Environment and Climate Change Canada
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TEMPERATURE CHANGE IN CANADA

CANADIAN ENVIRONMENTAL SUSTAINABILITY INDICATORS

Canada

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TEMPERATURE CHANGE IN CANADA

May 2023

Table of contents

Temperature change in Canada 5
- Key results 5
- Seasonal temperature change 7
  - Key results 7
- Regional temperature 8
  - Key results 8
- About the indicators 9
  - What the indicators measure 9
  - Why these indicators are important 9
  - Related initiatives 9
  - Related indicators 9
- Data sources and methods 10
  - Data sources 10
  - Methods 10
  - Caveats and limitations 10
- Resources 11
  - References 11
  - Related information 11

Annex 12
- Annex A. Data tables for the figures presented in this document 12

List of Figures

Figure 1. Annual average temperature departures from the 1961 to 1990 reference value, Canada, 1948 to 2022 5
Figure 2. Seasonal average temperature departures compared with the 1961 to 1990 reference value, Canada, 1948 to 2022 7
Figure 3. Regional average temperature departures from the 1961 to 1990 reference value, Canada, 2022 8

List of Tables

Table A.1. Data for Figure 1. Annual average temperature departures from the 1961 to 1990 reference value, Canada, 1948 to 202 12
Table A.2. Data for Figure 2. Seasonal average temperature departures compared with the 1961 to 1990 reference value, Canada, 1948 to 2022 13

Temperature change in Canada

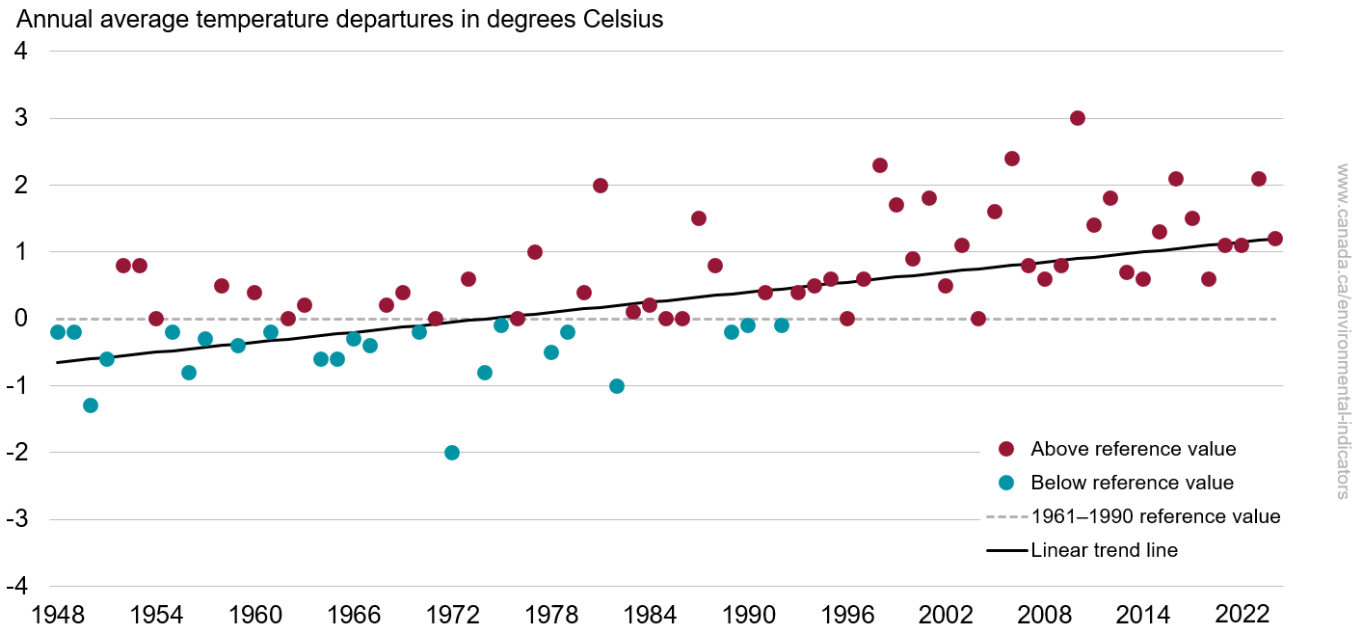
Temperature is a key indicator of how the climate is changing in response to greenhouse gas (GHG) emissions from human activities, as increasing GHG concentrations result in warming of the lower atmosphere. Temperature change can influence crops, forests, infrastructure, human health, the spread of disease, the availability of water and the health of ecosystems.

