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Canada

CCCR2026

REPORT SUMMARY

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This report contributes to the *Canada in a Changing Climate*: National Assessment Process, the national assessment of how and why Canada's climate is changing; the impacts of these changes on our communities, health, environment, and economy; and how we are adapting across the country. To find out more, please visit: canada.ca/changingclimate

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Report Summary

Canada's Changing Climate Report 2026

Chapter description

This report summary presents the main findings of the second edition of *Canada's Changing Climate Report* (CCCR2026). It also includes brief information about the overall content of the report and the assessment process and provides guidance on how to find information in the main chapters.

RS.1 About this report

This second edition of *Canada's Changing Climate Report* (CCCR2026) is a scientific assessment of past and future changes in Canada's climate. It provides an update to the first edition of *Canada's Changing Climate Report* (CCCR2019) (Bush & Lemmen, 2019), drawing on new science published in peer-reviewed scientific literature. It is similar in scope to the first edition, focusing on changes in the physical climate system. Assessing the impacts of climate change in Canada is outside the scope of this report. The report was primarily authored by experts from the Canadian climate science community, who were selected following an open call for authors. Formally, this report delivers on commitments in the Government of Canada Adaptation Action Plan to develop regular Canada-wide climate science assessments to inform decision-making on adaptation. Chapter 1 of the report provides more detail about the assessment process, including how this report contributes to the *Canada in a Changing Climate*: National Assessment Process.

RS.1.1 What's new

This report has new features compared to the 2019 edition (**Figure RS.1**). These new features are intended to cover more topics of interest, to provide both overview material and detailed technical material to help serve the needs of a variety of audiences, and to provide a specific chapter to help bridge the gap for decision-makers between using the information in this assessment report and finding more tailored information to support local adaptation planning and activities. A new feature for CCCR2026 is the inclusion of First Nations, Inuit, and Métis place-based case stories that document Indigenous science, observations, and perspectives on the implications of climate change (section RS.3, **Box RS.1**). These case stories provide complementary knowledge to the lines of evidence drawn from Western science that are formally assessed in this report. Chapter 1, section 1.3.5, explains some of the opportunities and challenges encountered during the CCCR2026 assessment process when engaging ethically and equitably with Indigenous experts and Indigenous science.

New features introduced in the second edition of *Canada's Changing Climate Report*

Figure take-away: CCCR2026 introduces some new features to expand the topics covered and improve accessibility of the report to different audiences.

Multi-audience structure

- Framing and guide to the report (Chapter 1)
- Synthesis of past and future changes in climate (Chapters 2–3)
- Plain language chapter summaries (all chapters)
- In-depth assessment of specific topics (Chapters 2–9)

New chapter topics

- Large-scale phenomena in the atmosphere and ocean that influence regional changes in climate (Chapter 4)
- Climate extremes, including compound events (Chapter 8)
- Global and Canadian carbon cycle insights for climate change mitigation (Chapter 9)

Indigenous science

- Improved consideration of Indigenous Knowledge systems and Indigenous science
- Place-based case stories by First Nations, Inuit, and Métis included

Bridge for decision-makers

- Improved content to bridge the gap between climate science assessment results and climate services (Chapter 10)
- Synthesis of findings in hazard tables

Figure RS.1: The second edition of *Canada's Changing Climate Report* (CCCR2026) includes a multi-layered structure that improves reader navigability for a variety of audiences. New chapters provide additional or expanded coverage of topics in climate science. Other new features are the inclusion of case stories from First Nations, Inuit, and Métis authors, and guidance on accessing and using tailored climate data for adaptation. Source: Chapter 1, **Figure 1.4.**

In addition to having new features, this report builds on important developments in climate science and on an increase in the number of scientific studies that made it possible to assess new topics. CCCR2026:

- uses enhanced observational datasets to provide a much more comprehensive assessment of past changes in Canada's climate and of the consistency of these changes with human influence (multiple chapters)

- assesses human-induced warming in Canada since the mid-19th century as well as since the mid-20th century (Chapter 2)
- draws on a stronger evidence base for the formal attribution of changes in some climate variables to human influence (multiple chapters)
- includes decadal predictions of climate change to help characterize near-term changes in temperature across Canada (Chapter 3)
- assesses long-term changes in climate in Canada for a range of policy-relevant greenhouse gas emissions scenarios and, for some variables, on the basis of future global warming levels (multiple chapters)
- narrows the range of long-term projected warming under a given emissions scenario, by constraining those projections with observations (Chapter 3)
- includes an assessment of past and future changes in large-scale atmosphere and ocean circulation patterns that influence regional climate variability in Canada (Chapter 4)
- expands the assessment of climate-related changes in freshwater availability across Canada to include the atmospheric component of the water cycle (Chapter 5)
- introduces landscape change as a new indicator of permafrost thaw (Chapter 6)
- includes an assessment of marine heatwaves (Chapter 7)
- includes an assessment of multiple types of extreme precipitation and of compound extreme events (Chapter 8)
- includes an assessment of trends in Canadian land and ocean carbon sources and sinks (Chapter 9)
- identifies key knowledge gaps and emerging issues (chapters 2 to 8)

RS.2 Findings of this report

The overarching conclusions of CCCR2026 are captured in a set of headline statements that can be found below. These headline statements tell a concise story about past and future changes in climate in Canada based on the findings of this report and encourage readers to delve into the report to learn more. Detailed findings of the report are provided by the chapter key messages, which can be found in the Annex to this summary and in the main chapters of this report.

An important part of a scientific assessment is determining and communicating the degree of uncertainty associated with assessment findings. In both CCCR2019 and this report, the authors adopted the calibrated uncertainty language[1] set out by the Intergovernmental Panel on Climate Change (IPCC) for use in its *Fifth Assessment Report* and *Sixth Assessment Report* (Mastrandrea et al., 2010). Unless otherwise stated, there is at least *high confidence* in the findings in this summary. *High confidence* findings are substantiated by a robust evidence base and strong agreement across independent scientific studies and multiple lines of evidence. For readability, the headline statements do not include confidence terms. Round brackets at the end of the headline statements contain references to the main sections of the report that provide supporting evidence for these statements, based on peer-reviewed scientific literature. For example, "2.2" refers to Chapter 2, section 2.2. Also for readability, the headline statements provide central best estimates for past and future changes. Uncertainty ranges are included in the chapter key messages. In this report summary, additional context, findings, and visualizations of key findings are provided below each headline statement, drawing primarily from the chapter key messages.

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1 This report uses the same calibrated uncertainty language as in the IPCC's fifth and sixth assessment reports. The following five terms are used to express assessed levels of confidence in findings based on the availability, quality and level of agreement of the evidence: *very low, low, medium, high,* and *very high*. The following terms are used to express assessed likelihoods of results: *virtually certain* (99%–100% probability), *extremely likely* (95%–100% probability), *very likely* (90%–100% probability), *likely* (66%–100% probability), *about as likely as not* (33%–66% probability), *unlikely* (0%–33% probability), *very unlikely* (0%–10% probability), *extremely unlikely* (0%–5% probability), and *exceptionally unlikely* (0%–1% probability). Occasionally, the calibrated likelihood term *more likely than not* (50%-100% probability) is also used. Confidence and likelihood terms are typeset in italics in the text. See guidance on calibrated uncertainty language in Chapter 1, section 1.4.3.

RS.2.1 Warming and warming-driven changes in climate

Changes in climate are occurring across Canada against a backdrop of global climate change. The IPCC concluded that human activities, principally through emissions of greenhouse gases, have unequivocally caused global warming (IPCC, 2021). The IPCC also concluded that limiting human-caused global warming requires net-zero carbon dioxide (CO_2) emissions, and that even after net-zero CO_2 emissions are reached and sustained, global temperature will remain elevated for millennia. These conclusions underscore the irreversible nature of human-caused climate change. The pace and scale of changes in climate that people in Canada will need to adapt to, especially in the second half of the century, when the current generation of children will be adults, will be determined by how global greenhouse gas emissions evolve. Since risks and adverse impacts from climate change escalate with every increment of global warming (IPCC, 2022), consequences of high emissions scenarios are much more severe than those of low emissions scenarios for those living in Canada and elsewhere.

Headline Statement 1

Canada has warmed over the past 75 years due to emissions of greenhouse gases from human activities. Over this period Canada has warmed by 2.0°C and Canada's North has warmed by 2.6°C. (2.2, 2.4, 4.2)

The coverage of temperature observations across Canada becomes extensive enough to confidently estimate annual temperature changes in Canada from 1948 onwards. The best estimate of warming in Canada over the full observation record from 1948 to 2023 is 2.0°C, while that for Canada's North[2] (Yukon, the Northwest Territories, and Nunavut) is 2.6°C. Annual average temperatures have risen almost everywhere in Canada. Canada's annual average temperature exceeded the 1961–1990 average in 30 of the 33 years after 1990. Canada has warmed in all regions and seasons, but warming has been greater in winter and fall than in spring and summer. Drawing on new and stronger evidence, there is higher confidence in the attribution of warming in Canada to human influence than the assessment made in CCCR2019.

2 In this report summary you will see three different terms used to refer to northern Canada. The term Canada's North is used to refer to the land area bounded by the territorial borders of Yukon, Northwest Territories and Nunavut combined. The term northern Canada is used to refer to the land area north of the 60th parallel (60°N latitude). The term Canadian Arctic is used to refer to the Canadian land area north of the Arctic Circle and adjacent seas. The choice to use one or the other of these regions in an analysis is determined by data availability, and the geographic scale and scope relevant to a particular analysis.

Past changes in annual average temperature across Canada

Figure take-away: Canada has warmed strongly over the past 75 years, with the greatest warming in the North.

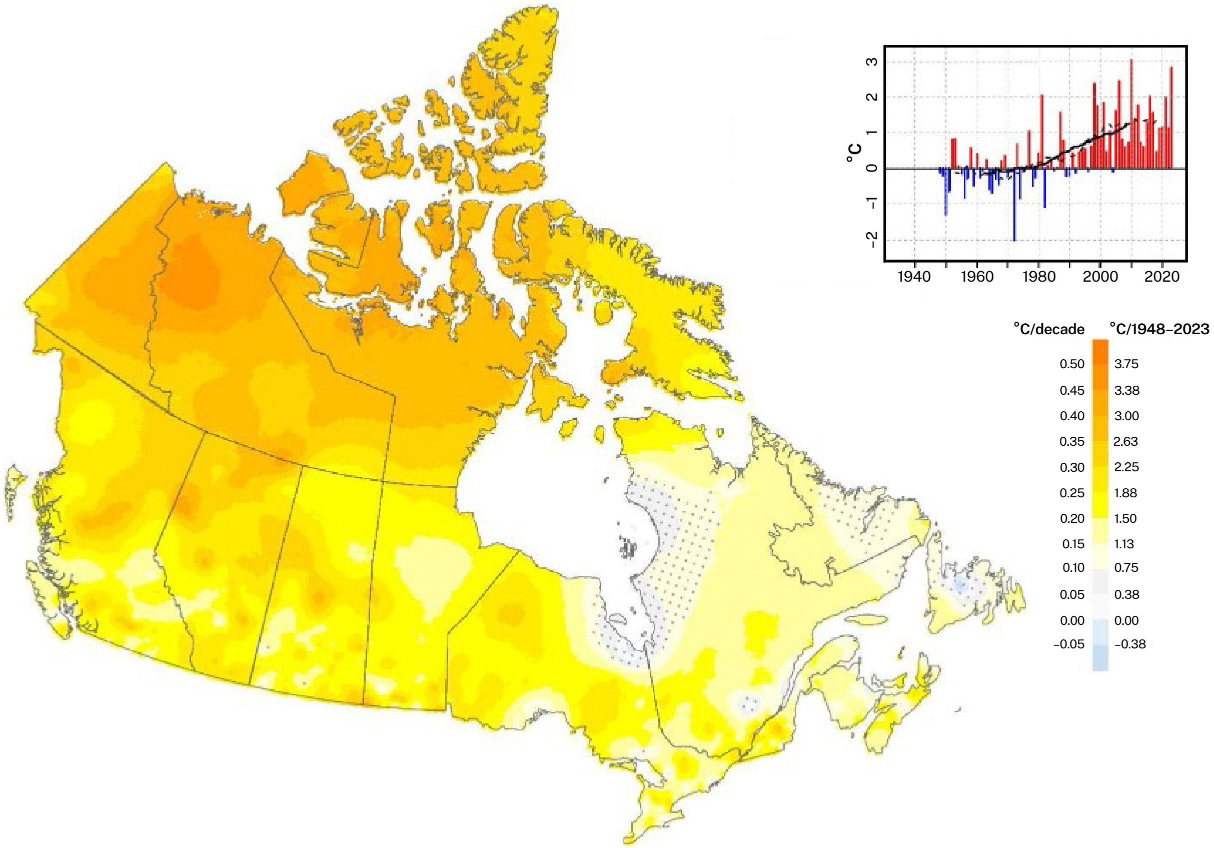


Figure RS.2: Map and time series of observed changes in annual average daily mean temperatures across Canada over the period from 1948 to 2023. Areas without dots are areas where the trends are statistically significant at the 5% level (meaning there is a ≤ 5% chance of concluding that an effect or trend exists when it does not). Source: Chapter 2, **figures 2.6** and **2.7**.

Headline Statement 2

Canada has warmed rapidly over the past 50 years, consistent with rapid global warming. Since 1970, Canada has warmed nearly twice as fast as the global average, and the Canadian Arctic has warmed three times as fast as the global average. (2.2, 2.4, 4.2)

Most of the warming since 1948 has happened since 1970, both in Canada and globally. Over this period, warming has happened more rapidly in Canada than in most other land areas, including the contiguous United States to our south, because our northern climate, particularly at higher latitudes, is affected by Arctic amplification. This phenomenon of greater warming in the Arctic than for the world as a whole is due to climate feedbacks that amplify warming in this region. Arctic amplification, and the greater rate of warming in Canada's Arctic compared to the rest of Canada, will continue over the 21st century.

Past trends in surface temperature for Canada, the Canadian Arctic, and the global average

Figure take-away: Canada has warmed at nearly twice the rate of the global average, and the Canadian Arctic has warmed at three times the rate of the global average since 1970.

