Environment and Climate Change Canada
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GREENHOUSE GAS CONCENTRATIONS

CANADIAN ENVIRONMENTAL SUSTAINABILITY INDICATORS

Canada

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CANADIAN ENVIRONMENTAL SUSTAINABILITY INDICATORS

GREENHOUSE GAS CONCENTRATIONS

June 2023

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Greenhouse gas concentrations

Greenhouse gases (GHGs) absorb energy from the sun and trap heat in the Earth's atmosphere. Without GHGs, Earth's average temperature would be around -18°C, rather than the current average of 15°C. The Earth's natural greenhouse gas effect is one key parameter that makes the planet livable for humans. Human activities, such as the burning of fossil fuels, agriculture practices and industrialization, are changing Earth's natural greenhouse effect. As concentrations of greenhouse gases increase in the atmosphere, more heat is trapped and atmospheric temperatures rise. These indicators present atmospheric concentrations as measured from sites in Canada and at a global scale for 2 greenhouse gases: carbon dioxide and methane.

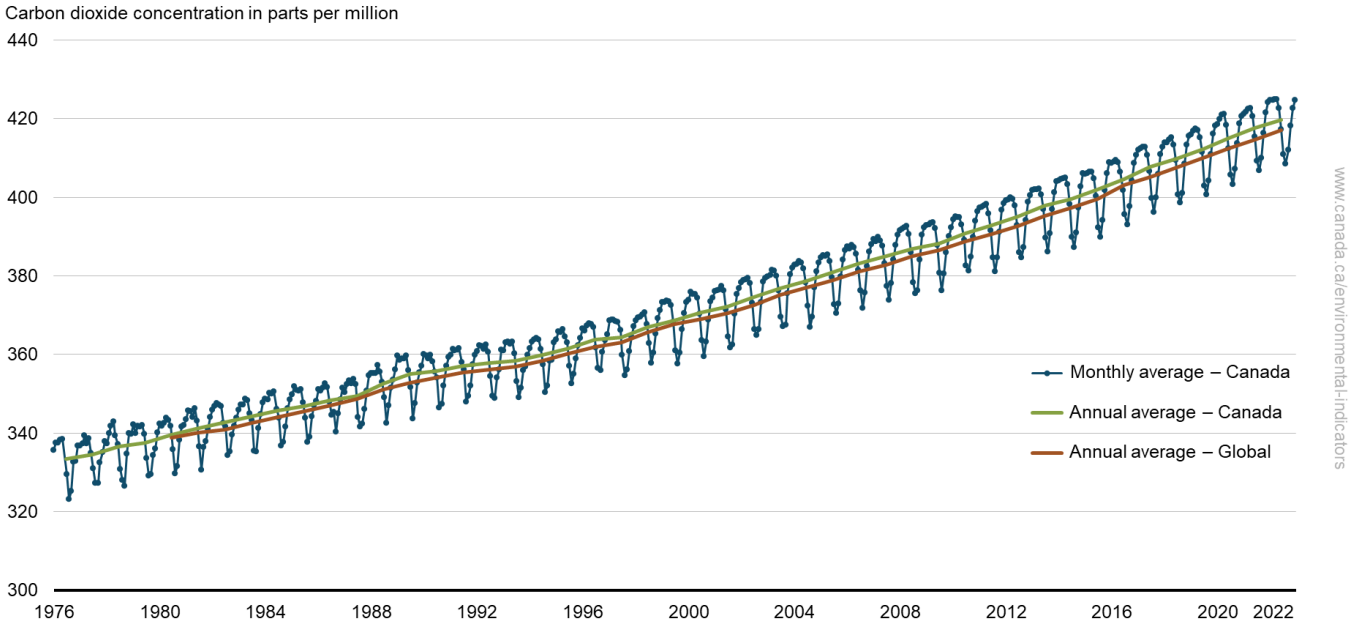
Carbon dioxide concentration in the atmosphere

Carbon dioxide (CO_2) is the most important greenhouse gas. It is responsible for approximately 66% of the radiative forcing that is currently observed.[1]

Key results

- Globally, annual average carbon dioxide (CO_2) concentrations increased by 23%, from 338.9 parts per million (ppm) to 417.1 ppm between 1980 to 2022
- In Canada, annual average concentration of CO_2 increased by 26%, from 333.4 ppm to 419.7 ppm over the period spanning 1976 to 2022
- In 2022, the average concentration of CO_2 in Canada was 419.7 ppm, up from 417.7 ppm in 2021
- Annual averages of CO_2 concentrations observed in Canada are similar to those observed globally

Figure 1. Carbon dioxide concentration, Canada and global, 1976 to 2022



Data for Figure 1

Note: From 1976 to 1999, averages were calculated based on data from 2 to 3 sampling stations. Since 1999, data from 5 sampling stations are used to represent CO_2 concentrations. Due to some site closures during the COVID-19 pandemic, data from Canada between 2020 and 2022 were interpolated based on data from the Alert station, which remained active throughout that period. Global annual averages are based

[1] Earth's long-term climate is regulated by a balance between energy arriving from the sun and energy leaving the Earth through radiation. The radiative forcing is defined as the difference between incoming and outgoing radiation due to an external factor. If the incoming energy is greater than the outgoing, the radiative forcing is positive and the Earth will warm.

on measurements from sampling stations that are part of the Global Greenhouse Gas Reference Network.
Source: Environment and Climate Change Canada (2023) Climate Research Division, Canadian Greenhouse Gas Measurement Program and National Oceanic and Atmospheric Administration (2023) Global Monitoring Laboratory - Trends in Atmospheric Carbon Dioxide.

In 2022, the global average concentration of CO_2 reached a new high of 417.1 ppm, up from 414.7 ppm in 2021. Prior to 1750, which was known as the pre-industrial era, global CO_2 concentration was about 278 ppm.[2]

In Canada, the annual change in CO_2 has increased from around 1.5 ppm per year in the 1990s to over 2 ppm per year in the last decade. Seasonal cycles can also be observed with lower concentrations in summer due to photosynthetic uptake (plants remove CO_2 from the atmosphere) and higher concentrations in winter due to the decay of plant material (breakdown of organic material releases CO_2).

The COVID-19 pandemic created an economic slowdown in 2020 and 2021 and important reductions in travel by air and land. This resulted in a reduction in anthropogenic CO_2 emissions, in Canada and worldwide. However, there was no recognizable impact on CO_2 concentrations between 2020 and 2022.

