Climate Projections for the Capital Region

2024

Updated April 2024

PACIFIC CLIMATE IMPACTS CONSORTIUM

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EXECUTIVE SUMMARY

The Earth's climate system is warming, and signs of climate change are becoming evident across the planet. The capital region, located on Southern Vancouver Island and Gulf Islands of British Columbia (BC), is no exception. The Capital Regional District (CRD) has partnered with the Pacific Climate Impacts Consortium (PCIC) to produce high-resolution regional projections for temperature, precipitation, and related indices of extremes. These projections use the most up-to-date global modeling data (i.e., the Sixth Coupled Model Intercomparison Project, CMIP6) to illustrate how the region's climate may change by the middle of this century. Information provided by this report and the accompanying data is intended to support decision makers and community partners in the region with an improved understanding of projected local climate change and related impacts.

At a high level, the results of this study show that in the coming decades, the capital region can expect:

- Hotter summer temperatures, with more extreme heat days and heatwaves;
- Warmer nights and a longer growing season;
- Warmer winter temperatures and less frequent frost;
- Less rain and more dry days in the summer months;
- More precipitation falling in fall, winter and spring;
- Less snowfall in the colder months;
- Extreme rainfall events becoming wetter.

More specifically, warming temperatures will shift seasonal patterns, prompting a longer growing season and greater cooling demand across the region. Extreme temperatures will continue to get hotter, with heat waves becoming longer and more frequent. By the 2050s, the capital region can expect the number of summer days exceeding 25°C to triple, going from an average of 10 days per year to 32 days per year. Nighttime temperatures in the summer will also increase. Nights where the temperature stays above 16°C (the lower threshold for heat alerts for Southern Vancouver Island) are projected to occur around 8 times per year. The temperature for the 1-in-20-year hottest is projected to increase from 32°C to 36°C.

By the end of this century, annual precipitation is projected to increase modestly (4% increase by the 2050s and 11% by the 2080s). However, these changes will not occur evenly across seasons. In the colder months, rainfall increases notably because of warmer temperatures that convert more snow into rain. (By the 2050s, total rainfall in the winter increases by 25%, while total snowfall drops by nearly 60%.) Much of the rainfall in the colder months will occur during extreme events, with the very wet days becoming wetter by mid-century. In contrast to the fall, winter and spring, the summer months will become increasingly dry. Total rainfall in the summer is projected to decrease by roughly 15% by the 2050s with the duration of dry spells becoming longer.

Many of the projected climate changes described in this report will be felt uniformly across the region. However, the magnitude of some variables will be accentuated by the existing West-to-East climatic gradient in the capital region. For example, the Western region is typically wetter and cooler compared to the Eastern Region, where conditions are typically warmer and drier. In addition, temperatures may be warmer or cooler in specific areas due to other factors including tree canopy cover (or a lack thereof), paved surfaces, and buildings density.

The projected warming for the capital region will have implications for regional ecosystems, watersheds, agriculture and horticulture, housing, energy demand, infrastructure, and community health and safety. Chapter 7 provides a high-level overview of some of the impacts that might be expected from the projected changes in this assessment. This chapter was informed by input from local government staff during a workshop in October 2023 and is not a comprehensive assessment of regional impacts. It is intended to support further discussion and analysis for how climate change may impact the capital region.

The CRD and PCIC also collected input from local government staff to understand how these climatic changes may impact the region as whole. Across the capital region, communities are already witnessing and experiencing varied impacts of climate change. These impacts will persist and, in many cases, intensify over the coming decades based on the future global greenhouse gas emissions trajectory. These impacts will not be experienced equally across the region. People facing the greatest burdens are often the ones who are most affected by climate change, particularly for impacts that are compounding.

Information within this report and the accompanying data provides the region's decision makers, community planners, and community partners with an improved understanding of projected local climate change and related impacts.

CONTRIBUTING AUTHORS

Charles Curry and Stephen Sobie from Pacific Climate Impacts Consortium (PCIC) conducted climate model downscaling, data analysis and interpretation and generated all data products, including maps, figures, and tables, for the report. Charles Curry and Izzy Farmer (PCIC) served as lead authors of this report, with advice and guidance from CRD staff.

ACKNOWLEDGMENTS

We would like to acknowledge the effort and input received from CRD staff, municipal staff, and the CRD Climate Action Inter-Municipal Working Group in the development of this report. Working together ensures that we share knowledge and build on each other's success to create a more resilient region.

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

Tables

Figures

Figures (continued)

1. INTRODUCTION

Over the last 150 years, the global average temperature has increased by over 1°C and this warming has been clearly linked to the emission of greenhouse gases (GHGs), aerosols, and other aspects of human development. This warming is expected to continue unless we make significant cuts to GHG emissions globally. Understanding, monitoring, and preparing for the regional and local manifestations of climate change is important for supporting safe and resilient communities in the decades to come.

The Capital Regional District (CRD) has undertaken this study to better understand how the climate of our region is expected to change over the coming decades. British Columbia's capital region spans an area of 2,340 km^2 and an elevation range of 1 to 1,100 m above sea level (Figure 1). Since 1950, air temperature observations for Vancouver Island have been increasing by 0.26 ± 0.07 °C per decade.[2] Both global and regional warming are expected to influence other climate variables, such as rainfall.

To explore the changes that may be in store for our region, the CRD has partnered with the Pacific Climate Impacts Consortium (PCIC) to produce high-resolution climate projections for the capital region. These projections are based on the latest generation of comprehensive global climate models (CMIP6). Like other populated areas worldwide, the region requires up-to-date, science-based, high-resolution information to enable effective planning and policy decisions in a changing climate. This information will be used with other resources to help prepare the capital region for the impacts of climate change.

A selected number of climate indicators are provided in this report to demonstrate how our climate is expected to change over time. In the first section, Chapter 2 provides a brief description of the study methodology and includes support for interpreting the figures and tables. Chapters 3 through 6 provide an analysis of selected climate indicators for the region, including information about summer temperatures, winter temperatures, precipitation, and climate extremes. Each section includes a description of each indicator and a summary of how it is projected to change over time.

In the second section, Chapter 7 identifies potential impacts from climate change expected across the capital region. These impacts are categorized by different sectors, including health and wellbeing, water supply and demand, rainwater management and sewerage, ecosystems and species, buildings and energy systems, transportation, food and agriculture, and recreation and tourism.

It should be noted that the information provided in this report is limited to changes in temperature and precipitation only. Other climate-related phenomena, like surface hydrology, wind, humidity, sea level rise and storm surge require different modelling techniques and are not included in the scope of this report. Therefore, the report should be used alongside other resources to help prepare our region for the impacts of climate change. For example, in 2021, working with and on behalf of municipal partners, the CRD undertook a coastal flood inundation mapping project, which includes an analysis of current and future storm surge due to sea level rise. Since that time, some municipalities in the region have been undertaking efforts to build upon this work.

This report and the supplementary data that accompany it are intended to support climate-focused decision making throughout the region and help community partners better understand how their work may be affected by our changing climate. The information provided here should be used with careful consideration for the local context. For guidance on how climate information can be used to support adaptation planning, see the appendices appearing at the end of this report.

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[1] IPCC, 2023: Summary for Policymakers. In: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, pp. 1-34, doi: 10.59327/IPCC/AR6-9789291691647.001.

[2] Results of an analysis conducted by PCIC for the annual "State of the Pacific Ocean" report; see Curry, C.L. and Lao, I., "Land temperature and hydrological conditions in 2022," pp 17-21. In: Boldt, J.L., Joyce, E., Tucker, S., and Gauthier, S. (Eds.), State of the physical, biological and selected fishery resources of Pacific Canadian marine ecosystems in 2022. Can. Tech. Rep. Fish. Aquat. Sci. 3542: viii + 312 p. (2023). The nearby Lower Fraser Valley displays a larger trend of magnitude 0.42 ± 0.07 °C per decade, which may be more similar to what the capital region has experienced.

