Environnement et Changement climatique Canada | Environment and Climate Change Canada

105TH ANNUAL MEETING
12–16 JANUARY
NEW ORLEANS & ONLINE
AMERICAN METEOROLOGICAL SOCIETY
AMS 2025

COVID-19 LOCKDOWN: IMPACTS ON THE 2021 CANADIAN ANTHROPOGENIC EMISSIONS AND IMPLICATIONS FOR THE AMBIENT AIR POLLUTANTS CONCENTRATIONS

Sandrine Trotechaud, and A. Duhamel, I. Popadic, N. Pentcheva, L. Bruneau Cossette, D. Niemi, M. Sassi, D. Beaudet, and D. Figueras-Nieto

Meteorological Service of Canada

Sandrine.Trotechaud@ec.gc.ca

Canada

SPRINGER NATURE Link

Home > Air Quality, Atmosphere & Health > Article

Isolating the impact of COVID-19 lockdown measures on urban air quality in Canada

Open access | Published: 18 May 2021

Volume 14, pages 1549–1570, (2021) Cite this article

EARTH | 4 MIN READ

Jet Propulsion Laboratory
California Institute of Technology

Emission Reductions From Pandemic Had Unexpected Effects on Atmosphere

Nov. 9, 2021

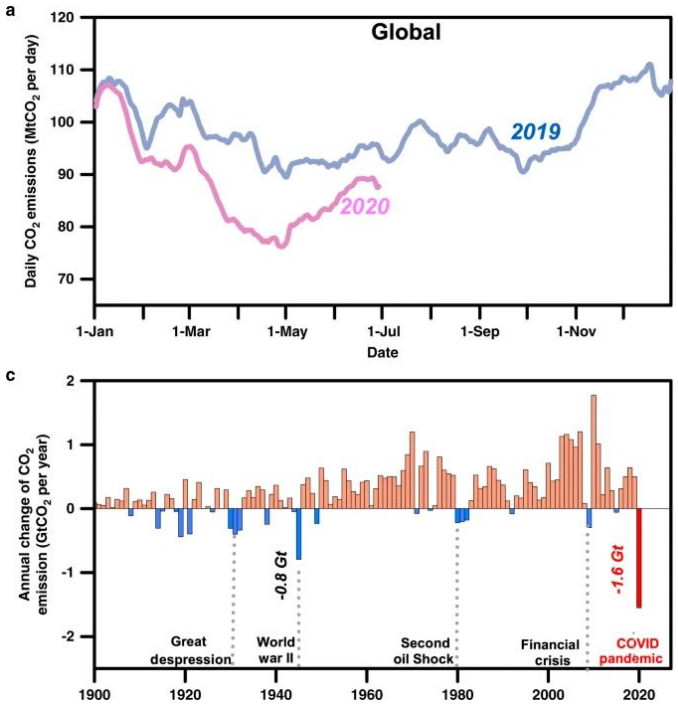


nature communications

Article | Open access | Published: 14 October 2020

Near-real-time monitoring of global CO_2 emissions reveals the effects of the COVID-19 pandemic

Zhu Liu, Philippe Ciais, Zhu Deng, Ruixue Lei, Steven J. Davis, Sha Feng, Bo Zheng, Duo Cui, Xinyu Dou, Biqing Zhu, Rui Guo, Piyu Ke, Taochun Sun, Chenxi Lu, Pan He, Yuan Wang, Xu Yue, Yilong Wang, Yadong Lei, Hao Zhou, Zhaonan Cai, Yuhui Wu, Runtao Guo, Tingxuan Han, ... Hans Joachim Schellnhuber



SPRINGER NATURE Link

Home > Air Quality, Atmosphere & Health > Article

Isolating the impact of COVID-19 lockdown measures on urban air qu

Open access | Published: 18 May 2021

Volume 14, pages 1549–1570, (2021) Cite this article

nature communications

Article | Open access | Published: 14 October 2020

Near-real-time monitoring of global CO_2 emissions reveals the effects of the COVID-19 pandemic

Zhu Deng, Ruixue Lei, Steven J. Davis, Sha Feng, Bo Zheng, Duo Cui, Xinyu Dou, ochun Sun, Chenxi Lu, Pan He, Yuan Wang, Xu Yue, Yilong Wang, Yadong ui Wu, Runtao Guo, Tingxuan Han, ... Hans Joachim Schellnhuber

EARTH | 4 MIN RE

Emissio

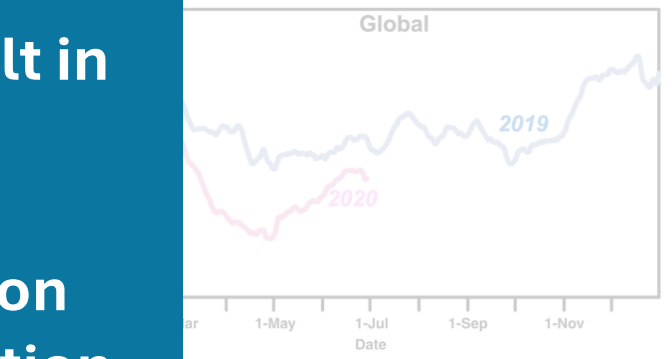
Unexpe

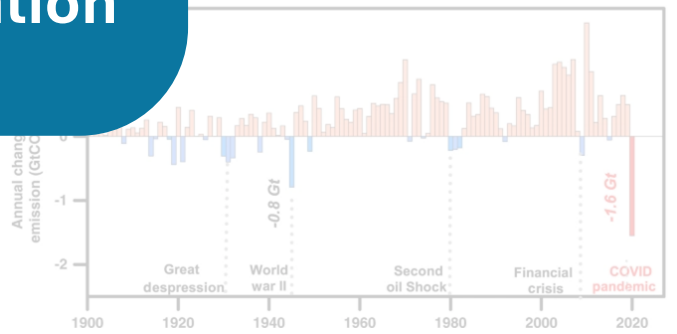
Nov. 9, 2021



Are the Effects of the COVID-19 Lockdown on Canadian Anthropogenic Emissions Still Felt in 2021?

If so, what are the implications on ambient air pollutants concentration (NO_2, O_3, $PM_{2.5}$)?