[2] World Meteorological Organization (2022) WMO Greenhouse Gases Bulletin 2021. Retrieved on March 27, 2023.

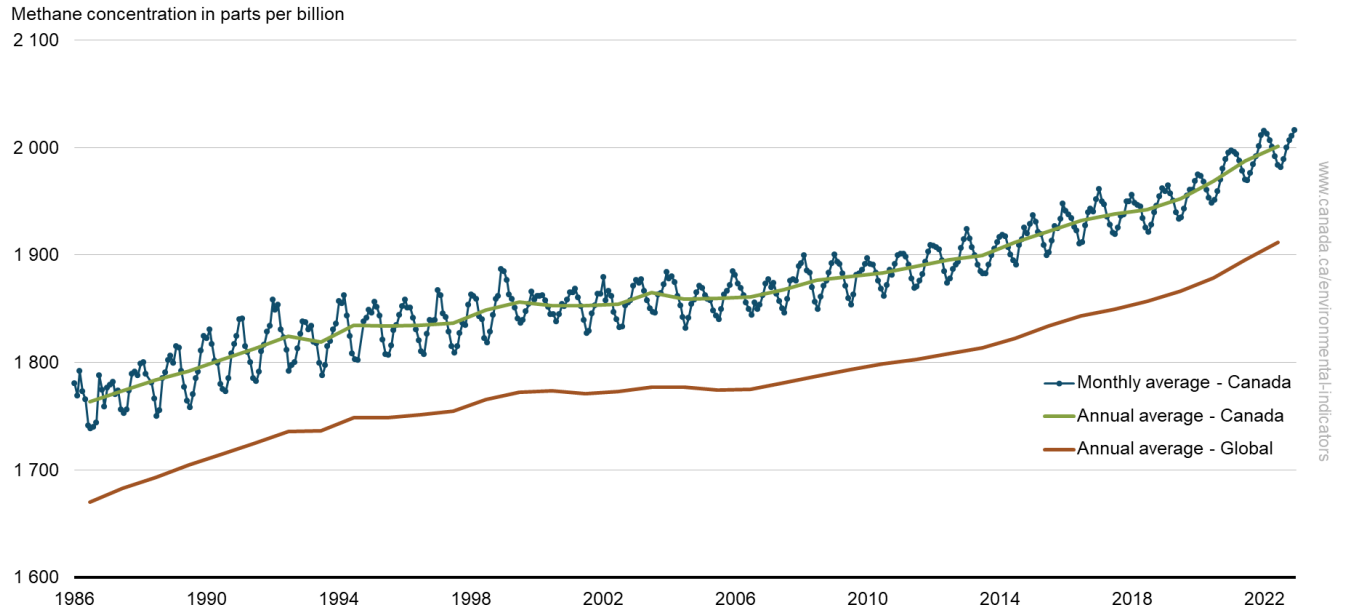
Methane concentration in the atmosphere

Methane (CH_4) is the second most important greenhouse gas generated by human activity. It is currently responsible for approximately 16% of the radiative forcing.[3]

Key results

- Globally, annual average methane (CH_4) concentrations increased by 14%, from 1 670 parts per billion (ppb) to 1 912 ppb between 1986 to 2022
- In Canada, the annual average concentration of CH_4 also increased by 13%, from 1 764 ppb to 2 001 ppb between 1986 to 2022
- In 2022, the average concentration of CH_4 in Canada was 2 001 ppb, up from 1 988 ppb in 2021

Figure 2. Methane concentration, Canada and global, 1986 to 2022



Data for Figure 2

Note: From 1986 to 1999, averages were calculated based on data from 1 to 2 sampling stations. Since 1999, data from 5 sampling stations are used to represent CH_4 concentrations. Due to some site closures during the COVID-19 pandemic, data from Canada between 2020 and 2022 were interpolated based on data from the Alert station, which remained active throughout that period. Global annual averages are based on measurements from sampling stations that are part of the Global Greenhouse Gas Reference Network.
Source: Environment and Climate Change Canada (2023) Climate Research Division, Canadian Greenhouse Gas Measurement Program and National Oceanic and Atmospheric Administration (2023) Global Monitoring Laboratory – Trends in Atmospheric Methane.

In 2022, the global average concentration of CH_4 reached a new high of 1 912 ppb, an increase of under 17 ppb from 2021. This increase is slightly higher than that observed in 2020 to 2021 and is about half of the average annual increase over the past decade. Pre-industrial global CH_4 concentrations were just under 730 ppb.[4]

From 2007 to 2022, average increases in CH_4 in Canada and globally were under 9 ppb per year. Although no definitive causes have been identified to explain this increase, stable isotope[5] measurements of atmospheric CH_4

[3] Earth's long-term climate is regulated by a balance between energy arriving from the sun and energy leaving the Earth through radiation. The radiative forcing is defined as the difference between incoming and outgoing radiation due to an external factor. If the incoming energy is greater than the outgoing, the radiative forcing is positive and the Earth will warm.

[4] World Meteorological Organization (2022) WMO Greenhouse Gases Bulletin 2021. Retrieved on March 27, 2023.

[5] Chemical molecules are made of elements and each element can have different forms, called isotopes. The isotopes differ in mass and physical properties, but have the same chemical properties. Methane (CH_4) contains two elements, carbon and hydrogen, each of which has two stable isotopes. The isotope analysis can help determine the origin of the molecules.

strongly suggest that increases in anthropogenic CH_4 emissions in Canada and wetland emissions in the tropics may be responsible.[6]

Methane concentrations are higher in the northern hemisphere because both natural and human caused sources of methane are more abundant there.[7] As a result, annual changes in observed CH_4 concentrations in Canada are similar to annual changes observed over the globe, but the magnitude is typically around 85 ppb higher. Globally, approximately 40% of the CH_4 emitted to the atmosphere is from natural sources such as wetlands. The remaining 60% of emissions are due to anthropogenic (human caused) sources such as cattle ranching, agriculture, fossil fuels and landfills.

About the indicators

What the indicators measure

The indicators show the trends in concentrations for 2 greenhouse gases: carbon dioxide (CO_2) and methane (CH_4). Concentrations are presented on monthly and annual bases for Canada. The indicators also include the global annual average concentrations.

