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

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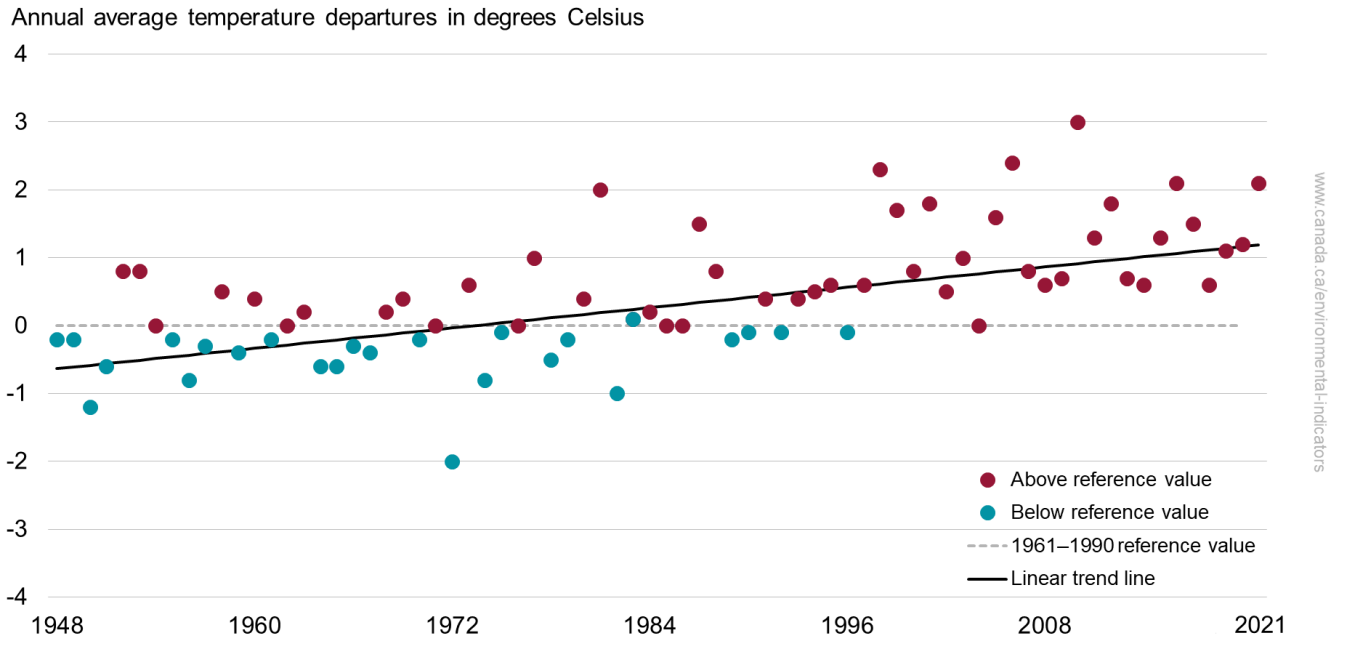
Temperature change in Canada

Changes in climate variables such as temperature, precipitation, and humidity affect a wide range of natural processes and human activities. For example, temperature change can influence crops, forests, infrastructure, the spread of disease, the availability of water and the health of ecosystems. Temperature is also 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. The indicators show the yearly and seasonal surface air temperature departures[1] for the years 1948 to 2021.

Key results

- In Canada, the national average temperature for the year 2021 was 2.1 degrees Celsius (°C) above the 1961 to 1990 reference value, making it the 5th warmest year since 1948
- From 1948 to 2021, 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 2021



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 (2022) Adjusted and homogenized Canadian climate data.

In addition to being one of the warmest years (5th) since nationwide recording began in 1948, the year 2021 also 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. The heat dome that affected the country over 2 weeks was responsible for over 1 000 new local daily temperature

[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".

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]

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 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. Because some further warming is unavoidable, these trends will continue (Bush and Lemmen, 2019).

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).