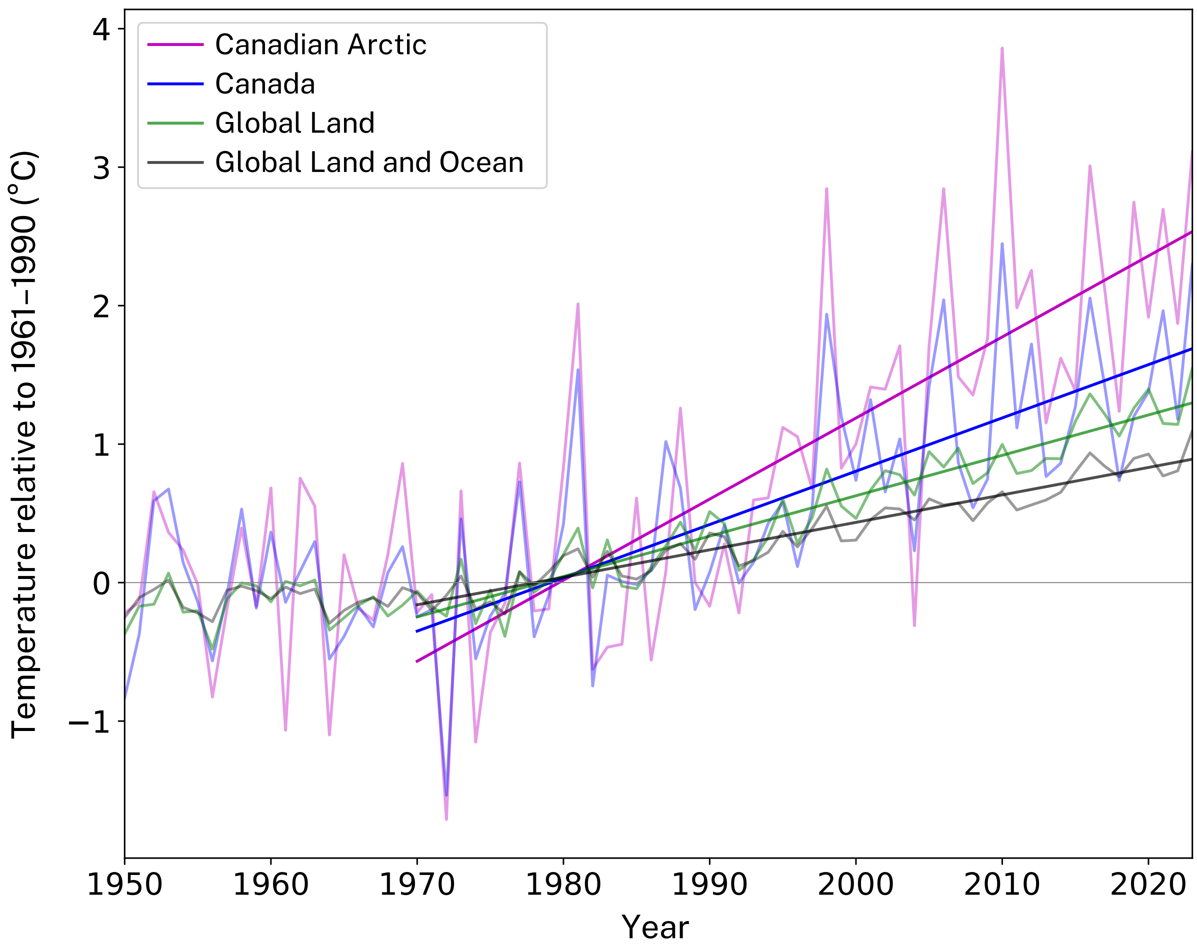


Figure RS.3: Observations of annual average surface temperature for the Canadian Arctic (magenta curve), for Canada as a whole (blue curve), the global land area (green curve), and the combined global land and ocean area (gray curve) from 1950 to 2023. The Canadian Arctic is bounded by 66.5°N to 83.11°N and 219°E to 307.38°E, which encompasses land north of the Arctic Circle and adjacent ocean areas. Source: Chapter 4, **FAQ 4.1 Figure 1.**

Headline Statement 3

Annual total precipitation has increased in Canada over the past 75 years, with the largest percentage increases in northern Canada. Annual total precipitation in Canada has increased much faster than for the global land area over this time frame. (2.2, 2.5)

The coverage of precipitation observations across Canada becomes extensive enough to confidently estimate annual precipitation changes in Canada from 1949 onwards. In CCCR2019, based on observations up to 2012, there was only *medium confidence* that annual precipitation had increased in Canada. Based on observations from 1949 to 2023, there is now *very high confidence* that annual precipitation has increased and that it has increased much faster in Canada than for the global land area. This finding, along with the higher relative increase in precipitation in northern Canada, is an expected feature of human-induced climate change. The best estimate of the annual precipitation increase in Canada is 9.7% from 1949 to 2023, with most of the increase attributable to human influence. The highest increase (expressed as a percentage) was observed in Canada's North (Yukon, the Northwest Territories, and Nunavut), where the regional average increased by 18.9% from 1949 to 2023.

Past changes in annual precipitation amounts across Canada

Figure take-away: Annual precipitation amounts have decreased in a few regions, but there has been an increase for Canada as a whole.

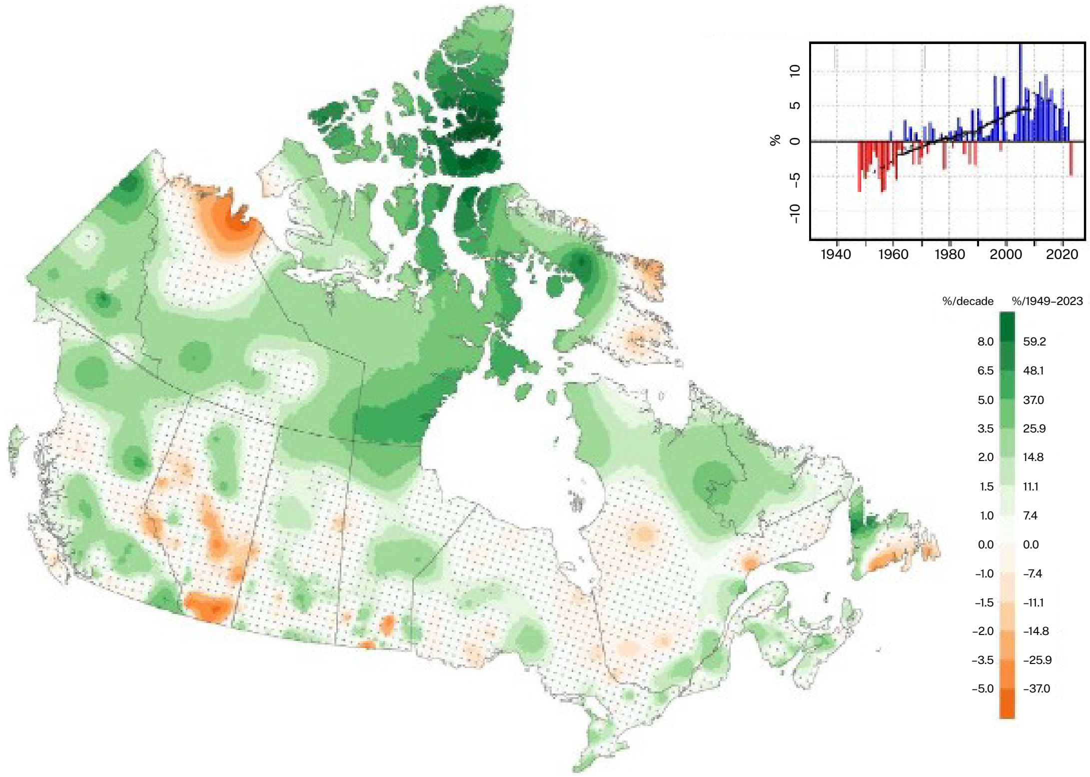


Figure RS.4: Map and time series showing changes in annual precipitation amounts across Canada for 1949–2023, expressed as a percentage of the average amount during the baseline (1961–1990). Areas without dots are areas where the trends are statistically significant at the 5% level (meaning there is a ≤ 5% chance of concluding that an effect or trend exists when it does not). Source: Chapter 2, **figures 2.11 and 2.12**.

Headline Statement 4

Warming temperatures have driven wide-ranging, interconnected, and sustained changes across Canada. The changes include more extreme heat, less extreme cold, longer growing seasons, longer fire seasons, earlier peak stream flow, shorter snow and ice cover seasons, thinning glaciers, thawing permafrost, warming oceans, and rising sea level. Human-caused warming is the only explanation for the collective changes observed. (2.2, 2.4, 2.5, 5.3, 6.2, 6.3, 6.4, 6.5, 6.7, 7.2, 7.4, 8.2, 8.7)

The effects of warming temperatures can be seen throughout Canada's environment. Changes consistent with a warming climate are observed in the atmosphere, on land, in freshwater, and in the ocean. The overall body of evidence, including the results of detection and attribution studies and knowledge of the physical processes by which climate warming drives other changes in the climate system, points unambiguously to human influence as the dominant cause of the observed changes.

Synthesis of past changes in the climate system across Canada

Figure take-away: The effects of a warming climate have been observed throughout the climate system in Canada.

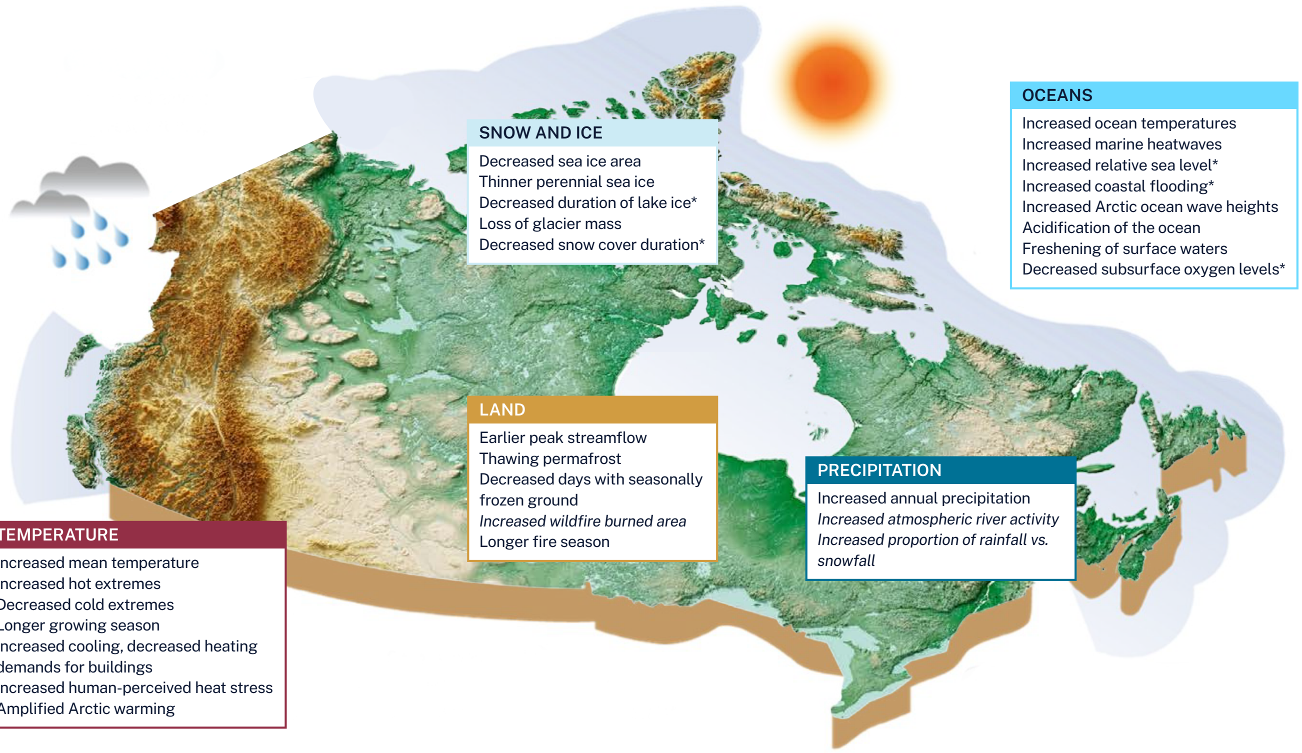


Figure RS.5: Synthesis of observed changes throughout the climate system in Canada. The changes noted are observed with *high* or *very high confidence*, except those in italics, which are observed with *medium confidence.* Changes with an asterisk indicate the statement is only applicable in some of the regions where the variable is observed. The blue shading in marine areas represents Canada's Exclusive Economic Zone. However, some of the changes noted for oceans in the figure have been assessed for ocean regions that extend beyond the Exclusive Economic Zone. Source: Chapter 2, **Figure 2.3**.

Headline Statement 5

In the near term, annual average temperature in Canada is expected to rise by about 1°C from 2021 to 2040. This unavoidable warming will exacerbate climate trends that are already observed. (3.2, 3.4)

The near term is an important time frame for many adaptation decision-makers to consider; therefore, greater emphasis is given to this time frame in this report than in CCCR2019. The amount of climate warming in the near term, defined in this report as 2021 to 2040, is largely independent of assumptions about how societies, economies, and technology will evolve, as emissions do not diverge much across different scenarios over this time frame. Canadian average temperature is projected to rise by about 0.9°C from 2021 to 2040, no matter how global emissions change. Canada is projected to be 2.7°C warmer on average over the two decades from 2021 to 2040 compared to the levels in the pre-industrial period (approximated in this report as 1850 to 1900), which is close to twice the projected global warming of 1.5°C for the same period. Note that the Paris Agreement commits countries to pursuing efforts to limit global warming to this level.

Headline Statement 6

Whether warming in Canada intensifies or stabilizes in the second half of the century will be determined by the level of global greenhouse gas emissions. Warming in Canada will intensify as long as global greenhouse gas emissions continue. Temperature in Canada will stabilize only if and when global carbon dioxide emissions reach net zero. (3.2, 3.4)

A scenario roughly representative of current global climate policies in which global emissions of greenhouse gases stabilize and then decline towards the end of the century corresponds to a future climate for Canada that is far from benign. Under this scenario, Canada is projected to warm through the century, with an average temperature increase (mean estimate) of 5°C by 2081–2100 relative to 1850–1900, while there is a greater than 50% chance that warming will exceed 10°C in much of Nunavut in winter. Also under this scenario, glaciers in western Canada are projected to lose more than 75% of their ice, intense precipitation is projected to increase by a median estimate of 40% in Canada as a whole, and there is a greater than two-thirds chance that the central Arctic Ocean will be ice-free most Septembers. Moreover, Canada is projected to still be warming at the end of the century under this scenario.

There is evidence that recent global emissions have dropped below levels projected in high emissions scenarios with no global climate policies and no mitigation of greenhouse gas emissions, in part because of the implementation of climate policies in many countries. However, such high emissions scenarios are still informative for climate change risk management. In a scenario with no global climate policies and increasing emissions, average temperature in Canada is projected to increase 6.9°C by 2081–2100 relative to 1850–1900, and changes in climate are projected to be substantially more severe even than that projected under the current-policies scenario.

By contrast, in a low emissions scenario in which the world reaches net-zero CO_2 emissions around 2075, Canada's climate is projected to stabilize in the second half of this century. Nonetheless, even in this net-zero scenario, average warming in Canada is projected to reach 3.5°C by 2081–2100 relative to 1850–1900, with some changes, such as glacier melt and sea-level rise, being only slightly reduced compared to the current-policies scenario. These findings emphasize the need to adapt to and plan for climate change even in such a net-zero future.

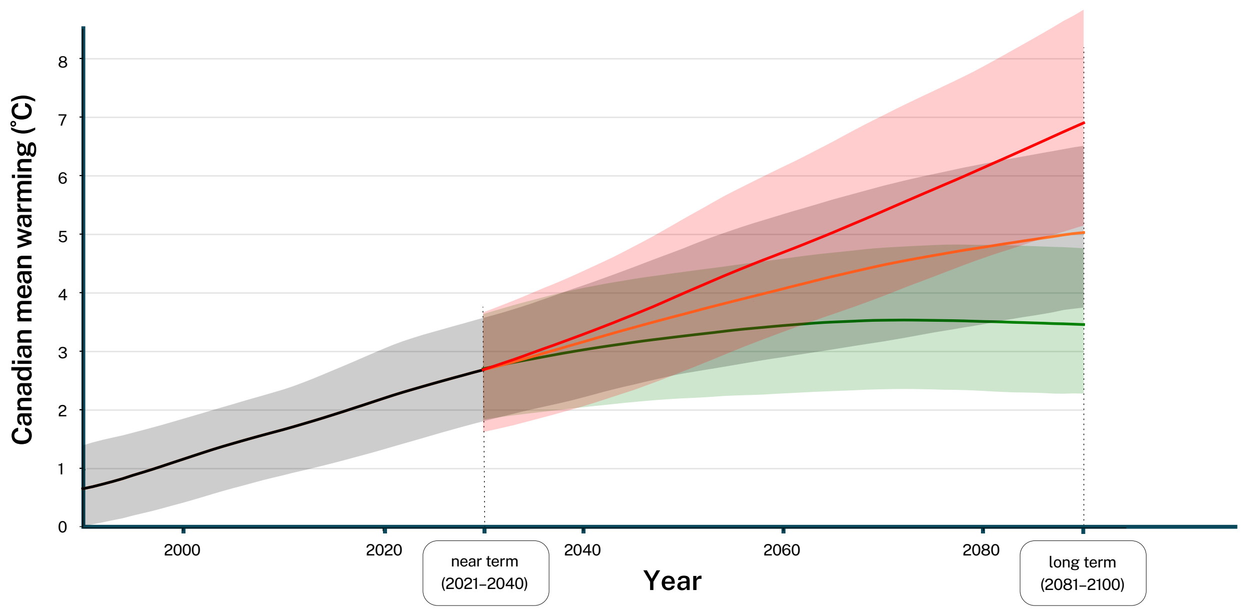
Headline Statement 7

The warming and associated changes in climate in Canada are effectively irreversible. Some warming-driven changes, such as sea ice loss, will stabilize if temperature stabilizes. Sea-level change, glacier melt, and permafrost thaw will continue even after surface temperatures stabilize. (3.2, 6.3, 6.5, 6.7, 7.4, 9.4)

CCCR2019 also emphasized the effectively irreversible nature of climate warming: "Regardless of the global mean surface temperature level attained when [global carbon dioxide] emissions become net zero, temperature will remain at about that level for centuries. In other words, global temperature change is effectively irreversible on multi-century timescales." (Flato et al., 2019). Some aspects of the physical climate will also stabilize if temperature stabilizes. If temperature stabilizes in Canada, average precipitation and precipitation extremes are projected to stabilize in Canada. Snow cover and sea ice area are also projected to stabilize. However, because of their slow response times, glacier melt and permafrost thaw are projected to continue through the century even after global net-zero CO_2 emissions have been reached. Global mean sea level will continue to rise for thousands of years, as excess heat due to past emissions continues to slowly spread into the deep ocean, and as glaciers and ice sheets continue to melt, contributing meltwater to the oceans.

