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TEMPERATURE CHANGE IN CANADA

CANADIAN ENVIRONMENTAL SUSTAINABILITY INDICATORS

Canada

Suggested citation for this document: Environment and Climate Change Canada (2024) Canadian Environmental Sustainability Indicators: Temperature change in Canada. Consulted on *Month day, year*. Available at: www.canada.ca/en/environment-climate-change/services/environmental-indicators/temperature-change.html.

Cat. No.: En4-144/77-2024E-PDF
ISBN: 978-0-660-72019-7
Project code: EC24019

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CANADIAN ENVIRONMENTAL SUSTAINABILITY INDICATORS

TEMPERATURE CHANGE IN CANADA

July 2024

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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.

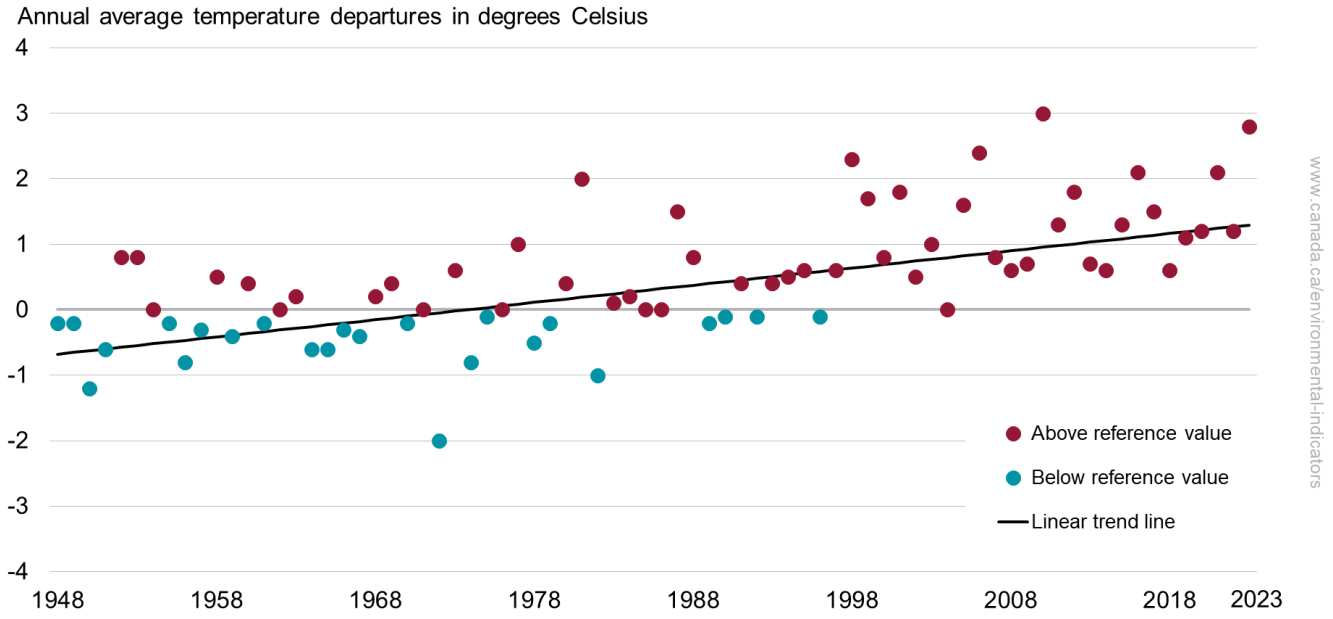
Using the average temperature values from 1961 to 1990 as a baseline, this indicator compares how much the temperature for a given year departs from the "normal". The indicator shows the national annual and seasonal air temperature departures[1] for the years 1948 to 2023. It also represents spatially the temperature departures for 2023 and the change in temperature since 1948.