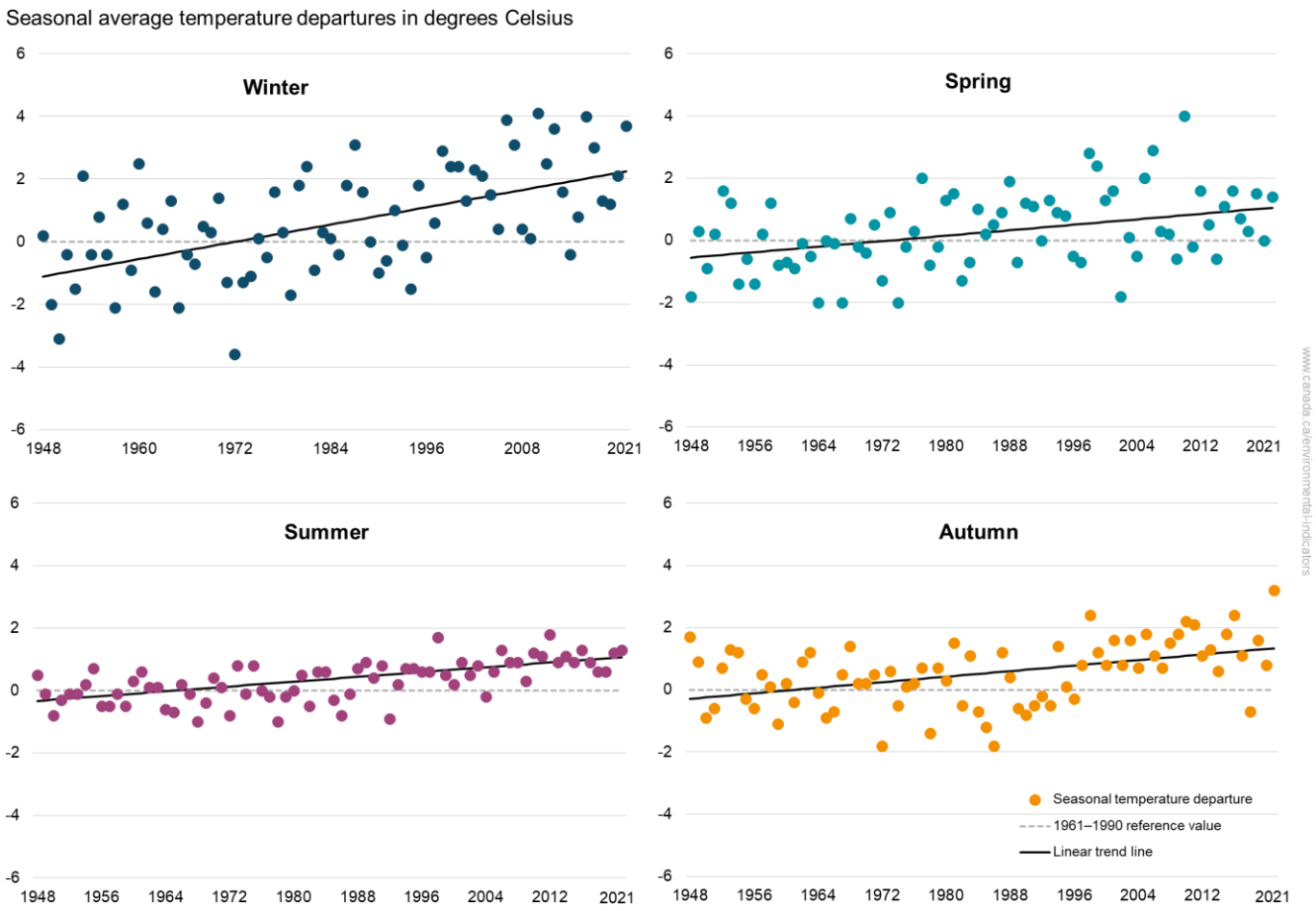
[2] Government of British Columbia (2022) Extreme Heat and Human Mortality: A Review of Heat-Related Deaths in B.C. in Summer 2021. Retrieved on July 7, 2022.