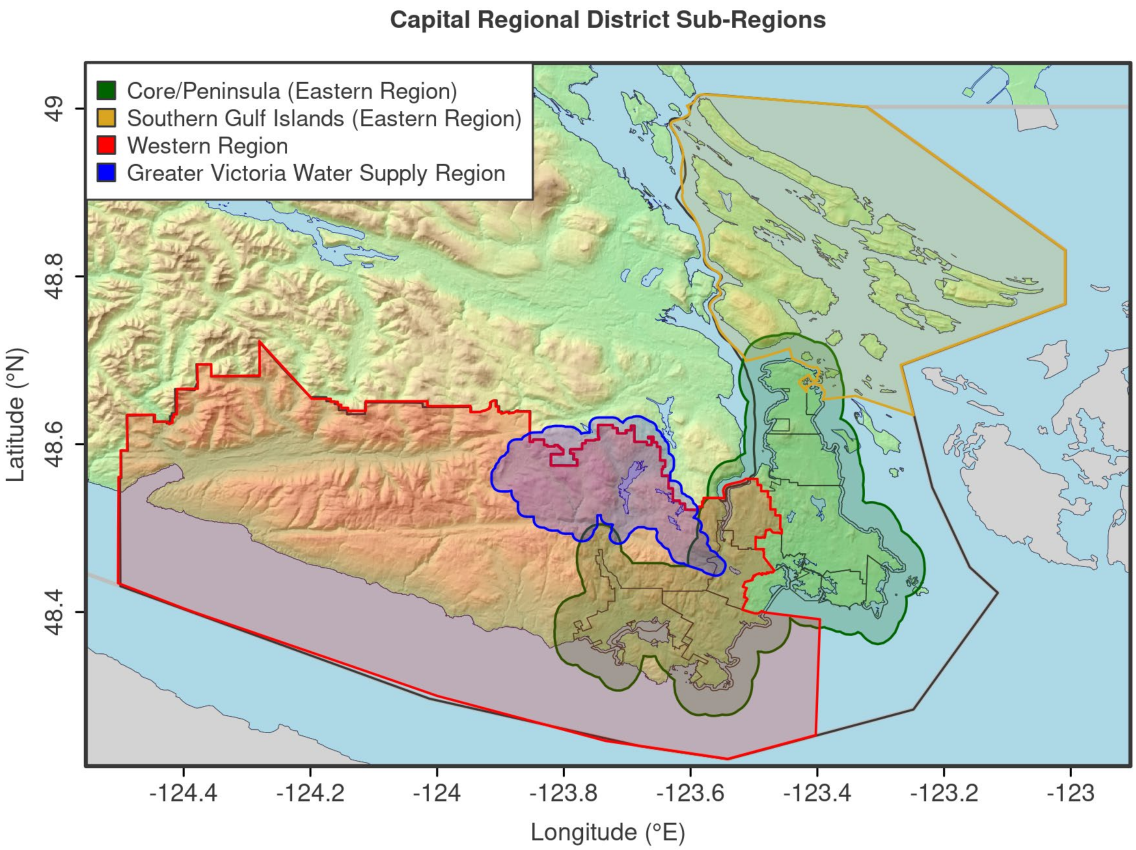


Figure 1. *Domain of interest, the Capital Regional District, with background relief map and four sub-regions of interest. In several of the tables in the report, results for the Core/Peninsula and Southern Gulf Islands are combined into a single Eastern Region.*

2. METHODS AND PRESENTATION

2.1 Climate Model Projections

The climate projections are based on an ensemble of 9 global climate models (GCMs) drawn from a larger collection of models developed during the Sixth Coupled Model Intercomparison Project (CMIP6), coordinated by the World Climate Research Programme. The climate projections presented here are based on a high greenhouse gas emissions scenario, known as the Shared Socioeconomic Pathway 5-8.5 (SSP585), which describes a trajectory of future emissions spurred by continued and expanded use of fossil-fuels worldwide. Two other scenarios are also presented in the data package accompanying this report: a medium-intensity emissions pathway, SSP245, and a low-intensity pathway, SSP126, which covers the possibility of a low-carbon technology transformation of worldwide energy systems.[3] Planning based on climate projections under SSP585 could be considered a "no regrets" strategy for adaptation. By the 2090s under SSP585, global mean surface air temperature reaches a level 4.3°C higher than the 1850-1900 average. The evolution of air temperature and precipitation under the three SSPs, for BC specifically, is shown in Figure 2.

Each GCM represents the climate system using a global, horizontal grid with a limiting resolution between 100 km and 250 km, depending on the model. These coarse-grained data are first bias-corrected against available observations (spanning 1950-2012) and then statistically downscaled to 10 km resolution.[4]

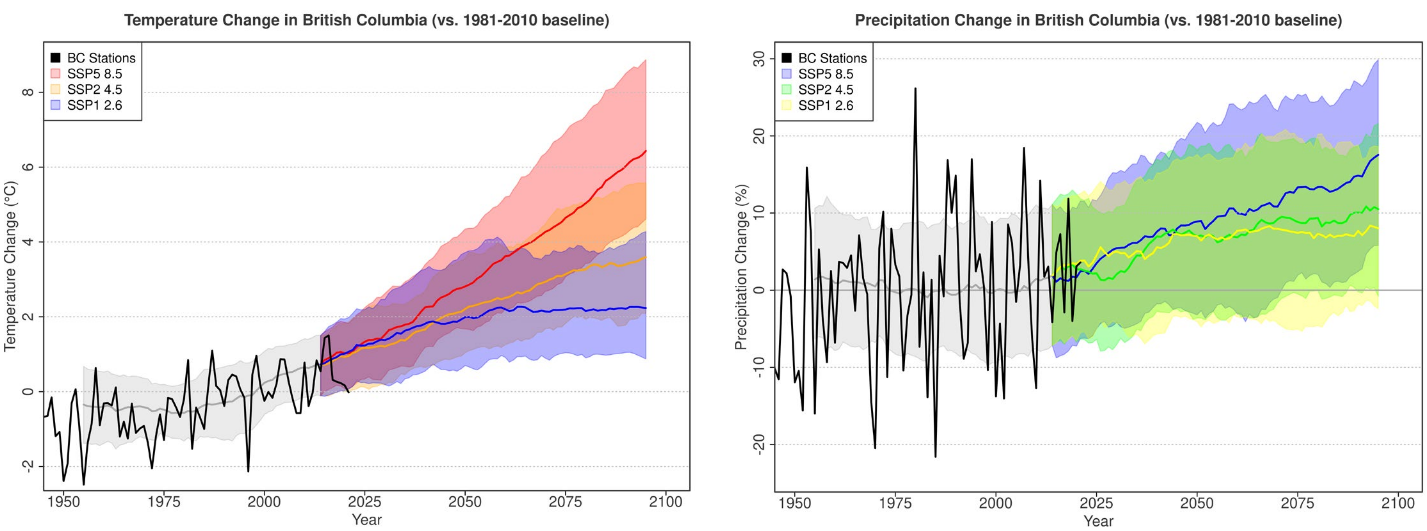


Figure 2. *Changes in annual mean air temperature (left) and total precipitation (right) relative to their values in 1981-2010, averaged over all of BC. The black curves show historical values obtained from the station data in BC from 1948-2021, while the coloured curves show median GCM projections under the three development pathways (SSPs) from 2015-2100. The shaded areas show the 10th-90th percentile range in model-simulated results over the historical and future periods, for each SSP.*

[3] An accessible description of the SSPs may be found at https://climatedata.ca/resource/understanding-shared-socio-economic-pathways-ssps/.

[4] Details on the downscaling methods used at PCIC may be found on the Data Portal section of our website, pacificclimate.org.

In a second downscaling step, the model data are further downscaled to a resolution of 800 m using fine-scale climatological maps. It should be recognized, however, that while the latter account for fine-scale topography, important features of, and influences on, local daily climate are not represented in the dataset.[5]

Downscaled climate model results are presented for three 30-year periods: the historical reference period, 1981-2010 (referred to as the "Past" or "1990s" for short), the near future, 2021-2050 (the "2030s"), mid-century, 2041-2070 (the "2050s") and the end-of-century, 2071-2100 (the "2080s"). These 30-year periods are chosen both to smooth out year-to-year climate variability, and to provide a long enough period to characterize the behaviour of fairly rare events. The seasonal definitions used are "meteorological" seasons: i.e., winter (December 1 to February 28), spring (March 1 to May 31), summer (June 1 to August 31) and fall (September 1 to November 30). A range of indices are computed from daily temperature and precipitation to describe various aspects of the climate. For projections, median estimates from the climate model ensemble are typically emphasized, with the 10th to 90th percentile ranges over the ensemble also provided where appropriate.