Using the average temperature values from 1961 to 1990 as a baseline, these indicators compare how much the temperature for a given year departs from the 1961 to 1990 "normal". The indicators show the yearly and seasonal surface air temperature departures[1] for the years 1948 to 2022.

Key results

- In Canada, the national average temperature for the year 2022 was 1.2 degrees Celsius (°C) above the 1961 to 1990 reference value, making it the 16th warmest year since 1948
- From 1948 to 2022, there is a trend in annual average temperature departures, showing 1.9°C of warming over that period
- Annual average temperatures were consistently above or equal to the reference value from 1997 onward

Figure 1. Annual average temperature departures from the 1961 to 1990 reference value, Canada, 1948 to 2022



Data for Figure 1

Note: Departures are calculated by subtracting the 1961 to 1990 reference value from the annual average.
Source: Environment and Climate Change Canada (2023) Adjusted and homogenized Canadian climate data.

2021 saw a historic heat wave hit the western parts of Canada in June. On June 29th, a new Canadian record high temperature of 49.6°C (nearly 24°C higher than normal) was set in the village of Lytton in British Columbia.

[1] The temperature departure corresponds to the difference between the observed temperature values and a temperature reference value, also called the "normal". The average of temperature annual values from 1961 to 1990 is commonly used as a baseline for comparing how temperature for a given year departs from what could be referred to as the "normal" in long-term climate change assessments.

The heat dome that affected the country over 2 weeks was responsible for over 1 000 new local daily temperature records and contributed to an early and above average wildfire season. This extreme heat also had human health consequences, causing 619 deaths in British Columbia.[2] A new episode of extreme heat was observed in late 2022, expanding into the rest of Canada. Resulting wildfires in Newfoundland and Labrador caused a weeklong state of emergency as essential supply routes were cut off in the communities of Grand Falls-Windsor and along the Bay d'Espoir highway.[3]

Nine (9) of the 10 warmest years have occurred during the last 25 years, with 2010 being the warmest on record (3.0°C above the 1961 to 1990 reference value). Canada's coldest year since 1948 occurred in 1972 at 2.0°C below the reference value.

The annual average temperature in Canada has increased at roughly twice the global mean (average) rate. Patterns are different across regions of the country, however. Temperatures have increased more in northern Canada than in southern Canada. Annual mean temperature over northern Canada increased by roughly 3 times the global mean warming rate.

The effects of widespread warming are evident in many parts of Canada and are projected to intensify in the future. In Canada, these effects include more extreme heat, less extreme cold, longer growing seasons, shorter snow and ice cover seasons, earlier spring peak streamflow, thinning glaciers, thawing permafrost, and rising sea level. (Bush and Lemmen, 2019).

[2] Government of British Columbia (2022) Extreme Heat and Human Mortality: A Review of Heat-Related Deaths in B.C. in Summer 2021. Retrieved on March 2, 2023.