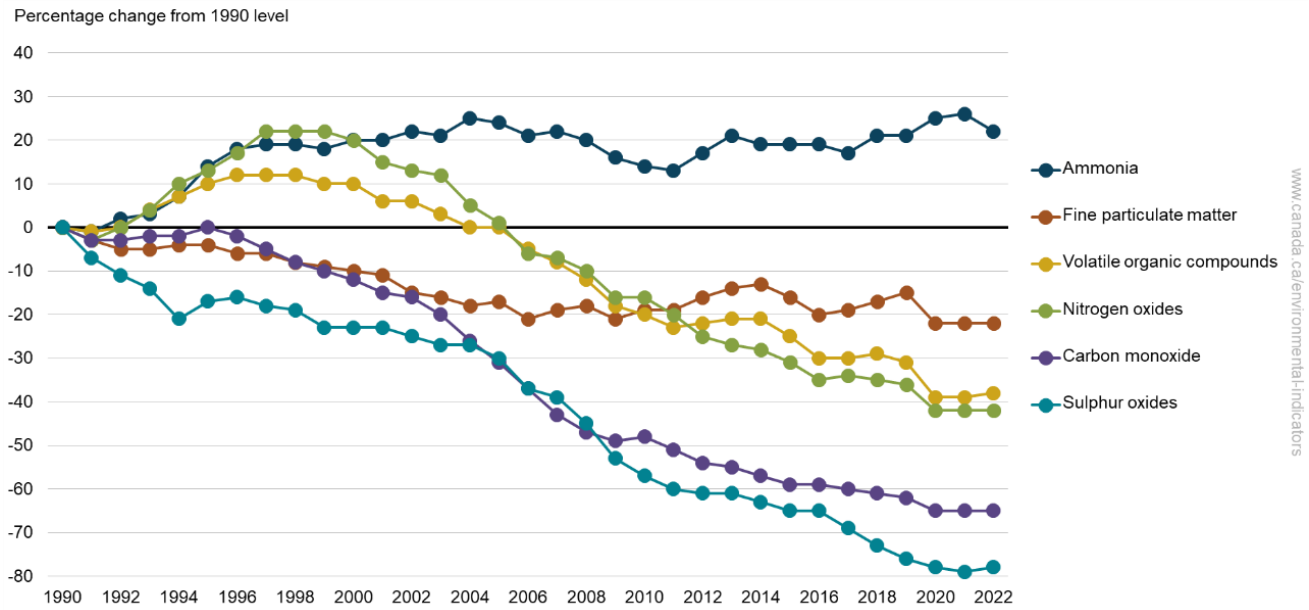




My team within ECCC: Air Quality Policy-Issue Response (AQIR/REQA) section

We work primarily on air quality modelling for policy support.

Importance of air quality policies: Decrease of the Canadian anthropogenic emissions in the past decades

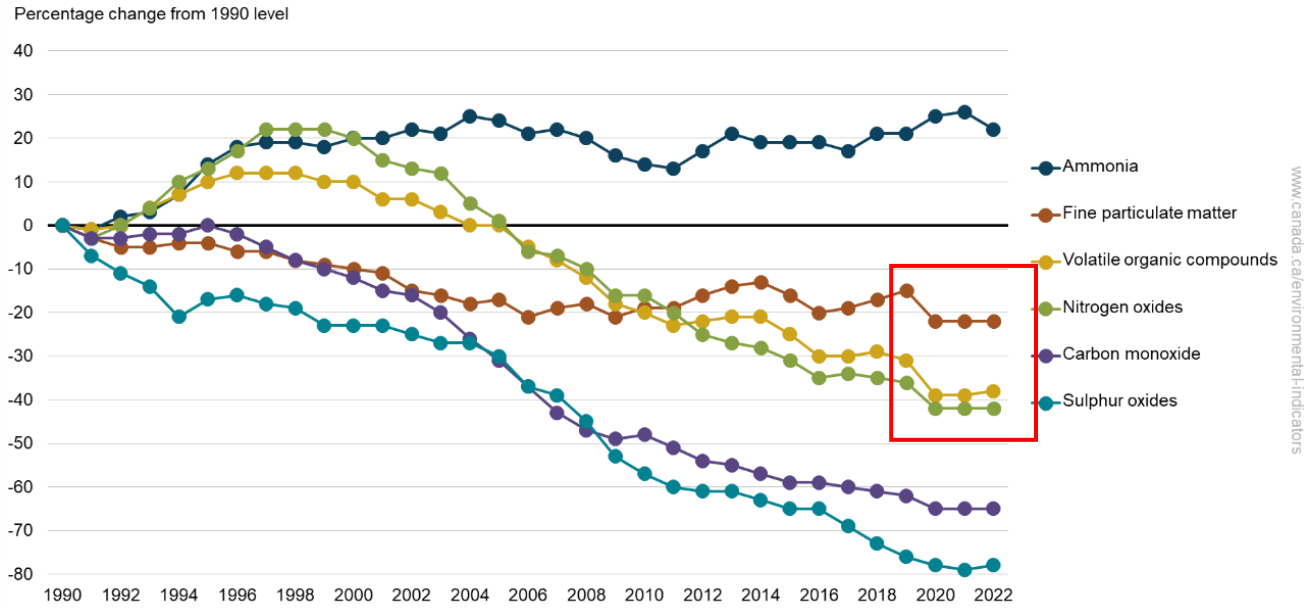


https://www.canada.ca/environmental-indicators

Impact of Canadian regulations

Decrease for all pollutants with respect to year 1990, except for NH_3 emissions.

COVID-19: Decrease in 2020 Canadian anthropogenic emissions. Semi-stable levels from 2020.



https://www.canada.ca/environmental-indicators

Air pollutant emissions, Canada, 1990 to 2022						
Year	Sulphur oxides (SOx)	Nitrogen oxides (NOx)	Volatile organic compounds (VOC)	Ammonia (NH3)	Carbon monoxide (CO)	Fine particulate matter (PM2.5)
	(percentage change from 1990 level)	(percentage change from 1990 level)	(percentage change from 1990 level)	(percentage change from 1990 level)	(percentage change from 1990 level)	(percentage change from 1990 level)
1990	0	0	0	0	0	0
2017	-69	-34	-30	17	-60	-19
2018	-73	-35	-29	21	-61	-17
2019	-76	-36	-31	21	-62	-15
2020	-78	-42	-39	25	-65	-22
2021	-79	-42	-39	26	-65	-22
2022	-78	-42	-38	22	-65	-22

Impact of Canadian regulations

Decrease for all pollutants with respect to year 1990, except for NH_3 emissions.

Impact of COVID-19

Notable decrease from 2019 to 2020 for $PM_{2.5}$, NO_X and VOC emissions. Then, from 2020 to 2022 notice the relative stability of emissions levels.

Difference in total Canadian anthropogenic emissions in some major cities

All Sectors: (2021-2019)*100/2019

City	PM2.5	VOC	NOX
Montreal	-2.8%	-17.4%	-36.1%
Toronto	1.4%	-17.9%	-39.4%
Winnipeg	-3.9%	-14.6%	-46.2%
Calgary	1.9%	-9.6%	-27.7%
Vancouver	-9.5%	-20.2%	-29.7%

Impact in major cities in Canada

General decrease in VOC and NO_X emissions, 9% to 20% for VOC, and 27% to 46% for NO_X.

Smaller relative $PM_{2.5}$ difference showing an increase in Toronto and Calgary with decreases in Montreal, Winnipeg and Vancouver.

Decrease up to 68% for the on-road transportation sector emissions in some major cities

All Sectors: (2021-2019)*100/2019

City	PM2.5	VOC	NOX
Montreal	-2.8%	-17.4%	-36.1%
Toronto	1.4%	-17.9%	-39.4%
Winnipeg	-3.9%	-14.6%	-46.2%
Calgary	1.9%	-9.6%	-27.7%
Vancouver	-9.5%	-20.2%	-29.7%

On-road: (2021-2019)*100/2019

City	PM2.5	VOC	NOX
Montreal	-60.5%	-52.9%	-67.0%
Toronto	-53.5%	-60.2%	-62.9%
Winnipeg	-62.5%	-68.1%	-67.6%
Calgary	-56.4%	-61.1%	-59.1%
Vancouver	-60.3%	-67.2%	-65.6%