It is important to recognize that not all projected changes emerging from the climate model ensemble are necessarily substantial. For a given variable, location, and emissions pathway, each model produces a projected future climate, resulting in a range of possible outcomes. Since no single model is "right," the median value of the ensemble can be used as a practical best-guess projection, with the 10th to 90th percentile spread indicating the uncertainty amongst the models. *If the spread includes zero change, meaning that not all models agree on the sign of the change, then relatively low confidence should be placed in the median value.* In the relatively rare cases when less than half of the models agree on the sign of change, users are alerted to the reduced confidence via a printed message on the maps.

[5] Examples of these being realistic day-to-day variability and co-variability between nearby locations, and fine-scale land cover type, for example. It should also be recognized that since the models are bias-corrected to daily observations spanning a specific time period, here 1981-2010, more recent observations will not be reflected in results displayed for the "Past."

2.2 Interpreting Figures and Tables

The data deliverables for the project comprise: (i) maps of climate variables over the region in Past and Future periods, for each of the three scenarios; and (ii) tables (Excel spreadsheets) of area-averaged results for the same. Results for absolute or relative difference are also provided, where appropriate. References to the tables are occasionally made in the report. Most of the figures presented below are maps, showing the capital region and the surrounding area. Colour contours indicate values of the indicated variable, with a nominal limiting resolution of 800 m. *Due to the limitations of the downscaling methodology mentioned above, along with the inherent uncertainty in future outcomes, the exact position of contours on the maps should not be taken literally.* On each map, the area average shown at bottom left is computed over the capital region only (area inside the black curve).

This report presents results for a number of key indicators, derived from the model-simulated daily temperature and precipitation, representing a "highlight reel" of the much more extensive set of climate indices delivered for this project. In consultation with CRD staff, they were selected either because they have implications for a range of climate-related impacts, because they feature particularly large changes from recent historical conditions, or both. In the next few chapters, a plain language definition is provided for each indicator, followed by a summary of its projected change for the 2030s, 2050s, and 2080s, under the high (SSP585) emissions scenario. Detailed definitions of all indicators are provided in the Appendix.

There are two types of maps: single period and future change. Single period maps, e.g., "Past: 1990s" or "Projection: 2050s," show actual values of a variable, e.g., temperature in °C. Future change maps, e.g., "Projected Change: 2050s - 1990s," show differences between historical and future-simulated periods, and may be in the units of the variable or in relative terms, e.g., percent change in precipitation. In the interest of concision, all future change maps shown in this summary report are for the 2050s under the high emissions (SSP585) pathway. For most indicators, the magnitude of these changes should be roughly comparable to that projected for the 2080s under the moderate emissions scenario (i.e., SSP245).

Other figures in the report use area-averages for the capital region while expressing the range of projected values over models and years for a certain variable. An example of this

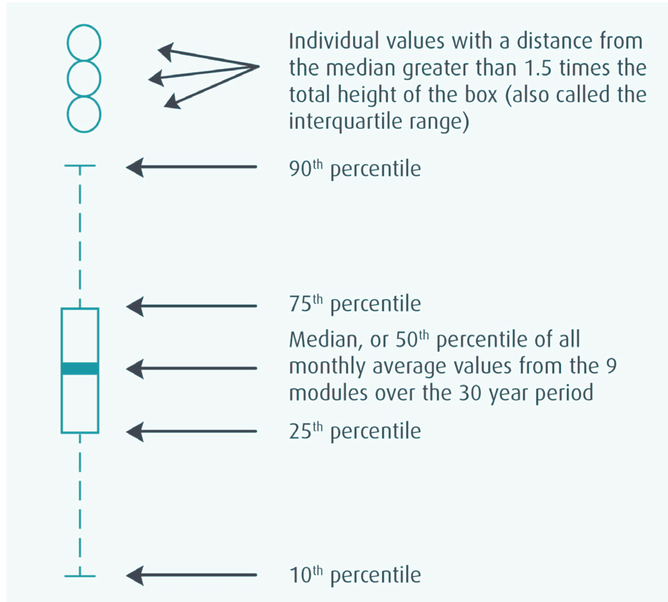


Figure 3. *Explanatory schematic of a box-and-whisker plot.*

type of presentation, the "box-and-whisker" plot, is shown in Figures 6 and 9, and an aid to their interpretation is given below. Note that, in these figures, the range shown by the whiskers reflects both year-to-year and model-to-model variability. Finally, note that when cited in the text, values from the spreadsheets are often rounded to indicate the likely precision of the quantity being discussed, given the known model uncertainties. For example, a temperature of 29.8°C would be cited as 30°C, while 2717 degree-days become 2715 degree-days. The tables contain median values with ranges given in parentheses (10th – 90th percentile of different model projections). Usually medians are cited in the text; but ranges encompass the range of possible behaviour, and should not be ignored, especially when the climate variable in question might enter into critical decision-making.

Values in tables are averaged over the capital region (within the regional boundary shown on the maps), unless labeled as *Eastern Region* (Greater Victoria and Southern Gulf Islands), *Western Region,* or *Greater Victoria Water Supply Area.*

3. GENERAL CLIMATE PROJECTIONS

3.1 Warmer Temperatures

We begin by examining future temperature change over the region. *Daytime High and Nighttime Low Temperatures* are averaged over each season and annually in the tables and maps below.

In concert with global and regional warming, both daytime and nighttime temperatures are projected to increase in the capital region in future, as detailed in the tables (all changes shown are positive). The accompanying maps show the spatial pattern of Past and future-projected temperatures throughout the region.

Projections

In the Past, winter daytime high temperatures in the region averaged around 6°C, while winter nighttime low temperatures averaged around 1°C. The median future-projected TX increases to around 8°C by the 2050s and to 9.5°C by the 2080s. The median future-projected TN reaches around 3°C by the 2050s and 4.5°C by the 2080s. Since the likelihood of snowfall rapidly decreases as temperatures rise above 0°C, we can anticipate that this local warming will affect the frequency of snowfall in the region, as detailed further below.

Table 1: Regional Average Daytime High Temperature (TX)

	Past (°C)	2050s Change (°C)	2080s Change (°C)
Winter	6	2.1 *(1.6 to 3.5)*	3.5 *(2.8 to 6.5)*
Spring	12	2.1 *(1.4 to 4.0)*	3.5 *(2.6 to 6.3)*
Summer	20	2.9 *(2.3 to 5.1)*	4.7 *(4.1 to 8.7)*
Fall	13	2.7 *(2.2 to 4.6)*	4.0 *(3.6 to 7.2)*
Annual	13	2.5 *(2.0 to 4.4)*	3.9 *(3.4 to 7.0)*

Table 2: Regional Average Nighttime Low Temperature (TN)

	Past (°C)	2050s Change (°C)	2080s Change (°C)
Winter	1	2.0 *(1.8 to 3.8)*	3.6 *(3.2 to 6.8)*
Spring	4	2.2 *(1.5 to 3.5)*	3.2 *(2.8 to 5.6)*
Summer	10	2.8 *(2.3 to 4.3)*	4.6 *(3.9 to 7.4)*
Fall	5	2.9 *(2.1 to 4.7)*	4.2 *(3.6 to 7.3)*
Annual	5	2.3 *(2.0 to 4.2)*	3.9 *(3.5 to 6.6)*