Why these indicators are important

Greenhouse gases trap heat in the Earth's atmosphere, just as the glass of a greenhouse keeps warm air inside. Human activity increases the amount of GHGs in the atmosphere, contributing to a warming of the Earth's surface. This is called the enhanced greenhouse effect. The release of GHGs and their increasing concentrations in the atmosphere are having significant impacts on the environment, human health and the economy. Consult Greenhouse gas emissions: drivers and impacts for information on the human health, environmental and economic impacts of greenhouse gas emissions.

These indicators serve to identify trends and seasonal variability of carbon dioxide and methane concentrations in Canada. They provide a coherent and consistent picture of the current and past states of these 2 greenhouse gases in the atmosphere, as a result of changing atmospheric transport patterns, emissions from natural sources and emissions to the atmosphere due to human activities.

GHG measurements improve our understanding of natural and anthropogenic sources of GHGs, the role of GHGs in warming the atmosphere, as well as the processes that govern the transport and fate of GHGs in the biosphere. GHG measurements in the atmosphere complement other key indicators used to assess progress in mitigating climate change by reducing GHG emissions. Since GHGs are long-lived in the atmosphere, atmospheric measurements are an indicator of the global and domestic efforts to date to address GHG emissions.

Related indicators

The Greenhouse gas emissions indicators report trends in anthropogenic (human-made) GHG emissions at the national level, per person and per unit gross domestic product, by province and territory and by economic sector.

The Global greenhouse gas emissions indicator provides a global perspective on Canada's share of global GHG emissions.

The Carbon dioxide emissions from a consumption perspective indicator shows the impact of Canada's consumption of goods and services, regardless of where they are produced, on the levels of carbon dioxide released into the atmosphere.

The Greenhouse gas emissions projections indicator provides an overview of Canada's projected GHG emissions up to 2035.

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[6] World Meteorological Organization (2022) WMO Greenhouse Gases Bulletin 2021. Retrieved on March 27, 2023.

[7] National Aeronautics and Space Administration (2016) A Global View of Methane. Retrieved on March 27, 2023.

The Greenhouse gas emissions from large facilities indicator reports GHG emissions from the largest GHG emitters in Canada (industrial and other types of facilities).

Data sources and methods

Data sources

Concentration data used for these indicators were retrieved from the Canadian Greenhouse Gas Measurement Program of the Climate Research Division of Environment and Climate Change Canada. The indicators are calculated using the greenhouse gas concentrations measured at the Alert (NU), Sable Island (NS), Estevan Point (BC), Fraserdale (ON) and East Trout Lake (SK) monitoring stations. The final ambient concentrations of carbon dioxide (CO_2) and methane (CH_4) are averaged to estimate the annual and monthly indicators values.

Global average annual concentrations were obtained from the National Oceanic and Atmospheric Administration's Global Monitoring Laboratory (NOAA), which developed the Carbon Cycle Greenhouse Gases research program.

More information

Canadian Greenhouse Gas Monitoring Network

Environment and Climate Change Canada has been continually building a long-term observation network for atmospheric measurements of CO_2, CH_4 and carbon monoxide (CO), which currently stands at 16 core continuous observational ground-based sites. These sites are spread across the country in coastal, interior and arctic regions, with the aim of providing high quality data to observe and monitor natural sources and sinks, and anthropogenic (human-caused) sources of greenhouse gases in Canada. Table A5 provides more specific information on each of the stations.

The data used for the indicators were measured at 3 coastal sites and 2 mid-continental forest sites that are part of the Canadian Greenhouse Gas Monitoring Network.

The coastal sites are located at:

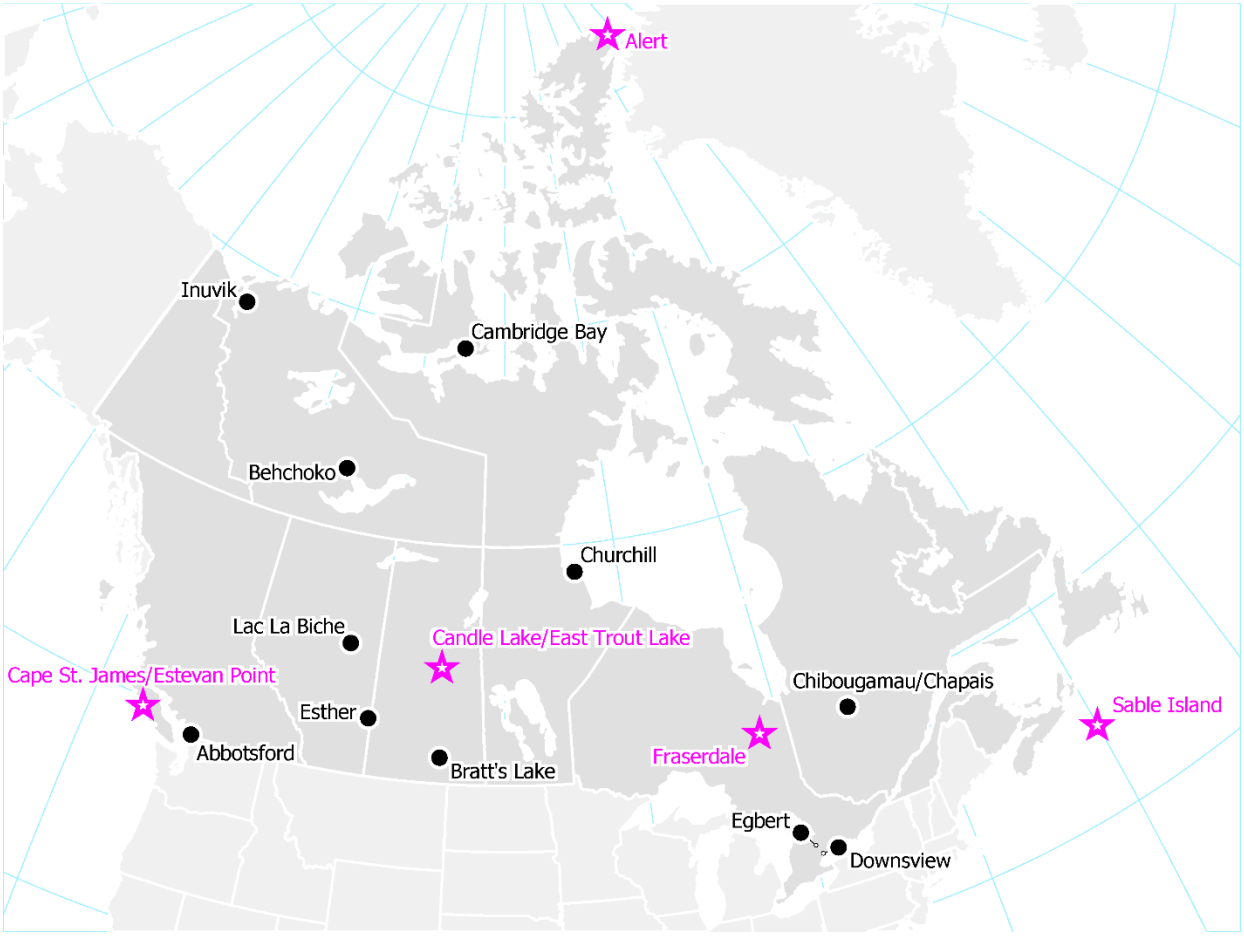
- Alert (NU), on Ellesmere Island in the Canadian high Arctic
- Sable Island (NS), located in the Atlantic Ocean
- Estevan Point (BC), a lighthouse station located on the coastline of Vancouver Island. Estevan Point became the replacement station for Cape St. James in 1992, when the weather station at Cape St. James was automated and no longer required a manned presence on site.

