural	5.92	7.79	5.55
landfill	64.75	119.21	45.13
mobile	1.06	1.50	0.40
upstream oil and gas		0.24	10.85
other	11.93	13.90	51.27
total	83.66	142.65	113.20

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1 - FLEXPART support by E. Chan, STILT support by A. Andrews (NOAA)
2 - Eulerian modelling in collaboration with C. Stroud (AQRD)
3 - Pugliese et al. 2018, doi.org/10.5194/acp-18-3387-2018
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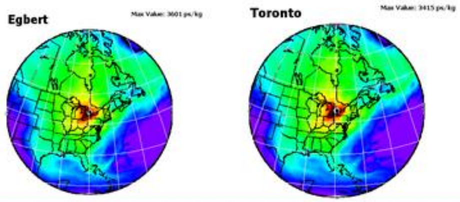

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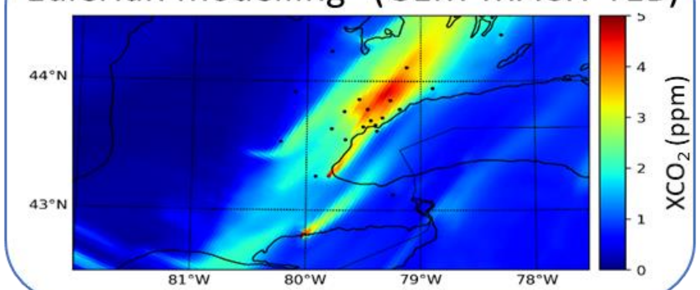

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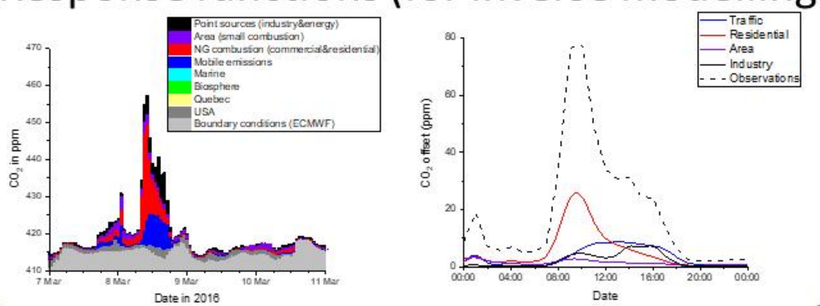

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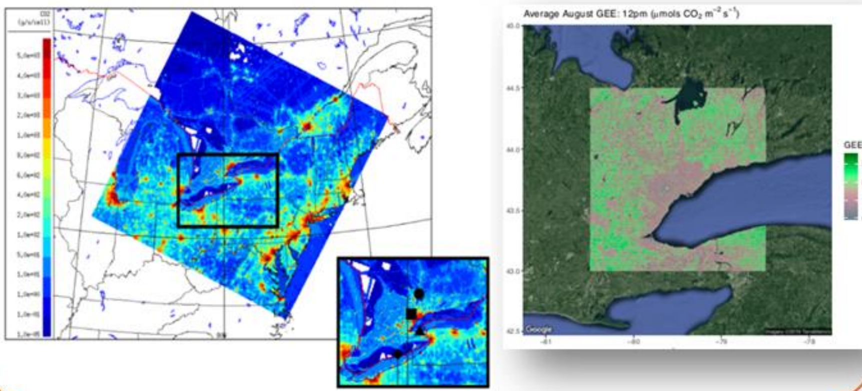

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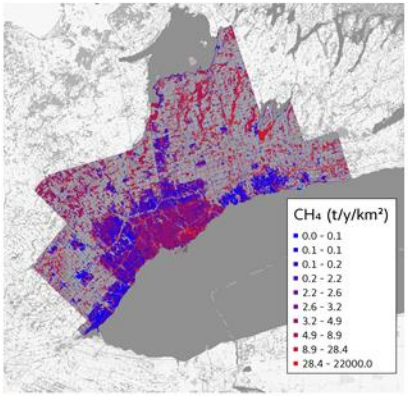

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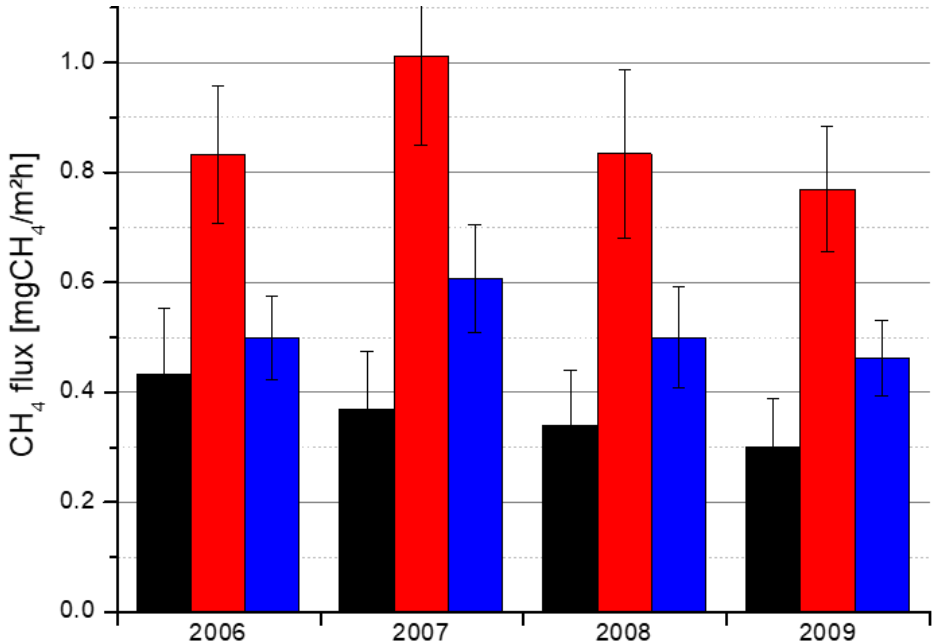
Methane in the Greater Toronto Area – ‘simple’ emission estimates



$$\frac{\frac{dC_{CH_4}(t)}{dt}}{\frac{dC_{Rn}(t)}{dt}} \cdot F_{Rn}(t) \cdot c = F_{CH_4}(t)$$