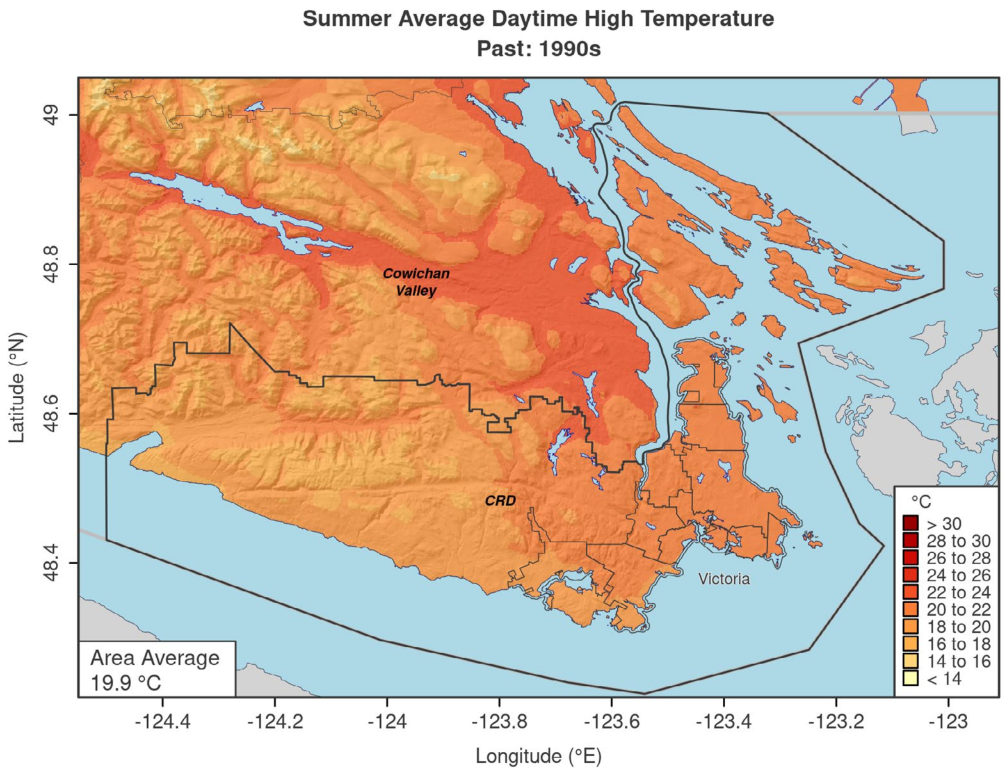


Figure 4a: *Summer average daytime high temperature in the Past.*

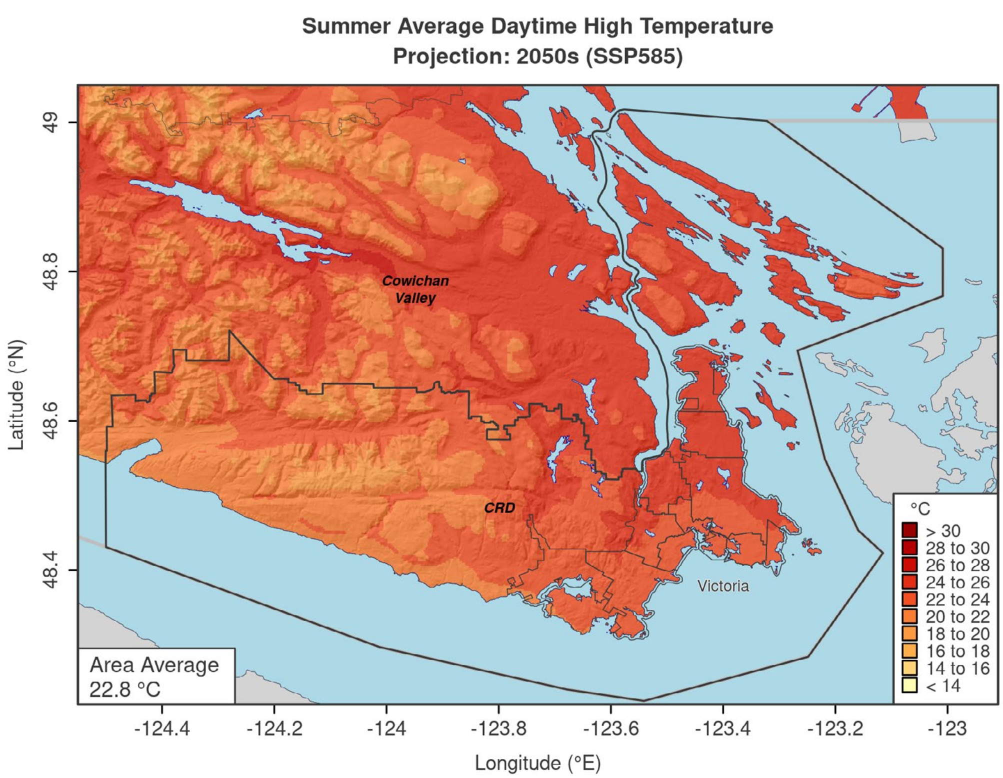


Figure 4b: *Projected summer average daytime high temperature in the 2050s.*

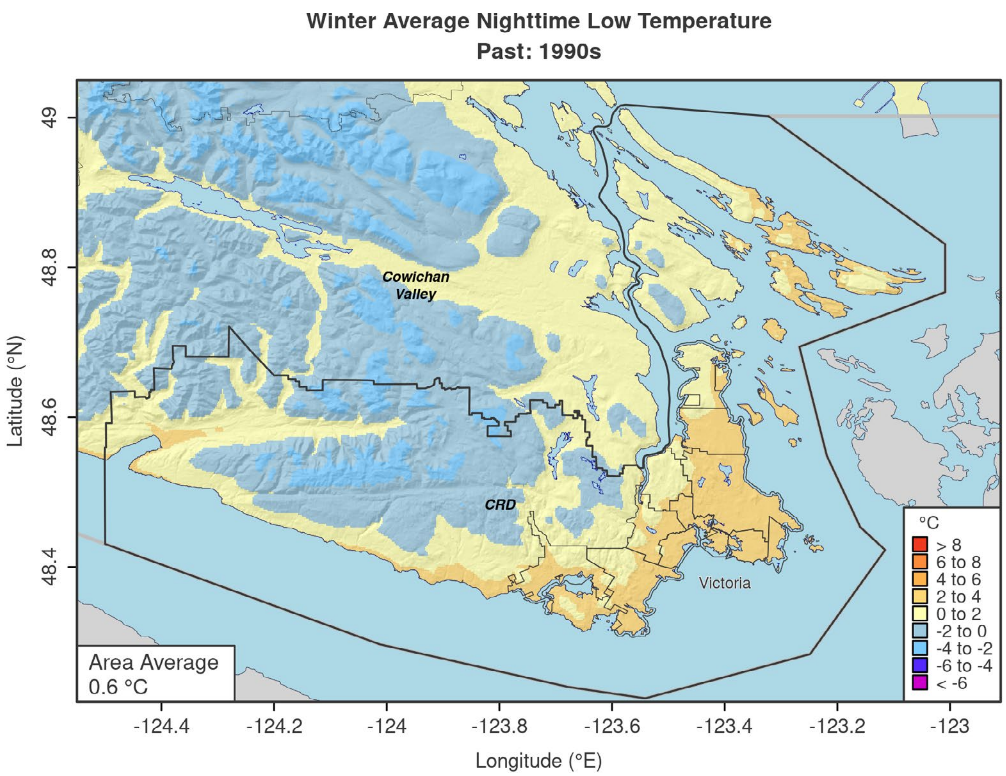


Figure 5a: *Winter average daytime high temperature in the Past.*

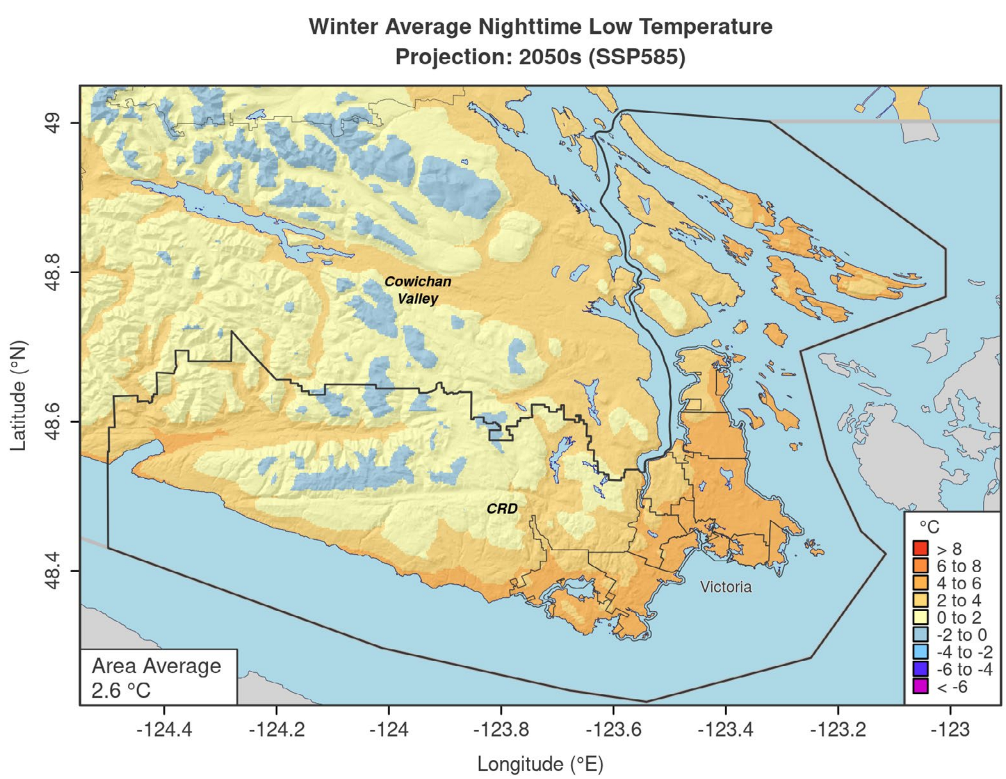


Figure 5b: *Projected winter average daytime high temperature in the 2050s.*

3.2 Seasonal Temperature Change and Variability

Future-projected temperatures are compared with Past temperatures on a monthly basis in the figure below. The box-and-whisker plots reflect both year-to-year and model-to-model variability in all 30 Januaries, Februaries, etc., over the Past and Future periods.

Some features worth noting are:

- Freezing temperatures in the cold months become increasingly rare in the Future.
- Spring—loosely defined as the beginning of the growing season, when daily mean temperature T_m consistently exceeds 5°C; see Temperature Indicators—begins earlier in the Future, while Fall—defined similarly as the end of the growing season—ends later, resulting in an effectively shorter winter season.
- The frequency of high extremes in summer increases notably, with July and August average daytime high temperatures exceeding 23°C in about three-quarters of models and years by the 2050s.

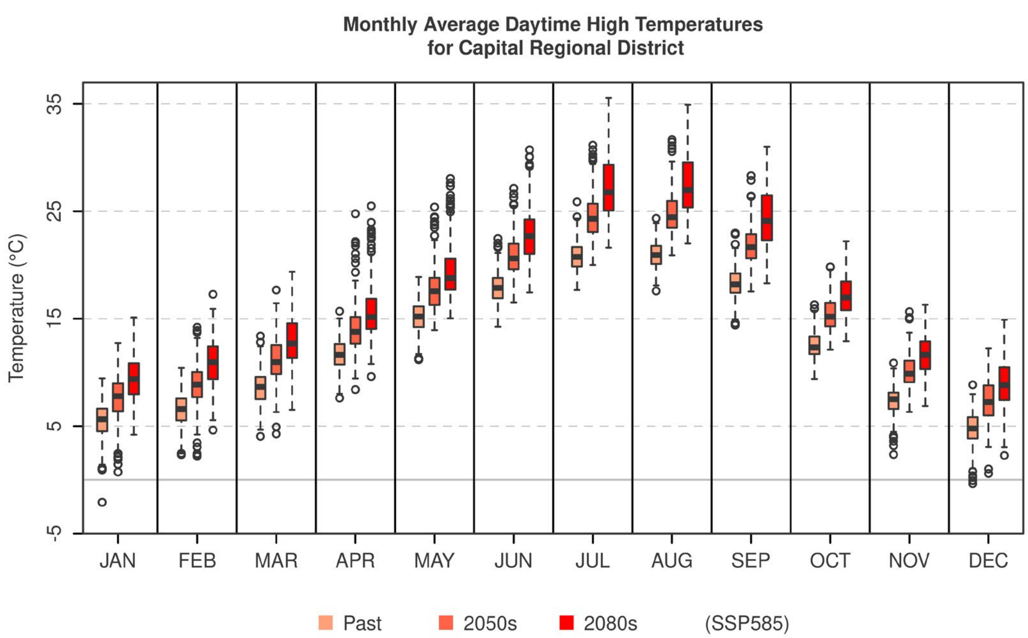