Synthesis of future climate change in Canada

Figure take-away: Future climate-related changes in Canada would be much larger under current or weaker policies than in a net-zero future.



		Near term	Long term		
			No policies	Current policies	Net zero
Global average temperature		+1.5°C	+3.6°C	+2.7°C	+1.8°C
Canadian average temperature		+2.7°C	+6.9°C	+5.0°C	+3.5°C
Canadian warming trend per 20 yrs		+0.9°C	+1.5°C	+0.5°C	-0.1°C
Canadian hottest day of the year		+2.6°C	+6.2°C	+4.6°C	+3.1°C
Canadian average precipitation		+7%	+17%	+13%	+10%
Canadian extreme precipitation		+20%	+59%	+40%	+27%
Western Canada glacier mass		–	-99%	-94%	-76%
Tuktoyaktuk sea level rise		+16cm	+74cm	+65cm	+56cm
Increase in area burned in Canada		–	+287%	–	+46%
Probability of seasonally ice-free Arctic Ocean		5%	100%	80%	20%

Figure RS.6: Synthesis of future changes in Canadian climate under different global emissions scenarios. In the top panel, changes in Canadian average warming are expressed relative to 1850–1900. The black line shows estimated average temperature based on historical simulations. The coloured lines (central estimates) and shaded areas (5–95% uncertainty ranges) show projections through to the late century (2081–2100) for three different emissions scenarios: the blue line, for SSP2-4.5 (a current-policies scenario); the green line, for SSP1-2.6 (a net-zero scenario); and the red line, for SSP3-7.0 (a no-policies scenario). The table in the bottom panel shows changes (central estimates) in key indicators for the near term (2021–2040) and long-term (2081–2100). For details on the projections for each indicator and on baseline reference levels, see the full caption for **Figure 3.2** in Chapter 3. Dashes indicate that the report does not include an assessment of the change in that indicator for that period and scenario combination. Source: Chapter 3, **Figure 3.2.**

RS.2.2 Changes in extremes

Average temperature and precipitation trends are widely tracked as key indicators of climate change in Canada and around the globe. While changes in average conditions can pose hazards, much of the concern about human-caused climate change stems from the potentially devastating consequences to human and natural systems from long-term changes in weather and climate extremes. "Extreme" generally refers to an event that is rare for a given location and time of year. Short-duration events are considered weather extremes and longer-duration events are considered climate extremes. Given the wide range of weather and climate extremes, making general statements about how they have changed and are projected to continue changing in frequency or intensity is not possible. For example, there are many different types of floods, each with different driving factors; therefore, it is not possible to derive summary findings about floods in general. Both excess water and scarcity of water caused by extreme events related to the water cycle (e.g., floods and droughts) are important considerations for adaptation. In general, confidence is highest for changes in temperature-related extreme events, which exhibit comparatively little spatial variability and are directly caused by the additional heat trapped by the atmosphere due to human-caused increases in greenhouse gas concentrations.

Headline Statement 8

Human-caused warming has already affected the frequency and intensity of extreme temperature events in Canada. Increases in hot extremes and human heat-stress, as well as decreases in cold extremes, have been observed. These changes will intensify with additional global warming. (8.2)

The evidence base is stronger in CCCR2026 (compared to CCCR2019) that temperature extremes have changed in Canada: Hot extremes have become more intense and frequent, and cold extremes, less intense and frequent. Human-caused warming has been the dominant driver of these observed changes in temperature extremes. Increases in the intensity and frequency of hot extremes and decreases in the intensity and frequency of cold extremes are projected for all regions of Canada, with changes becoming larger as global average temperature rises. Human-perceived heat stress (driven by a combination of high temperature and humidity) is a compound extreme that is amplified by warming. The intensity and frequency of human-perceived heat stress have increased in Canada and are projected to increase in the future, driven mainly by increases in air temperature.

Projected changes in the frequency of hot extremes in Canada

Figure take-away: Hot extremes are projected to occur more frequently with every increment of global warming, with greater changes for rarer events.

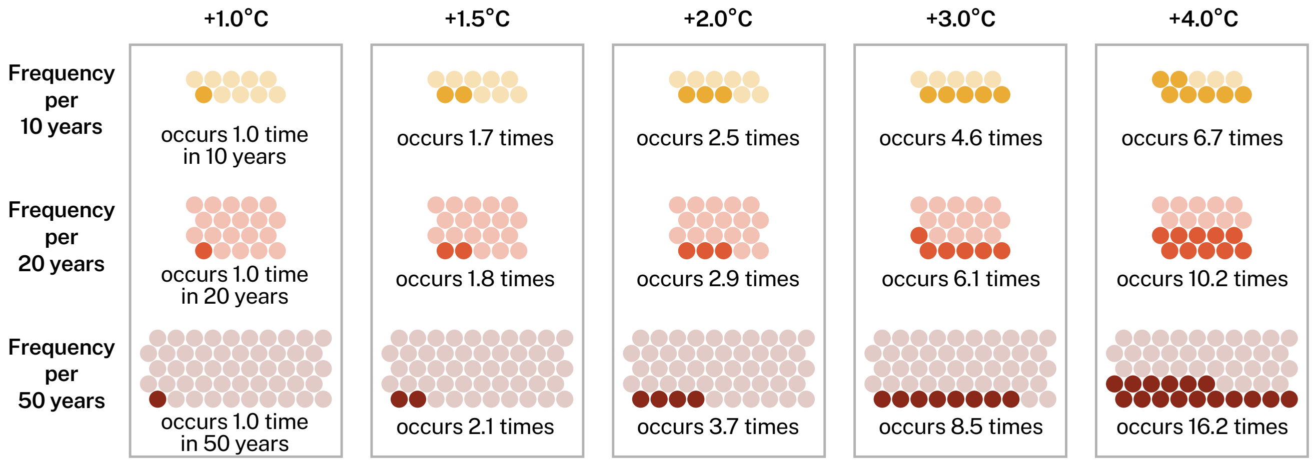


Figure RS.7: Chart showing projected changes in the frequency of hot extremes in Canada as a whole by increment of global warming. Frequency is defined as the number of times in which the highest daily maximum temperature that occurred, on average, once in 10, 20, and 50 years in the recent past (i.e., 1.0°C of global warming since the pre-industrial era, approximated in this report as the period from 1850 to 1900) is projected to occur under different global warming levels (1.5°C to 4°C). The top row shows the frequency in 10 years (with 10 dots), the middle row in 20 years (with 20 dots), and the bottom row in 50 years (with 50 dots). Dots in each grouping are shaded darker to indicate the average number of occurrences, with text indicating the value just below. Source: Chapter 8, **Figure 8.8**.

Headline Statement 9

Droughts and flash floods will become more frequent and severe with additional warming. Summer droughts are projected to become longer and more intense and occur more frequently in central and southern Canada. Increases in the frequency and intensity of atmospheric rivers (in high emissions scenarios) and of extreme rainfall will lead to more frequent and intense flash flooding. (4.5, 5.6, 5.7, 8.3)

Different types of droughts are assessed in CCCR2026. There is *high confidence* in projected increases in the frequency and intensity of meteorological droughts (decreased precipitation and increased evaporation) and agricultural droughts (decreased soil moisture) during summer months across central and southern Canada. These changes are expected to be more prominent under higher warming levels later in the century. Historically, periodic droughts have occurred across much of Canada, but no long-term changes in their frequency are detectable.

Projected changes in once-in-a-decade warm-season occurrences of meteorological droughts

Figure take-away: Once-in-a-decade meteorological droughts are projected to increase in frequency in late-century (2081–2100) across many areas of Canada.

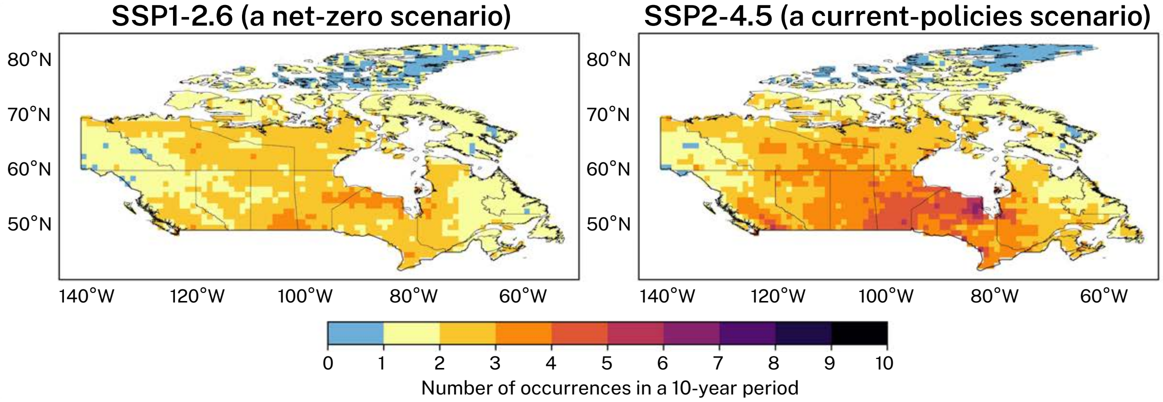


Figure RS.8: Maps of projected changes in once-in-a-decade warm-season (April–September) occurrences of meteorological drought under different emissions scenarios for 2081 to 2100, based on 22 projections from the CMIP6 global climate models. The projections are based on a low emissions (net zero) scenario (SSP1-2.6) (left column) and on an intermediate emissions (current policy) scenario (SSP2-4.5) (right column) for the Standardized Precipitation Evapotranspiration

Index. Areas on the maps shown in warm colours indicate places where droughts that currently occur once-in-a-decade are projected to become more frequent, whereas in areas shaded blue, current once-in-a-decade droughts are projected to occur less frequently. Source: Chapter 5, **Figure 5.18.**

Projected increases in extreme precipitation will lead to increased flash flooding across Canada, including in urban areas. There is *high confidence* in projected increases in the frequency and intensity of one-day and five-day total precipitation extremes and short-duration (timescales less than a day) rainfall extremes, with changes becoming larger as global average temperature rises. In addition, there is *medium confidence* in projected increases in precipitation rates associated with North Atlantic hurricanes affecting Canada.

In general, there is higher confidence in the projected changes in precipitation extremes than in the observed changes. This is because the physical relationship between warming and extreme precipitation is robust and well supported by climate model simulations, whereas historical data records are comparatively short and noisy relative to the underlying trend. In CCCR2019, the observational data record had not yet shown evidence of consistent increases in short-duration precipitation extremes across Canada. Now there is *medium confidence* that the intensity and frequency of one-day and five-day precipitation extremes have increased in Canada as a whole since the mid-20th century.

Future changes in the number of heavy precipitation days (≥ 10 mm per day) across Canada

Figure take-away: In the future, heavy precipitation events will occur more frequently.

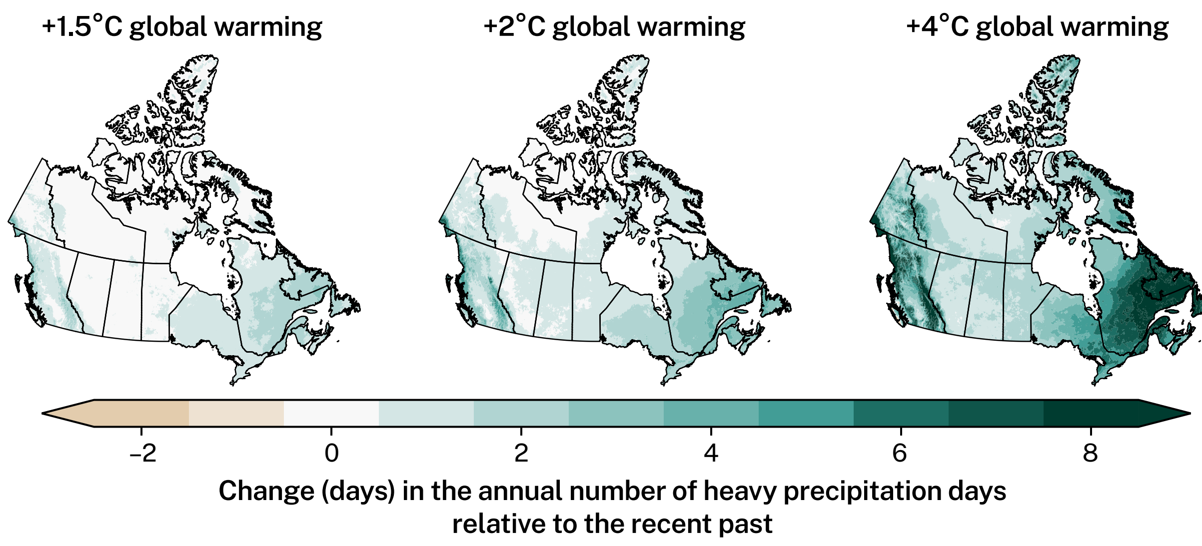


Figure RS.9: Maps showing future changes in the frequency (in number of days per year) of heavy precipitation days (defined as ≥ 10 mm of precipitation per day) across Canada, with the number of days represented by different colours. Projected changes are relative to the recent past (i.e., 1°C of global warming above the pre-industrial level) and are shown for three different global warming levels (1.5°C, 2°C, and 4°C above the pre-industrial level). Source: Chapter 8, **Figure 8.13**.

Headline Statement 10

More frequent and intense extreme fire weather is projected for most regions of Canada. Fire seasons are already longer and will lengthen further with additional global warming. (8.7)

Wildfires are a recurrent feature of the Canadian landscape. Concerns about climate-related changes in wildfires arise from the significant risks these events pose to ecosystems, air quality, and communities. The assessment of climate related changes to wildfires in CCCR2026 focuses on fire weather, fire season duration, and area burned. Multiple lines of evidence support the finding that the length of the fire season has increased in most parts of Canada and is projected to continue to lengthen as global temperature rises. While there is only *medium confidence* that the annual forest area burned by fires in Canada has increased since the early 1980s, there is *high confidence* that area burned will increase further with additional climate warming. Fire weather is a compound extreme event characterized by hot, dry, and windy conditions conducive to wildfires. Significant trends in fire weather metrics were found for some parts of Canada, mostly in the west, but most trends in the rest of the country were not significant. High year-to-year variability hinders the detection of trends. However, there is *high confidence* that the frequency and intensity of extreme fire weather conditions are projected to increase in most regions of Canada as global average temperature rises.

Future changes in fire season length across Canada

Figure take-away: The fire season is projected to become longer across Canada.