“known“ “derived“

CH_4 observation-based estimate (RTM)

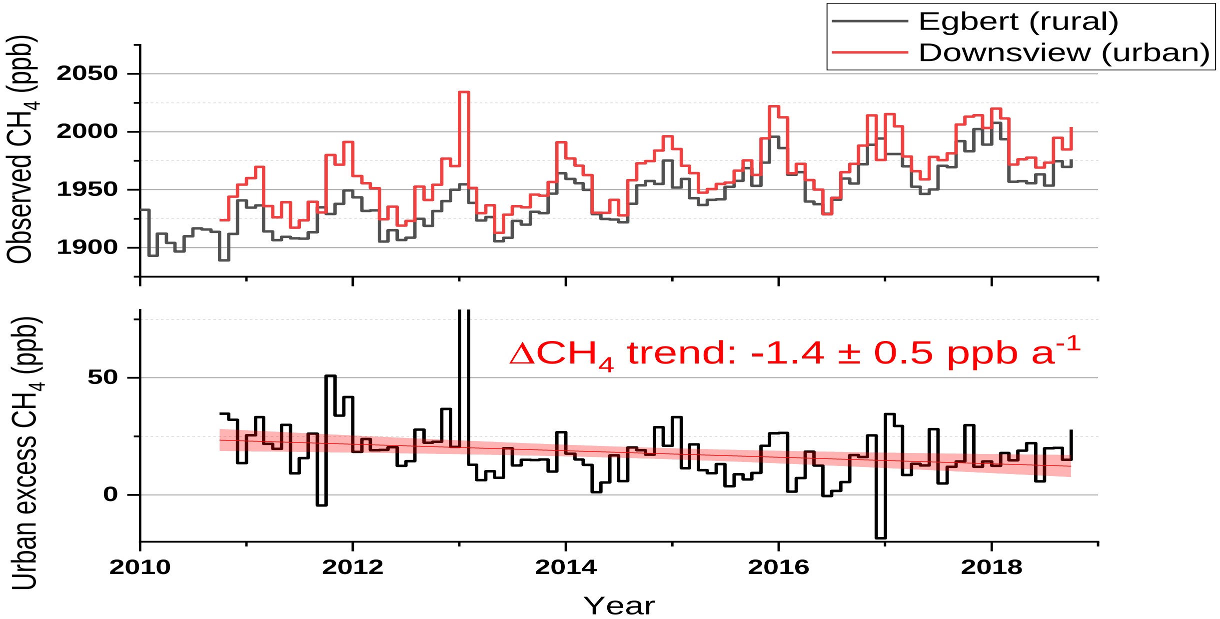
Adjusted ECCC emission estimate

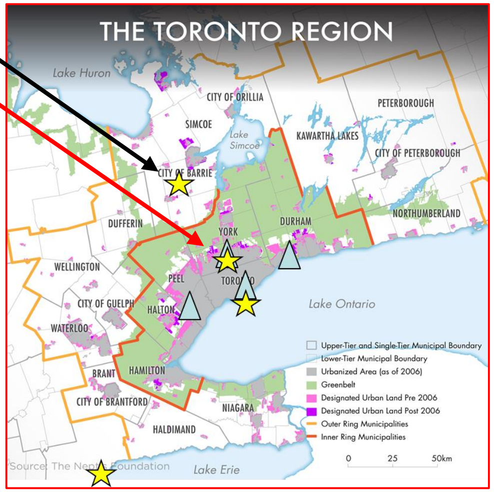
EDGAR V4.1

Atmospheric observation-based emission estimate of CH_4 in Southern Ontario is lower than EDGAR inventory and slightly lower then ECCC-adjusted estimate.

Vogel et al. 2013
DOI: [10.1080/1943815X.2012.691884](https://doi.org/10.1080/1943815X.2012.691884)

Methane in the Greater Toronto Area – long-term monitoring





- Noticeable long-term trend in urban atmospheric CH_4 enhancements
- This coincides with mitigation measures (natural gas, waste), but could it be meteo driven?