Impact in major cities in Canada

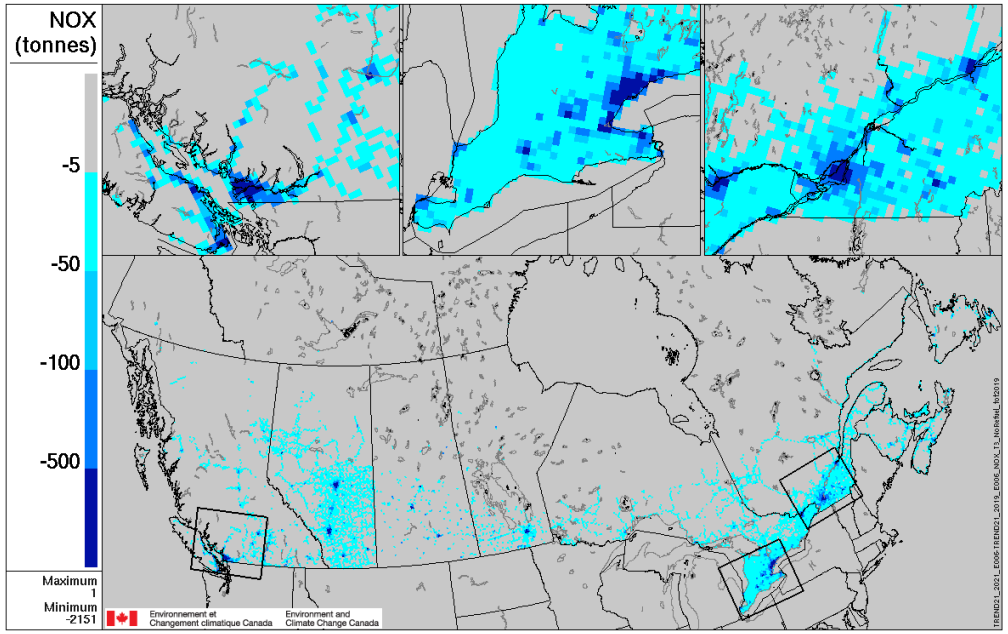
General decrease in VOC and NO_X emissions, 9% to 20% for VOC, and 27% to 46% for NO_X.

Smaller relative $PM_{2.5}$ difference showing an increase in Toronto and Calgary with decreases in Montreal, Winnipeg and Vancouver.

Impact of on-road transportation sector

Notable decrease from 2021 to 2019 ranging from 52% to 68% for all pollutants.

On-road: 2021 – 2019



Decrease up to 68% for the on-road transportation sector emissions in some major cities

All Sectors: (2021-2019)*100/2019

City	PM2.5	VOC	NOX
Montreal	-2.8%	-17.4%	-36
Toronto	1.4%	-17.9%	-3
Winnipeg	-3.9%	-14.6%	-4
Calgary	1.9%	-9.6%	-2
Vancouver	-9.5%	-20.2%	-2

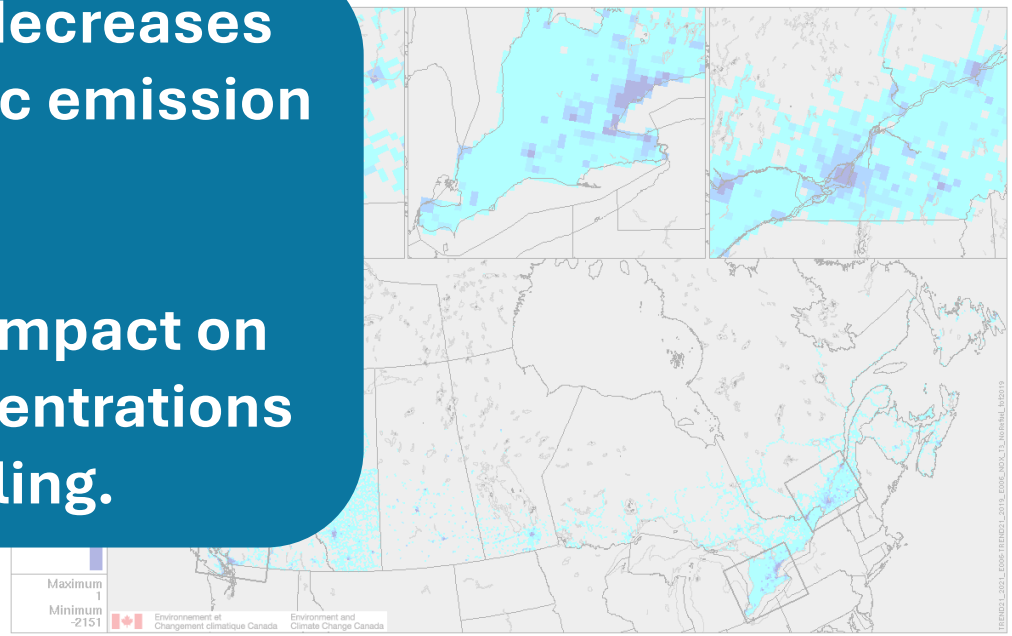
On-road: (2021-2019)*100/2019

City	PM2.5	VOC	NOX

We do see some notable decreases between 2019 pre-pandemic emission levels and 2021.

Let's now investigate the impact on ambient air pollutant concentrations via air quality modelling.

On-road: 2021 – 2019



Impact in major cities in Canada

General decrease in VOC and NO_X emissions, 9% to 20% for VOC, and 27% to 46% for NO_X.

Smaller relative $PM_{2.5}$ difference showing an increase in Toronto and Calgary with decreases in Montreal, Winnipeg and Vancouver.

Impact on ambient air pollutants concentration

Assess the difference in ambient air pollutants between year 2019 and 2021 using ECCC's GEM-MACH model.

Impact on ambient air pollutants concentration

Assess the difference in ambient air pollutants between year 2019 and 2021 using ECCC's GEM-MACH model.

ECCC's air quality prediction model **GEM-MACH** v2.4.6:

GEM: Global Environmental Multiscale (advection + diffusion)

MACH: Modelling Air Quality and Chemistry (gas-phase, aqueous-phase and heterogenous chemistry; aerosol chemistry (nucleation, condensation, dry deposition, etc.), 2-bin of the PM size distribution, etc.)

Impact on ambient air pollutants concentration

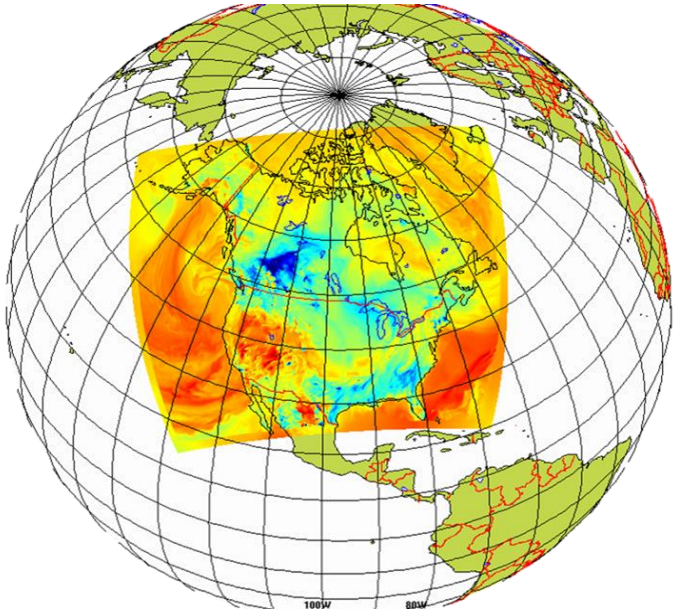
Assess the difference in ambient air pollutants between year 2019 and 2021 using ECCC's GEM-MACH model.