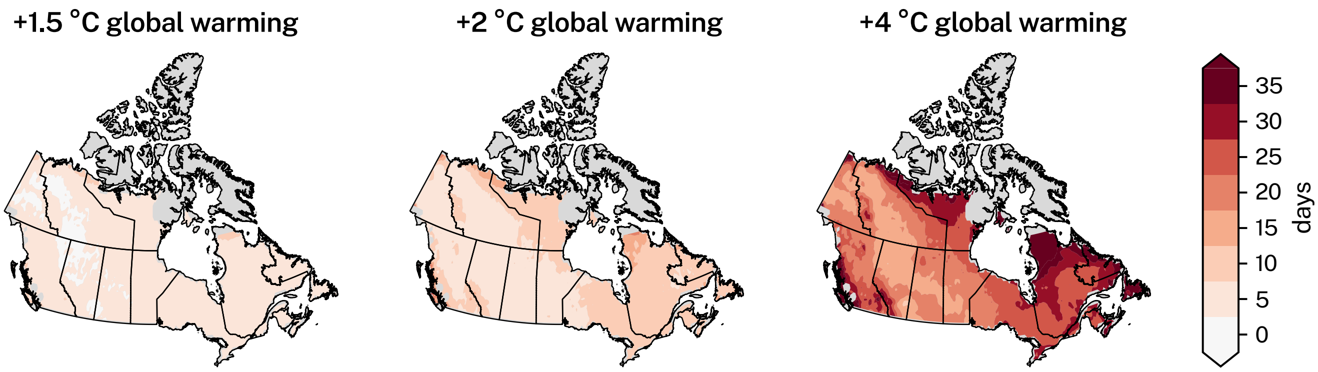
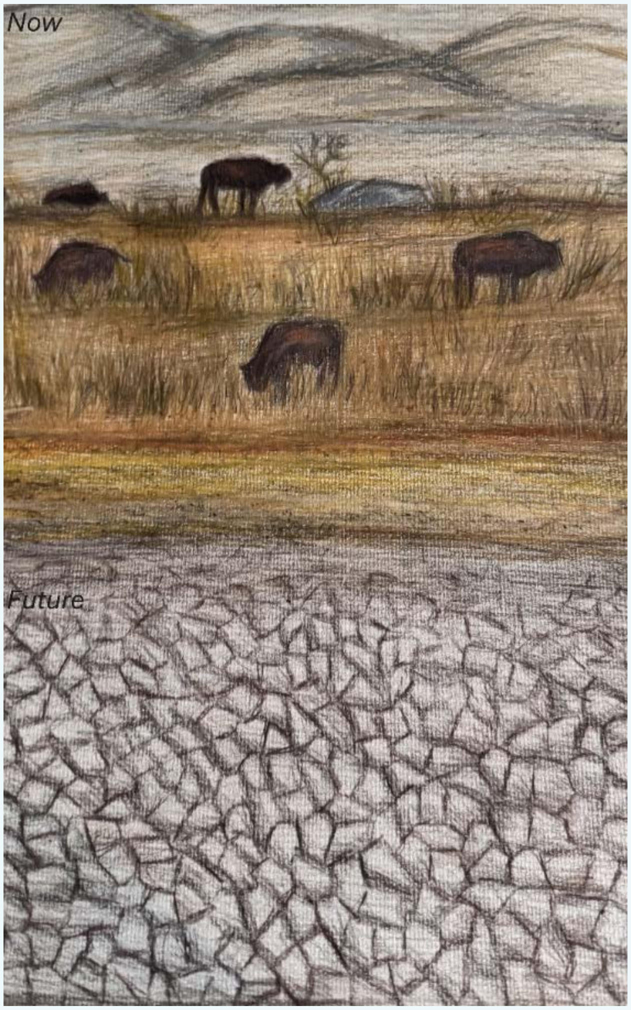


Figure RS.10: Maps showing projected changes in fire season length across Canada at three different levels of global warming (1.5°C, 2°C, and 4°C above the pre-industrial level), with changes expressed in relation to the recent past (i.e., 1°C of global warming).
Source: Chapter 8, **Figure 8.23**.

Art competition winners

The Government of Canada, through the *Canada in a Changing Climate*: National Assessment Process, invited students across Canada in grades 7 to 12 to express their perspectives on climate change through visual art. The three works of art showcased here were winners under the theme "The climate we live in, now and in the future." They are reproduced with permission from Natural Resources Canada and the students.

Canada's Prairies - Climate Impact by Zoe, Grade 8



Zoe's testimony: I visited the Ecotour Scenic Drive in Grasslands National Park, Saskatchewan. I wanted to depict the deeply engrained image in my memory of the stunning landscapes with bison sightings during this trip, which is currently under threat from climate change.

The top image shows bison grazing in Saskatchewan's grasslands, their selective feeding creating a mosaic of heavily and lightly grazed areas. However, as the bottom image suggests, climate change disrupts prairie water patterns. Earlier snowmelt reduces spring runoff, and hotter temperatures lead to drought. This drastically impacts these ecosystems.

Multiple Paths by Sophie, Grade 11

Sophie's testimony: The bottom half shows, in a humorous way, what our world might look like if climate change gets out of hand (i.e., penguin on a tropical island). The top half shows a brighter future, with a healthy forest ecosystem, the sunrise symbolizing a new beginning. In between the destruction and the healthy climate, there is a fossil fuel car driving towards the destruction—that is where we are headed if we don't change our ways. However, windmills are featured within the forest, showing what our climate can resemble if we act now.

Wildfire by Savana, Grade 12

Savana's testimony: This drawing represents a wildfire burning near our community two years ago. Two years ago we had a fire evacuation order for almost two weeks. Last year we had a fire evacuation alert, but thankfully, didn't have to evacuate. Fires seem to be more frequent and intense today.

RS.2.3 Changes specific to freshwater, snow and ice, oceans, and the carbon cycle in Canada

The headline statements in this third cluster are related to changes in specific components of the physical climate system. These can have profound consequences on living and built systems. Changes to the cryosphere—the parts of the climate system with frozen water—will threaten water availability in Canada, alter ecosystems and habitat across the country, and compromise northern infrastructure. Changes to the water cycle will have important consequences for future water security in Canada. Both the timing and the amount of freshwater availability are subject to changes in the water cycle. Ocean temperature, acidity, oxygen levels, and salinity are crucial habitat features, and changes to these properties will have implications for marine ecosystems. Relative sea level is rising in many locations along Canadian coastlines but also falling in some other areas, which creates different challenges for different areas.

Changes in the water cycle

Headline Statement 11

Summer freshwater availability in southern Canada is threatened by changes in the water cycle. Many important water cycle processes are occurring earlier in spring, such as snowmelt, peak stream flow, and groundwater recharge, with risks to summer water availability. In some western Canada watersheds, declines in glacier contributions to summer streamflow have already been observed. (5.3, 5.5, 5.8, 6.2, 6.5)

In this report, freshwater availability is defined as water at the surface (streams, lakes, and wetlands), in the soil, and in aquifers (groundwater) that is available for both human and ecosystem use. Freshwater availability is governed by many complex processes and interactions in the water cycle. The most identifiable effect of climate warming is that the timing of many water cycle processes—such as snowmelt, spring freshet (higher flows resulting from snow and ice melt in spring), and groundwater aquifer recharge—has shifted to earlier in the spring. These changes are projected to continue and will alter the expected timing of freshwater supplies, particularly in the many snowmelt-fed basins across Canada that rely on this water source during the summer season, as well as in regions that depend on glacial meltwater for their main dry-season water supply. Changes in freshwater availability are expected to be greater toward the end of this century under higher warming levels.

Human-caused climate warming and Canada's water cycle

Figure take-away: Past and future warming influence all aspects of Canada's water cycle and freshwater availability.

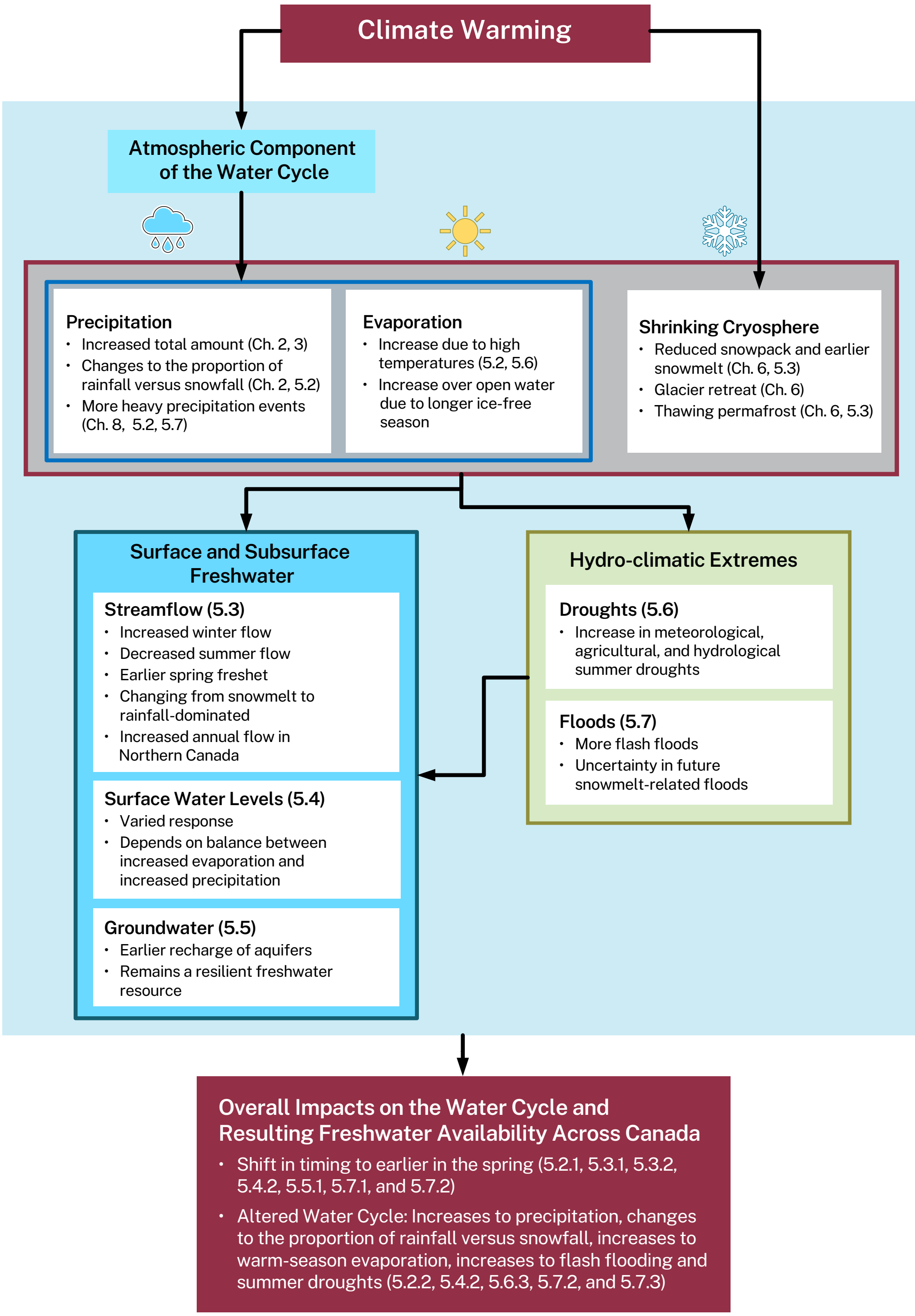


Figure RS.11: Diagram summarizing how warming temperatures have influenced and are projected to continue to influence Canada's water cycle and resulting freshwater availability. The statements in the text boxes are representative of general findings in Ch. 5. The chapter key messages provide more detailed assessed findings. The assessments of different topics are set out in multiple chapters of CCCR2026, as indicated by the chapter-and section-specific notations. Source: Chapter 5, **Figure 5.20.**

Changes in snow and ice

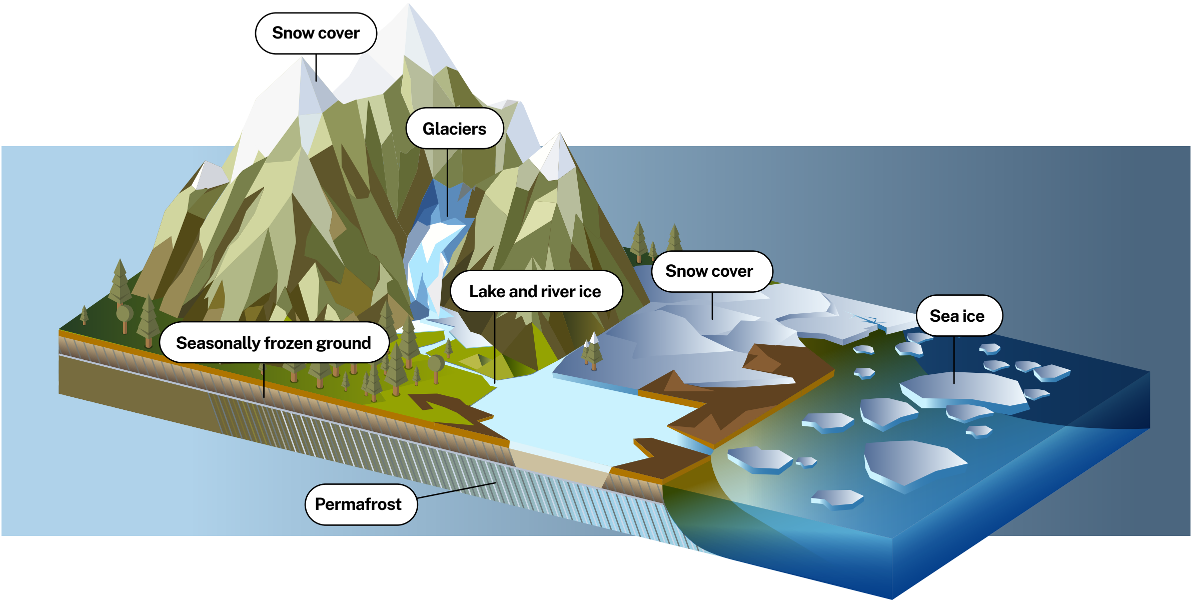
Headline Statement 12

Iconic landscapes are changing across Canada as snow and ice disappear. Glaciers in western Canada will largely disappear by the end of this century. Warming temperatures have shortened the snow cover season and reduced sea ice cover of all types. Permafrost thaw is transforming the land in many places across northern Canada. These changes will intensify with additional warming. (Ch. 6)

All glaciers in western Canada and the Canadian Arctic have thinned and lost mass over the past two and a half decades and are projected to continue losing mass under every future emissions scenario. In western Canada, more than 55% of glacier ice is predicted to disappear by 2100, even if global warming is limited to 2°C. Snow cover duration has shortened in Canada as a whole over the past four decades. In waters across the Canadian Arctic and Hudson Bay region, the sea ice–free period has already lengthened, and it is projected to lengthen further, increasing by about one month for each additional degree of global warming. Even though the ice-free period will lengthen across the Canadian Arctic, the shipping season through the Northwest Passage is not expected to lengthen by the same amount because of the continued flow of multi-year ice into the region from farther north. As ice-rich permafrost thaws, it can change support for the ground above, leading to a variety of observed landscape changes such as ground settlement, pond formation, lake expansion or drainage, and thaw slumps.

Changes in the cryosphere

Figure take-away: In the collective elements of the cryosphere, we see similar, interconnected changes in both what has been observed in the past and what we expect for the future.



Coherent changes across these components of the cryosphere are evident across Canada and globally. Because air temperature exerts a dominant control on all components of the cryosphere, human-caused global warming is the key cause of past snow and ice loss. Changes in all components of the cryosphere are projected to worsen or intensify with additional global warming. Limiting the increases in global average temperature will limit these changes.

Figure RS.12: Representation of various elements of the cryosphere that are changing across Canada as snow and ice disappear.

Changes in sea level

Headline Statement 13

Extreme high sea-level events will occur more often where local sea level is rising. Local sea level is projected to rise faster than the global average along parts of the Atlantic and western Arctic coastlines of Canada. In these areas, extreme high sea-level events will be exacerbated during periods of high storm surge and high tides. (7.4, 7.5, 7.6)

Future sea-level change along Canada's coastlines by 2100

Figure take-away: The amount of projected relative sea-level change along Canada's coastlines depends on the location and emissions scenario.

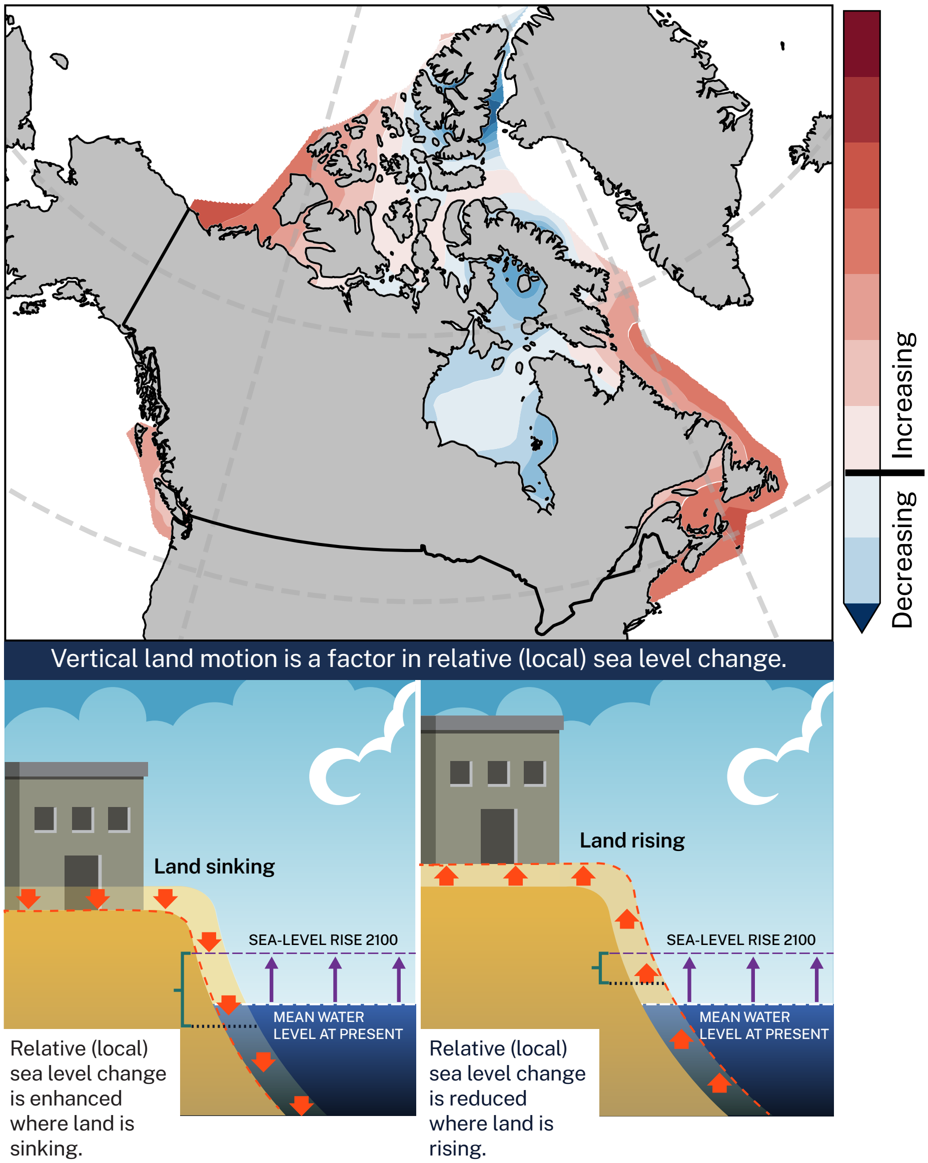


Figure RS.13: The upper panel shows projected patterns of relative (local) sea-level change along Canada's coastlines by 2100 under an intermediate emissions scenario (SSP2-4.5). Shades of red and blue indicate the magnitude of relative (local) sea-level rise and fall, respectively. The lower panel illustrates how vertical land motion along the coast increases relative sea-level change (indicated by the height of the green vertical line) where land is sinking and decreases it where land is rising. Source: Chapter 7, **figures 7.18** and **7.21**.