The mid-continental forest monitoring stations are situated in:

- Fraserdale (ON), located 150 km north of Timmins (ON)
- East Trout Lake (SK), located 150 km north-east of Prince Albert (SK). It became the replacement station for Candle Lake in 2005.

The Alert Station is also an official World Meteorological Organization Global Atmosphere Watch Program (WMO-GAW) station, one of 26 global stations around the world. Alert is the most northerly site in the WMO-GAW Network. The Alert site is also one of three sites, along with Mauna Loa and Cape Grim, which have been identified by the WMO-GAW as official greenhouse gas intercomparison sites.

Figure 3. Core greenhouse gas concentration monitoring stations in Canada, 2022



Note: The map displays the 16 core long-term greenhouse gas concentration monitoring stations in Canada. The 5 sites of Alert (NU), Sable Island (NS), Fraserdale (ON) East Trout Lake (SK) and Estevan Point (BC) used in the indicators are shown using pink stars. Only Alert remained continuously active from 2020 to 2022. For more information on the core monitoring stations, please refer to Table A5 in the Annex.
Source: Environment and Climate Change Canada (2023) Climate Research Division, Canadian Greenhouse Gas Measurement Program.

Temporal coverage

The indicator presenting the carbon dioxide (CO_2) concentrations covers the period from 1976 to 2022. However, no data on global CO_2 concentrations were available from 1976 to 1980.

The methane (CH_4) concentrations at the national and global levels were calculated using data for the years 1986 to 2022.

Data availability

Greenhouse gas observations at the 5 monitoring stations are all currently monitored continuously and provide hourly, daily and monthly data. Prior to 1988, carbon dioxide (CO_2) observations were monitored using weekly grab (flask) sampling procedures.

Data availability varies by station and by greenhouse gas over time. Table 1 shows the time periods for which data are available for each greenhouse gas at the 5 monitoring stations.

Table 1. Data availability by greenhouse gas and monitoring station

Greenhouse gas	Time period	Monitoring stations
Carbon dioxide	1976 to 2022	Alert
Carbon dioxide	1976 to 2020	Sable Island [A]
Carbon dioxide	1979 to 2020	Estevan Point/Cape St. James [A]
Carbon dioxide	1999 to 2020	Fraserdale [A]
Carbon dioxide	2002 to 2020	East Trout Lake/Candle Lake [A]
Methane	1985 to 2022	Alert
Methane	1999 to 2020	Sable Island [A]
Methane	1999 to 2020	Estevan Point/Cape St. James [A]
Methane	1990 to 2020	Fraserdale [A]
Methane	2002 to 2020	East Trout Lake/Candle Lake [A]

Note: [A] For the years 2020 to 2022, data is incomplete due to site closures as a result of the COVID-19 pandemic.

Global concentrations from the Carbon Cycle Greenhouse Gases research program

The Carbon Cycle Greenhouse Gases (CCGG) research program from the National Oceanic and Atmospheric Administration's Global Monitoring Laboratory operates the Global Greenhouse Gas Reference Network, measuring the atmospheric distribution and trends of the 3 main long-term drivers of climate change [carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O)] as well as carbon monoxide (CO).

Methods

The monthly and annual concentrations are an average of the daily values over the corresponding period of time.

For the years 2020 to 2022, a large amount of data at the national level are missing as a result of site closures during the COVID-19 pandemic. To calculate the monthly and annual concentrations over Canada for these years, concentrations were interpolated based on long-term trends observed at the Alert site and the average of the mean seasonal cycles observed in all 5 sites.

More information

Carbon dioxide

The continuous measurement of carbon dioxide (CO_2) follows the set of principles and protocols established by the World Meteorological Organization (WMO). The atmospheric CO_2 observational programs at Alert, Fraserdale, East Trout Lake, Sable Island and Estevan Point were all initially based on non-dispersive infrared (NDIR) methodology. A rigorous set of measurement calibrations and data processing are in place to obtain valid ambient 5 minute data measurements. Hourly, daily, monthly and annual data are then estimated from the 5 minute values. Starting in 2009, Cavity Ring-Down Spectrometer (CRDS) analytical setups for CO_2 were beginning to be introduced to the network. The CRDS instruments provide similar measurement precision as NDIR methodology, however, the CRDS systems contain an overall simpler design, are simpler to operate and require much less effort to maintain. Hourly, daily, monthly and annual data are estimated from the 1 minute CRDS values. All CO_2 measurements are directly traceable to the international absolute WMO x2007 mole fraction scale maintained by the WMO Central Calibration Laboratory (CCL) at the National Oceanic and Atmospheric Administration's Earth System Research Laboratories calibration facilities in Boulder, Colorado.

For the earlier parts of the record, CO_2 was also sampled weekly with flasks using NDIR methodology. As for the continuous method, many calibration steps are executed in order to obtain the final measured values. For more information on the flask CO_2 NDIR and continuous CO_2 NDIR and CRDS measurement procedures and data processing please consult the parameter metadata section for the Environment and Climate Change Canada network on the World Data Centre for Greenhouse Gases website.