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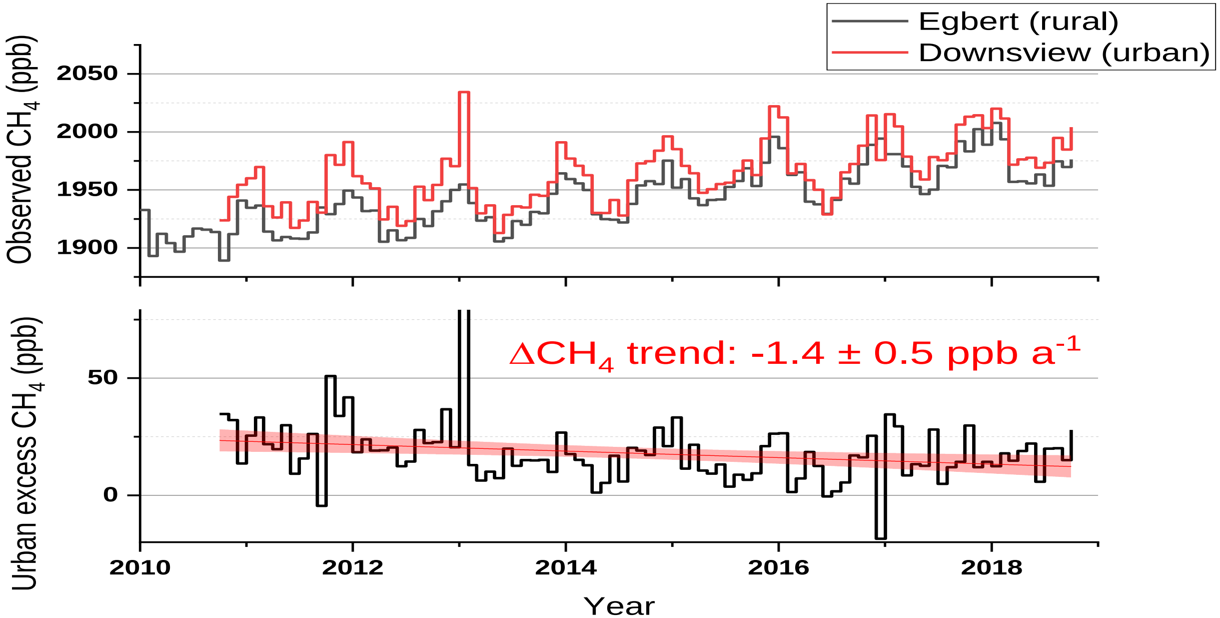
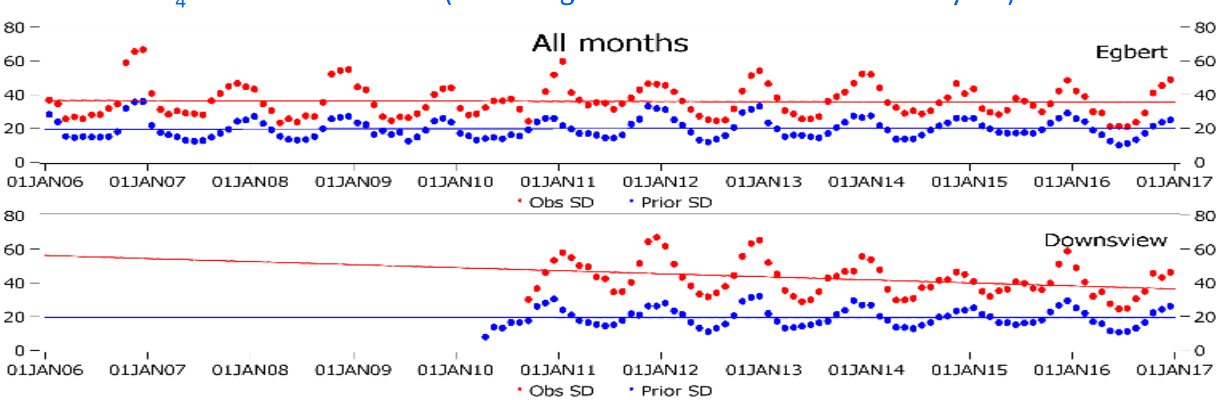


- Noticeable long-term trend in urban atmospheric CH_4 enhancements
- This coincides with mitigation measures (natural gas, waste), but could it be meteo driven?

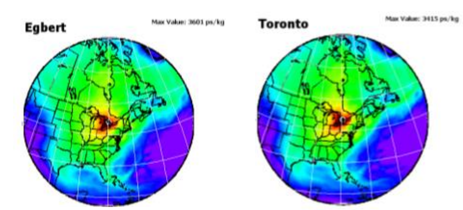
… unlikely …

Observed CH_4 standard deviation (monthly time-scale: for hourly data)

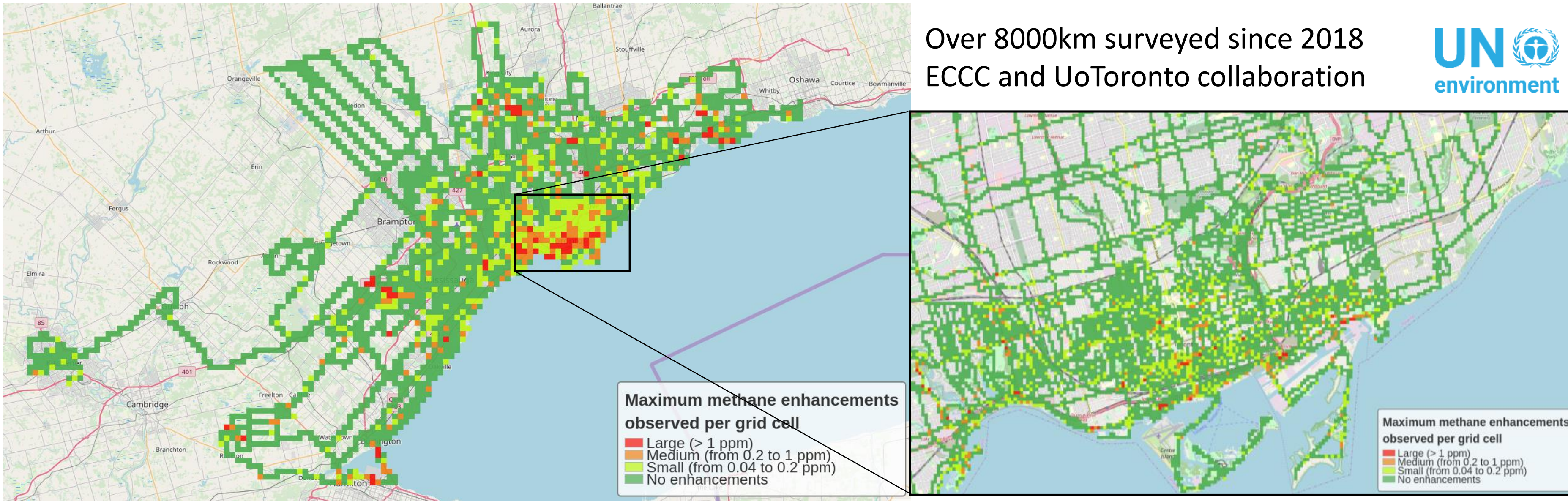
Modelled CH_4 standard deviation (assuming constant emissions for each year)