Global sea-level rise, totaling about 20 cm since 1900, is impacting Canada's coastlines, with rates accelerating in the past three decades as glaciers and ice sheets melt. At specific locations along Canada's coastlines, sea levels have either risen faster, risen slower or even fallen as local vertical land motion, namely, land subsidence or land uplift, either adds to or subtracts from global sea-level rise, respectively. Land subsidence and uplift are caused by the continuing adjustment of the land surface due to the loss of ice mass after the last continental glaciation. Rates of sea-level rise up to 34 cm per century in southern Atlantic Canada and the western Arctic have been observed, with lower rates in British Columbia.

Global mean sea level is projected to rise many tens of centimetres by the end of the century with the amount dependent on the emissions scenario. Extreme sea-level events are therefore projected to occur more often in many parts of Canada. These events will be further exacerbated by increased waves and storm surges where sea ice is projected to decline along Canada's Arctic and Atlantic coasts.

Changes in the oceans

Headline Statement 14

The oceans around Canada have warmed and acidified because of greenhouse gas emissions from human activity. Marine heatwaves have become more frequent and intense. The oceans will continue to warm, absorb carbon dioxide, and acidify as long as air temperature and carbon dioxide continue to rise. (7.2, 7.7, 7.8)

The general warming of the oceans around Canada is consistent with the warming observed in the global upper ocean, for which human influence is *extremely likely* to be the main driver. The greatest warming has occurred during summer in the ocean bordering eastern Canada, including Hudson Bay. New scientific literature supports this report's robust assessment of past and future changes in marine heatwaves, which were not assessed in CCCR2019. More frequent and intense marine heatwaves have been observed in the Pacific and Atlantic oceans around Canada since the 1980s, and such events are expected to continue to increase in frequency and intensity in the three oceans around Canada because of human influence on the climate system.

The ocean is rapidly absorbing CO_2 from the atmosphere and has the capacity to store large amounts of carbon. However, this absorption is causing ocean acidification, with higher acidity levels now observed in all oceans around Canada. This higher-carbon, acidified water is carried beneath the surface by the ocean circulation. The level of projected acidification in the latter half of this century will strongly depend on the level of future CO_2 emissions.

Past summer sea surface temperatures and marine heatwaves in oceans around Canada

Figure take-away: Sea surface temperatures have risen in the oceans around Canada since the 1950s, particularly in summer, with a corresponding increase in marine heatwaves.

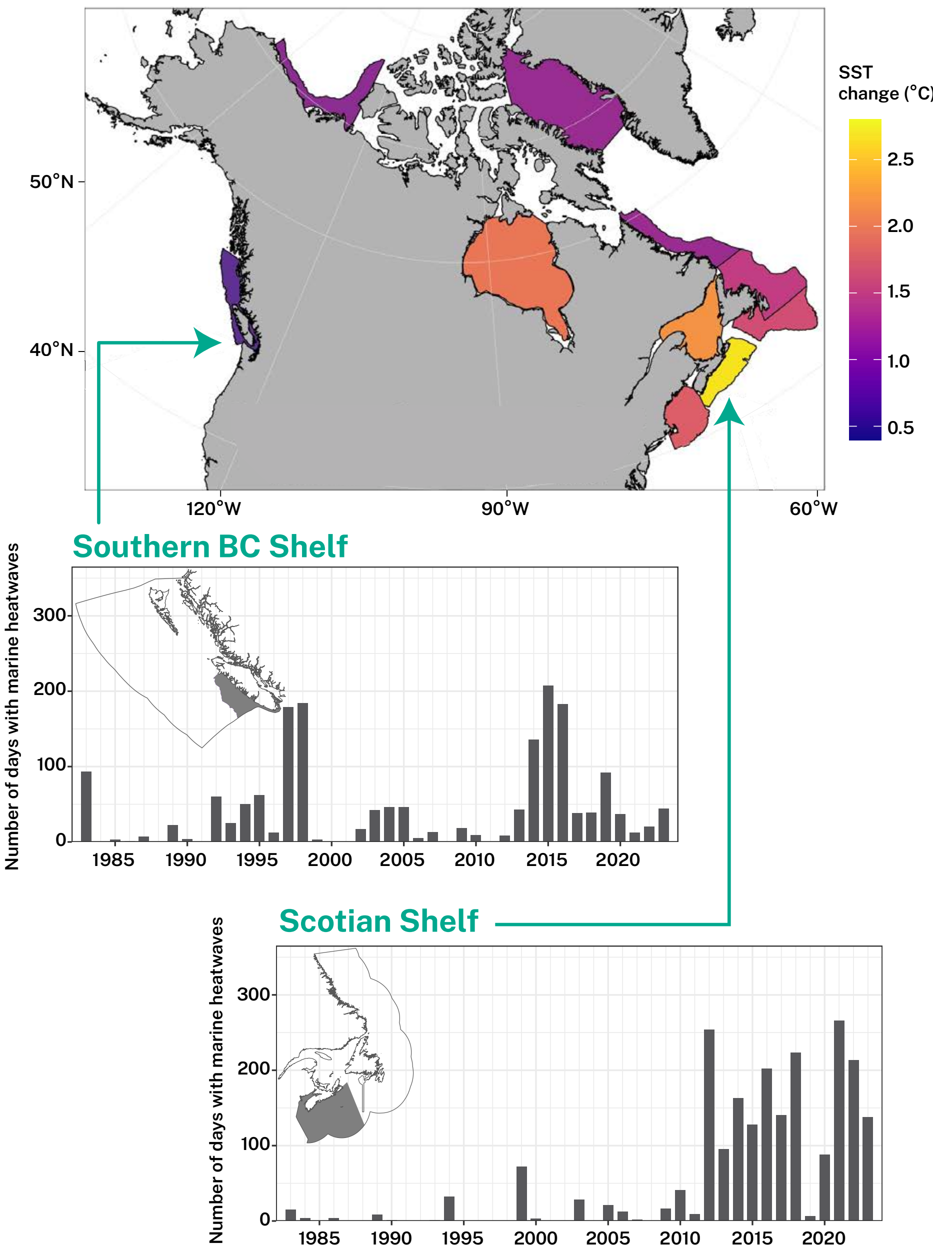


Figure RS.14: Rising sea surface temperature (SST) in the oceans around Canada is a contributing factor to the increasing occurrence of marine heatwaves. The top panel shows summer SST change in the oceans around Canada for 2012–2022 relative to a baseline period of 1951–1980. The lower two panels show the number of days per year in which 25% of the area in two zones defined in the map, the southern British Columbia and the Scotian shelves, met marine heatwave criteria. Source: Chapter 7, **figures 7.11** and **7.12**.

Changes in the carbon cycle

Headline Statement 15

Canada's land and oceans are currently a carbon sink, consistent with their behaviour over recent decades (*medium confidence*). Canada's oceans are expected to continue to be a sink in the future. In contrast, whether Canada's land remains a sink or becomes a carbon source is uncertain. Increases in carbon uptake from vegetation growth on land may be offset by carbon emissions from permafrost thaw, wildfires, and other disturbances. (9.5)

A carbon sink is a region or a reservoir that removes carbon from the atmosphere. Globally, less than half of the CO_2 emitted by human activities has remained in the atmosphere, because both land and ocean have acted as carbon sinks in response to increased atmospheric CO_2. The emitted CO_2 that remains in the atmosphere is driving global warming.

Canada's land and oceans have acted as carbon sinks in recent decades in response to increasing atmospheric CO_2 and the associated climate change (*medium confidence*). In the future, both carbon uptake from increased vegetation growth (*medium confidence*) and carbon emissions from permafrost thaw, wildfires, and other disturbances (*high confidence*) are expected to increase. However, the net effect of these competing processes on the carbon balance of Canada's land ecosystems remains uncertain. Canada's oceans will continue to take up CO_2 as long as CO_2 in the atmosphere continues to increase (*medium confidence*).

RS.3 Signposts to content in this report

This section serves as a brief guide for readers of the report. For a more in-depth guide, consult Chapter 1, section 1.4.

National climate assessments serve a variety of audiences who will make use of assessment reports in different ways for different purposes. For this reason, CCCR2026 has a layered structure that delivers information tailored to various audiences who may seek summary information or detailed scientific analyses (**Figure RS.15**).

The organization of information in the second edition of *Canada's Changing Climate Report* into hierarchical layers

Figure take-away: Information is presented in CCCR2026 through layers of increasing detail.

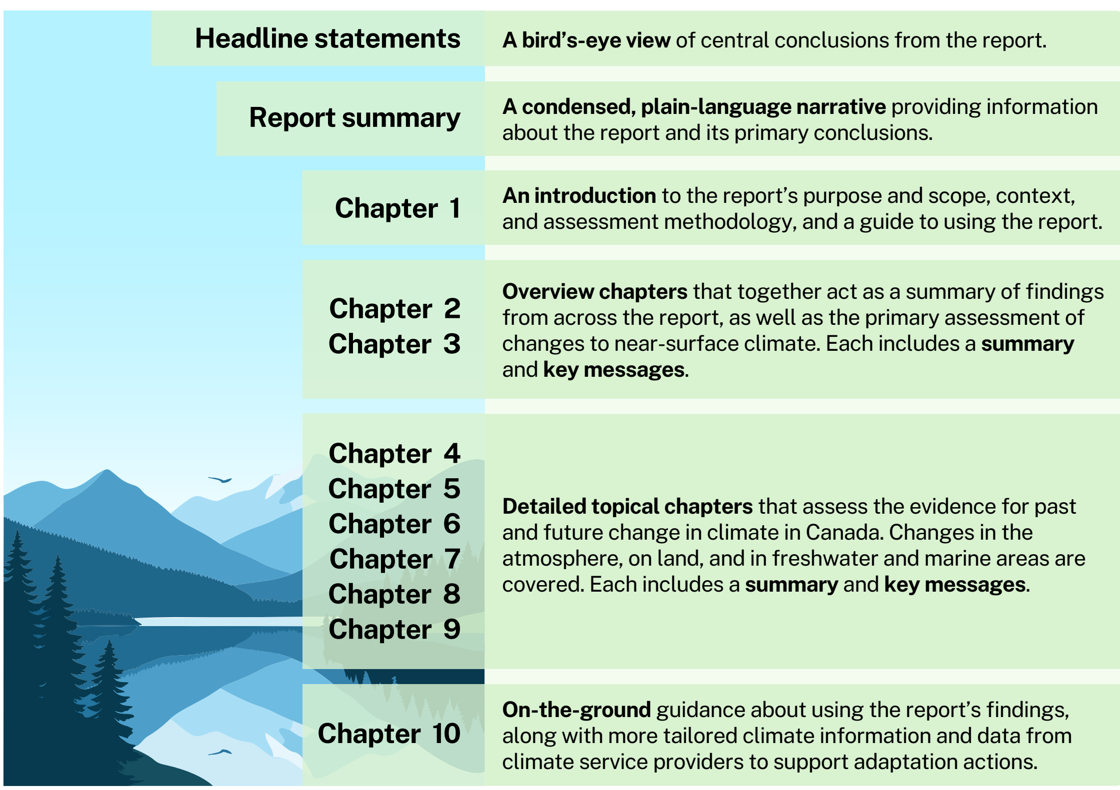


Figure RS.15: Diagram illustrating how the structure of the second edition of *Canada's Changing Climate Report* provides information in layers of increasing detail that are intended to serve multiple audiences with varying needs. Source: Chapter 1, **Figure 1.7**.

A number of features have been included in CCCR2026 to help direct readers of this report to material that may be of particular interest. Each chapter's introduction includes a visual guide to the chapter and to important cross-chapter connections. The Annex to Chapter 1 includes an index of cross-cutting topics in the report, including topics related to assessment methods (such as baseline periods, detection, and attribution) and thematic topics (such as wildfires and net-zero emissions).

The chapter key messages appear together at the start of each chapter and are repeated at the start of relevant sections in the body of the chapter. Key messages include the authors' assessment of the levels of certainty in the findings using calibrated uncertainty terms that are explained in detail in Chapter 1 of this report. For those who primarily want to read chapter key messages and get a snapshot of the evidence supporting them, each chapter includes dedicated sections summarizing the evidence leading to the selection of the confidence and likelihood terms associated with key messages.

To make it easier for adaptation decision-makers to use the climate information in this report, CCCR2026 includes Chapter 10: Climate services and using climate information. The aim is to assist readers in applying the report's assessment of changes in physical climate to their own decision-making contexts on local and regional scales. Hazard tables in section 10.4 summarize climate indicators found in this report, broken down into 12 common climate hazard categories in Canada, such as droughts and wildfires.

First Nations, Inuit, and Métis case stories are included throughout the report and draw on Indigenous science, observations, and perspectives on the implications of climate change (**Box RS.1**). Separate citations are provided with the case stories to properly recognize the contribution of the case story authors. Finally, a short set of FAQs are included in multiple chapters of this report in anticipation of helping readers find answers to some frequently asked questions related to topics in climate science (**Box RS.2**).

Box RS.1 First Nations, Inuit, and Métis case stories in CCCR2026

- **Case Story 2.1** For the love of the land: Observations on Nuna Aliannaittuq melt
- **Case Story 2.2** Chisasibi Eeyou Elder shares his perspective on environmental change in Eeyou Istchee
- **Case Story 3.1** A story of the seasons in Ulukhaktuuq, Northwest Territories
- **Case Story 5.1** Towards a sustainable water supply for Ausuiktuq (Grise Fiord), Nunavut
- **Case Story 5.2** Red River Métis Community-Based Climate Monitoring Program
- **Case Story 6.1** A lifetime of climate change in the Arctic
- **Case Story 6.2** SmartICE
- **Case Story 6.3** Landscape change in the Gwich'in and Inuvialuit settlement regions
- **Case Story 8.1** "Smoke and Peaches" – Effects of compound extreme events on Métis cultural food practices
- **Case Story 9.1** Returning Good Fire to the land in a changing climate
- **Case Story 10.1** Climate change, food security, and Tŝilhqot'in wild food harvesting
- **Case Story 10.2** Ecosystem services and shifting seasonal rounds: A Gitxsan perspective
- **Case Story 10.3** Mâmawi Nistam: Resilience Through Seasons, a climate risk and vulnerability report by the Otipemisiwak Métis Government, of the Métis Nation within Alberta

Box RS.2 Frequently asked questions in CCCR2026

- **FAQ 1.1** What is CCCR2026, and who wrote it?
- **FAQ 1.2** What is new in CCCR2026 compared to CCCR2019?
- **FAQ 3.1** What is the difference between climate projections and decadal climate predictions?
- **FAQ 3.2** What are the main differences between the projections in CCCR2019 and CCCR2026?
- **FAQ 4.1** Why is Canada warming faster than the world as a whole?
- **FAQ 7.1** Is sea level rising everywhere in Canada?
- **FAQ 7.2** Are marine heatwaves any different from heatwaves we experience on land?
- **FAQ 7.3** Why does the carbon dioxide that humans emit into the atmosphere cause ocean acidification?
- **FAQ 8.1** Will all weather and climate extremes get worse in the future?
- **FAQ 9.1** How does global temperature respond to increasing, decreasing, and net-zero carbon dioxide emissions?