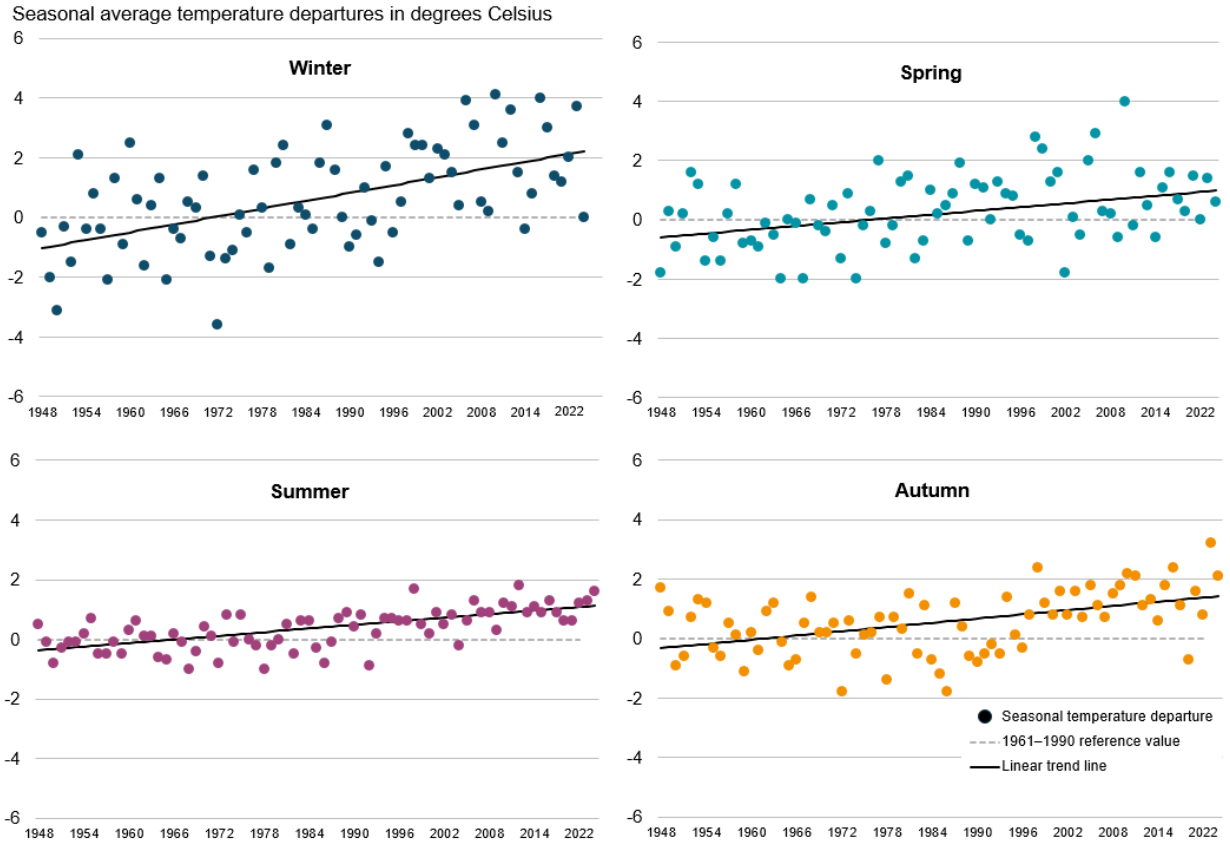
[3] Government of Canada (2022) Canada's top 10 weather stories of 2022. Retrieved March 2, 2023.

Seasonal temperature change

Key results

- Like the national annual average temperature, seasonal average temperature increased over the 1948 to 2022 period. Warming trends were detected for all 4 seasons:
  - winter,[4] with an increase of 3.3°C
  - spring, with an increase of 1.6°C
  - summer, with an increase of 1.6°C
  - autumn, with an increase of 1.8°C
- The warmest winter and spring recorded were both in 2010. The warmest summer was in 2012, while the warmest autumn was in 2021

Figure 2. Seasonal average temperature departures compared with the 1961 to 1990 reference value, Canada, 1948 to 2022



Data for Figure 2

Note: Departures are calculated by subtracting the 1961 to 1990 reference value from the seasonal average. Seasons are defined as winter (December, January, and February), spring (March, April, and May), summer (June, July, and August), and autumn (September, October, and November).
Source: Environment and Climate Change Canada (2023) Adjusted and homogenized Canadian climate data.

[4] Winter 2022 includes the months of December 2021, January 2022, and February 2022.