Seasonal temperature change

Key results

- Like the national annual average temperature, seasonal average temperature increased over the 1948 to 2021 period. Warming trends were detected for all 4 seasons:
    - winter,[3] with an increase of 3.5°C
    - spring, with an increase of 1.6°C
    - summer, with an increase of 1.5°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 2021



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 (2022) Adjusted and homogenized Canadian climate data.

[3] Winter 2021 includes the months of December 2020, January 2021, and February 2021.

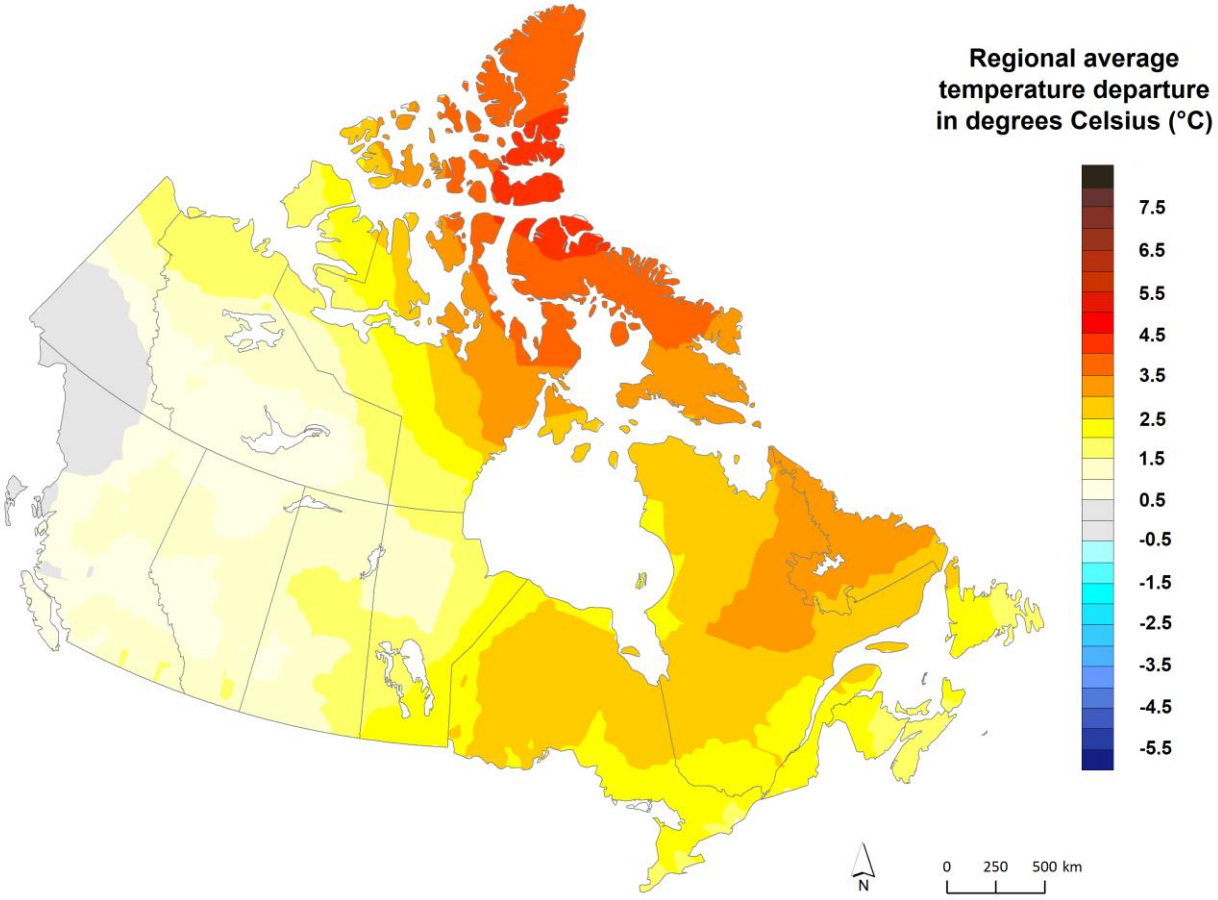
Regional temperature

Key results

In 2021,

- most of Canada experienced annual temperatures above the baseline average
- annual temperatures near the baseline average were observed in the southern areas of Yukon and northern British Columbia
- most of eastern Canada and northern parts of the Arctic archipelago experienced temperatures notably above the 1961 to 1990 reference value

Figure 3. Regional average temperature departures from the 1961 to 1990 reference value, Canada, 2021



Note: 2021 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 (2022) Canadian gridded temperature and precipitation anomalies.