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Annex: Key Messages from chapters of Canada's Changing Climate Report 2026

The key messages from *Canada's Changing Climate Report 2026* are chapter-specific findings that chapter authors judged to be most important to communicate to readers. The key messages emerged from the body of evidence assessed in chapters 2 to 9 of the report. Chapter 1 (About this report) and Chapter 10 (Climate services and using climate information) do not have key messages. Assessed levels of confidence in findings, and likelihood of results are indicated with italicized terms[3]. Each chapter includes dedicated sections summarizing the evidence leading to the selection of the confidence and likelihood terms associated with key messages.

Chapter and Section	Key Messages
Chapter 2: Overview of past changes in climate	
2.2 Synthesis of past changes **(Continue)**	**Observed climate warming in Canada and its causes** **Key Message 2.1** Canada is warming in all regions and seasons. Canada warmed by 2.0°C during the 1948–2023 period (*very likely* 0.9–3.1°C), with northern regions experiencing warming of 2.6°C (*very likely* 1.4–4.1°C) and generally more warming occurring in winter than in summer.

3 This report uses the same calibrated uncertainty language as in the IPCC's fifth and sixth assessment reports. The following five terms are used to express assessed levels of confidence in findings based on the availability, quality and level of agreement of the evidence: *very low*, *low*, *medium*, *high*, and *very high*. When statements in key messages appear without confidence terms, this means they are statements of fact. The following terms are used to express assessed likelihoods of results: *virtually certain* (99%–100% probability), *extremely likely* (95%–100% probability), *very likely* (90%–100% probability), *likely* (66%–100% probability), *about as likely as not* (33%–66% probability), *unlikely* (0%–33% probability), *very unlikely* (0%–10% probability), *extremely unlikely* (0%–5% probability), and *exceptionally unlikely* (0%–1% probability). Occasionally, the calibrated likelihood term *more likely than not* (50%-100% probability) is also used. Confidence and likelihood terms are typeset in italics in the text. See guidance on calibrated uncertainty language in Chapter 1, section 1.4.3.

<table>
<tr><th>Chapter and Section</th><th>Key Messages</th></tr>
<tr><td rowspan="4">2.2 Synthesis of past changes

(Continued)</td><td>Key Message 2.2
Human influence has warmed Canadian average 2015–2024 temperatures to a level that is 2.2°C (likely 1.8–2.6°C) above that in the pre-industrial era, which is double the amount of warming in the global average temperature that is attributable to human influence when comparing 2010–2019 with global average temperatures in the pre-industrial era (high confidence). The observed warming in Canada of 2.0°C from 1948 to 2023 is very strongly dominated by human influences and indistinguishable from the warming that can be attributed to external influences on the climate (very high confidence).</td></tr>
<tr><td>Observed climatic effects of warming in Canada

Key Message 2.3
Most observed climate changes across Canada — on land, in the oceans around Canada, and in the atmosphere — are consistent with a warming climate. Emissions of greenhouse gases from human activity provide the only plausible explanation for this collective change (very high confidence).</td></tr>
<tr><td>Key Message 2.4
The observed occurrence in summer of longer growing seasons, increased building cooling requirements, and higher hot temperature extremes are all consistent with a warming climate, as is the occurrence in winter of reduced building heating requirements and less severe cold temperature extremes. Fire seasons have become longer (high confidence), and the area burned in wildfires has increased (medium confidence). The warming climate has also led to substantial changes in the water cycle and cryosphere (very high confidence), as indicated by increased annual precipitation and intensified precipitation extremes, snow cover and glacier mass reductions, earlier spring streamflow in rivers, decreasing lake and river ice, and thawing permafrost.</td></tr>
<tr><td>Key Message 2.5
The effects of the warming climate are also clearly seen in Canada's ocean areas, through increases in ocean water temperature, more frequent marine heatwaves, freshening of near-surface ocean waters, and decreasing sea ice cover, which has resulted in increasing ocean wave heights in the Arctic (high confidence). Some of Canada's coastal areas are also experiencing the effects of sea-level rise (very high confidence) and more frequent extreme sea-level events (high confidence), which can contribute to coastal flooding. The oceans around Canada have also absorbed anthropogenic carbon dioxide from the atmosphere, which has resulted in ocean acidification in the ocean's near-surface layers (very high confidence).</td></tr>
</table>

Chapter and Section	Key Messages
2.4 Past temperature changes	**Key Message 2.6** Canada's climate has warmed rapidly over the past 75 years. Warming rates have fluctuated over the past century. Annual mean temperatures are estimated to have increased at a rate of 0.26°C (*very likely* 0.12–0.41°C) per decade between 1948 and 2023 for Canada as a whole and 0.35°C (*very likely* 0.18–0.55°C) per decade for Canada's North.[4] Canada's estimated annual average temperature has exceeded the 1961–1990 average in 30 of the 33 years since 1990.
	Key Message 2.7 Canada has warmed more quickly than most of the rest of the world. Canada's warming rate over the 1948–2023 period is similar to that for the global land area (*high confidence*), but Canada's North has warmed at a rate that is more than twice the rate for the global land and ocean area combined over the 1948–2023 period (*high confidence*). Most of the observed warming has occurred since 1970. Canada's warming rate was almost twice the global warming rate over the 1970–2023 period (*high confidence*).
	Key Message 2.8 Human influence has warmed Canadian average temperatures during the 2015–2024 period to a level that is 2.2°C (*likely* 1.8–2.6°C) above the pre-industrial era (approximated in this report as the period from 1850 to 1900). Human influences acting on their own would *likely* have caused more warming than the observed warming of 1.6°C between the decades of 1948–1957 and 2014–2023, with natural external influences and internal climate variability combined preventing a small portion of that influence from being realized (*high confidence*).
2.5 Past precipitation changes **(Continue)**	**Key Message 2.9** Annual total precipitation has increased in Canada since 1949, with larger percentage increases in northern Canada (*very high confidence*). Annual total precipitation has increased much faster in Canada than for the global land area as a whole over a similar period (*very high confidence*).
	Key Message 2.10 Annual precipitation in Canada increased by 9.7% (*likely* 7.0–12.3%) in Canada as a whole, by 18.9% (*more likely than not* 8.6–29.5%, *medium confidence*) in Canada's North, and by 7.5% (*likely* 2.4–11.8%) in Canada's South between 1949 and 2023, with most of the increase attributable to human influence on the climate (*medium confidence*).

4 The term Canada's North is used to refer to the land area of Yukon, the Northwest Territories, and Nunavut combined. A map describing the regions considered in this report and the terms used to refer to those regions is provided in **Figure 2.2**.

Chapter and Section	Key Messages
2.5 Past precipitation changes **(Continued)**	**Key Message 2.11** Precipitation has not changed uniformly in all seasons. Precipitation has increased in a zonal band centred at 62°N latitude in summer, and in most areas in British Columbia and along the St. Lawrence River in spring and fall (*medium confidence*). Precipitation has increased in all seasons in an area from southern Nunavut to the Arctic Archipelago and from Labrador to northeastern Quebec (*low confidence*).
	Key Message 2.12 The annual snowfall amount and annual number of days with snowfall are estimated to have decreased at most stations in Canada's South but increased at most stations in Canada's North (*medium confidence*). Both the proportion of precipitation days with snow and the proportion of precipitation amount falling as snow have decreased across most of Canada (*medium confidence*).
2.6 Past wind speed changes	**Key Message 2.13** Annual and seasonal average surface wind speeds decreased during the 1953–2023 period across a large part of southern Canada stretching from the southern Prairies to central Quebec (*medium confidence*). In contrast, average wind speeds increased in British Columbia in spring and summer (*low confidence*). There is *low confidence* overall in assessments of the magnitude of annual average wind speed changes due to inconsistency between observational data products. It is currently not possible to attribute any aspect of the observed wind speed changes to human influence on the climate system.
	Key Message 2.14 The sparseness of station data in northern Canada makes it very difficult to assess long-term wind speed trends in that region, but consistency between the available station data and a modern reanalysis dataset suggests that wind speeds increased during the 1953–2023 period in northern Canada (*low confidence*), particularly in fall and spring.

Chapter and Section	Key Messages
Chapter 3: Overview of future changes in climate	
3.2 Synthesis of projected changes **(Continue)**	**Canada's near-term future climate** **Key Message 3.1** In the near term, Canada will continue warming at close to twice the global rate, with an increase of about 0.9°C (0.2–1.6°C) from 2021 to 2040 in all emissions scenarios (*high confidence*). On average over this 20-year period, Canada is projected to be 2.7°C (1.8–3.6°C) warmer (*high confidence*) and receive 7% (5–10%) more precipitation (*medium confidence*) compared to the 1850–1900 average. Trends already observed, towards more frequent hot extremes, earlier peak streamflow, warmer and more acidic waters around the coasts, and increasing area burned by wildfire, are projected to continue (*high confidence*). The duration of snow, sea ice, and lake ice cover in Canada will shorten with every increment of global warming (*very high confidence*).
	Canada's long-term future climate under current global climate policies **Key Message 3.2** Climate change in Canada will intensify through the century if emissions continue on a path approximately consistent with current global climate policies (*high confidence*). In 2081–2100, average warming across Canada relative to 1850–1900 is projected to reach 5.0°C (3.8–6.6°C) (*high confidence*), and precipitation is projected to increase by 13% (9–18%) (*medium confidence*). The intensity and frequency of heavy precipitation are projected to increase (*high confidence*). There is *medium confidence* that atmospheric rivers will strengthen. Glaciers in western Canada are projected to lose more than 75% of their mass (*medium confidence*), and permafrost thaw in northern Canada will continue (*very high confidence*).
	Canada's long- term future climate in a net-zero world **Key Message 3.3** Most aspects of Canada's climate will stabilize in the second half of this century if global CO_2 emissions immediately start to decline and reach net zero in the 2070s (*high confidence*). Under such a scenario, Canadian temperatures are projected to warm by about 0.8°C between the 2021–2040 and 2081–2100 periods, reaching 3.5°C (2.3–4.8°C) above 1850–1900 average temperatures (*high confidence*). However, because of slow response times, sea level in most coastal areas is projected to continue to rise, glaciers to continue to melt, and permafrost to continue to thaw through the century, even after surface temperatures stabilize (*high confidence*).

Chapter and Section	Key Messages
3.2 Synthesis of projected changes **(Continued)**	**Canada's long-term future climate in a world with no climate policies** **Key Message 3.4** Climate change will continue to intensify strongly in all regions of Canada if emissions continue to rise throughout the century (*high confidence*), which would reflect a scenario in which current global climate policies are rolled back or fail to mitigate global emissions. In 2081–2100 under this scenario, Canadian temperatures are projected to increase to 6.9°C (5.2–8.9°C) above the 1850–1900 average (*high confidence*). Precipitation is projected to increase on average by 17% (12–24%) for Canada as a whole (*medium confidence*), with larger increases in the intensity and frequency of heavy precipitation events than under the current-policies scenario (*high confidence*). Atmospheric rivers over Canada are projected to strengthen (*high confidence*), while summer drought is projected to intensify in southern Canada (*high confidence*). With higher warming levels, the duration of snow, sea ice, and seasonally frozen ground in Canada is projected to shorten even more than under current global climate policies, and glacier melt, permafrost thaw, and sea level rise along most of Canada's coasts are projected to be higher (*high confidence*).
3.3 Climate projections and their uncertainties	**Key Message 3.5** Uncertainties in climate projections result from uncertainties in future emissions of greenhouse gases and other climate change drivers, uncertainties in how the climate system will respond to those changes, and internal climate variability. The range of plausible future global emissions has shifted towards lower emissions scenarios, partly because of developments in global policy and technology (*medium confidence*). For each emissions scenario, climate response uncertainty has narrowed, owing to improved synthesis of climate models and observations (*high confidence*). Some internal variability in Canadian climate can now be predicted for periods of up to five years (*medium confidence*), reducing this source of uncertainty in estimates of near-term climate.

Chapter and Section	Key Messages
3.4 Temperature	**Key Message 3.6** Average surface air temperature is projected to increase across Canada in all seasons (*very high confidence*). The projected warming for Canada based on new techniques and climate models is higher than assessed in the first (2019) edition of *Canada's Changing Climate Report* for nominally equivalent scenarios (*high confidence*).
	Key Message 3.7 Under a current-policies scenario, annual average temperature is projected to increase by 5.0°C (3.8–6.6°C) relative to 1850–1900 by 2081–2100 (*high confidence*), with larger increases in northern Canada in winter that could exceed 10°C in some regions (*medium confidence*). Under a no-policies scenario, average warming for Canada is projected to reach 6.9°C (5.2–8.9°C) by the same period (*high confidence*). Under a net-zero scenario, annual average temperature for Canada is projected to stabilize after 2050, reaching 3.5°C (2.3–4.8°C) above 1850–1900 levels in 2081–2100 (*high confidence*).
3.5 Precipitation	**Key Message 3.8** Winter and annual average precipitation are expected to increase everywhere in Canada, especially in northern Canada and around Hudson Bay (*high confidence*). Summer average precipitation is expected to increase in northern Canada (*medium confidence*) and decrease in parts of southern Canada (*low confidence*). Annual average precipitation is projected to increase for Canada as a whole by 10% (7–15%) under a net-zero scenario, 13% (9–18%) under a current-policies scenario, and 17% (12–24%) under a no-policies scenario by 2081–2100 relative to 1850–1900 (*medium confidence*). Increases in winter precipitation could exceed 50% in parts of Nunavut and Nunavik (northern Quebec) in the current-policies scenario (*medium confidence*).
	Key Message 3.9 Annual snowfall is projected to increase in northern Canada, but it is projected to decrease in southernmost Canada, particularly in coastal regions (*medium confidence*). This pattern reflects an increase in precipitation everywhere in Canada but warming causing less of it to fall as snow in southernmost regions. Under current-policies and no-policies scenarios, freezing rain is projected to become more frequent over much of Canada, but less frequent over Atlantic Canada and southern Ontario (*medium confidence*), driven by changes in the simultaneous occurrence of freezing conditions at the surface and warmer air aloft.
3.6 Average near-surface wind	**Key Message 3.10** Average near-surface wind speed and wind power potential are projected to decrease for Canada (*low confidence*). Wind speed projections for Canada are highly uncertain due to low model agreement.

Chapter and Section	Key Messages
Chapter 4: Large-scale atmosphere-ocean processes affecting climate	
4.2 Arctic amplification	**Key Message 4.1** The Arctic (the region north of the Arctic circle) has warmed at more than three times the rate of the global average over the past five decades (*high confidence*). Most of this increased warming, known as Arctic amplification, is caused by human influence (*high confidence*) and involves local climate processes and feedbacks, including sea ice loss. It largely explains why Canada has warmed nearly twice as fast as the global average and the Canadian Arctic three times as fast for the period 1970-2023 (*high confidence*).
	Key Message 4.2 Arctic amplification, and the greater rate of warming in Canada's Arctic compared to the rest of Canada, will continue over the 21st century (*very high confidence*). In the coming decades, the Canadian Arctic is projected to warm at more than twice the rate of the global average (*medium confidence*).
4.3 Jet streams, storm tracks, and atmospheric modes of variability	**Key Message 4.3** Changes in recent decades in the jet streams and storm tracks that affect Canada are small and seen only in limited seasons and regions. There is *low confidence* in any human influence on these past changes. An overall poleward shift in the jet streams and storm tracks is projected by the end of the 21st century, but the changes are small and depend on the region and season (*low confidence*).
4.4 Extratropical storms and atmospheric blocks	**Key Message 4.4** Changes in recent decades in the frequency and intensity of extratropical storms and of atmospheric blocks are uncertain. There is *low confidence* in any human influence on these past changes. A poleward shift in extratropical storms and a decrease in the frequency of summer extratropical storms are projected over Canada (*low confidence*). Atmospheric blocks are projected to occur less frequently over Canada, but there are large regional variations (*low confidence*).