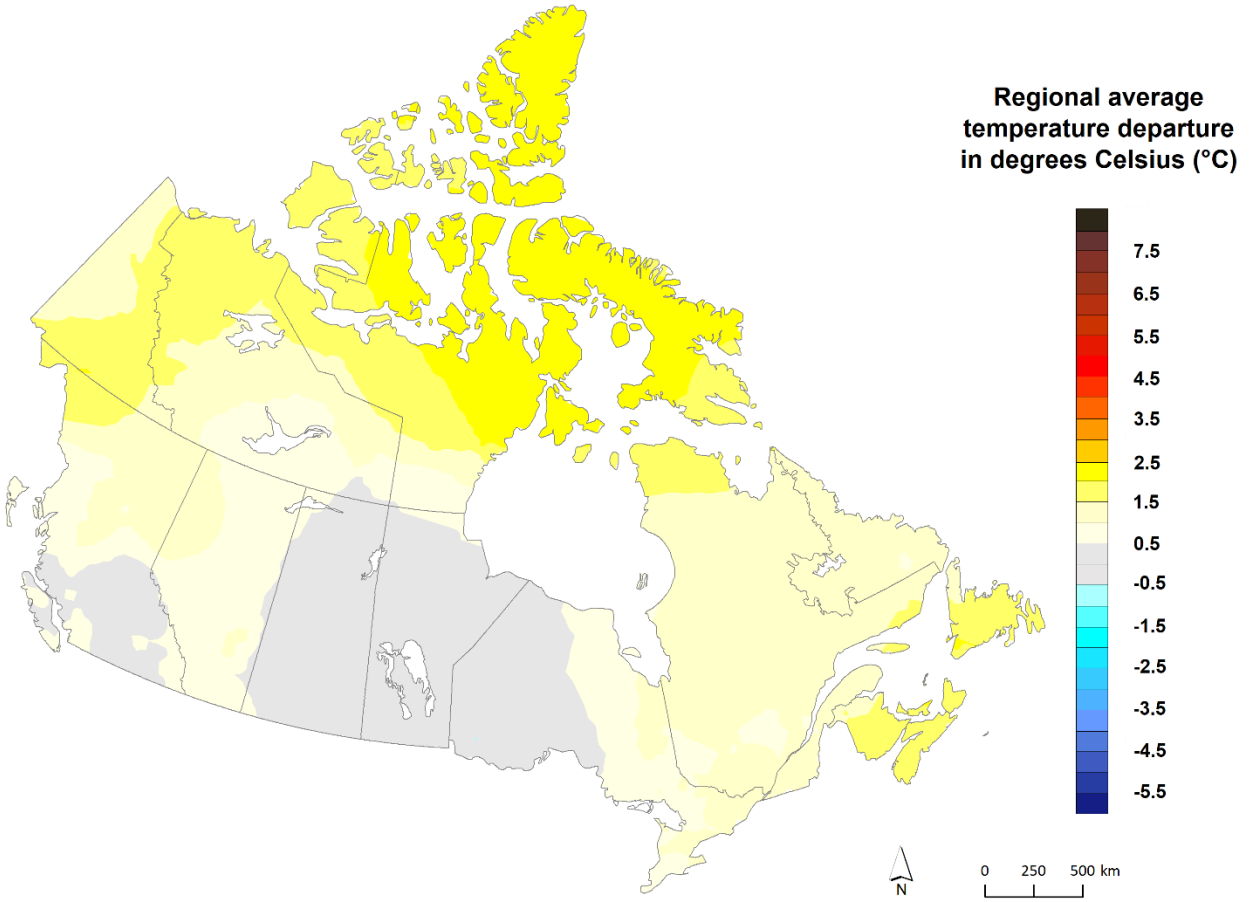
Regional temperature

Key results

In 2022,

- Most of Canada experienced annual temperatures above the 1961 to 1990 reference value
- Annual temperatures near the baseline average were observed in southern British Columbia, northern Ontario, and most of Manitoba and Saskatchewan
- Most of northern Canada, northern parts of British Columbia and Quebec, and most of the Maritimes experienced temperatures significantly above the baseline average

Figure 3. Regional average temperature departures from the 1961 to 1990 reference value, Canada, 2022



Note: 2022 annual average temperature departures were computed for 561 active weather stations across Canada. Departures are calculated by subtracting the reference value from the annual average.
Source: Environment and Climate Change Canada (2023) Canadian gridded temperature and precipitation anomalies.

About the indicators

What the indicators measure

These indicators of Temperature change in Canada show the yearly and seasonal surface air temperature departures for the years 1948 to 2022. As well, they present a spatial distribution of surface air temperature departures for the year 2022.

An annual departure (or anomaly) is the difference between the value for a given year and a baseline value. The baseline values used in these indicators are the annual and seasonal temperature averages for the reference period of 1961 to 1990 (often referred to as the 1961 to 1990 normal). This reference period is consistent with the approach used to compare anomalies in the Intergovernmental Panel on Climate Change Sixth Assessment Report and the World Meteorological Organization Annual Statements on the Status of the Global Climate. The temperature departures are measured in degrees Celsius and calculated using data from weather stations across Canada with sufficiently long data records to allow for a meaningful trend calculation.