Figure 6a. *Annual cycle of monthly mean daytime high temperature in the Past, 2050s and 2080s periods under the SSP585 scenario.*

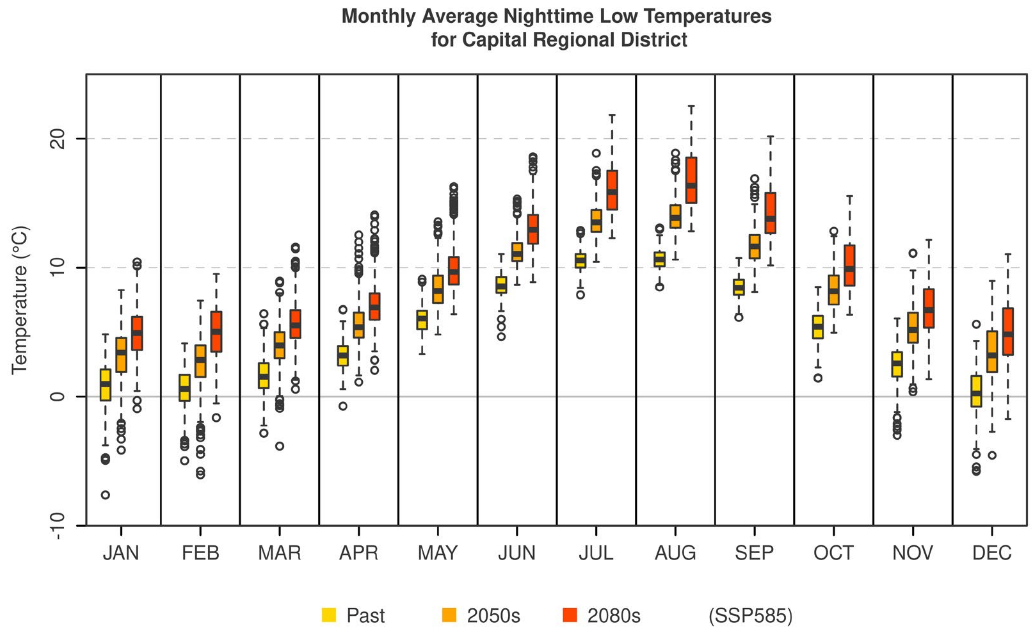


Figure 6b. *Annual cycle of monthly mean nighttime low temperature in the Past, 2050s and 2080s periods under the SSP585 scenario.*

3.3 Wetter Winters, Drier Summers

Precipitation is the sum of rainfall and snowfall (expressed as water equivalent). Precipitation in the capital region has a strong seasonality, characterized by wet winters and dry summers. In the future projections, this behaviour is reinforced, so that winter becomes wetter (as do spring and fall) while summer becomes drier.

Projections

In tandem with the higher summer temperatures mentioned above— which increase potential evaporation — reduced summer rainfall heightens the possibility of drought conditions. Rainfall increases are highest in winter, displaying a 25% increase in the 2050s region-wide, considerably higher in the west (+145 mm in the Western Region) than in the east (+25 mm in the Gulf Islands). Since the median increase in total winter precipitation by then is only +1%, we conclude that this is primarily due to the conversion of snow to rain under warmer winter conditions. While snowfall comprised about 15% of total precipitation in the Past, it amounts to only 5% in the 2050s. By the 2080s, the capital region should receive as little snowfall annually as it did in spring alone in the Past.