Chapter and Section	Key Messages
4.5 Atmospheric rivers	**Key Message 4.5** The frequency and intensity of atmospheric rivers have increased for Canada as a whole in recent decades (*medium confidence*). However, there is *very low confidence* in the magnitude of these increases due to the limited number of studies and the sensitivity of results to how atmospheric rivers are defined and detected. There is insufficient evidence to attribute long-term trends for Canada as a whole to human influence. However, human influence has increased the likelihood of extreme atmospheric-river events in southern British Columbia (*low confidence*).
	Key Message 4.6 The frequency and intensity of atmospheric rivers over Canada will increase in the future in high emissions scenarios (*high confidence*) and intermediate emissions scenarios (*medium confidence*). However, the magnitude of these increases is uncertain.
4.6 North Atlantic hurricanes	**Key Message 4.7** The strength and associated precipitation rates of North Atlantic hurricanes have increased (*medium confidence*). However, since only a small proportion of Atlantic hurricanes affect Canada, there is *low confidence* in the degree to which these changes have affected eastern Canada.
	Key Message 4.8 The average precipitation rates, maximum precipitation rates, and peak wind speeds associated with North Atlantic hurricanes, as well as the proportion of hurricanes in the North Atlantic that reach categories 4 and 5, are projected to increase (*high confidence*). However, regarding the small number of hurricanes affecting Canada, there is *medium confidence* in increasing precipitation rates and *low confidence* in increasing wind speeds. Changes in frequency of hurricanes affecting Canada are uncertain.

Chapter and Section	Key Messages
4.7 Large-scale environmental conditions favouring thunderstorms	**Key Message 4.9** There is *low confidence* that large-scale environmental conditions favouring thunderstorms in Canada have changed over the past several decades. This is due to a lack of regional studies for Canada, the weak, conflicting trends across different environmental-condition indicators and data products, and large internal climate variability.
	Key Message 4.10 Large-scale environmental conditions favouring thunderstorms are projected to become more prevalent across central and eastern Canada in spring, summer, and fall (*high confidence*). However, there is *low confidence* that thunderstorms and other severe weather events will increase, because an increase in favourable environmental conditions does not always lead to more thunderstorms.
4.8 El Niño-Southern Oscillation and other atmosphere-ocean coupled modes of variability	**Key Message 4.11** The El Niño–Southern Oscillation (ENSO) is the dominant source of year-to-year climate variability in western Canada. Year-to-year climate fluctuations associated with ENSO have been larger since 1950 than in the previous century (*medium confidence*). However, there is *low confidence* that this change is due to human-caused climate change because internal climate variability is large.
	Key Message 4.12 The El Niño–Southern Oscillation (ENSO) will remain the dominant source of climate variability in western Canada in the 21st century (*high confidence*), but there is *low confidence* in projected changes in year-to-year climate fluctuations associated with ENSO. While climate models consistently show that by the end of the century, the effect of ENSO on winter climate fluctuations will extend into central and eastern Canada, there is *low confidence* in these projections due to systematic climate model biases.

Chapter and Section	Key Messages
4.9 Ocean circulation	**Key Message 4.13** The primary large-scale ocean current system affecting climate in Canada is the Atlantic Meridional Overturning Circulation (AMOC). A weaker than normal AMOC is associated with cooler and drier than normal winters over eastern Canada. There is *high confidence* that a temporary weakening of the AMOC between 2007 and 2015 led to a period of cooler North Atlantic Ocean surface temperatures and *low confidence* that this AMOC weakening can be attributed to human influence.
	Key Message 4.14 There is *high confidence* that the Atlantic Meridional Overturning Circulation (AMOC) will gradually weaken over the remainder of the 21st century due to human influence, and that this will slightly reduce the warming of eastern and northern Canada. However, the possibility that the AMOC could shut down, leading to a more pronounced regional cooling influence, cannot be ruled out. There is *medium confidence* that the AMOC will not shut down in the 21st century.
4.10 Synthesis of changes in atmosphere-ocean processes and phenomena	**Key Message 4.15** Changes that are due to thermodynamic processes are generally robust and well understood.
	Key Message 4.16 Regional variations in Canadian climate depend strongly on changes in dynamical processes, which are uncertain and less well understood.
	Key Message 4.17 There is generally more confidence in future human-caused changes than in the attribution of past changes to human-caused climate change.
Chapter 5: Changes in the water cycle	
5.2 Atmospheric component of the water cycle	**Key Message 5.1** The atmospheric component of Canada's water cycle has been altered and will continue to be altered by human influence (*medium confidence*). Total annual precipitation has increased and is projected to continue to increase (*high confidence*). While there is only *low* to *medium confidence* in observed increases in the frequency and intensity of different types of heavy precipitation, there is *high confidence* these will increase in the future. Warm-season evaporation has increased and is projected to continue to increase across much of Canada, including over open water because of longer ice-free periods (*low confidence*). The 0°C air temperature isotherm (constant temperature line) is projected to move farther north and to higher elevations across Canada (*medium confidence*), which is expected to result in changes in the proportion of rainfall versus snowfall.

Chapter and Section	Key Messages
5.3 Streamflow magnitude and timing	**Key Message 5.2** The greatest changes in streamflow magnitude across Canada have occurred and are projected to continue to occur on a seasonal basis. During the last 50 to 70 years, streamflow amounts have increased in winter and spring, and in some areas have decreased during summer (*high confidence*). Winter increases are projected to continue across the entire country, while summer decreases are projected across western Canada (*high confidence*).
	Key Message 5.3 Annual streamflow amounts have increased in regions of northern Canada dominated by permafrost and will continue to do so (*high confidence*). No long-term historical or projected changes in annual streamflow are evident across the rest of the country (*high confidence*).
	Key Message 5.4 The timing of spring peak streamflow has shifted across Canada to earlier in the season because of the earlier onset of spring freshets. This shift has resulted in changes from more snowmelt-dominated streamflow regimes to rainfall-dominated regimes. These changes are projected to continue (*high confidence*).
5.4 Surface water levels - lakes and wetlands	**Key Message 5.5** Over the period of observation, there is no indication of long-term changes in water levels in lakes and wetlands for Canada as a whole, and considerable regional and temporal variability is apparent. Levels are projected to decrease in some regions and increase in others (*medium confidence*) because of the many complex factors that affect surface water storage. These factors include ice cover duration, open-water evaporation, increased precipitation, and permafrost thaw and associated lake drainage or lake expansion.
5.5 Groundwater	**Key Message 5.6** Groundwater recharge is anticipated to occur earlier in the year across the country, largely because of earlier snowmelt and more winter rain events (*high confidence*). The greatest changes in groundwater systems are expected to occur in northern Canada because of thawing permafrost, which may result in new groundwater pathways (*medium confidence*). This would allow more interaction between deeper groundwater and surface water systems with possible effects on surface water quality.
	Key Message 5.7 Groundwater is expected to remain one of the more resilient freshwater resources in a changing climate in comparison to surface water (*medium confidence*), given its naturally slow flow and enormous storage capacity, and if extraction through pumping does not markedly increase.

Chapter and Section	Key Messages
5.6 Droughts	**Key Message 5.8** Meteorological and agricultural droughts are projected to be longer and more frequent and intense across central and southern Canada during summer, and to be more prominent with higher amounts of global warming and at the end of the century (*high confidence*). Summer hydrological droughts are also projected to be longer and more frequent and intense in many regions of southern Canada, mainly because of increased evaporation and lower runoff from mountainous regions (*low confidence*). Historically, periodic droughts have occurred across much of Canada, but no long-term changes in their frequency are detectable (*high confidence*).
5.7 Floods	**Key Message 5.9** Over the period of observation, there have been no consistent trends in streamflow flood events across the country (*high confidence*). Streamflow-related floods in Canada are driven by multiple factors, including extreme precipitation, rapid snowmelt, rain-on-snow events, and ice jams, with complex interactions among these drivers.
	Key Message 5.10 Projected increases in extreme precipitation are expected to lead to more frequent and intense flash flooding across Canada (*high confidence*). Warmer temperatures are expected to lead to the earlier occurrence of snowmelt, rain-on-snow events, and ice jam breakups, resulting in earlier streamflow-related spring floods (*medium confidence*). However, their future frequency remains uncertain because of the interactions among rising temperatures, reduced snow cover, and the complex dynamics of ice jam–related and snowmelt-related floods.
5.9 Synthesis of water cycle changes	**Key Message 5.11** There has been a shift in the timing of many water cycle–related processes to earlier in the spring (*high confidence*). The shifts include earlier occurrences of snowmelt, spring freshet, groundwater aquifer recharge, and freshwater ice-free dates. These changes are projected to continue (*high confidence*) with possible consequences for future freshwater security.
	Key Message 5.12 Canada's water cycle has been altered and will continue to be altered by climate warming (*medium confidence*). This involves more precipitation, changes in the proportion of rainfall versus snowfall, increases in warm-season evaporation, and a greater potential for flash flooding and summer drought. These changes are expected to directly impact the availability of surface and subsurface freshwater across Canada.

Chapter and Section	Key Messages
Chapter 6: Changes in the cryosphere	
6.2 Terrestrial snow	**Key Message 6.1** Snow cover duration has shortened in Canada as a whole over the past four decades (*high confidence*). Snow cover duration has shortened in northern Canada, southern Ontario, and parts of eastern Canada by one to four weeks, while snow cover duration has lengthened across central Canada by one to four weeks (*medium confidence*). This regional variability is also reflected in changes in peak snowpack amounts over the past four decades (*high confidence*).
	Key Message 6.2 Snow cover duration is projected to shorten across all of Canada and peak snowpack amounts are projected to decrease across most of Canada with increasing climate warming (*very high confidence*). Unlike the rest of Canada, the western and central parts of northern Canada are projected to experience larger peak snowpack amounts due to increased snowfall despite a shorter projected snow season (*medium confidence*).
	Key Message 6.3 Past amounts and changes in snowpack are more uncertain for mountainous regions than elsewhere (*high confidence*). In a warmer climate, mountainous regions in Canada are expected to have less snowpack accumulation and experience more mid-winter melt events, changing the timing and reducing the predictability of Canadian water resources (*high confidence*).

Chapter and Section	Key Messages
6.3 Sea ice	**Key Message 6.4** Sea ice cover has declined in Canadian waters over the past four to five decades (*very high confidence*). Regions once covered by thick, multi-year sea ice are now covered by thinner seasonal sea ice that melts every summer (*very high confidence*). Landfast ice cover, which provides habitat for wildlife and is important for transportation, hunting, and the culture of northern communities, has also declined across the Canadian Arctic and Hudson Bay region (*high confidence*).
	Key Message 6.5 The transport of sea ice from the central Arctic Ocean into Canadian Arctic waters has increased over the past two and a half decades (*high confidence*). This increased transport of sea ice out of the central Arctic Ocean depletes its reserves of thick, multi-year sea ice, while the corresponding flow of multi-year ice into southern Canadian Arctic waters, such as the Northwest Passage, creates hazardous conditions for shipping.
	Key Message 6.6 The sea ice–free period is projected to lengthen further across Canadian Arctic and Hudson Bay waters with increasing climate warming (*very high confidence*). In regions with seasonal sea ice cover, the number of ice-free days is projected to increase by approximately one month for each degree of global warming, with smaller increases in the Labrador Sea and larger increases in the Beaufort Sea (*medium confidence*). The transport of multi-year ice into the Northwest Passage is projected to continue beyond mid-century thereby continuing to limit the shipping season (*medium confidence*).
6.4 Lake and river ice	**Key Message 6.7** Lake ice duration has shortened in Canada as a whole over the past four decades (*high confidence*). Lake ice duration has shortened in northern Canada, British Columbia, southern Ontario, and parts of Atlantic Canada by one to four weeks, while lake ice duration has lengthened across central Canada by up to two weeks (*medium confidence*). The timing of river ice breakup during spring has changed in response to temperature, and the number of mid-winter breakups is increasing in Canada (*medium confidence*).
	Key Message 6.8 Lake ice duration is projected to shorten across Canada as climate warming increases, leading to corresponding decreases in maximum ice thickness (*very high confidence*). River ice duration and thickness are also expected to decrease generally with increasing climate warming (*high confidence*), but there is *low confidence* that such changes will be consistently accurate for individual rivers.

Chapter and Section	Key Messages
6.5 Glaciers	**Key Message 6.9** All glaciers in western Canada and the Canadian Arctic have thinned and lost mass over the past two and a half decades, as shown by satellite measurements with comprehensive spatial coverage (*very high confidence*). Longer-term field measurements on a small number of reference glaciers show that glaciers in Canada have been losing mass since at least the 1960s, and that the rate of loss has accelerated in recent decades (*high confidence*). In western Canada, declines in glacier contributions to summer streamflow have been observed in several watersheds (*high confidence*), marking an irreversible decrease in a critical source of freshwater for these regions.
	Key Message 6.10 Canada's glaciers are projected to continue losing mass under every future emissions scenario (*very high confidence*). In western Canada, more than 55% of glacier ice is predicted to disappear by 2100, even if global warming is limited to 2°C (*high confidence*). The number and severity of glacier-related hazards, such as flooding and landslides, are expected to increase, particularly in western Canada (*medium confidence*). Melt water from glaciers and ice caps in the Canadian Arctic will continue to be among the largest glacier sources of global sea-level rise up to and beyond 2100 (*very high confidence*).
6.6 Seasonally frozen ground	**Key Message 6.11** The annual number of days with seasonally frozen ground has decreased in Canada over the past four decades (*high confidence*). At locations without underlying permafrost, decreases in the depth of seasonal freezing are expected to have occurred, while at most locations with underlying permafrost, increases in the depth of seasonal thawing are expected to have occurred (*medium confidence*), but the limited number of observations prevent direct assessment of such changes.
	Key Message 6.12 The annual number of days with seasonally frozen ground, and the maximum annual depth of seasonally frozen ground outside permafrost areas, are expected to decrease across Canada until mid-century before stabilizing under a low emissions scenario (*high confidence*). In contrast, these indicators of seasonally frozen ground are expected to continue declining until the end of century and beyond under emissions scenarios with higher levels of carbon emissions and increasing global temperatures (*high confidence*).

Chapter and Section	Key Messages
6.7 Permafrost	**Key Message 6.13** Permafrost at monitored locations in northern Canada has warmed and thawed since the 1980s (*very high confidence*). Landscapes in the parts of northern Canada with ice-rich terrain have changed in response to climate-driven permafrost thaw (*very high confidence*).
	Key Message 6.14 Permafrost warming and thaw-driven landscape changes are expected to continue with increased climate warming (*very high confidence*). Even if the climate stabilizes, some thawing will continue at depth (*very high confidence*). However, there is *low confidence* regarding the magnitude and timing of these changes because of the influence of local ground characteristics.
6.8 Synthesis	**Key Message 6.15** Coherent changes across many components of the cryosphere are evident both globally and across Canada.
	Key Message 6.16 The evidence for formal attribution of changes in the cryosphere to human influence, and for correlations between cryospheric and temperature signals, has strengthened. Because air temperature exerts the dominant control on many components of the cryosphere, human-caused climate change is certain to be influencing widespread changes in the cryosphere in Canada.
	Key Message 6.17 Changes in all components of the cryosphere are projected to worsen or intensify with additional global warming, but limiting the increases in global average temperature will limit these changes.

Chapter and Section	Key Messages
Chapter 7: Changes in the oceans	
7.2 Ocean temperatures	**Key Message 7.1** Ocean temperatures around Canada have increased in ice-free periods since the mid-20th century (*high confidence*). This increase is consistent with the warming observed in the global upper ocean, for which human influence is *extremely likely* to be the main driver. The largest increase in annual average sea surface temperatures has been observed adjacent to southern Atlantic Canada (*high confidence*). By season, the greatest warming has occurred in summer and extends throughout the ocean bordering eastern Canada, including Hudson Bay (*high confidence*).
	Key Message 7.2 Continued warming is projected for the oceans around Canada, with the magnitude increasing with higher greenhouse gas emissions (*high confidence*). The increase in annual average sea surface temperatures is expected to be greater in the waters next to Atlantic Canada and British Columbia than in the Arctic (*medium confidence*). During the summer period, sea surface temperatures are expected to increase the most in the Beaufort Sea and Hudson Bay, in part due to the decline of seasonal sea ice cover there (*medium confidence*).
	Key Message 7.3 More frequent and intense marine heatwaves have been observed in the Pacific and Atlantic oceans around Canada since the 1980s and are expected to continue to increase in all oceans, including the Arctic, because of human-caused climate change (*high confidence*).
7.3 Ocean salinity and stratification	**Key Message 7.4** The surface waters of the oceans around Canada are characterized by relatively low salinity and have become even fresher since the 1950s (*high confidence*). The increasing freshwater input to these oceans results from warming-driven increases in precipitation and runoff from land, which includes glacier and ice sheet meltwater (*high confidence*). Ocean freshening is projected to continue throughout the 21st century; however, the limited number of emissions scenarios studied and the variability among model projections have resulted in *low confidence* for the Arctic and *medium confidence* for the Atlantic and Pacific.
	Key Message 7.5 Increased stratification, or layering of the upper ocean according to water density, in the northeast Pacific and southern Atlantic Canada regions has resulted from warming and freshening of the sea surface (*high confidence*). Increased stratification reduces the vertical mixing of nutrients and other chemical compounds in the upper ocean, which is an important process in the marine ecosystem.