Methane

The atmospheric methane (CH_4) observational measurements at Alert, Fraserdale, East Trout Lake, Sable Island and Estevan Point were all initially made using a gas chromatography technique equipped with a flame ionization detector (FID). In 2009, Cavity Ring-Down Spectrometer (CRDS) analytical setups for CH_4 were being introduced to the network. All CH_4 measurements are reported in 10^{-9} mol CH_4 per mol of dry air [nmol/mol] or parts per billion [ppb] and directly traceable to the international absolute WMO x2004 CH_4 mole fraction scale maintained by the WMO Central Calibration Laboratory (CCL) at the National Oceanic and Atmospheric Administration's Earth System Research Laboratories calibration facilities in Boulder, Colorado.

For more information on the continuous CH_4 measurements procedures and data manipulation please consult the parameter metadata section for the Environment and Climate Change Canada network on the World Data Centre for Greenhouse Gases website.

COVID-19 impact on data availability

For 2020 to 2022, there are extensive data gaps due to the temporary suspension of measurement activities at 4 of the 5 stations during the COVID-19 pandemic. Due to the stationing of a permanent contractor, the Alert station was not impacted. To minimize the potential biases due to missing data, a synthesized mean approach was used to calculate the monthly and annual means of CO_2 and CH_4 in Canada. This approach is based on the long-term trend of observed data at Alert and the average of the mean seasonal cycles of all 5 stations in recent years when the stations were all operational. The synthesized mean was calculated as

$$Synthesized\ mean\ (t) = x(t) + y + z(t)$$

where

- $x(t)$ = the long-term trend at Alert from 2020 to 2022
- y = the offset that is a mean difference for 2010 to 2019, between the annual mean at Alert and the annual mean based on all five stations
- $z(t)$ = the mean seasonal cycle constructed by averaging the mean seasonal cycles for each of the 5 stations for the 10 years from 2010 to 2019. This constructed mean seasonal cycle is used for each year from 2020 to 2022

The long-term trend and mean annual cycles are derived by applying a curve-fitting procedure to the observational data.

Global annual concentrations

The global annual concentration estimate is based on measurements from a subset of network sites. This estimation only includes sites where samples are predominantly of well-mixed marine boundary layer (MBL) air representative of a large volume of the atmosphere are considered. Measurements from sites close to anthropogenic and natural sources and sinks are excluded from the global estimate.

Global averages are constructed by first fitting a smoothed curve as a function of time to each site, and then the smoothed value for each site is plotted as a function of latitude for 48 equal time steps per year. A global average is calculated from the latitude plot at each time step. For more details on the methodology used, please consult National Oceanic and Atmospheric Administration's Global Monitoring Laboratory website.

Caveats and limitations

Given greenhouse gas (GHG) are long-lived in the atmosphere and are transported globally from the site of emission, these indicators are an integrated measure of global and domestic GHG emissions to the atmosphere.

For more information on Canada's emissions, and to assess Canada's progress in reducing its emissions, please refer to the related indicators which present information on greenhouse gas emissions in Canada.

For both carbon dioxide and methane concentrations, the number of monitoring stations used in the analyses increased in 1999. The change in the number of monitoring sites may have influenced calculations of the average values and make it difficult to compare trends prior and post 1999. In the particular case of methane concentrations, values prior to 1999 were based on data from 1 station and may not be representative of the concentrations over Canada.

Due to the COVID-19 pandemic, many monitoring stations were out of operation for much of 2020 to 2022. As such, monthly and annual values were interpolated from the trends observed at Alert and the seasonal variations observed at the 5 monitoring stations. This method may miss inter-annual variations related to sub-regional scale emission changes in Canada.

Resources

References

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World Meteorological Organization (2020) WMO Greenhouse Gases Bulletin 2019. Retrieved on March 27, 2023.

Related information

Canada's action on climate change

Canada's changing climate report

Climate change

Greenhouse gas emissions indicator

Greenhouse gas emissions: drivers and impacts

WMO Greenhouse Gases Bulletin

Annex

Annex A. Data tables for the figures presented in this document

Table A.1. Annual data for Figure 1. Carbon dioxide concentration, Canada and global, 1976 to 2022

Year	Carbon dioxide concentration – Canada (parts per million)	Carbon dioxide concentration – Global (parts per million)
1976	333.4	n/a
1977	334.6	n/a
1978	336.5	n/a
1979	337.5	n/a
1980	339.6	338.9
1981	341.2	340.1
1982	342.8	340.9
1983	344.2	342.5
1984	345.8	344.1
1985	346.9	345.5
1986	348.4	347.0
1987	349.5	348.7
1988	352.6	351.2
1989	355.0	352.8
1990	355.8	354.1
1991	357.2	355.4
1992	357.8	356.1
1993	358.3	356.8
1994	359.8	358.3
1995	361.6	360.2
1996	363.8	361.9
1997	364.4	363.1
1998	366.9	365.7
1999	368.6	367.8
2000	370.7	369.0
2001	372.1	370.6
2002	374.7	372.6
2003	376.8	375.2
2004	378.7	377.0
2005	380.8	379.0
2006	383.1	381.1
2007	385.0	382.9
2008	386.8	385.0
2009	388.2	386.5
2010	390.9	388.8
2011	393.0	390.6
2012	395.0	392.7
2013	397.9	395.4
2014	399.5	397.3
2015	401.9	399.7
2016	404.6	403.1
2017	407.8	405.2
2018	409.9	407.6
2019	412.3	410.1
2020	415.1	412.4
2021	417.7	414.7
2022	419.7	417.1

Note: n/a: not available. From 1976 to 1999, averages were calculated based on data from 2 to 3 sampling stations. Since 1999, data from 5 sampling stations are used to represent CO_2 concentrations. Due to some site closures during the COVID-19 pandemic, data from Canada between 2020 and 2022 were interpolated based on data from the Alert station, which remained active throughout that period. Global annual averages are based on measurements from sampling stations that are part of the Global Greenhouse Gas Reference Network.
Source: Environment and Climate Change Canada (2023) Climate Research Division, Canadian Greenhouse Gas Measurement Program and National Oceanic and Atmospheric Administration (2023) Global Monitoring Laboratory - Trends in Atmospheric Carbon Dioxide.