Why these indicators are important

The heat-trapping effect of atmospheric greenhouse gases is well-established. It is extremely likely that human activities, especially emissions of greenhouse gases, are the main cause of observed warming since the mid-20th century. Natural factors cannot explain this observed warming. Evidence is widespread of a human influence on many other changes in climate as well (Bush et al., 2019).

Much of Canadian economic and social activity, as well as individual health, is climate dependent. Studies have shown that extreme heat (over 30°C) increases deaths in Canadian cities. However, this impact is not seen equally in Canada. Those with underlying conditions such as cardiovascular disease, schizophrenia and pregnancy may experience more severe effects of extreme heat. In addition, sociological factors such as income, housing status, age and those experiencing social isolation may impact the degree in which individuals can manage extreme temperatures (Bush et al., 2019).

Understanding how Canada's climate is changing is important for developing adaptive responses to these effects. The Temperature change in Canada indicators help show how Canada's surface air temperature has changed since nationwide recording of consistent and comparable climate observations began in 1948.

The Intergovernmental Panel on Climate Change and the United Nations Framework Convention on Climate Change uses surface air temperature, among other variables, to assess long-term changes in climate. Surface air temperature is considered by the World Meteorological Organization - Global Climate Observing System as an Essential Climate Variable.

Related initiatives

These indicators support the measurement of progress towards the following 2022 to 2026 Federal Sustainable Development Strategy long-term Goal 13: Take action on climate change and its impacts.

In addition the indicators contribute to the Sustainable Development Goals of the 2030 Agenda for Sustainable Development. They are linked to Goal 13, Take urgent action to combat climate change and its impacts.

Related indicators

The Precipitation change in Canada indicators present annual and seasonal precipitation departures.

The Sea ice in Canada indicators provide information on variability and trends in sea ice in Canada during the summer season.

The Snow cover indicators provide information on spring snow cover extent and annual snow cover duration in Canada.

Data sources and methods

Data sources

The Temperature change in Canada indicators are based on Environment and Climate Change Canada's gridded temperature departures, or anomalies, data (Canadian gridded temperature and precipitation anomalies [CANGRD]), which in turn is based on the Adjusted and homogenized Canadian climate data for historical climate observations and on near real-time data in the national climate archives for the current year.

More information

The indicators are calculated using surface air temperature data collected in weather stations across Canada for the period 1948 to 2022.

The dataset contains daily data from 780 weather stations: 508 active stations with long record (starting prior to 1990); 53 active stations with short record (starting in or after 1990); and 219 locations with no current observations (station closed) but with more than 30 years of data.

The Third Generation of Homogenized Temperature datasets replaced the first and second generation datasets that were used in the previous versions of the Temperature change in Canada indicators.

This dataset was prepared for use in climate trend analysis in Canada. The list of stations was revised to include observations from a larger number of surface monitoring stations, in particular those collected at Reference Climate Stations and at some Canadian Aviation Weather Services stations. The procedures used to produce the Third Generation are described in the publication A third generation of homogenized temperature for trend analysis and monitoring changes in Canada's climate.

Methods

The seasonal and annual average temperature departures are computed at each observing station and for each season and year by subtracting the reference value (defined as the average over the 1961 to 1990 reference period) from the relevant seasonal and annual values.

More information

The annual departure is the average of all monthly departures and the seasonal departure is the average of the monthly departures in the corresponding season.

Seasons are defined as winter (December of previous year, January, and February), spring (March, April and May), summer (June, July, and August) and autumn (September, October, and November).

Temperature departures were computed for the 780 weather stations across Canada and were then applied to a grid with cells of 50 square kilometers. Temperature departures were assumed to be uniform and equal for a given cell. Values for each grid cell were averaged together to produce the annual and seasonal time series of temperature departures representing the entire country. Values for grid boxes over large bodies of water are excluded. More information about the calculation method for annual average temperature departures can be found in the Climate Trends and Variations Bulletin documentation.

Statistical linear trends at the 95% confidence level were obtained by using the Mann-Kendall and Sen's methods (Kendall-tau).