Using FLEXPART footprints (10km x 10km)



Methane in the Greater Toronto Area – mobile surveys



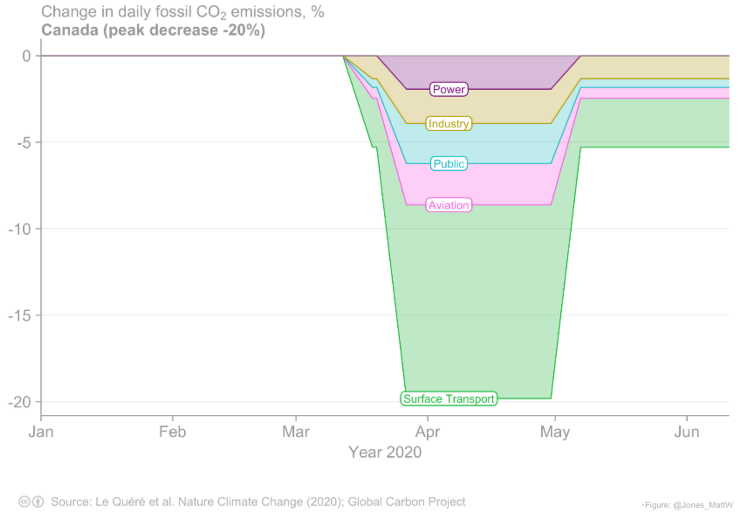
Over 8000km surveyed since 2018
ECCC and UoToronto collaboration

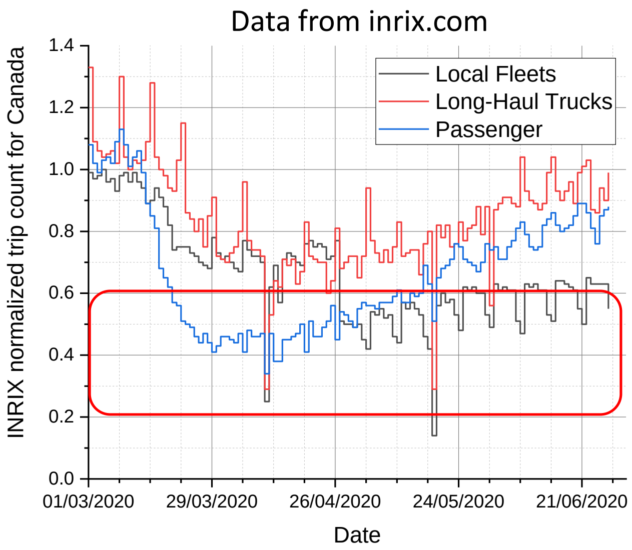
UN environment

- Visible hot spots at waste and natural gas transmission facilities and some natural sources
- Emission rate estimation for facilities using Gaussian plume modelling
- Very low leak occurrences compared to many US cities (new ‘small’ category added)
- Low contribution of natural gas emissions to overall CH_4 budget
- Loss rates relative to consumption possibly well below IPCC emission factors

More details in Ars et al. 2020 (to be submitted this month)