National annual temperature change

Key results

- In Canada, the national average temperature for the year 2023 was 2.8 degrees Celsius (°C) above the 1961 to 1990 reference value, making it the second warmest year since 1948
- From 1948 to 2023, there is a trend in annual average temperature departures, showing 2.0°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 2023



Data for Figure 1

Note: Departures are calculated by subtracting the 1961 to 1990 reference value from the annual average. A positive departure indicates that the observed temperature was warmer than the reference value, while a negative departure indicates the opposite.
Source: Environment and Climate Change Canada (2024) Adjusted and homogenized Canadian climate data.

[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.

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.

While 2023 was the second warmest year in Canada, the World Meteorological Organization established that, globally, it was the warmest year on record.[2]

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).

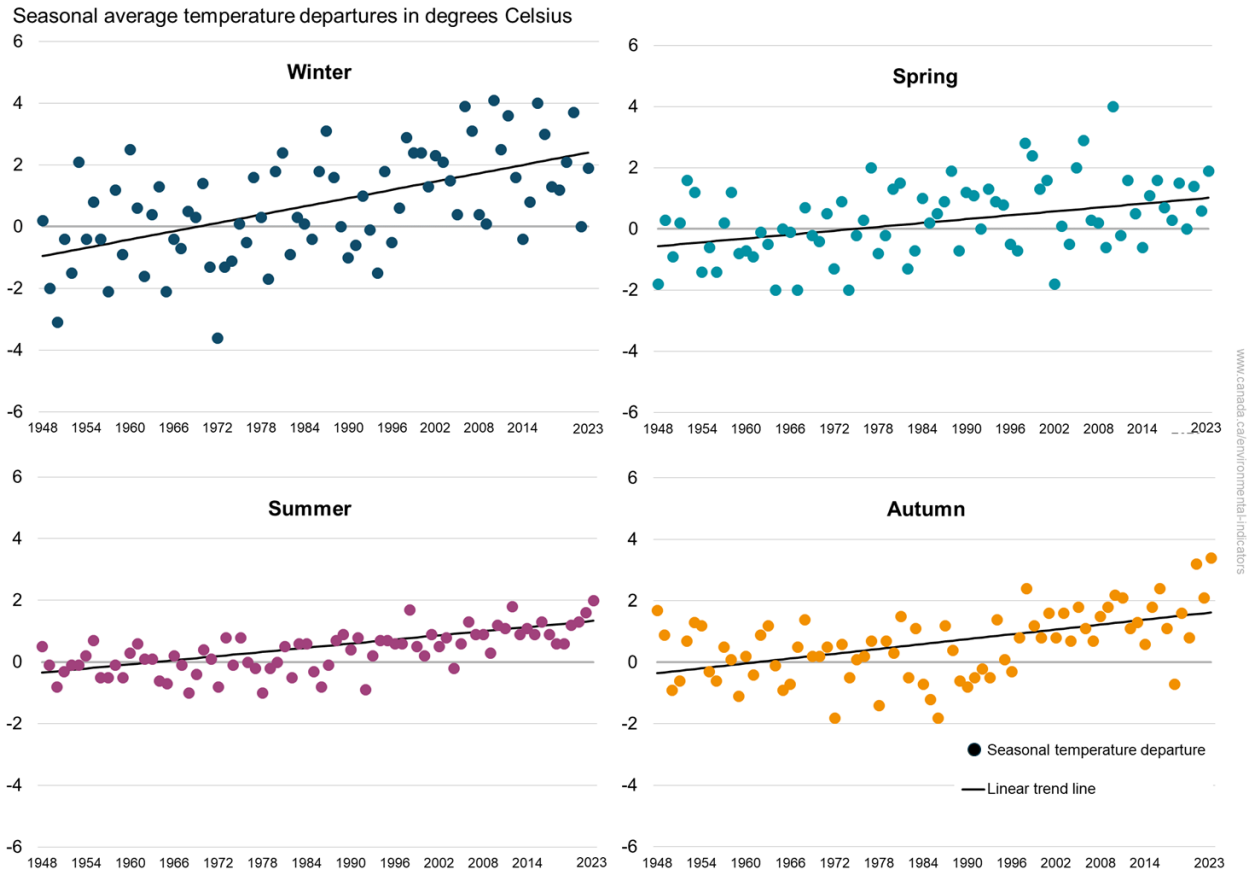
[2] World Meteorological Organization (2024) State of the global climate 2023. Retrieved on July 2, 2024.