Table A.2. Monthly data for Figure 1. Carbon dioxide concentration, Canada, 1976 to 2022

Year	January (parts per million)	February (parts per million)	March (parts per million)	April (parts per million)	May (parts per million)	June (parts per million)	July (parts per million)	August (parts per million)	September (parts per million)	October (parts per million)	November (parts per million)	December (parts per million)
1976	335.6	337.5	337.6	338.3	338.5	n/a	329.6	323.1	325.2	332.8	332.9	336.8
1977	336.8	337.3	339.3	337.3	338.7	334.8	331.0	327.3	327.3	332.5	335.1	337.9
1978	337.4	339.9	341.9	342.8	339.3	337.1	330.9	328.1	326.6	334.7	339.9	339.8
1979	342.2	340.0	341.8	341.6	342.0	339.8	333.6	329.2	329.6	334.5	336.1	340.1
1980	342.3	341.9	342.6	343.8	343.2	341.9	335.8	329.7	331.7	338.3	341.7	342.0
1981	343.5	345.8	345.5	344.0	346.4	343.0	336.6	330.6	336.4	337.8	341.1	344.0
1982	346.0	346.8	347.6	347.2	346.8	342.6	341.7	334.4	335.3	339.5	341.8	343.9
1983	346.0	347.2	347.2	348.7	348.3	345.1	343.4	335.5	335.3	341.3	344.8	347.7
1984	348.8	348.6	350.1	350.0	350.5	346.1	343.9	336.8	337.8	341.7	346.3	348.6
1985	349.8	351.9	350.9	350.8	351.1	347.8	343.8	337.6	339.0	344.3	347.1	348.2
1986	351.2	350.8	351.4	352.6	351.7	348.1	344.6	345.4	340.4	345.0	348.5	351.4
1987	350.5	352.4	353.3	352.6	353.7	352.4	344.1	341.6	342.3	346.1	350.7	354.7
1988	355.3	355.2	355.2	357.3	355.7	352.9	349.1	342.6	347.1	351.5	353.5	356.2
1989	359.7	358.6	358.9	359.0	359.8	355.9	351.7	343.7	347.5	352.9	355.3	357.1
1990	360.1	359.7	359.0	359.8	358.2	355.7	354.2	346.5	347.4	352.1	357.2	359.3
1991	359.9	361.3	361.1	361.2	361.5	358.1	356.1	347.9	349.5	352.0	357.5	359.9
1992	360.8	362.4	362.1	361.4	362.5	360.6	354.5	349.4	348.9	354.1	356.2	361.2
1993	361.1	363.0	363.2	362.8	363.2	360.2	353.1	349.1	351.5	355.9	356.9	360.0
1994	361.6	363.2	363.9	364.1	363.8	361.4	357.5	350.5	352.1	358.3	358.6	363.1
1995	363.8	365.9	365.7	366.3	364.5	363.0	357.1	352.7	355.1	358.9	362.3	364.2
1996	366.6	366.0	367.3	367.9	367.7	367.0	361.8	356.5	356.0	360.7	363.6	365.1
1997	368.7	368.9	368.8	368.4	368.3	366.2	359.9	354.7	356.2	360.8	364.6	367.2
1998	368.6	369.3	369.6	370.2	370.8	367.8	362.8	357.9	360.4	365.2	369.1	371.2
1999	373.3	373.4	373.6	373.4	372.6	368.3	361.0	357.6	360.4	366.4	370.5	373.3
2000	373.9	375.9	375.3	375.3	374.5	370.4	363.7	359.6	363.3	368.8	373.5	374.5
2001	376.1	376.2	376.4	377.3	376.3	371.4	364.6	361.8	362.5	370.3	375.3	376.9
2002	378.4	378.9	379.1	379.5	378.1	373.1	366.5	364.9	366.5	373.4	378.6	379.4
2003	379.7	380.3	381.5	381.4	380.0	376.3	369.6	367.1	367.6	375.5	380.4	382.1

Year	January (parts per million)	February (parts per million)	March (parts per million)	April (parts per million)	May (parts per million)	June (parts per million)	July (parts per million)	August (parts per million)	September (parts per million)	October (parts per million)	November (parts per million)	December (parts per million)
2004	382.8	383.1	383.7	383.4	382.0	378.3	372.4	366.9	369.7	377.1	381.1	383.5
2005	384.7	385.2	385.0	385.4	383.7	379.6	372.8	370.7	372.4	379.2	383.9	386.4
2006	387.4	387.0	387.9	387.4	385.6	381.5	376.3	371.9	375.7	382.5	386.2	388.0
2007	389.3	388.8	389.9	389.0	387.7	383.2	377.5	373.9	378.1	384.2	387.9	390.4
2008	391.5	392.0	392.3	392.7	390.6	385.9	378.4	375.6	376.2	384.2	390.4	392.2
2009	392.8	393.1	393.5	393.9	392.0	387.5	380.3	375.7	380.4	385.7	390.6	392.3
2010	394.4	395.1	394.9	395.0	393.1	389.1	382.7	381.4	384.8	389.9	394.0	396.4
2011	397.3	397.6	397.9	398.3	395.9	391.6	384.7	381.2	384.7	391.2	396.7	398.4
2012	399.2	399.5	399.9	399.5	397.9	392.9	386.0	384.8	387.4	394.1	398.9	400.5
2013	401.8	402.1	402.1	402.3	400.7	397.0	389.8	386.2	390.8	396.9	401.2	404.0
2014	404.3	404.7	404.9	404.9	403.3	398.3	390.0	387.2	391.0	397.3	402.7	406.0
2015	405.9	406.2	406.5	406.4	404.7	400.2	392.3	390.0	394.3	401.8	406.0	408.9
2016	408.6	409.0	409.4	409.0	406.5	401.9	395.7	393.1	397.8	404.3	408.6	410.8
2017	412.0	412.5	412.8	412.8	410.8	406.6	399.8	396.2	400.0	406.0	410.9	412.8
2018	413.9	413.9	414.7	415.3	413.4	409.4	400.8	398.7	401.1	408.6	413.3	415.5
2019	416.1	416.9	417.3	417.1	415.3	411.6	403.0	400.6	404.2	410.9	416.2	418.1
2020	418.5	419.8	421.1	421.2	418.5	412.4	405.8	403.4	407.1	413.8	418.7	420.6
2021	421.1	421.7	422.6	422.8	420.6	415.3	409.2	406.8	410.1	416.4	421.6	424.1
2022	424.8	424.8	425.0	424.9	422.8	417.3	410.9	408.5	412.0	418.1	422.7	424.7

Note: n/a = not available. From 1976 to 1999, averages were calculated based on data from 2 to 3 sampling stations. Since 1999, data from 5 sampling stations are used to represent CO_2 concentrations. Due to some site closures during the COVID-19 pandemic, data from Canada between 2020 and 2022 were interpolated based on data from the Alert station, which remained active throughout that period.
Source: Environment and Climate Change Canada (2023) Climate Research Division, Canadian Greenhouse Gas Measurement Program.