ECCC's air quality prediction model **GEM-MACH** v2.4.6:

GEM: Global Environmental Multiscale (advection + diffusion)

MACH: Modelling Air Quality and Chemistry (gas-phase, aqueous-phase and heterogenous chemistry; aerosol chemistry (nucleation, condensation, dry deposition, etc.), 2-bin of the PM size distribution, etc.)

Model domain: North American regional grid at **10-km** horizontal resolution and **84 vertical levels**.



Impact on ambient air pollutants concentration

Assess the difference in ambient air pollutants between year 2019 and 2021 using ECCC's GEM-MACH model.

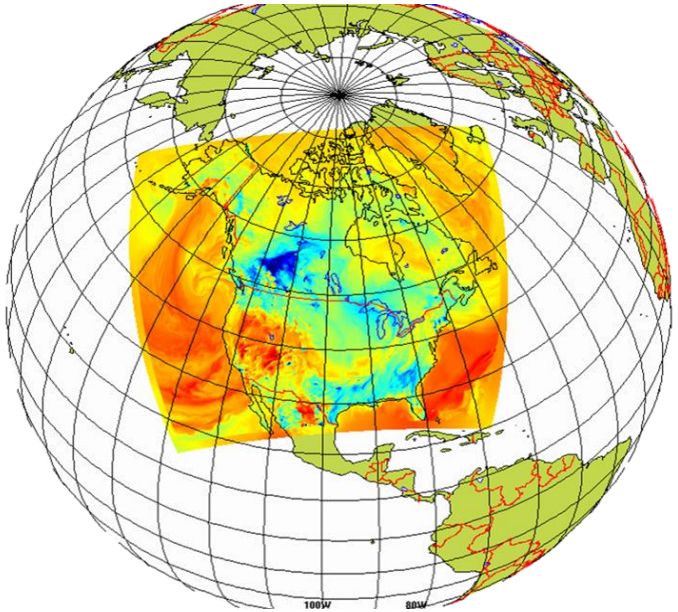
ECCC's air quality prediction model **GEM-MACH** v2.4.6:

GEM: Global Environmental Multiscale (advection + diffusion)

MACH: Modelling Air Quality and Chemistry (gas-phase, aqueous-phase and heterogenous chemistry; aerosol chemistry (nucleation, condensation, dry deposition, etc.), 2-bin of the PM size distribution, etc.)

Model domain: North American regional grid at **10-km** horizontal resolution and **84 vertical levels**.

Models' inputs are the same in the 2 scenarios except for the **Canadian anthropogenic** emissions (2019 versus 2021 from TREND21 REF23).



Impact on ambient air pollutants concentration

Assess the difference in ambient air pollutants between year 2019 and 2021 using ECCC's GEM-MACH model.

ECCC's air quality prediction model **GEM-MACH** v2.4.6:

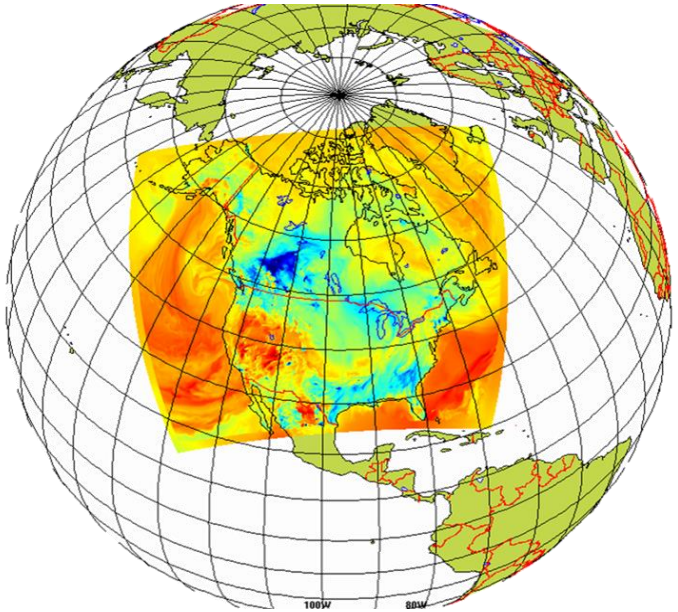
GEM: Global Environmental Multiscale (advection + diffusion)

MACH: Modelling Air Quality and Chemistry (gas-phase, aqueous-phase and heterogenous chemistry; aerosol chemistry (nucleation, condensation, dry deposition, etc.), 2-bin of the PM size distribution, etc.)

Model domain: North American regional grid at **10-km** horizontal resolution and **84 vertical levels**.

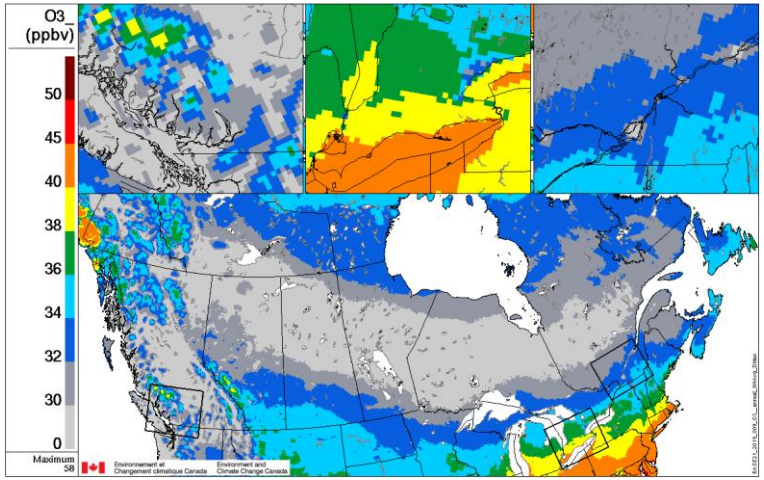
Models' inputs are the same in the 2 scenarios except for the **Canadian anthropogenic** emissions (2019 versus 2021 from TREND21 REF23).

- The US and Mexican **anthropogenic** emissions based on:
  - The US National Emission Inventory (**NEI**) for the **year 2019**.
  - Mexican Emission Inventory for the **year 2016**.
- Exclude wildfire emissions.