National seasonal temperature change

Key results

- Like the national annual average temperature, seasonal average temperature increased over the 1948 to 2023 period. Warming trends were detected for all 4 seasons:
    - winter,[3] with an increase of 1.9°C
    - spring, with an increase of 1.9°C
    - summer, with an increase of 2.0°C
    - autumn, with an increase of 3.4°C
- The warmest winter and spring recorded were both in 2010. The warmest summer and autumn were in 2023

Figure 2. Seasonal average temperature departures compared with the 1961 to 1990 reference value, Canada, 1948 to 2023



Data for Figure 2

Note: Departures are calculated by subtracting the 1961 to 1990 reference value from the seasonal average. A positive departure indicates that the observed temperature was warmer than the reference value, while a negative departure indicates the opposite. 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 (2024) Adjusted and homogenized Canadian climate data.

[3] Winter 2023 includes the months of December 2022, January 2023, and February 2023.

Regional temperature change

Regional temperature departures

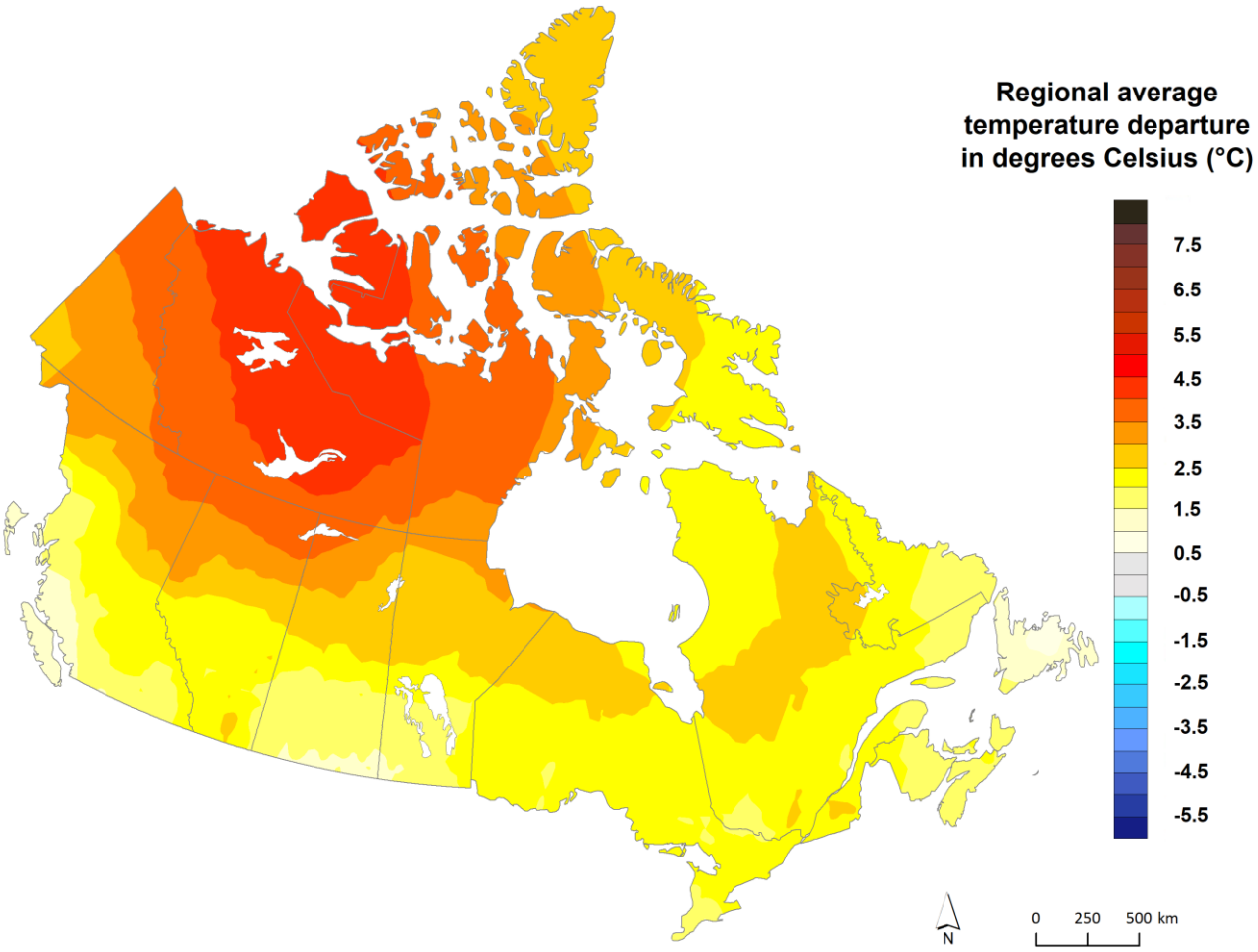
This section presents the difference between temperatures recorded in 2023 and the normal (departures from the 1961 to 1990 reference value) at the regional level.