Caveats and limitations

Breaks in the data can be a concern. To mitigate this, the Temperature change in Canada indicators use homogenized and adjusted station data for temperature. Adjustments for data variations caused by changes in site exposure, location, instrumentation, observer, and observing procedures over the 75-year reporting period were performed on the dataset. Observations from nearby co-located stations are sometimes merged to produce longer time series.

Resources

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Related information

Vincent LA, Wang XL, Milewska EJ, Wan H, Yang F and Swail V (2012) A second generation of homogenized Canadian monthly surface air temperature for climate trend analysis. Journal of Geophysical Research – Atmospheres 117 (D18):1–13.

Vincent LA, Zhang X, Brown R, Feng Y, Mekis E, Milewska EJ, Wan H and Wang XL (2015) Observed trends in Canada's climate and influence of low frequency variability modes. Journal of Climate 28 (11):4545–4560.

Annex

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

Table A.1. Data for Figure 1. Annual average temperature departures from the 1961 to 1990 reference value, Canada, 1948 to 2022

Year	Temperature departure (degree Celsius)	Warmest year ranking
1948	-0.2	56
1949	-0.2	57
1950	-1.2	74
1951	-0.6	68
1952	0.8	23
1953	0.8	22
1954	0.0	47
1955	-0.2	58
1956	-0.8	71
1957	-0.3	64
1958	0.5	34
1959	-0.4	66
1960	0.4	37
1961	-0.2	61
1962	0.0	48
1963	0.2	42
1964	-0.6	69
1965	-0.6	70
1966	-0.3	63
1967	-0.4	65
1968	0.2	43
1969	0.4	40
1970	-0.2	59
1971	0.0	51
1972	-2.0	75.0
1973	0.6	28
1974	-0.8	72
1975	-0.1	55
1976	0.0	46
1977	1.0	19
1978	-0.5	67
1979	-0.2	62
1980	0.4	39
1981	2.0	6

Year	Temperature departure (degree Celsius)	Warmest year ranking
1982	-1.0	73
1983	0.1	44
1984	0.2	41
1985	0.0	50
1986	0.0	45
1987	1.5	12
1988	0.8	24
1989	-0.2	60
1990	-0.1	54
1991	0.4	36
1992	-0.1	53
1993	0.4	38
1994	0.5	35
1995	0.5	32
1996	-0.1	52
1997	0.6	29
1998	2.3	3
1999	1.7	9
2000	0.8	20
2001	1.8	8
2002	0.5	33
2003	1.0	18
2004	0.0	49
2005	1.6	10
2006	2.4	2
2007	0.8	21
2008	0.6	30
2009	0.7	25
2010	3.0	1
2011	1.3	13
2012	1.8	7
2013	0.7	26
2014	0.6	27
2015	1.3	14

Year	Temperature departure (degree Celsius)	Warmest year ranking
2016	2.1	4
2017	1.5	11
2018	0.6	31
2019	1.1	17

Year	Temperature departure (degree Celsius)	Warmest year ranking
2020	1.2	15
2021	2.1	5
2022	1.2	16

Note: Annual average temperature departures were computed for weather stations across Canada with sufficiently long data records to allow for trend calculation and were then interpolated to a 50-kilometre spaced grid. Annual grid point values were averaged together to produce an annual time series of temperature departures representing the entire country. Departures are calculated by subtracting the 1961 to 1990 reference value from the annual average.
Source: Environment and Climate Change Canada (2023) Adjusted and homogenized Canadian climate data.

Table A.2. Data for Figure 2. Seasonal average temperature departures compared with the 1961 to 1990 reference value, Canada, 1948 to 2022