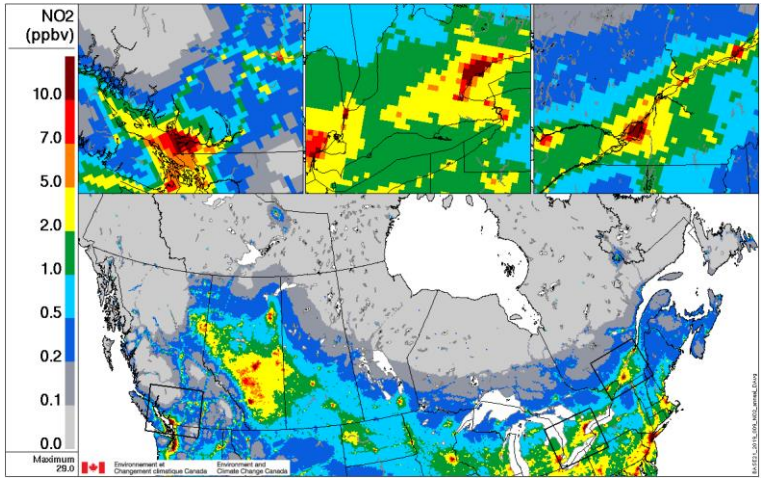


2019

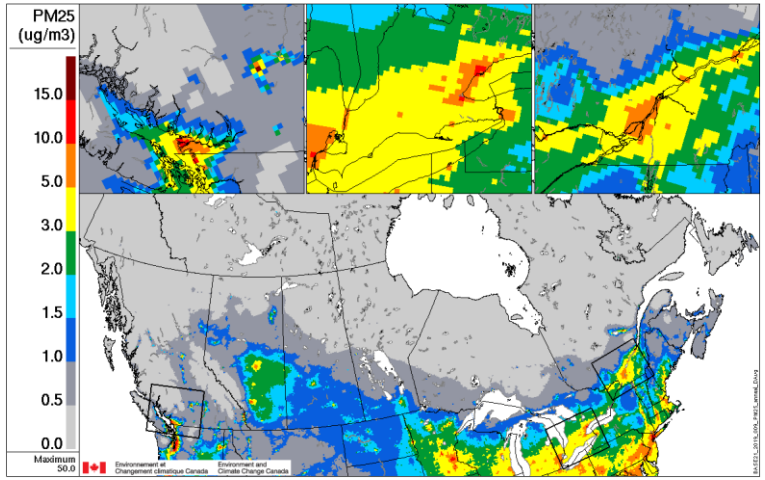
O3 yearly average of the 8h average DMax



NO2 yearly average

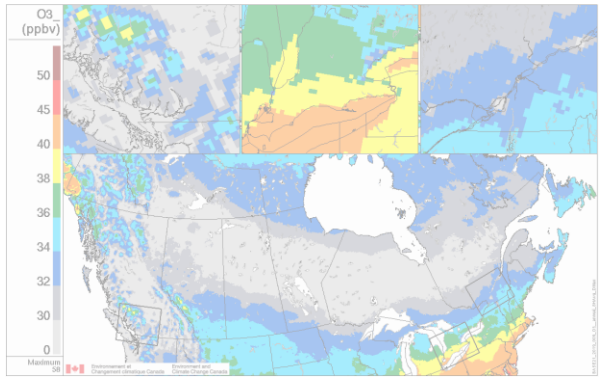


PM2.5 yearly average

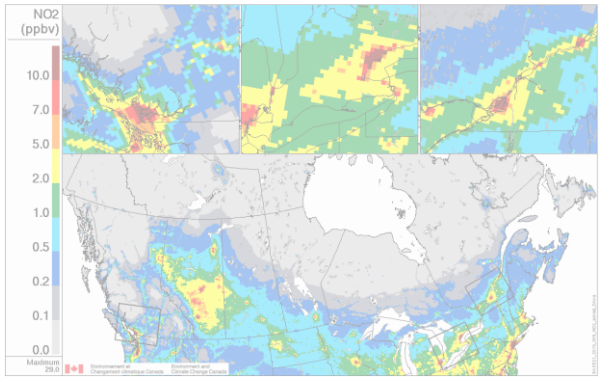


2019

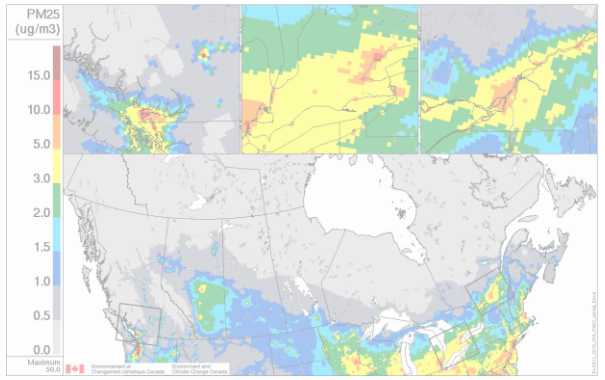
O3 yearly average of the 8h average daily max



NO2 yearly average

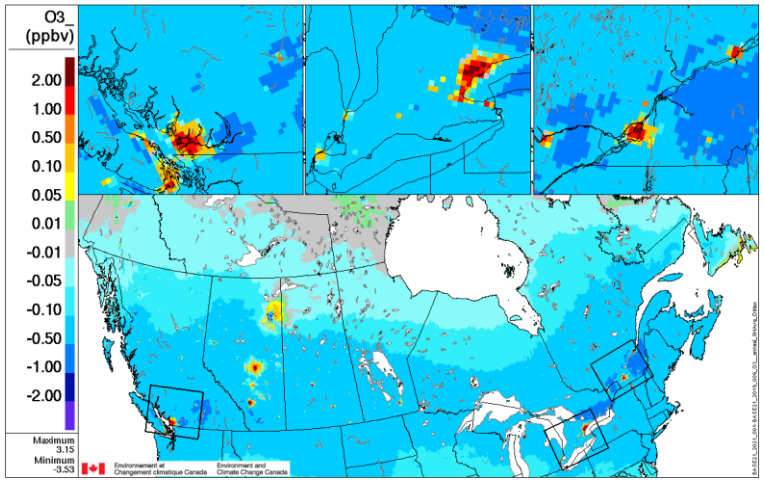


PM2.5 yearly average

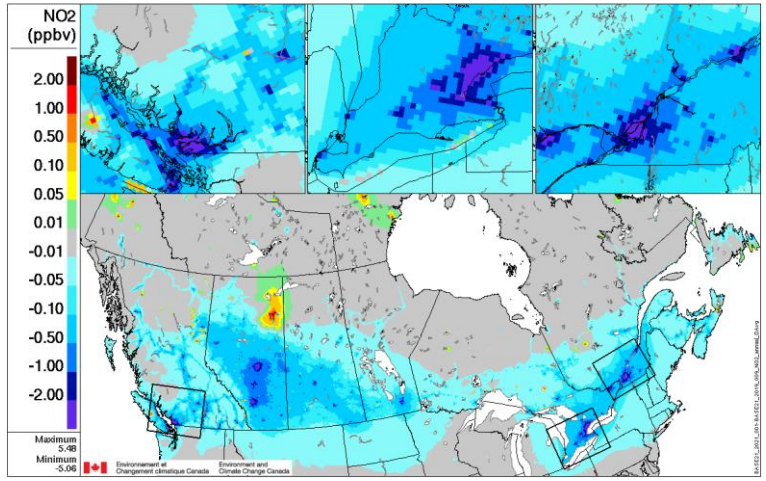


2021 - 2019

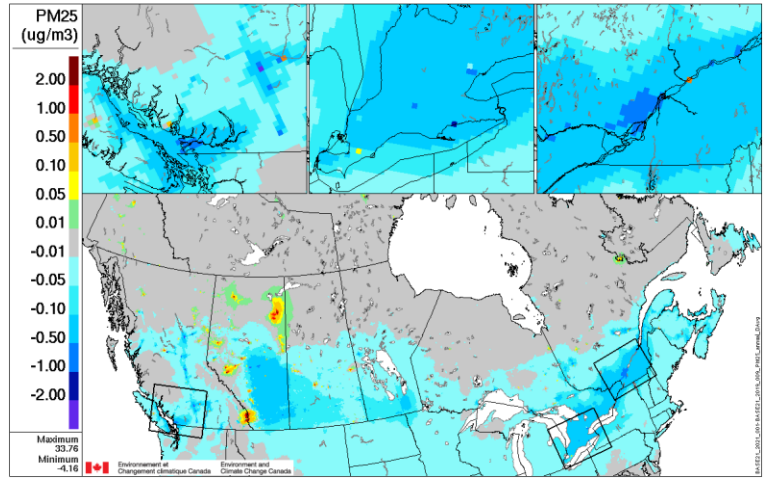
O3 yearly average of the 8h average DMax