Key results

In 2023,

- All of Canada experienced annual temperatures above the 1961 to 1990 reference value
- Most of northern Canada and the northern parts of British Columbia, the Prairies, Ontario and Quebec, experienced temperatures significantly above the baseline average
- Annual temperatures that least exceeded the baseline average were observed in eastern Newfoundland and Labrador and western British Columbia

Figure 3. Regional average temperature departures from the 1961 to 1990 reference value, Canada, 2023



Note: 2023 annual average temperature departures were computed for 561 active weather stations across Canada. Departures are calculated by subtracting the 1961 to 1990 reference value from the annual average. A positive departure indicates that the observed temperature was warmer than the reference value, while a negative departure indicates the opposite.
Source: Environment and Climate Change Canada (2024) Canadian gridded temperature and precipitation anomalies.

Regional temperature change trends

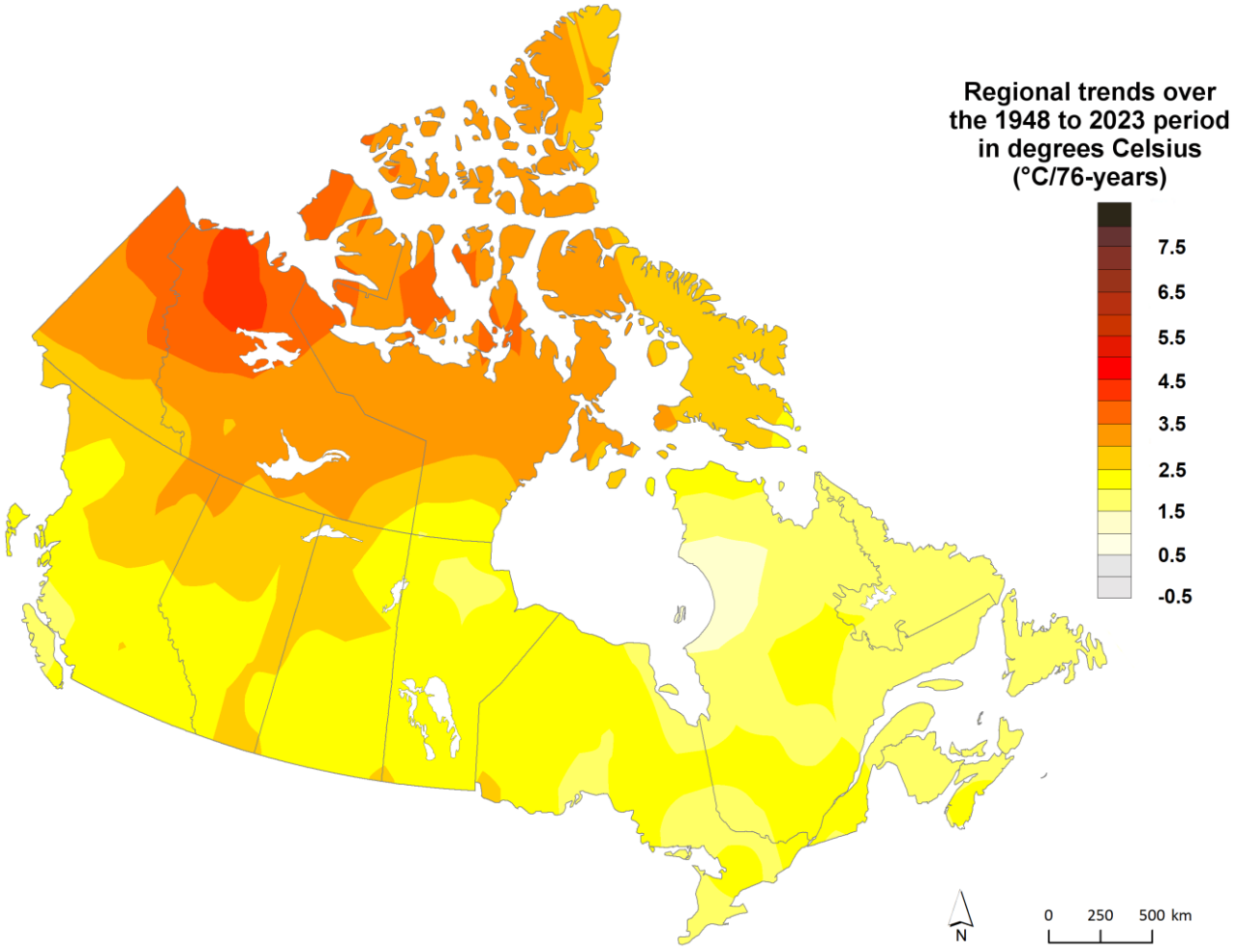
This section presents the long-term trends in temperature change over the period from 1948 to 2023 at the regional level.

Key results

Over the period from 1948 to 2023,

- All of Canada experienced an increase in annual mean temperature
- Most of northern Canada and the northern parts of British Columbia, Alberta and Saskatchewan experienced an increase in temperature exceeding 2°C
- Significant trends in annual mean temperature ranging from 1° to 3°C were observed almost everywhere across the country

Figure 4. Regional temperature change trend, Canada, 1948 to 2023



Note: Annual average temperature trends were computed for 780 weather stations across Canada. The change in temperature was obtained through a linear trend analysis.
Source: Environment and Climate Change Canada (2024) Canadian gridded temperature and precipitation anomalies.

About the indicator

What the indicator measures

The indicator of Temperature change in Canada shows the yearly and seasonal surface air temperature departures for the years 1948 to 2023. As well, it presents a spatial distribution of surface air temperature departures for the year 2023 and trends in temperature over the period from 1948 to 2023.

An annual departure (or anomaly) is the difference between the value for a given year and a baseline value. The baseline values used in this indicator 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 (°C) and calculated using data from weather stations across Canada with sufficiently long data records to allow for a meaningful trend calculation.

Why this indicator is 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 indicator helps 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

This indicator supports the measurement of progress towards Goal 13 of the 2022 to 2026 Federal Sustainable Development Strategy: Take action on climate change and its impacts.

In addition, the indicator contributes to the Sustainable Development Goals of the 2030 Agenda for Sustainable Development. It is linked to Goal 13, Take urgent action to combat climate change and its impacts.

Related indicators

The Precipitation change in Canada indicator presents annual, seasonal and regional precipitation departures (or anomalies).

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

The Snow cover indicator provides information on spring snow cover extent and annual snow cover duration in Canada.