Atmospheric monitoring during COVID shutdown – what to expect





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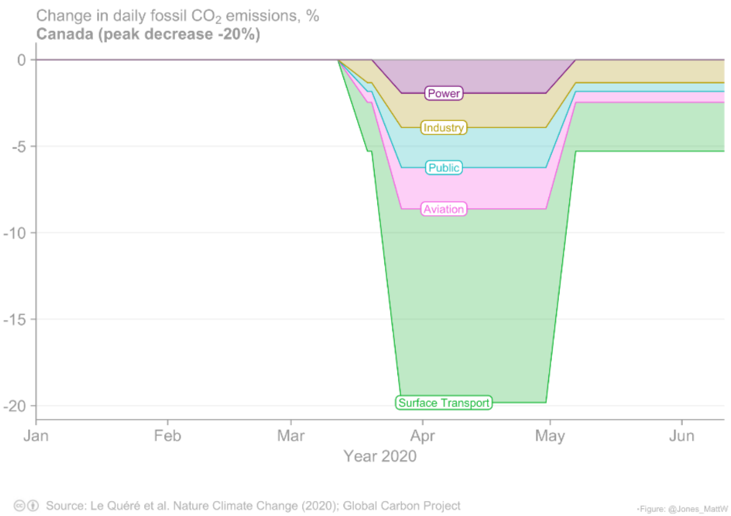
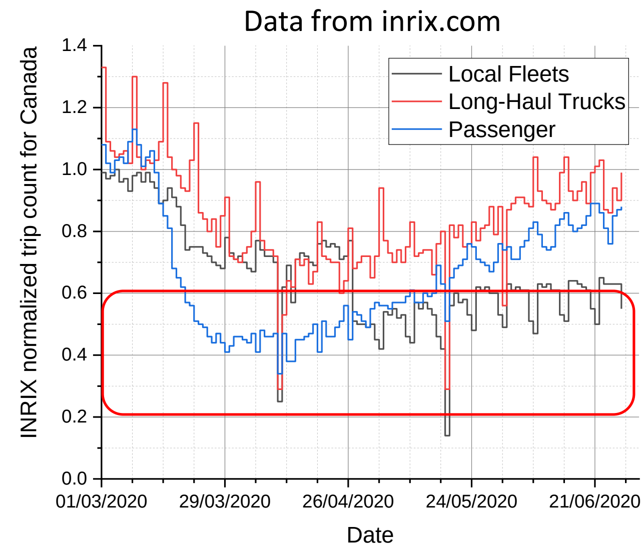
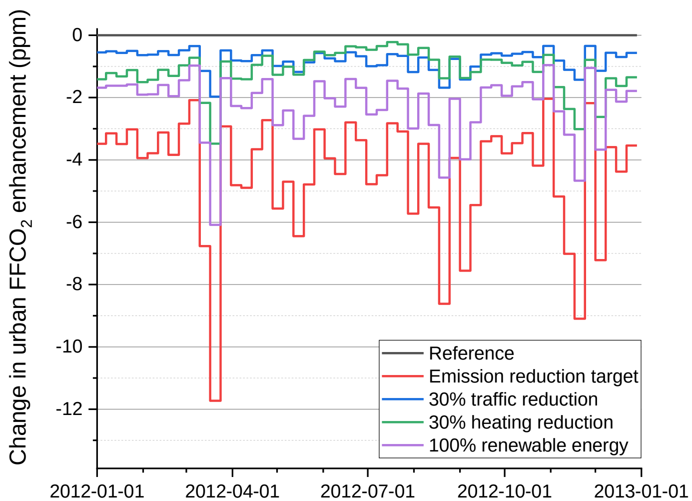
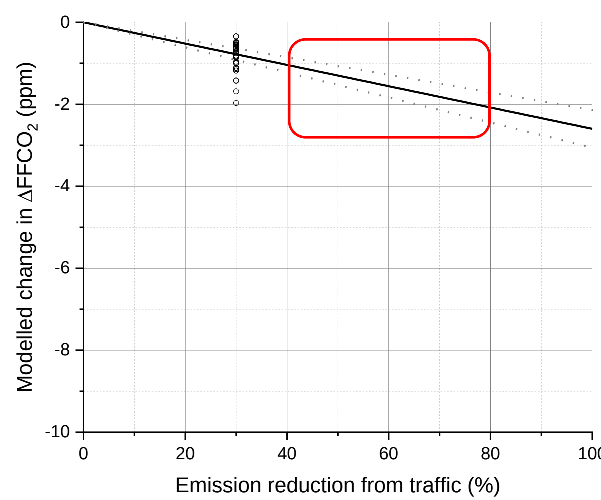