Table A.3. Annual data for Figure 2. Methane concentration, Canada and global, 1986 to 2022

Year	Methane concentration – Canada (parts per billion)	Methane concentration – Global (parts per billion)
1986	1 764	1 670
1987	1 774	1 683
1988	1 784	1 693
1989	1 792	1 705
1990	1 803	1 714
1991	1 813	1 725
1992	1 824	1 736
1993	1 819	1 736
1994	1 835	1 742
1995	1 834	1 749
1996	1 835	1 751
1997	1 836	1 755
1998	1 849	1 766
1999	1 856	1 772
2000	1 853	1 773
2001	1 853	1 771
2002	1 855	1 773
2003	1 864	1 777
2004	1 859	1 777
2005	1 863	1 774
2006	1 861	1 775
2007	1 868	1 781
2008	1 877	1 787
2009	1 878	1 794
2010	1 883	1 799
2011	1 889	1 803
2012	1 895	1 808
2013	1 900	1 813
2014	1 912	1 823
2015	1 922	1 834
2016	1 932	1 843
2017	1 938	1 850
2018	1 942	1 857
2019	1 952	1 867
2020	1 969	1 879
2021	1 988	1 895
2022	2 001	1 912

Note: From 1986 to 1999, averages were calculated based on data from 1 to 2 sampling stations. Since 1999, data from 5 sampling stations are used to represent CH_4 concentrations. Due to some site closures during the COVID-19 pandemic, data from Canada between 2020 and 2022 were interpolated based on data from the Alert station, which remained active throughout that period. Global annual averages are based on measurements from sampling stations that are part of the Global Greenhouse Gas Reference Network.
Source: Environment and Climate Change Canada (2023) Climate Research Division, Canadian Greenhouse Gas Measurement Program and National Oceanic and Atmospheric Administration (2023) Global Monitoring Laboratory - Trends in Atmospheric Methane.

Table A.4. Monthly data for Figure 2. Methane concentration, Canada and global, 1986 to 2022

Year	January (parts per billion)	February (parts per billion)	March (parts per billion)	April (parts per billion)	May (parts per billion)	June (parts per billion)	July (parts per billion)	August (parts per billion)	September (parts per billion)	October (parts per billion)	November (parts per billion)	December (parts per billion)
1986	1 780	1 769	1 792	1 773	1 766	1 741	1 738	1 740	1 744	1 788	1 774	1 759
1987	1 776	1 779	1 782	1 771	1 774	1 756	1 753	1 756	1 774	1 789	1 791	1 788
1988	1 799	1 800	1 789	n/a	1 781	1 767	1 750	1 755	1 785	1 791	1 802	1 806
1989	1 800	1 815	1 813	1 792	1 777	1 764	1 758	1 771	1 785	1 791	1 811	1 825
1990	1 822	1 831	1 817	1 801	1 800	1 780	1 775	1 773	1 785	1 808	1 817	1 825
1991	1 840	1 841	1 815	1 809	1 800	1 785	1 782	1 791	1 810	1 817	1 829	1 834
1992	1 858	1 849	1 854	1 830	1 823	1 812	1 792	1 797	1 800	1 813	1 826	1 838
1993	1 837	1 830	1 834	1 819	1 818	1 799	1 788	1 797	1 815	1 820	1 831	1 836
1994	1 857	1 855	1 862	1 844	1 824	1 808	1 803	1 802	n/a	1 838	1 842	1 849
1995	1 846	1 856	1 852	1 844	1 821	1 808	1 807	1 816	1 830	1 835	1 844	1 852
1996	1 858	1 851	1 851	1 841	1 831	1 821	1 811	1 808	1 827	1 839	1 839	1 840
1997	1 867	1 862	1 846	1 842	1 829	1 815	1 809	1 815	1 827	1 837	1 834	1 854
1998	1 863	1 861	1 859	1 843	1 840	1 823	1 819	1 829	1 844	1 859	1 862	1 887
1999	1 885	1 876	1 863	1 859	1 851	1 841	1 837	1 840	1 848	1 855	1 866	1 858
2000	1 861	1 862	1 862	1 858	1 851	1 845	1 845	1 838	1 845	1 854	1 852	1 859
2001	1 865	1 865	1 869	1 861	1 852	1 840	1 828	1 829	1 845	1 853	1 864	1 863
2002	1 879	1 858	1 866	1 862	1 847	1 840	1 833	1 833	1 853	1 855	1 858	1 871
2003	1 877	1 874	1 877	1 866	1 857	1 850	1 843	1 845	1 857	1 864	1 872	1 883
2004	1 878	1 880	1 875	1 862	1 853	1 842	1 832	1 841	1 854	1 858	1 865	1 872
2005	1 877	1 874	1 863	1 860	1 850	1 847	1 846	1 854	1 863	1 866	1 872	1 885
2006	1 881	1 873	1 869	1 862	1 856	1 849	1 844	1 855	1 850	1 854	1 862	1 873
2007	1 878	1 870	1 874	1 864	1 857	1 850	1 846	1 859	1 876	1 878	1 876	1 890
2008	1 892	1 900	1 885	1 883	1 870	1 856	1 849	1 861	1 871	1 876	1 883	1 892
2009	1 893	1 889	1 890	1 883	1 871	1 859	1 852	1 865	1 879	1 883	1 883	1 891
2010	1 897	1 892	1 891	1 883	1 876	1 868	1 862	1 872	1 886	1 882	1 891	1 900
2011	1 901	1 901	1 899	1 891	1 878	1 869	1 871	1 876	1 882	1 894	1 903	1 909
2012	1 909	1 907	1 905	1 895	1 885	1 874	1 878	1 887	1 891	1 894	1 906	1 914
2013	1 924	1 915	1 907	1 899	1 891	1 885	1 883	1 882	1 891	1 900	1 906	1 912