Table 3: Average Precipitation (Rain and Snow) over the Region

	Past (mm)	2050s (mm)	2080s (mm)	2050s Change (%)	2080s Change (%)
Winter					
Rain	643	804	864	25 (*11 to 39*)	34 (*19 to 54*)
Snow	197	83	36	-58 (*-85 to -45*)	-82 (*-97 to -75*)
Spring					
Rain	409	460	477	12 (*7 to 21*)	17 (*3 to 26*)
Snow	37	10	2	-73 (*-95 to -44*)	-95 (*-100 to -78*)
Summer					
Rain	159	135	129	-15 (*-32 to -2*)	-19 (*-46 to -4*)
Fall					
Rain	620	710	770	15 (*9 to 22*)	24 (*13 to 34*)
Snow	38	8	4	-79 (*-95 to -62*)	-89 (*-99 to -83*)
Annual					
Rain	1827	2102	2279	15 (*9 to 25*)	25 (*12 to 28*)
Snow	274	109	40	-60 (*-88 to -50*)	-85 (*-97 to -78*)
Precipitation[6]	2101	2179	2325	4 (*0 to 12*)	11 (*-1 to 13*)

[6] Note that in future, the summed medians of rain and snow may not equal the median precipitation, since the distribution of the two quantities may vary across the model ensemble.