NO2 yearly average



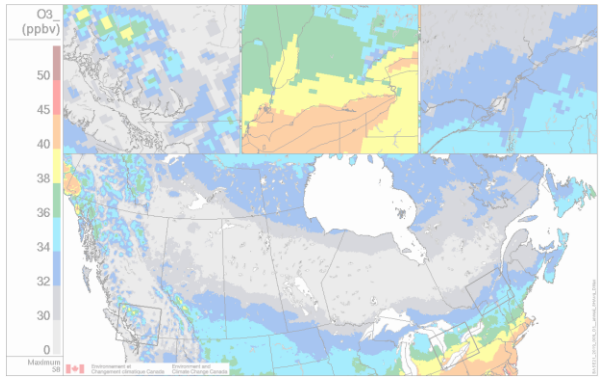
PM2.5 yearly average



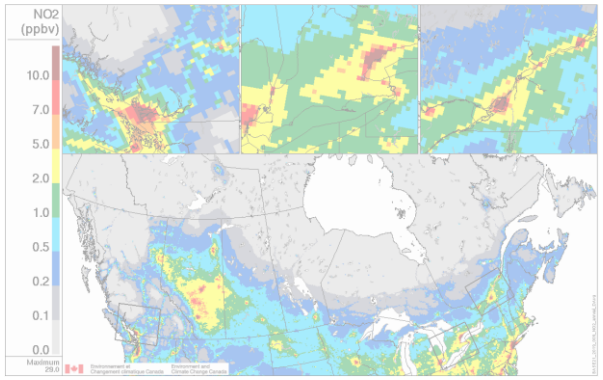
- **General decrease** between 2019 and 2021.

2019

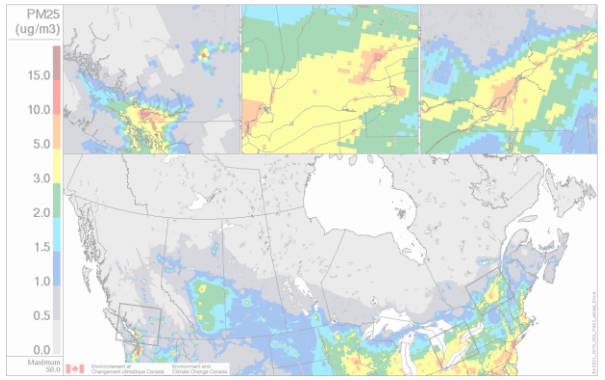
O3 yearly average of the 8h average daily max



NO2 yearly average

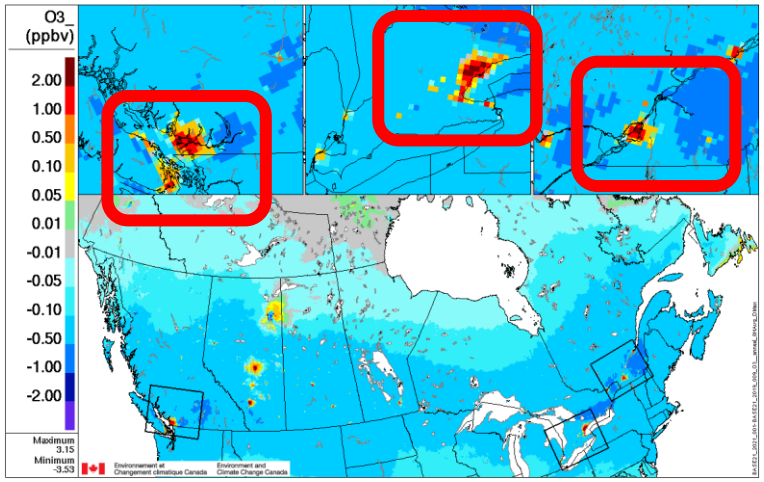


PM2.5 yearly average

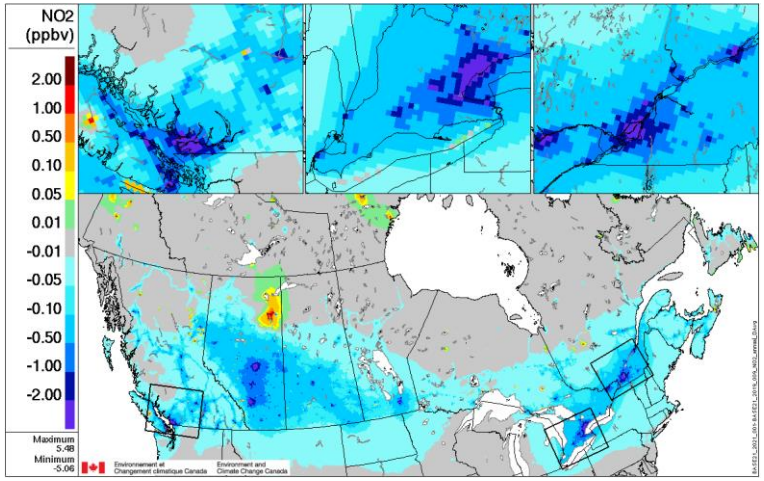


2021 - 2019

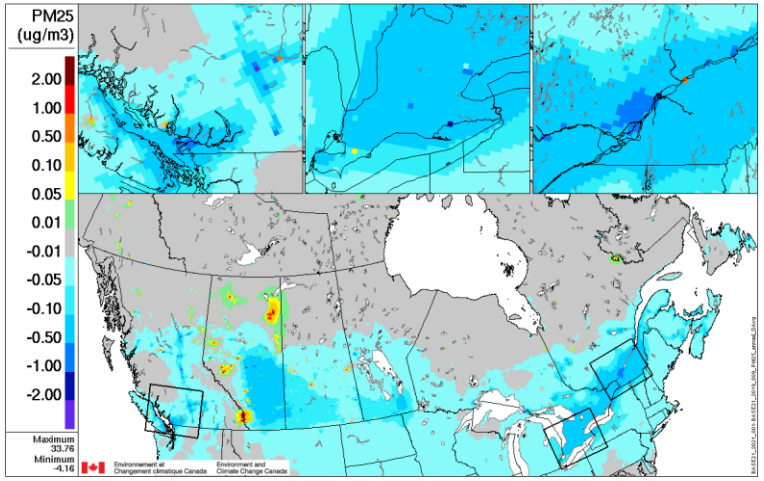
O3 yearly average of the 8h average DMax