About the indicators

What the indicators measure

Indicators of Temperature change in Canada show the yearly and seasonal surface air temperature departures for the years 1948 to 2021. As well, they present a spatial distribution of surface air temperature departures for the year 2021.

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 Fifth 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

Much of Canadian economic and social activity is climate dependent. Understanding how Canada's climate is changing is important for developing adaptive responses. 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.

Effective action on climate change

These indicators support the measurement of progress towards the following 2019 to 2022 Federal Sustainable Development Strategy long-term goal: A low-carbon economy contributes to limiting global average temperature rise to well below 2°C and supports efforts to limit the increase to 1.5°C.

These indicators are being proposed to track progress in the draft 2022 to 2026 Federal Sustainable Development Strategy.

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 data collected in weather stations across Canada for the period 1948 to 2021.

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 74-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

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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 2021

Year	Temperature departure (degree Celsius)	Warmest year ranking
1948	-0.2	55
1949	-0.2	56
1950	-1.2	73
1951	-0.6	67
1952	0.8	22
1953	0.8	21
1954	0.0	46
1955	-0.2	57
1956	-0.8	70
1957	-0.3	63
1958	0.5	33
1959	-0.4	65
1960	0.4	36
1961	-0.2	60
1962	0.0	47
1963	0.2	41
1964	-0.6	68
1965	-0.6	69
1966	-0.3	62
1967	-0.4	64
1968	0.2	42
1969	0.4	39
1970	-0.2	58
1971	0.0	50
1972	-2.0	74
1973	0.6	27
1974	-0.8	71
1975	-0.1	54
1976	0.0	45
1977	1.0	18
1978	-0.5	66
1979	-0.2	61
1980	0.4	38
1981	2.0	6

Year	Temperature departure (degree Celsius)	Warmest year ranking
1982	-1.0	72
1983	0.1	43
1984	0.2	40
1985	0.0	49
1986	0.0	44
1987	1.5	12
1988	0.8	23
1989	-0.2	59
1990	-0.1	53
1991	0.4	35
1992	-0.1	52
1993	0.4	37
1994	0.5	34
1995	0.5	31
1996	-0.1	51
1997	0.6	28
1998	2.3	3
1999	1.7	9
2000	0.8	19
2001	1.8	8
2002	0.5	32
2003	1.0	17
2004	0.0	48
2005	1.6	10
2006	2.4	2
2007	0.8	20
2008	0.6	29
2009	0.7	24
2010	3.0	1
2011	1.3	13
2012	1.8	7
2013	0.7	25
2014	0.6	26
2015	1.3	14

Year	Temperature departure (degree Celsius)	Warmest year ranking
2016	2.1	4
2017	1.5	11
2018	0.6	30

Year	Temperature departure (degree Celsius)	Warmest year ranking
2019	1.1	16
2020	1.2	15
2021	2.1	5

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 (2022) 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 2021

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	0.2	-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	-0.4	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	1.2	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	-1.3	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	1.8	0.8	0.7	0.1
1996	-0.5	-0.5	0.6	-0.3
1997	0.6	-0.7	0.6	0.8
1998	2.9	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	0.4	0.2	0.9	1.5
2009	0.1	-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	1.6	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	1.3	0.3	0.6	-0.7
2019	1.2	1.5	0.6	1.6
2020	2.1	0.0	1.2	0.8
2021	3.7	1.4	1.3	3.2

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 (2022) Adjusted and homogenized Canadian climate data.

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