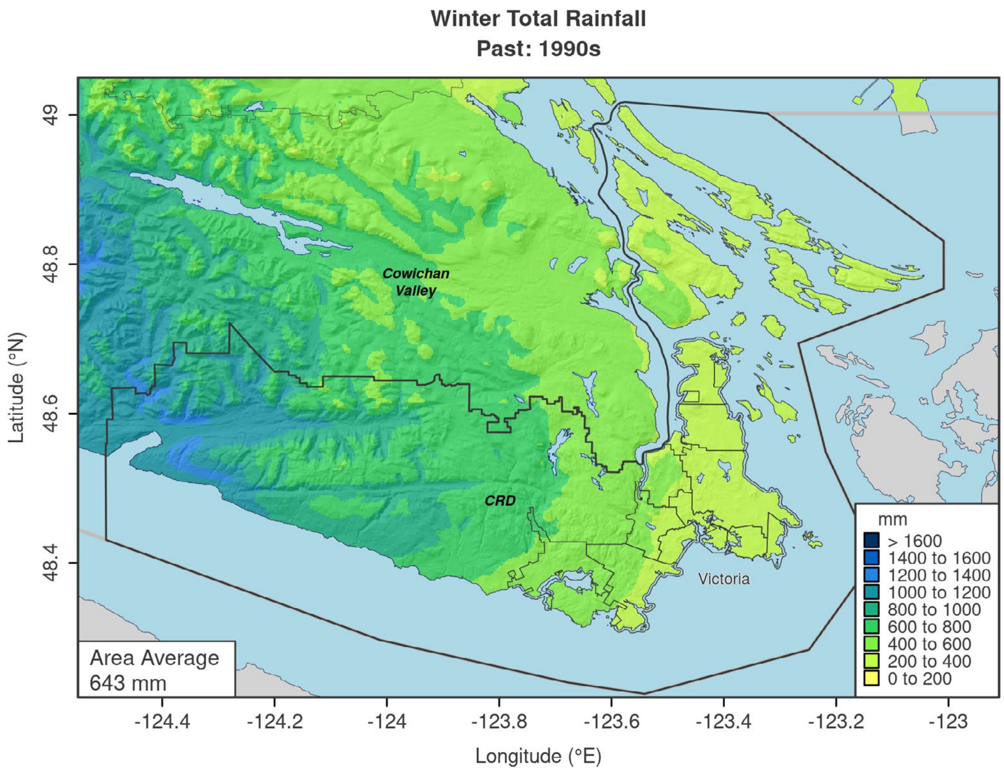


Figure 7a. *Winter rainfall in the Past.*

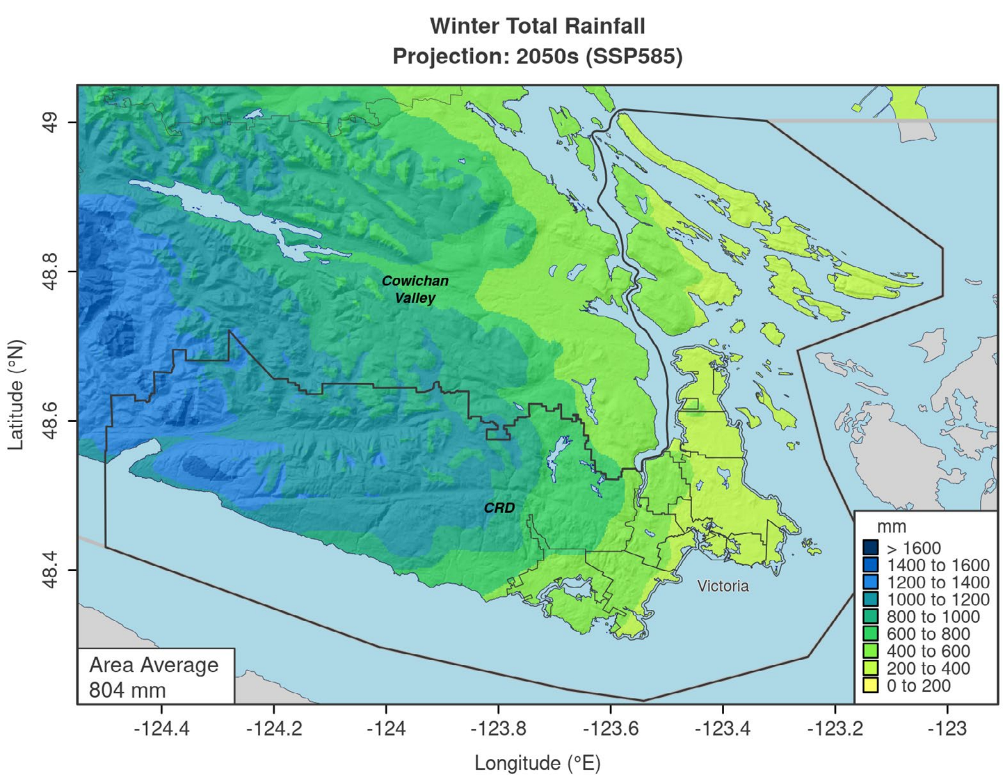


Figure 7b. *Projected winter rainfall in the 2050s.*

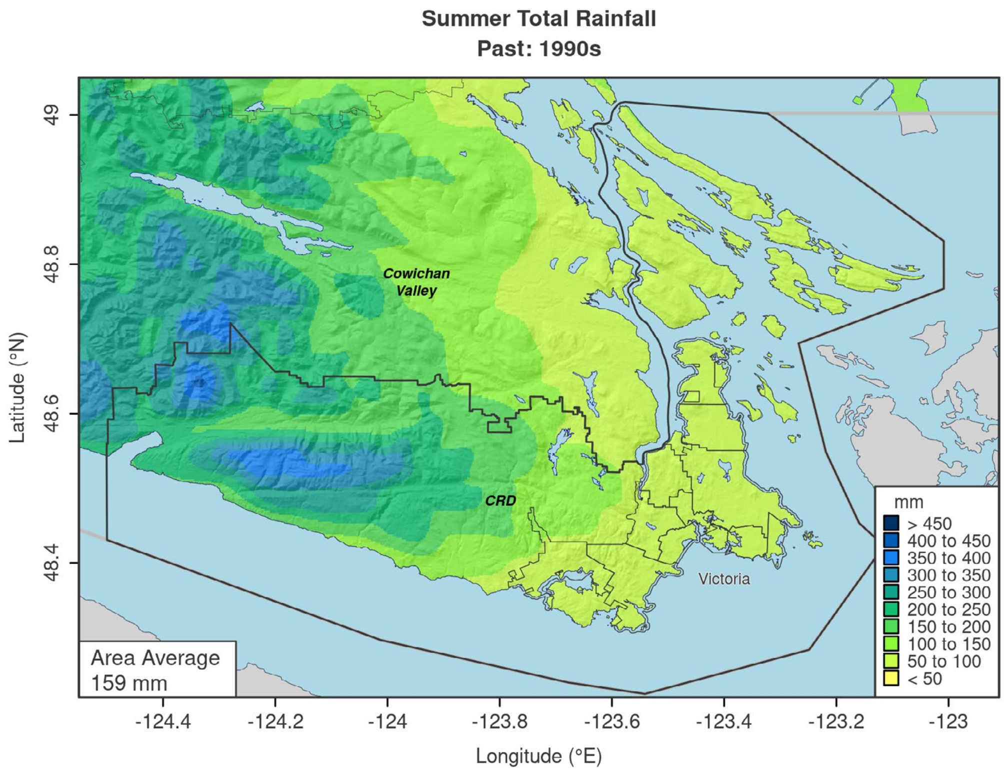


Figure 8a. *Summer rainfall in the Past.*

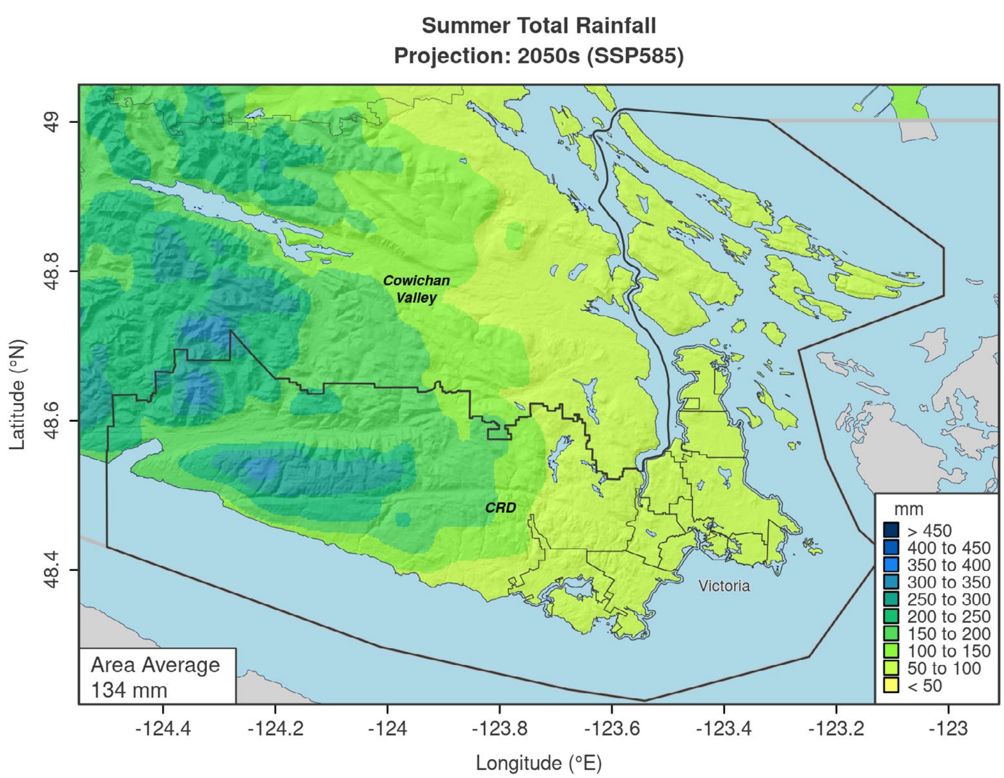


Figure 8b. *Summer rainfall in the 2050s.*

3.4 Seasonal Precipitation Change and Variability

While precipitation in the capital region exhibits a notable seasonality, with far larger amounts in the colder months, this occurs against the background of high year-to-year variability. As a result, a climate change signal is more difficult to distinguish in precipitation than in temperature. One exception is the projected strong decline in snowfall, summarized in Table 3 and Figure 17. Combined with an increase in annual total precipitation of +4%, the resulting median projection of annual total rainfall for the entire region in the 2050s is +15%.

The figure below shows model estimates of monthly total rainfall in the Past and both Future periods. While median values increase in the colder months throughout the century, what is more striking are the changes in variability (occurring across both individual models and years, as shown for temperature above). For example, we note the occurrence of higher extreme monthly rainfall amounts in future periods, especially during the autumn months; some November rainfall totals could exceed 750 mm in future, compared to around 600 mm in the Past.[7]

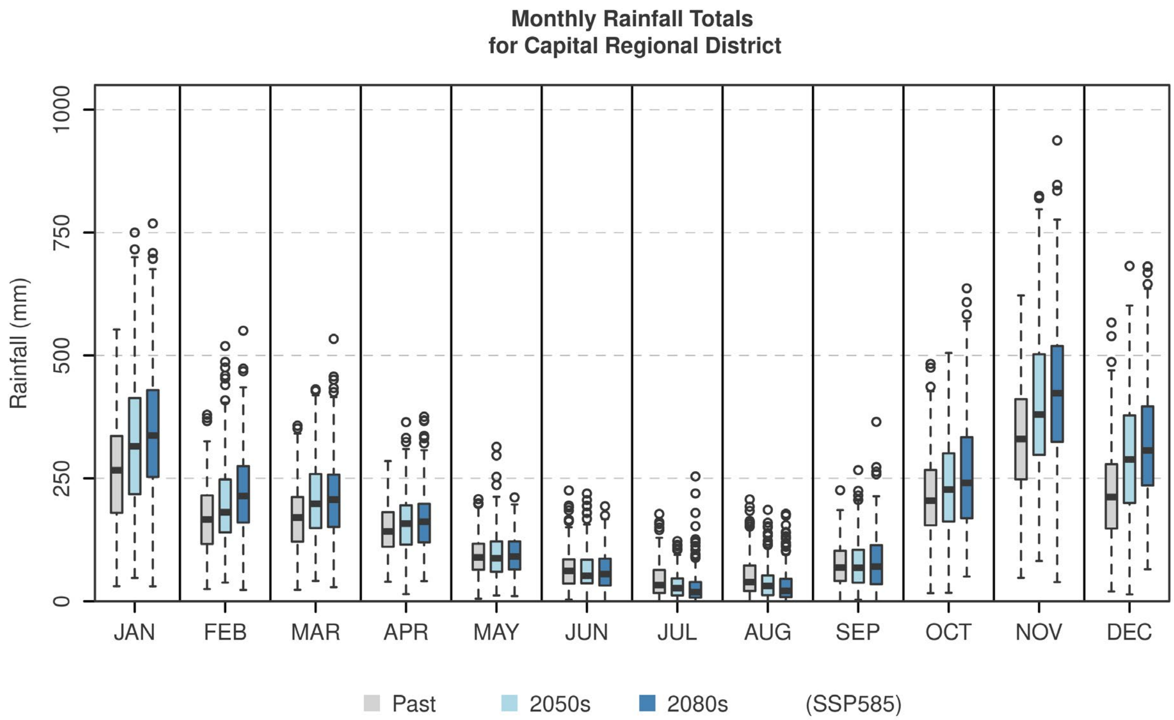


Figure 9. *Annual cycle of total monthly rainfall in the Past, 2050s and 2080s periods.*

[7] 90th percentile values are cited. These totals are averaged across the region, with Past November values spanning a large range from the wetter Western Region (~650 mm) to the drier Gulf Islands Region (~300 mm). For reference, the highest recorded November precipitation at Victoria International Airport is 316 mm (in 2021).

4. WINTER TEMPERATURE INDICATORS

4.1 Warmest Winter Day, Coldest Winter Night

The *Warmest Winter Day* is the highest daily maximum temperature recorded during the winter months, in an average year. When considered along with the *Coldest Winter Night* (i.e., lowest daily minimum temperature), these indicators describe the projected “new normal” for winters in our region.

Projections

By the 2050s, we can expect to see the warmest winter daytime temperature to rise from its Past value of 11°C to about 13°C, with a further increase to about 15°C by the 2080s.

In the Past, the coldest winter night had a temperature of about −8°C. Models project winter lows to increase by roughly 3.5°C by the 2050s, to −4.5°C, and by 6.5°C by the 2080s, to −1.5°C. The maps below illustrate that in the future, temperatures below freezing will usually occur only at the highest elevations in the region.