NO2 yearly average



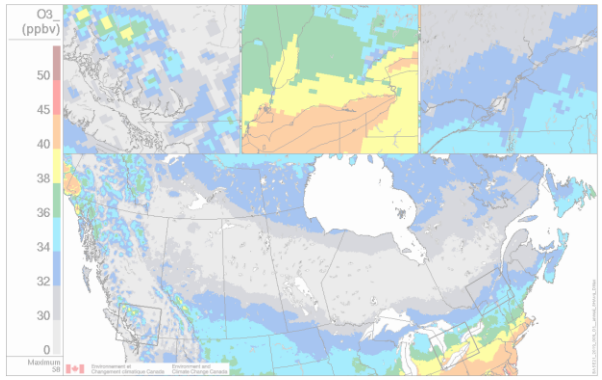
PM2.5 yearly average



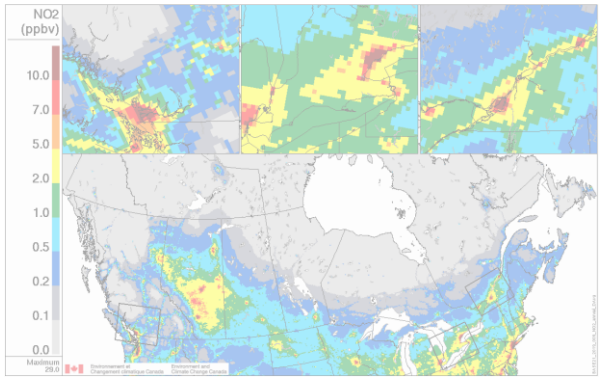
- General decrease between 2019 and 2021.
- **Increase** of O3 also in **cities** due to **reduced NOx titration**. $NO + O_3 \rightarrow NO_2 + O_2$

2019

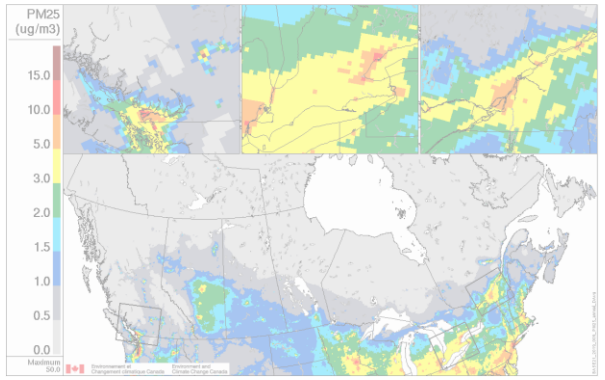
O3 yearly average of the 8h average daily max



NO2 yearly average

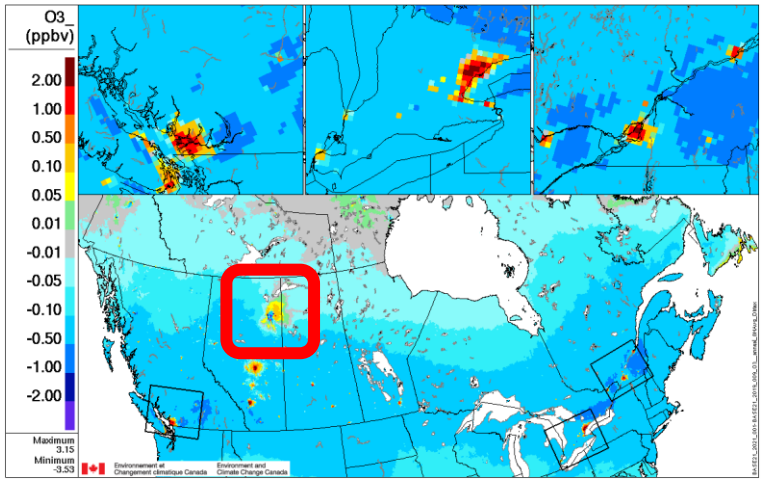


PM2.5 yearly average

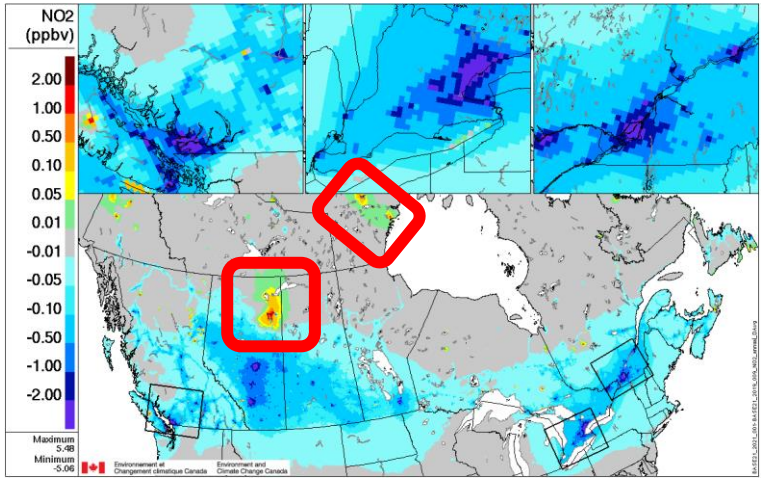


2021 - 2019

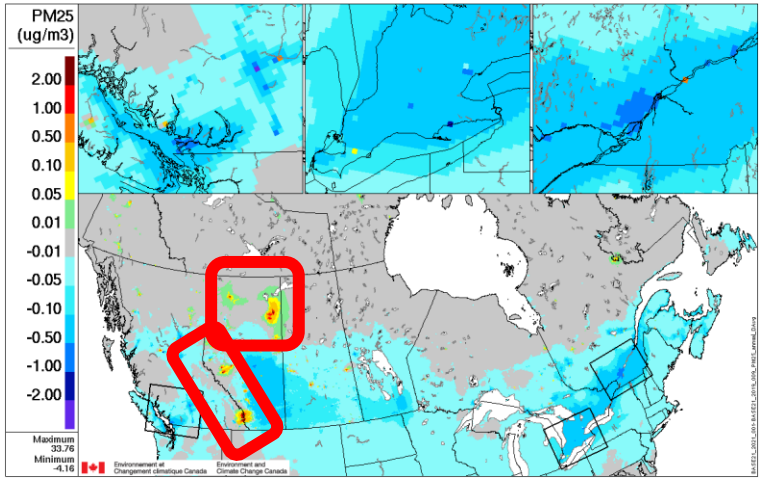
O3 yearly average of the 8h average DMax



NO2 yearly average



PM2.5 yearly average



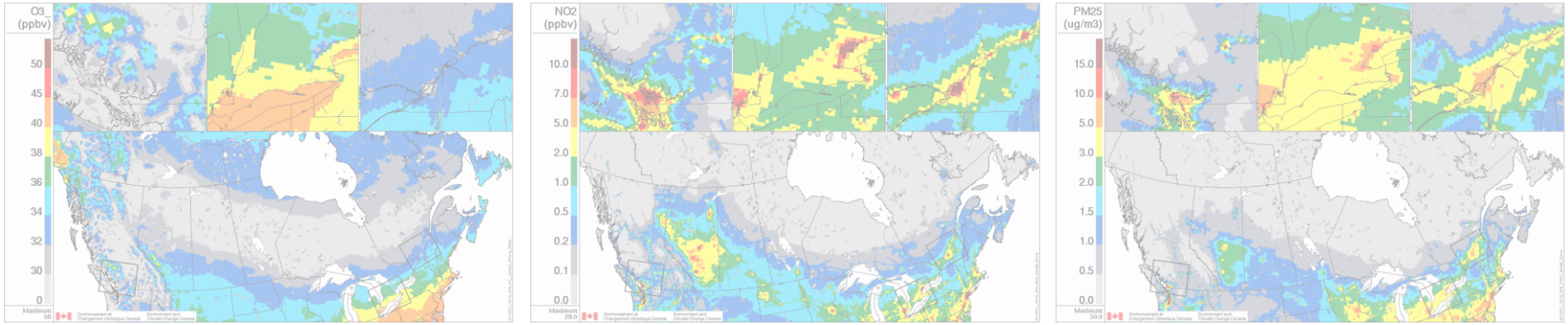
- General decrease between 2019 and 2021.
- Increase of O3 also in cities due to reduced NOx titration. $NO + O_3 \rightarrow NO_2 + O_2$
- **Increase** in the some Alberta regions and up North (due to **increased emissions/activities** for some coal industries as well as oilsands).