Year	January (parts per billion)	February (parts per billion)	March (parts per billion)	April (parts per billion)	May (parts per billion)	June (parts per billion)	July (parts per billion)	August (parts per billion)	September (parts per billion)	October (parts per billion)	November (parts per billion)	December (parts per billion)
2014	1 916	1 919	1 918	1 907	1 900	1 895	1 891	1 909	1 914	1 926	1 920	1 929
2015	1 937	1 931	1 922	1 919	1 909	1 900	1 902	1 913	1 927	1 924	1 934	1 947
2016	1 941	1 938	1 934	1 926	1 923	1 911	1 912	1 927	1 939	1 943	1 940	1 952
2017	1 961	1 950	1 947	1 936	1 928	1 921	1 919	1 926	1 936	1 938	1 950	1 949
2018	1 956	1 948	1 946	1 945	1 934	1 926	1 921	1 928	1 940	1 946	1 955	1 962
2019	1 960	1 965	1 958	1 951	1 939	1 934	1 935	1 943	1 955	1 961	1 961	1 969
2020	1 975	1 974	1 968	1 960	1 953	1 949	1 951	1 960	1 970	1 980	1 989	1 995
2021	1 997	1 996	1 993	1 988	1 978	1 970	1 970	1 976	1 984	1 991	2 001	2 011
2022	2 016	2 013	2 007	2 000	1 992	1 983	1 982	1 989	2 000	2 007	2 011	2 016

Note: n/a = not available. From 1986 to 1999, averages were calculated based on data from 1 to 2 sampling stations. Since 1999, 5 sampling stations are collecting CH_4 concentrations data. Due to some site closures during the COVID-19 pandemic, data from Canada between 2020 and 2022 were interpolated based on data from the Alert station, which remained active throughout that period.
Source: Environment and Climate Change Canada (2023) Climate Research Division, Canadian Greenhouse Gas Measurement Program.

Table A.5. Data for Figure 3. Core greenhouse gas concentration monitoring stations in Canada, 2022

Start Date	Site Name (3 Letter Station Code)	Coordinates	Elevation (asl)	Intake Height	In-situ Parameters	In-situ Instrumentation	Flask Sampling Frequency (CO_2, CH_4, CO, N_2O, SF_6)
March, 1975	Sable Island, Nova Scotia (WSA)	43.932237N, 60.009275W	5 m	25 m	CO_2, CH_4, CO	NDIR, GC, CRDS	Single flask every three days
July, 1975	Alert, Nunavut (ALT)	82.450833N, 62.507222W	200 m	10 m	CO_2, CH_4, CO, N_2O	NDIR, GC, CRDS OA-ICOS	One pair of flasks each week
May, 1979	Cape St. James, British Columbia (CSJ)*	51.9360N, 131.0158W	92 m	94 m	CO_2	NDIR	One pair of flasks each week
January, 1990	Fraserdale, Ontario (FSD)	49.875222N, 81.570083W	210 m	40 m	CO_2, CH_4, CO, N_2O, SF_6	NDIR, GC, CRDS	Single flask once per week (in the afternoon)
June, 1992	Estevan Point, British Columbia (ESP)	49.382954N, 126.544101W	7 m	40 m	CO_2, CH_4, CO	NDIR, GC, CRDS	One pair of flasks once per week
June, 2002	Candle Lake, Saskatchewan (CDL)*	53.987108N, 105.117939W	600 m	30 m	CO_2, CH_4, CO	NDIR, GC	
October, 2003	Downsview, Ontario (DWS)	43.780491N, 79.468010W	198 m	20 m	CO_2, CH_4, CO, N_2O, SF_6, CO_2	NDIR, GC, CRDS, OA-ICOS	Single flask once per week
March, 2005	Egbert, Ontario (EGB)	44.231037N, 79.783834W	251 m	3m, 25 m	CO_2, CH_4, CO, N_2O, SF_6, Radon, CO_2	NDIR, GC, CRDS	One pair of flasks every other week
August, 2005	East Trout Lake, Saskatchewan (ETL)	54.354130N, 104.986835W	493 m	105 m	CO_2, CH_4, CO, N_2O, SF_6	NDIR, GC, CRDS	Single flask once per week (in the afternoon
April, 2007	Churchill, Manitoba (CHL)	58.737885N, 93.819403W	29 m	60 m	CO_2, CH_4, CO	CRDS	Single flask twice per week (in the afternoon)
April, 2007	Lac La Biche, Alberta (LLB)	54.953851N, 112.466646W	540 m	10 m, 50 m	CO_2, CH_4, CO	NDIR, GC, CRDS	NOAA Sampling
August, 2007	Chibougamau, Quebec (CHM)*	49.692510N, 74.342296W	393 m	30 m	CO_2, CH_4, CO	NDIR, GC	
October, 2009	Bratt's Lake, Saskatchewan (BRA)	50.201683N, 104.711268W	595 m	35 m	CO_2, CH_4, CO	CRDS	Single flask once per week
January, 2010	Esther, Alberta (EST)	51.670681N, 110.206009W	707 m	3m, 50 m	CO_2, CH_4 CO	CRDS	
October, 2010	Behchoko, Northwest Territories (BCK)	62.798087N, 115.919426W	160 m	60 m	CO_2, CH_4, CO	CRDS	
December, 2011	Chapais, Quebec (CPS)	49.822317N, 74.975274W	391 m	8m, 40 m	CO_2, CH_4	CRDS	Single flask once per week

Start Date	Site Name (3 Letter Station Code)	Coordinates	Elevation (asl)	Intake Height	In-situ Parameters	In-situ Instrumentation	Flask Sampling Frequency (CO_2, CH_4, CO, N_2O, SF_6)
February, 2012	Inuvik, Northwest Territories (INU)	68.317817N, 133.534232W	113 m	10 m	CO_2, CH_4 CO	CRDS	Single flask once per week
December, 2012	Cambridge Bay, Northwest Territories (CBY)	69.128418N, 105.057709W	35 m	12 m	CO_2, CH_4, CO	CRDS	Single flask once per week
March, 2014	Abbotsford, British Columbia (ABT)	49.011386N, 122.335332W	60 m	33 m	CO_2, CH_4, CO, N_2O, Radon	CRDS, OA-ICOS	Single flask once per week

Note: The stations marked with an asterisk (*) are no longer operational and have since been replaced.
Source: Environment and Climate Change Canada (2023) Climate Research Division, Canadian Greenhouse Gas Measurement Program.

Additional information can be obtained at:

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