Data sources and methods

Data sources

The Temperature change in Canada indicator is 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 indicator is calculated using surface air temperature data collected in weather stations across Canada for the period 1948 to 2023.

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 indicator.

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 the previous year, January and February of the current year), 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.

Non-parametric statistical tests were carried out on annual and seasonal average temperature departures data to detect the presence of a linear trend and, if present, to determine the orientation (positive or negative) and magnitude of the rate of change (slope). The standard Mann-Kendall trend test was used to detect trend presence and orientation, while the Sen's pairwise slope method was used to estimate the slope. A trend was reported when the Mann-Kendall test indicated the presence of a trend at the 95% confidence level.

For the regional temperature change trend, statistical tests were carried out on the temperature departure time series for each individual grid cell. From the obtained slope, the change in temperature was calculated over the period from 1948 to 2023: slope value (°C/year) x 76 years. For 99% of the cells, the Mann-Kendall test indicated the presence of a trend at the 95% confidence level. However, the trend results from all cells were displayed on the map.

Recent changes

Regional temperature change trends has been added to present the long-term trend across Canada for the period from 1948 to 2023.

Caveats and limitations

Breaks in the data can be a concern. To mitigate this, the Temperature change in Canada indicator uses 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 76-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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Canada's top 10 weather stories of 2023

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 2023

Year	Temperature departure (degree Celsius)	Warmest year ranking
1948	-0.2	57
1949	-0.2	58
1950	-1.2	75
1951	-0.6	69
1952	0.8	24
1953	0.8	23
1954	0.0	48
1955	-0.2	59
1956	-0.8	72
1957	-0.3	65
1958	0.5	35
1959	-0.4	67
1960	0.4	38
1961	-0.2	62
1962	0.0	49
1963	0.2	43
1964	-0.6	70
1965	-0.6	71
1966	-0.3	64
1967	-0.4	66
1968	0.2	44
1969	0.4	41
1970	-0.2	60
1971	0.0	52
1972	-2.0	76
1973	0.6	29
1974	-0.8	73
1975	-0.1	56
1976	0.0	47
1977	1.0	20
1978	-0.5	68
1979	-0.2	63
1980	0.4	40
1981	2.0	7
1982	-1.0	74
1983	0.1	45
1984	0.2	42
1985	0.0	51
1986	0.0	46
1987	1.5	13
1988	0.8	25
1989	-0.2	61
1990	-0.1	55
1991	0.4	37
1992	-0.1	54
1993	0.4	39
1994	0.5	36
1995	0.5	33
1996	-0.1	53
1997	0.6	30
1998	2.3	4
1999	1.7	10
2000	0.8	21
2001	1.8	9
2002	0.5	34
2003	1.0	19
2004	0.0	50
2005	1.6	11
2006	2.4	3
2007	0.8	22
2008	0.6	31
2009	0.7	26
2010	3.0	1
2011	1.3	14
2012	1.8	8
2013	0.7	27

Year	Temperature departure (degree Celsius)	Warmest year ranking
2014	0.6	28
2015	1.3	15
2016	2.1	5
2017	1.5	12
2018	0.6	32

Year	Temperature departure (degree Celsius)	Warmest year ranking
2019	1.1	18
2020	1.2	16
2021	2.1	6
2022	1.2	17
2023	2.8	2

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. A positive departure indicates that the observed temperature was warmer than the reference value, while a negative departure indicates the opposite.
Source: Environment and Climate Change Canada (2024) 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 2023

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

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)
1970	1.4	-0.4	0.4	0.2
1971	-1.3	0.5	0.1	0.5
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

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)
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
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
2022	0.0	0.6	1.6	2.1
2023	1.9	1.9	2.0	3.4

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. A positive departure indicates that the observed temperature was warmer than the reference value, while a negative departure indicates the opposite.
Source: Environment and Climate Change Canada (2024) Adjusted and homogenized Canadian climate data.

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