Modelling impact on weekly $\Delta FFCO_2$ due to mitigation



Semi-quantitative estimate of expected signal



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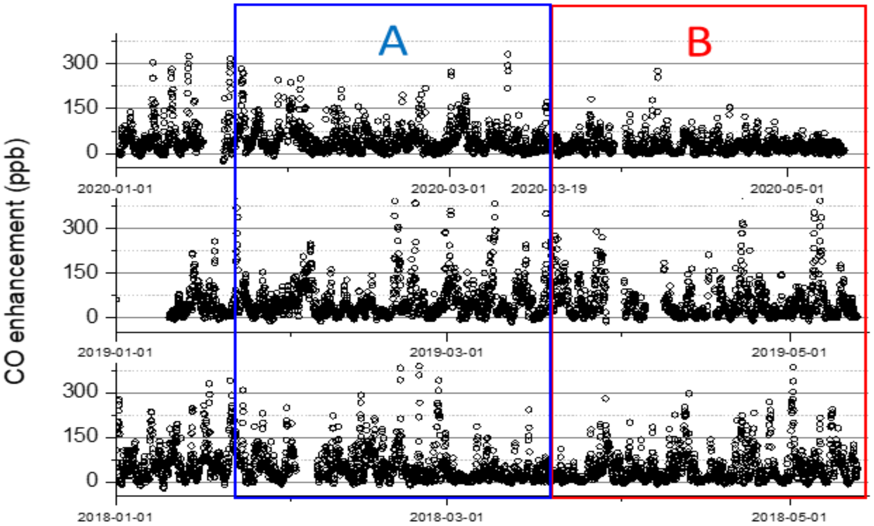
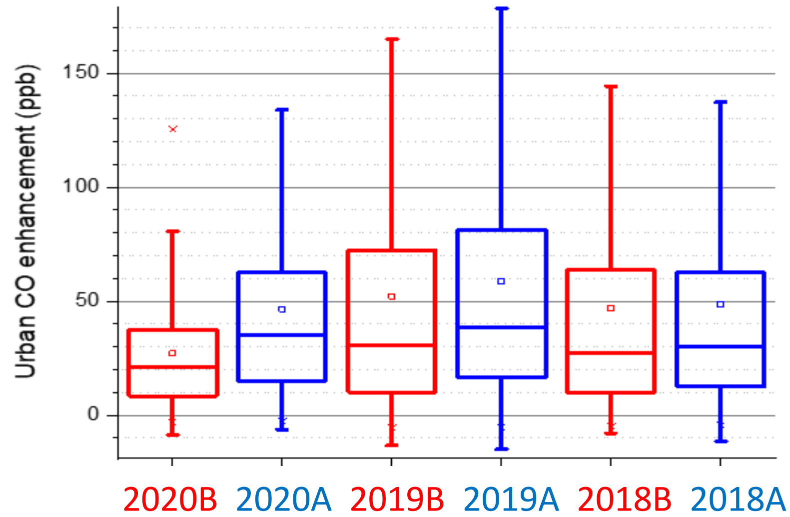
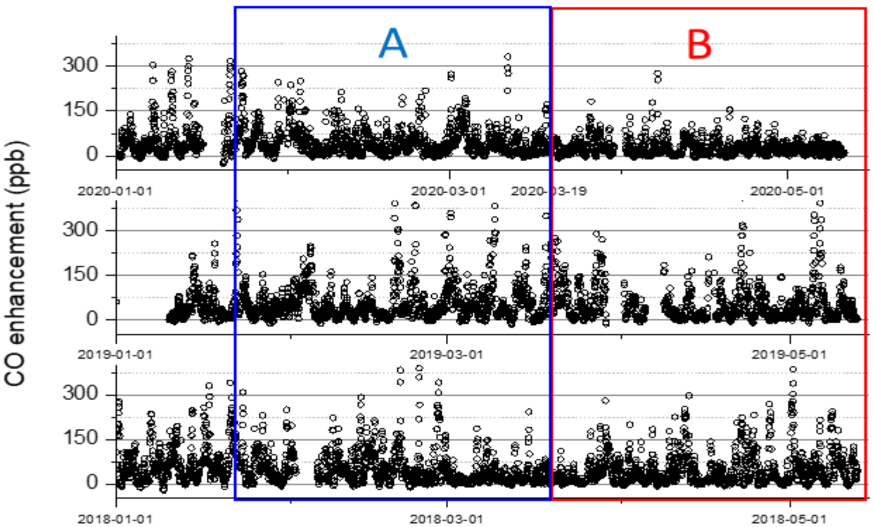
Atmospheric monitoring during COVID shutdown – CO and CH_4

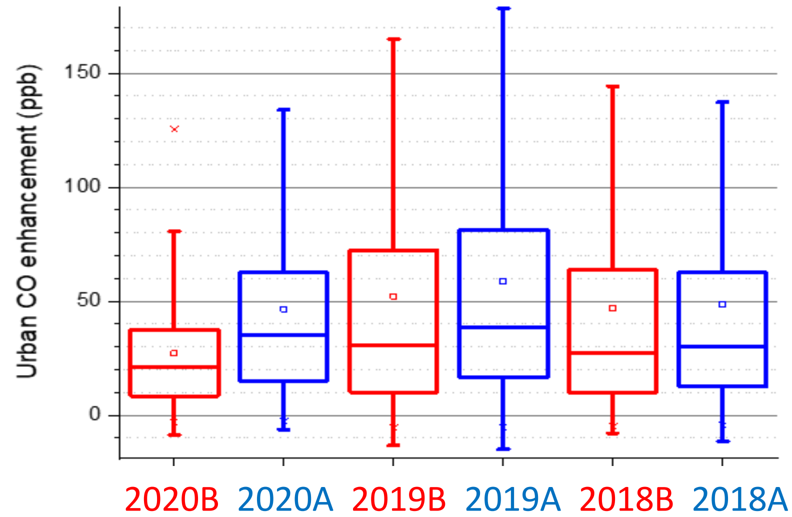




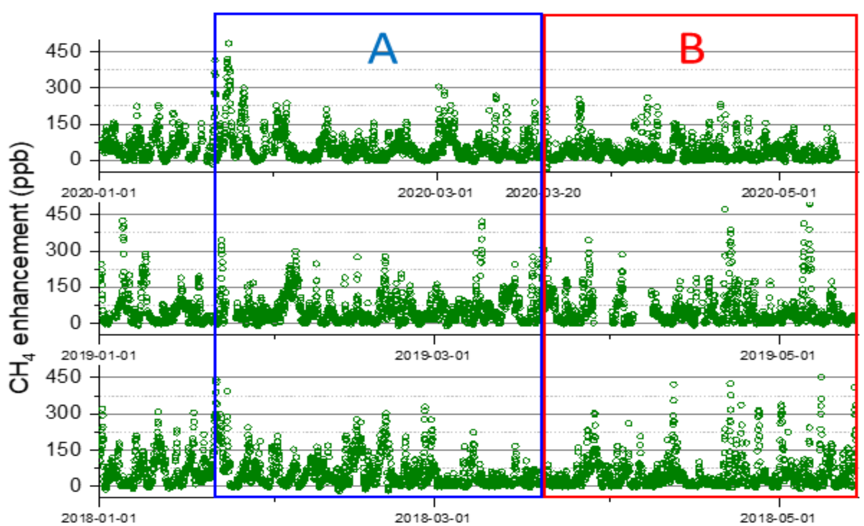
Reference	Median ΔCO	Mean ΔCO
2020B to 2019B/2018B	-8ppb	-22ppb
2020A to 2020B	-14ppb	-19ppb