Year	Temperature departure in winter (degree Celsius)	Temperature departure in spring (degree Celsius)	Temperature departure in summer (degree Celsius)	Temperature departure in autumn (degree Celsius)
1948	-0.5	-1.8	0.5	1.7
1949	-2.0	0.3	-0.1	0.9
1950	-3.1	-0.9	-0.8	-0.9
1951	-0.3	0.2	-0.3	-0.6
1952	-1.5	1.6	-0.1	0.7
1953	2.1	1.2	-0.1	1.3
1954	-0.4	-1.4	0.2	1.2
1955	0.8	-0.6	0.7	-0.3
1956	-0.4	-1.4	-0.5	-0.6
1957	-2.1	0.2	-0.5	0.5
1958	1.3	1.2	-0.1	0.1
1959	-0.9	-0.8	-0.5	-1.1
1960	2.5	-0.7	0.3	0.2
1961	0.6	-0.9	0.6	-0.4
1962	-1.6	-0.1	0.1	0.9
1963	0.4	-0.5	0.1	1.2
1964	1.3	-2.0	-0.6	-0.1
1965	-2.1	0.0	-0.7	-0.9
1966	-0.4	-0.1	0.2	-0.7
1967	-0.7	-2.0	-0.1	0.5
1968	0.5	0.7	-1.0	1.4
1969	0.3	-0.2	-0.4	0.2
1970	1.4	-0.4	0.4	0.2
1971	-1.3	0.5	0.1	0.5

Year	Temperature departure in winter (degree Celsius)	Temperature departure in spring (degree Celsius)	Temperature departure in summer (degree Celsius)	Temperature departure in autumn (degree Celsius)
1972	-3.6	-1.3	-0.8	-1.8
1973	-1.4	0.9	0.8	0.6
1974	-1.1	-2.0	-0.1	-0.5
1975	0.1	-0.2	0.8	0.1
1976	-0.5	0.3	0.0	0.2
1977	1.6	2.0	-0.2	0.7
1978	0.3	-0.8	-1.0	-1.4
1979	-1.7	-0.2	-0.2	0.7
1980	1.8	1.3	0.0	0.3
1981	2.4	1.5	0.5	1.5
1982	-0.9	-1.3	-0.5	-0.5
1983	0.3	-0.7	0.6	1.1
1984	0.1	1.0	0.6	-0.7
1985	-0.4	0.2	-0.3	-1.2
1986	1.8	0.5	-0.8	-1.8
1987	3.1	0.9	-0.1	1.2
1988	1.6	1.9	0.7	0.4
1989	0.0	-0.7	0.9	-0.6
1990	-1.0	1.2	0.4	-0.8
1991	-0.6	1.1	0.8	-0.5
1992	1.0	0.0	-0.9	-0.2
1993	-0.1	1.3	0.2	-0.5
1994	-1.5	0.9	0.7	1.4
1995	1.7	0.8	0.7	0.1
1996	-0.5	-0.5	0.6	-0.3
1997	0.5	-0.7	0.6	0.8
1998	2.8	2.8	1.7	2.4
1999	2.4	2.4	0.5	1.2
2000	2.4	1.3	0.2	0.8
2001	1.3	1.6	0.9	1.6
2002	2.3	-1.8	0.5	0.8
2003	2.1	0.1	0.8	1.6
2004	1.5	-0.5	-0.2	0.7
2005	0.4	2.0	0.6	1.8
2006	3.9	2.9	1.3	1.1
2007	3.1	0.3	0.9	0.7
2008	0.5	0.2	0.9	1.5
2009	0.2	-0.6	0.3	1.8
2010	4.1	4.0	1.2	2.2

Year	Temperature departure in winter (degree Celsius)	Temperature departure in spring (degree Celsius)	Temperature departure in summer (degree Celsius)	Temperature departure in autumn (degree Celsius)
2011	2.5	-0.2	1.1	2.1
2012	3.6	1.6	1.8	1.1
2013	1.5	0.5	0.9	1.3
2014	-0.4	-0.6	1.1	0.6
2015	0.8	1.1	0.9	1.8
2016	4.0	1.6	1.3	2.4
2017	3.0	0.7	0.9	1.1
2018	1.4	0.3	0.6	-0.7
2019	1.2	1.5	0.6	1.6
2020	2.0	0.0	1.2	0.8
2021	3.7	1.4	1.3	3.2
2022	0.0	0.6	1.6	2.1

Note: Seasonal average temperature departures were computed for weather stations across Canada with sufficiently long data records to allow for trend calculation and were then interpolated to a 50-kilometre spaced grid. Seasonal grid point values were averaged together to produce a seasonal time series of temperature departures representing the entire country. Seasons are defined as winter (December, January, and February), spring (March, April, and May), summer (June, July, and August), and autumn (September, October, and November). Departures are calculated by subtracting the 1961 to 1990 reference value from the annual average.
Source: Environment and Climate Change Canada (2023) Adjusted and homogenized Canadian climate data.

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