Chapter and Section	Key Messages
7.4 Global and relative mean sea level	**Key Message 7.6** Global mean sea level has risen by about 20 cm since 1900 as a result of human influence on the climate system (*very high confidence*). The main contributions to this rise have been thermal expansion of the warming ocean and widespread melting of ice on land, which results in runoff into the ocean (*very high confidence*). In regions of Canada where the land is subsiding, the relative mean sea level has risen more than would be expected from global sea level rise alone (*very high confidence*). Rates of up to 34 cm per century in southern Atlantic Canada and the western Arctic have been observed, with smaller rates in British Columbia (*very high confidence*). In contrast, the sea level in western Hudson Bay has fallen by 88 cm per century, owing to rapid land uplift (*very high confidence*). Land uplift and subsidence are caused by the continuing adjustment of the land surface, due to the loss of ice mass after the last continental glaciation.
	Key Message 7.7 Global mean sea level is projected to rise by many tens of centimetres in the 21st century under a low emissions scenario and is *unlikely* to be more than a metre under a very high emissions scenario (*medium confidence*). Relative sea levels in different parts of Canada are, however, projected to rise or fall depending on local vertical land motion as well as the amount of global sea-level rise. Owing to land subsidence, parts of Atlantic Canada and the western Arctic are projected to experience increases in relative sea level that are larger than the change in the global mean sea level during the coming century (*high confidence*).
7.5 Waves and storm surge	**Key Message 7.8** Mean and extreme wave heights have increased in Arctic and sub-Arctic regions, primarily as a result of the warming-driven reduction in sea ice (*high confidence*). Wave heights in the northwest Atlantic have also increased over the last few decades (*medium confidence*), but the changes in ice-free areas that would result in increased wave heights cannot be directly attributed to human-caused climate change. Wave height trends in the northeast Pacific are not statistically significant. Extreme storm surges have increased in areas of the western Arctic, Hudson Bay, and Atlantic Canada (*low confidence*).
	Key Message 7.9 The projected lengthening of the Arctic ice-free season will cause increases in mean and extreme wave heights (*high confidence*) and storm surges (*medium confidence*). In areas of Atlantic Canada not affected by sea ice, mean wave heights are projected to decrease (*medium confidence*), while weak changes are projected in the northeast Pacific (*low confidence*). Projections of extreme wave heights in areas without sea ice provide limited evidence of increases in Atlantic Canada (*low confidence*).

Chapter and Section	Key Messages
7.6 Extreme sea level	**Key Message 7.10** Extreme sea-level events have increased in frequency and magnitude in places along Canada's coastline where the relative sea level has risen over the past century, such as southern Atlantic Canada, the western Arctic, and British Columbia (*high confidence*).
	Key Message 7.11 Extreme sea-level events are projected to occur more often and to become larger because of future increases in relative sea-level rise in many parts of Canada (*high confidence*). The projected decline of sea ice along Canada's Arctic and Atlantic coasts will result in increased waves and storm surges, which will exacerbate extreme sea-level events (*high confidence*).
7.7 Ocean chemistry	**Key Message 7.12** At the surface, observations over the last three decades show that the oceans around Canada have absorbed anthropogenic carbon dioxide from the atmosphere, causing ocean acidification (*very high confidence*). This higher-carbon, acidified water is carried beneath the surface by ocean circulation.
	Key Message 7.13 Beneath the surface, oxygen has declined over many decades in the offshore and coastal waters of the northeast Pacific, in the Estuary and Gulf of St. Lawrence, and on the Scotian Shelf (*high confidence*), but the processes responsible vary by region and are not fully understood. Since biological respiration both consumes oxygen and adds carbon dioxide, acidification is exacerbated in regions experiencing oxygen declines (*high confidence*). Year-to-year variations in water circulation and biological activity have caused extreme low-oxygen and high-acidity events in the subsurface oceans around Canada (*medium confidence*).
	Key Message 7.14 Over the rest of the 21st century, the oceans around Canada are projected to continue to absorb anthropogenic carbon dioxide, to increase in acidity (*very high confidence*), and to lose oxygen in the subsurface (*medium confidence*). The level of projected acidification in the latter half of this century will strongly depend on the level of future carbon dioxide emissions (*very high confidence*).
7.8 Synthesis	**Key Message 7.15** The oceans slow the rate of climate-driven atmospheric warming by absorbing heat and carbon dioxide; however, this absorption, in turn, warms and acidifies the oceans around Canada (*very high confidence*). Impacts on the ocean include more frequent and intense marine heatwaves, increasing stratification, rising sea levels in many regions, more frequent coastal flooding events, and decreasing ocean oxygen levels (*high confidence*). Continued emissions will intensify these changes, but with impacts varying substantially along Canada's coastlines, which will result in differing needs for climate change adaptation (*high confidence*).

Chapter and Section	Key Messages
Chapter 8: Changes in extremes	
8.2 Temperature extremes	**Key Message 8.1** The intensity and frequency of hot extremes in Canada as a whole and in multiple regions have increased since the mid-20th century (*high confidence*). The intensity and frequency of cold extremes in Canada as a whole and in all Canadian regions have decreased since the mid-20th century (*high confidence*). Human influence on the climate is the dominant driver of the observed warming of both hot and cold extremes (*high confidence*).
	Key Message 8.2 Increases in the intensity and frequency of hot extremes and decreases in the intensity and frequency of cold extremes are projected for all regions of Canada, with changes becoming larger as global mean temperature increases (*very high confidence*).
8.3 Precipitation extremes	
8.3.1 One-day and five-day total precipitation extremes	**Key Message 8.3** The intensity and frequency of one-day and five-day precipitation extremes have increased in Canada as a whole since the mid-20th century (*medium confidence*), consistent with an increase in atmospheric moisture across Canada due to warming. Human influence on the climate is the main driver of the observed intensification of extreme precipitation at the continental scale across North America (*high confidence*). Increases in the intensity and frequency of one-day and five-day precipitation extremes have been observed with *low confidence* in many, but not all, regions of Canada since the mid-20th century. These regional changes are uncertain, due to large spatial and temporal variability.
	Key Message 8.4 Increases in the frequency and intensity of one-day and five-day precipitation extremes are projected for all regions of Canada (*high confidence*), with changes becoming larger as global average temperature increases (*high confidence*).

Chapter and Section	Key Messages
8.3.2 Short-duration rainfall extremes	**Key Message 8.5** The intensity and frequency of short-duration (i.e., timescales shorter than a day) rainfall extremes have increased for Canada as a whole (*low confidence*) since the mid-20th century. The lower confidence in shorter-duration precipitation extremes is due to greater spatial and temporal variability, the lower density of observing stations, and shorter length of records. Local and regional changes cannot be assessed with confidence for these same reasons.
	Key Message 8.6 The intensity and frequency of short-duration rainfall extremes in Canada are projected to increase in the future (*high confidence*), with the increases becoming larger as global average temperature increases (*high confidence*). The projected rate of intensification of short-duration rainfall extremes for Canada as a whole is consistent with the rate of increase in atmospheric moisture along with average warming in Canada (*medium confidence*).
8.3.3 One-day snowfall extremes	**Key Message 8.7** The intensity and frequency of heavy one-day snowfalls have increased at most locations in northern Canada since the mid-20th century (*medium confidence*). Under future warming, these heavy snowfall amounts are projected to increase across much of northern and eastern Canada (*medium confidence*). In southwestern Canada, heavy one-day snowfall amounts have decreased since the mid-20th century (*medium confidence*), while no clear pattern has been observed in southeastern Canada. There is *low confidence* in the magnitude and direction of future changes in extreme snowfall events for southern Canada.
8.3.4 Freezing rain extremes	**Key Message 8.8** There is insufficient evidence to assess historical changes in extreme freezing rain events — those that cause an accumulation of ice sufficient to disrupt infrastructure — in Canada, due to limited observational data and a paucity of studies focusing on historical trends. The frequency of extreme freezing rain is projected to increase in most regions of Canada (*low confidence*), while some decreases or no significant changes are projected in parts of southern Ontario, the Atlantic provinces, and coastal regions of Hudson Bay (*low confidence*).
8.3.5 Hail	**Key Message 8.9** There is insufficient evidence to assess historical changes in severe hail (≥ 2 cm in diameter) for Canada as a whole. Limited studies examining trends in hail of any diameter suggest regionally contrasting patterns, with increasing trends in Alberta and decreasing trends in Saskatchewan and Manitoba over recent decades (*very low confidence*). Projections indicate a potential increase in the frequency of severe hail across parts of western Canada (*very low confidence*), but this assessment is based on limited evidence and involves substantial modelling challenges.

Chapter and Section	Key Messages
8.4 Wind extremes	**Key Message 8.10** There is insufficient evidence to assess historical changes in extreme winds in Canada due to limited station coverage and representativeness, significant uncertainties in reanalysis products, and the paucity of studies examining trends in wind extremes. There is *very low confidence* in the direction and magnitude of future changes in extreme winds due to the limited number of studies and the substantial uncertainty related to model projections of wind-related phenomena.
8.5 Water cycle extremes **8.6 Oceans**	Key messages for these sections of Ch. 8 are positioned in their home chapters. Chapter 5 assessed changes in the water cycle and Chapter 7 assessed changes in the oceans.
8.7 Compound events	
8.7.1 Fire weather and wildfires	**Key Message 8.11** The fire season has lengthened in most parts of Canada (*high confidence*) and is projected to continue to lengthen as the global average temperature increases (*high confidence*). Fire weather — characterized by hot, dry, and windy conditions conducive to wildfires — has increased in Alberta and British Columbia (*medium confidence*), with some indications of increases in other regions (*very low confidence*). The frequency and intensity of extreme fire weather conditions are projected to increase in most regions of Canada as global average temperature rises (*high confidence*).
8.7.2 Compound coastal flooding	**Key Message 8.12** Compound coastal flooding arises from jointly occurring climate conditions, such as heavy rain during episodes of extreme water levels. Such co-occurring drivers have increased in frequency and intensity in some parts of Canada, with evidence primarily from Atlantic locations (*low confidence*), and are projected to become more frequent and intense at locations along the Atlantic, Pacific and Western Arctic coastlines (*medium confidence*). These projected increases are mostly due to rising sea levels and increases in the frequency and intensity of extreme precipitation events (*medium confidence*).
8.7.3 Compound wind and rainfall	**Key Message 8.13** There is insufficient evidence to assess historical changes in compound wind and rainfall events in Canada, due to limited studies focusing on observed trends. Compound extreme wind and rainfall events are projected to increase (*medium confidence*), driven mainly by the greater frequency of future extreme rainfall, but with *very low confidence* in the regional pattern and magnitude of changes.

Chapter and Section	Key Messages
8.7.4 Human-perceived heat stress	**Key Message 8.14** The intensity and frequency of human-perceived heat stress — which results from the combined effects of high temperatures and humidity — have increased in Canada as a whole (*high confidence*). Human-perceived heat stress is projected to increase in Canada, driven mainly by increases in air temperature (*high confidence*).
8.8 Synthesis of the effects of warming on climate extremes	**Key Message 8.15** Warming has led to increases in the frequency and intensity of hot extremes, human-perceived heat stress, and marine heatwaves, and decreases in cold extremes (*high confidence*), as well as increases in the frequency and intensity of extreme fire weather conditions and the intensification of heavy precipitation events in Canada (*medium confidence*), with projections indicating continued and larger changes under higher global warming levels (*high confidence*).
Chapter 9: The role of the carbon cycle in climate change	
9.2 Natural global carbon cycle	**Key Message 9.1** Before the industrial era, carbon stored in fossil fuels had remained isolated for millions of years, playing no discernable role in the exchange of carbon between the land, ocean, and atmosphere (*very high confidence*).
	Key Message 9.2 During the last 800,000 years before the industrial era, the atmospheric carbon dioxide concentration varied between 170 and 300 parts per million (*very high confidence*). For comparison, the atmospheric carbon dioxide concentration for the year 2024 was 423 parts per million.

Chapter and Section	Key Messages
9.3 Human-caused changes to the global carbon cycle	**Key Message 9.3** The increase in atmospheric carbon dioxide concentrations since the pre-industrial era has unequivocally been caused by emissions from the burning of fossil fuels and human-caused land-use change. In 2023, annual human-caused global CO_2 emissions reached 41 Gt CO_2/yr (± 3 Gt CO_2/yr) (gigatonnes of carbon dioxide per year); including contributions from other greenhouse gases, total greenhouse gas emissions were 57 Gt CO_2-eq/yr (carbon dioxide equivalent units per year).
	Key Message 9.4 Based on Canada's national inventory report, total anthropogenic greenhouse gas emissions for Canada peaked in 2007 at 774 Mt CO_2-eq (megatonnes of carbon dioxide equivalent units). Notable reductions occurred in 2008–2009 during the global recession (714 Mt CO_2-eq/yr) and in 2020 during the COVID-19 pandemic (682 Mt CO_2-eq/yr). Emissions for 2023 (694 Mt CO_2-eq/yr; most recent year reported) are approximately 10% lower than their 2007 peak, despite continued growth in Canada's population and economy.
	Key Message 9.5 Land and ocean together have taken up more than half of the global anthropogenic carbon dioxide emissions since the pre-industrial era (*very high confidence*). The ocean is expected to continue taking up carbon dioxide in the long term (beyond a century), but the land carbon sink may weaken or become a carbon source (*high confidence*).
9.4 Global climate response to carbon dioxide emissions	**Key Message 9.6** There is an approximately linear relationship between global warming and cumulative carbon dioxide (CO_2) emissions (*high confidence*). This relationship implies a limit to the total amount of CO_2 that can be emitted into the atmosphere while keeping warming below a given level (e.g., 2°C).
	Key Message 9.7 There will be little to no further global warming from carbon dioxide (CO_2) after CO_2 emissions cease (*medium confidence*).
	Key Message 9.8 In addition to carbon dioxide (CO_2), other greenhouse gases (non-CO_2 GHGs) in the atmosphere cause global warming. Limiting warming to a specific level requires emissions of long-lived GHGs such as CO_2 to reach net zero and emissions of short-lived GHGs to decline strongly (*high confidence*).

Chapter and Section	Key Messages
9.5 The carbon cycle in Canada	**Key Message 9.9** Carbon in Canada's oceans is mainly stored in seawater and marine sediments. On land, almost all (about 95%) of the carbon in Canada is stored in soils, including permafrost and peatlands, with the rest (about 5%) stored in vegetation (*very high confidence*).
	Key Message 9.10 Since the last Ice Age, there has been a net uptake of carbon by Canada's land mass. At present (2000–2019), the land continues to be a carbon sink (*medium confidence*). However, extreme events like the 2023 fire season can cause the land to become a temporary source of carbon (*low confidence*). In the future, both carbon uptake from increased vegetation growth (*medium confidence*) and carbon emissions from permafrost thaw, wildfires, and other disturbances (*high confidence*) are expected to increase. However, their net effect on the carbon balance of Canada's land ecosystems remains uncertain.
	Key Message 9.11 The annual forest area burned by fires in Canada has increased since the early 1980s (*medium confidence*). The area burned is projected to increase further as the climate continues to warm (*high confidence*).
	Key Message 9.12 On average, Canada's oceans (inside the Exclusive Economic Zone) take up carbon dioxide (CO_2) (*medium confidence*), although some nearshore areas emit CO_2 (*low confidence*). Overall, Canada's oceans will continue to take up CO_2, as long as atmospheric CO_2 concentrations continue to increase (*medium confidence*).
9.6 Nature-based approaches to climate change mitigation	**Key Message 9.13** Nature-based climate solutions (NBCS) play a complementary rather than a central role in achieving climate change mitigation goals (*very high confidence*).
	Key Message 9.14 In Canada, the protection of existing nature-based carbon stocks and carbon dioxide (CO_2) drawdown resulting from the expansion of nature-based carbon sinks is estimated to reach as much as 78 Mt CO_2-eq/yr (CO_2-equivalent units per year) after 10 years of implementation (*low confidence*).