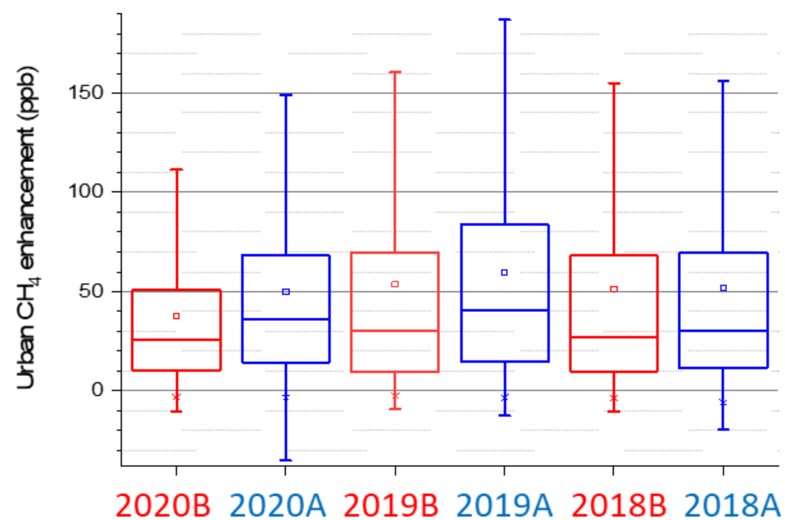
Atmospheric monitoring during COVID shutdown – CO and CH_4



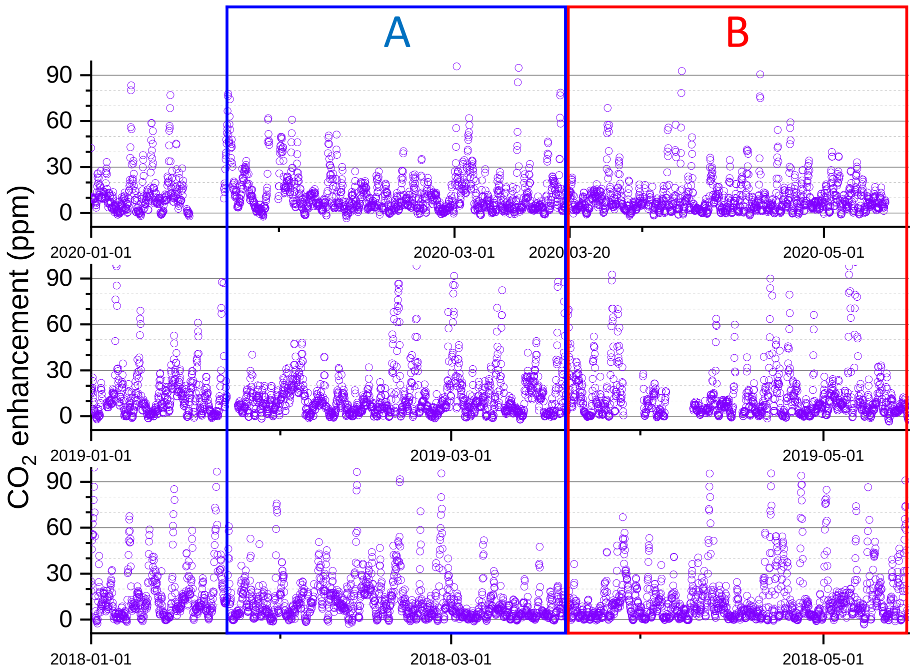


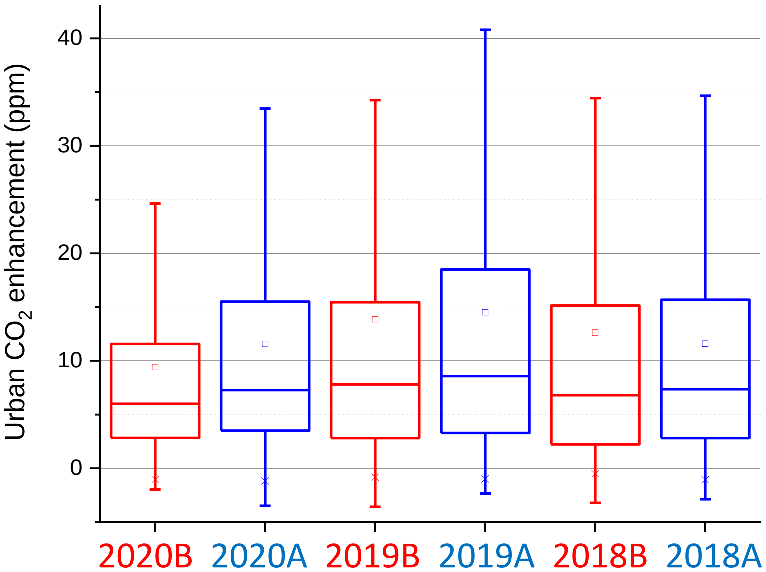
Reference	Median ΔCO // ΔCH_4	Mean ΔCO // ΔCH_4
2020B to 2019B/2018B	-8ppb // -3ppb	-22ppb // -15 ppb
2020A to 2020B	-14ppb // -11ppb	-19ppb // -12 ppb





Atmospheric monitoring during COVID shutdown – CO_2





Reference	Mean	Median
2020B to 2019B/2018B	-3.8ppm	-1.3ppm
2020A to 2020B	-2.3ppm	-1.3ppm