O3 yearly average of the 8h average daily max

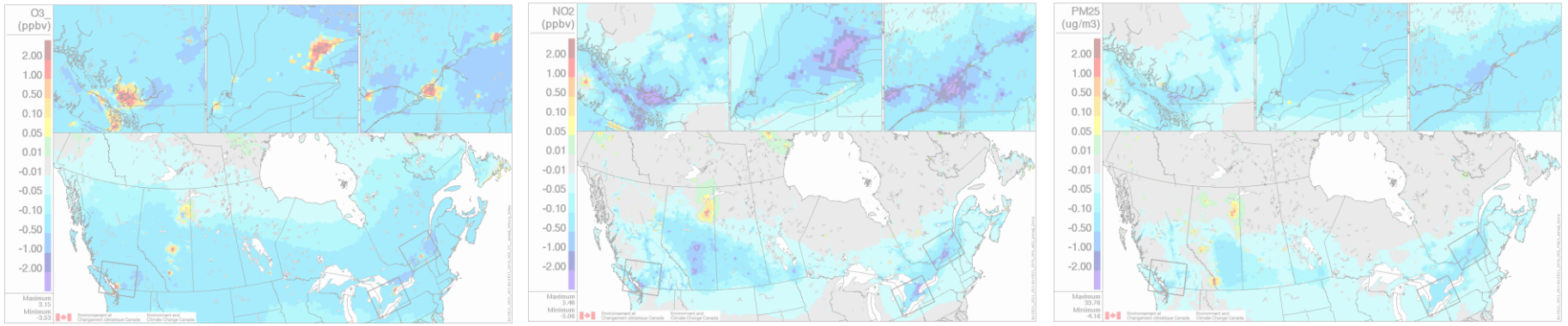
NO2 yearly average

PM2.5 yearly average

2019



2021 - 2019



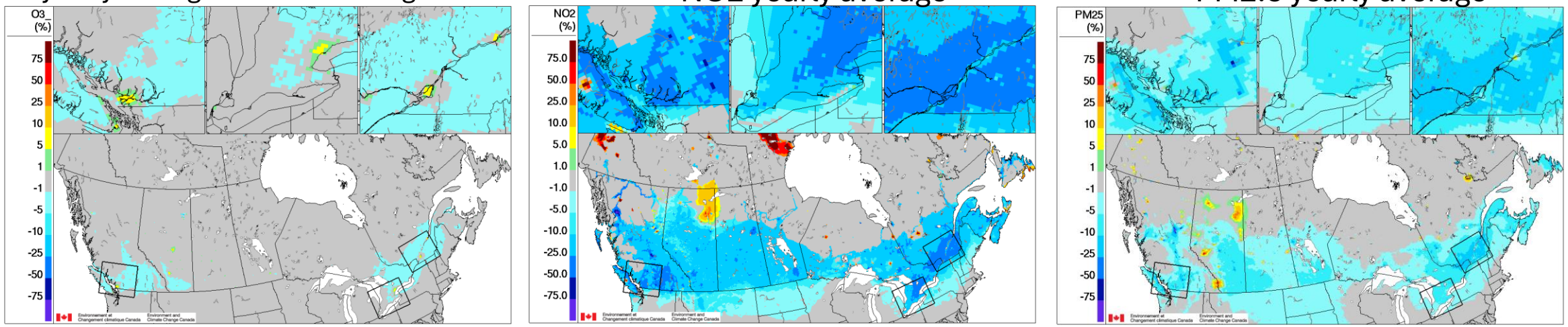
When looking at the **relative difference**, the impact on O_3 are of smaller magnitude, but the NO_2 and $PM_{2.5}$ signals remain.

(2021- 2019) *100/ 2019

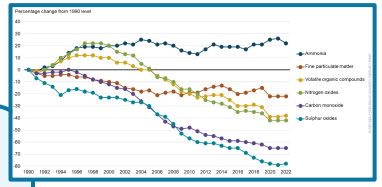
O3 yearly average of the 8h average DMax

NO2 yearly average

PM2.5 yearly average

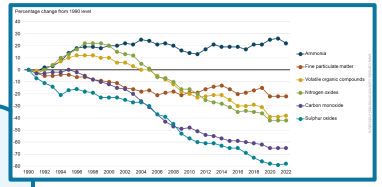


What's the take-home message?

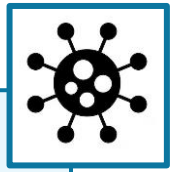


Decrease in the past decades of the **Canadian anthropogenic emissions** except for NH3, showing the impact of Canadian **regulations**. We can see a notable decrease in 2020 coinciding with COVID-19.

What's the take-home message?

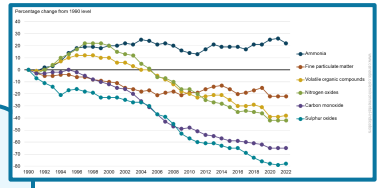


Decrease in the past decades of the **Canadian anthropogenic emissions** except for NH3, showing the impact of Canadian **regulations**. We can see a notable decrease in 2020 coinciding with COVID-19.

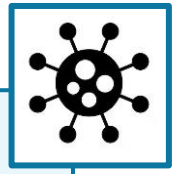


Question: Did **COVID-19** also affect 2021 emissions?
Yes! Notable decrease in Canadian anthropogenic emissions.

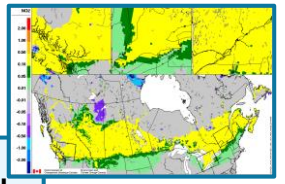
What's the take-home message?



Decrease in the past decades of the **Canadian anthropogenic emissions** except for NH3, showing the impact of Canadian **regulations**. We can see a notable decrease in 2020 coinciding with COVID-19.

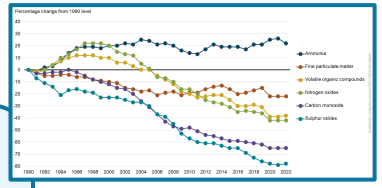


Question: Did **COVID-19** also affect 2021 emissions?
Yes! Notable decrease in Canadian anthropogenic emissions.

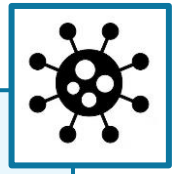


In terms of air ambiant pollutant concentrations, we see a general **decrease** in **NO2** and **PM2.5** in 2021 across the country, with some more localized **increases** in parts of Alberta and up North.

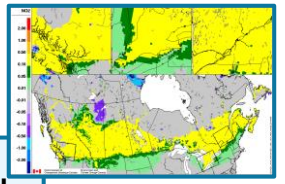
What's the take-home message?



Decrease in the past decades of the **Canadian anthropogenic emissions** except for NH3, showing the impact of Canadian **regulations**. We can see a notable decrease in 2020 coinciding with COVID-19.



Question: Did **COVID-19** also affect 2021 emissions?
Yes! Notable decrease in Canadian anthropogenic emissions.



In terms of air ambiant pollutant concentrations, we see a general **decrease** in **NO2** and **PM2.5** in 2021 across the country, with some more localized **increases** in parts of Alberta and up North.

If you have any questions, don't hesitate to contact me at Sandrine.Trotechaud@ec.gc.ca