- We see a decrease in urban CO_2 enhancements similar the expected 1-2ppm drop
- However, we do need other indicators to ensure it is $\Delta FFCO_2$ that has changed

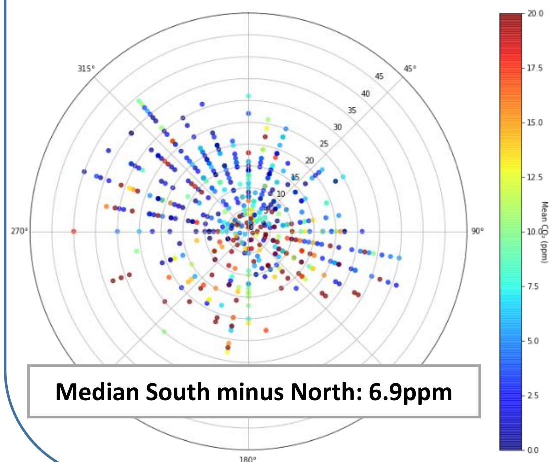
Atmospheric monitoring during COVID shutdown – CO_2

More circumstantial evidence for $FFCO_2$ as main driver:

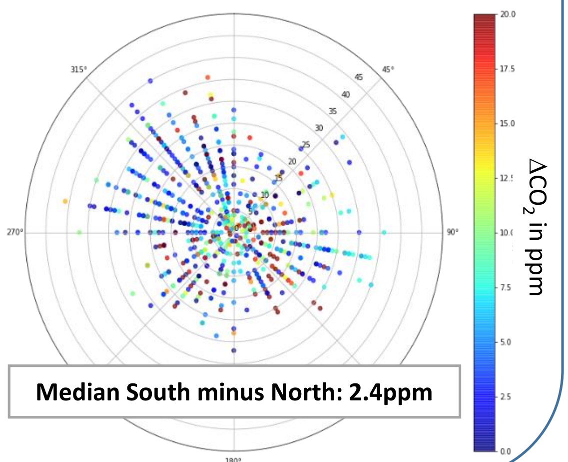
Ratio of reduction is close to traffic signature:
-19ppbCO/-2.3ppmCO_2 = 8.3ppbCO/ppmCO_2

Pollution rose plot shows that decrease is mostly related to air coming from Downtown (S) and not the Greenbelt (N)

Pollution rose for April 2019



Pollution rose for April 2020



Reduction/steady amplitude of the daily cycle of CO_2

Atmospheric monitoring during COVID shutdown – CO_2

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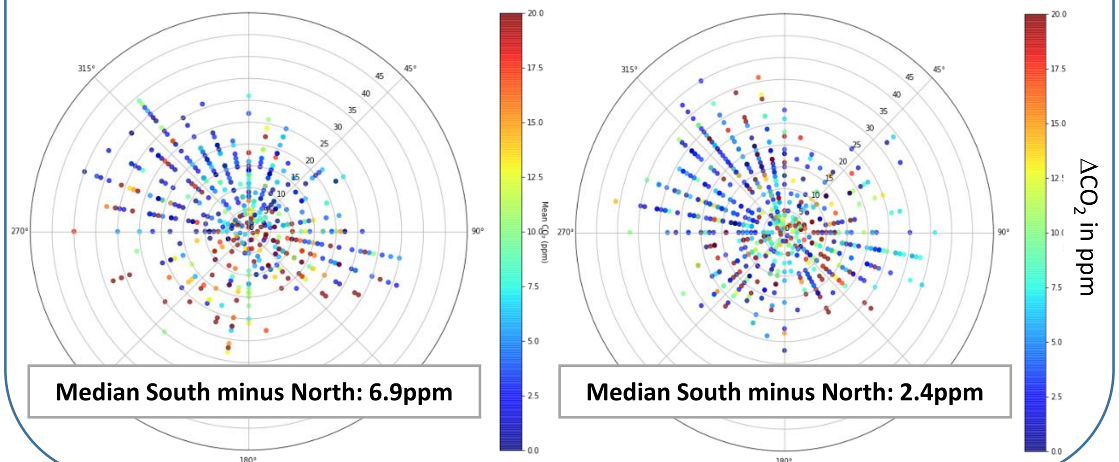

Reduction/steady amplitude of the daily cycle of CO_2

<u>Future conclusive evidence:</u>

- Changes during recovery period
- $^{14}CO_2$ samples to be analysed
- Biosphere modelling
- Atm. transport proxies (^{222}Rn, PBLH)
- Atm. transport modelling
- Uncertainties and sensitivity studies

Summary

- Toronto will see significant urbanization within this decade, while reducing GHG emissions
- ECCC uses multiple instruments, platforms and modelling tools to analyse and track atmospheric GHGs in the Greater Toronto Area
- Methane emissions in Toronto are lower than previously expected, continue to decrease and are not dominated by natural gas infrastructure, but waste sector emissions
- During the COVID shutdown decreases in atmospheric ΔCO, ΔCH_4 and ΔCO_2 are visible in the preliminary data. The ΔCO_2 decrease is consistent with our predicted reductions and circumstantial evidence also points towards fossil fuel related combustion as main cause.

Take home

We are able to track long-term atmospheric trends, perform process and facility scale studies, able to detect short-term emission changes (COVID) and our modelling tools provide reasonable predictions of atmospheric changes in response to emission reductions

In brief: we have already gathered many necessary components for our tool kit to help track future GHG mitigation impacts at urban scale – but more work is required