Warming winter temperatures will lead to an increased fraction of precipitation falling as rain instead of snow. Snow accumulation events, which typically occur a few times each winter in the region, will still occur, but less frequently.

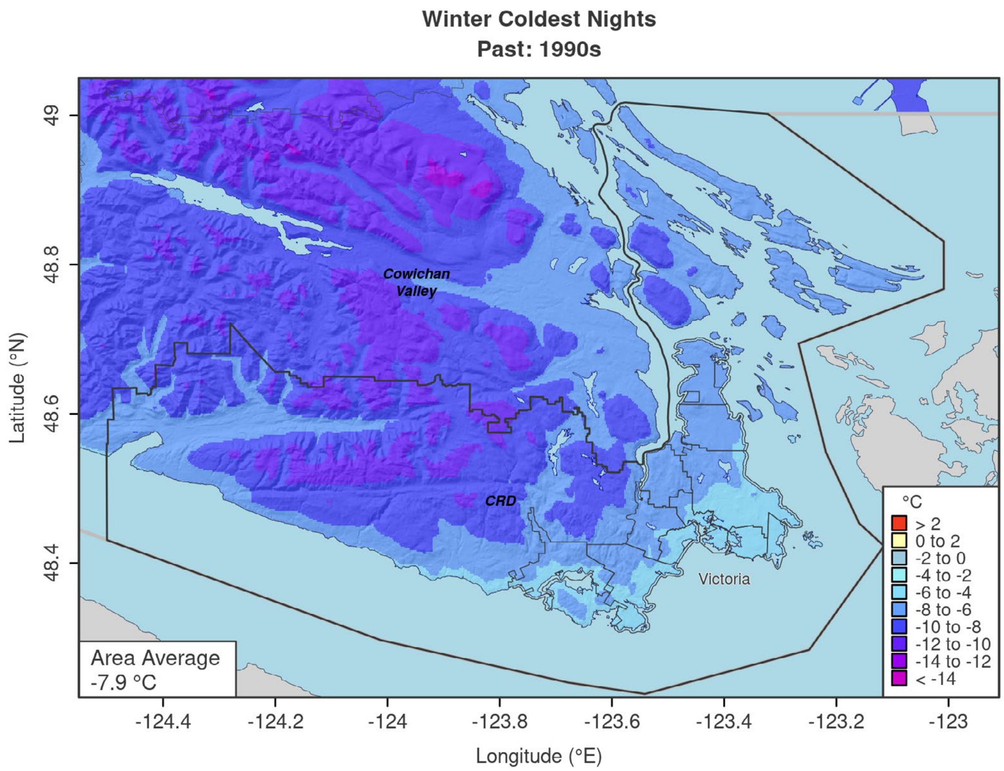


Figure 10a. *Coldest winter night in the Past.*

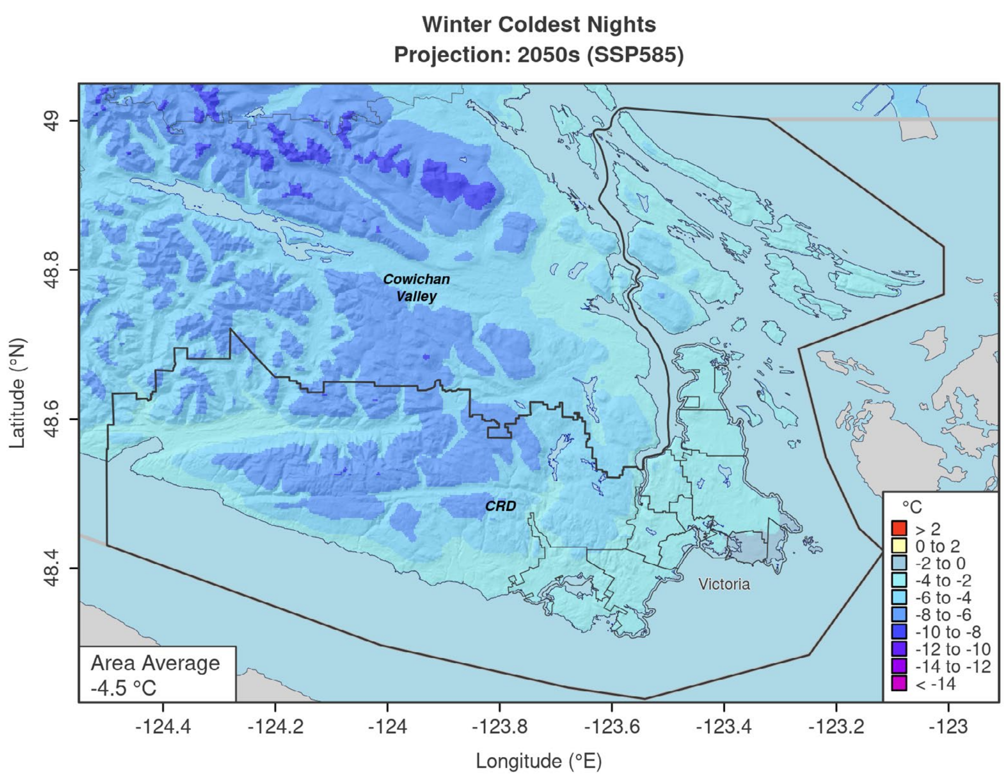


Figure 10b. *Projected coldest winter night in the 2050s.*

4.2 1-in-20 Year Coldest Nighttime Low Temperature

This indicator describes extreme cold temperatures so low that they are expected to occur only once every 20 years in the historical climate. Equivalently, in the recent past the *1-in-20 Year Coldest Night* had a 5% chance of occurring in any given year. [8]

Projections

In the Past, the 1-in-20 year coldest night had a temperature of −15°C. In the Future, the 1-in-20 year coldest night across the region will increase by about 5°C by the 2050s and by about 8.5°C by the 2080s.

[8] Note that the occurrence of such an event in one year doesn't preclude its occurrence in the following years, which is why the annual exceedance probability (i.e. 5% chance, in this case) is a helpful equivalent measure.

4.3 Frost Days and Ice Days

Frost Days is an annual count of days when the daily minimum temperature is less than 0°C which may result in frost at ground level. This indicator is useful to help predict how changes in the number of days with minimal temperatures below freezing could affect native and agricultural plant species.

Ice Days occur when daytime high temperatures do not exceed 0°C. While some of the same effects are expected as for frost days, these freezing temperatures may also affect transportation via the increased chance of icy road conditions.

Projections

In the Past, the capital region experienced an average of 60 frost days and 6 ice days per year. In the 2050s, we should expect far fewer such days: around half as many frost days by the 2050s and only around one-fifth as many by the 2080s. Ice days may be very rare by the mid- to late-century.

Table 4: Warmer Winter Extreme Temperatures

	Past (°C)	2050s (°C)	2080s (°C)	2050s Change (°C)	2080s Change (°C)
Warmest Winter Day	11	13	15	2.4 *(1.7 to 4.2)*	4.2 *(3.2 to 6.9)*
Coldest Winter Night	-8	-4.5	-1.3	3.4 *(2.9 to 5.5)*	6.6 *(5.4 to 10.4)*
1-in-20 Year Coldest Nighttime Low	-15	-10	-6.5	5.0 *(3.2 to 7.2)*	8.5 *(7.5 to 13)*

Table 5: Annual Frost and Ice Days

	Past (days)	2050s (days)	2080s (days)	2050s Change (days)	2080s Change (days)
Frost Days (TN <0 °C)					
Region	60	27	12	−33 *(−51 to −27)*	−48 *(−58 to −45)*
Eastern Region*	30	11	3	−19 *(−28 to −16)*	−27 *(−30 to −23)*
Water Supply Area	80	38	17	−42 *(−67 to −36)*	−63 *(−76 to −59)*
Ice Days (TX <0 °C)					
Region	6	2	0	-4 *(-6 to -3)*	-6 *(-7 to -5)*

**The Eastern Region encompasses both the Southern Gulf Islands and Core/Peninsula subregions (Figure 1).*

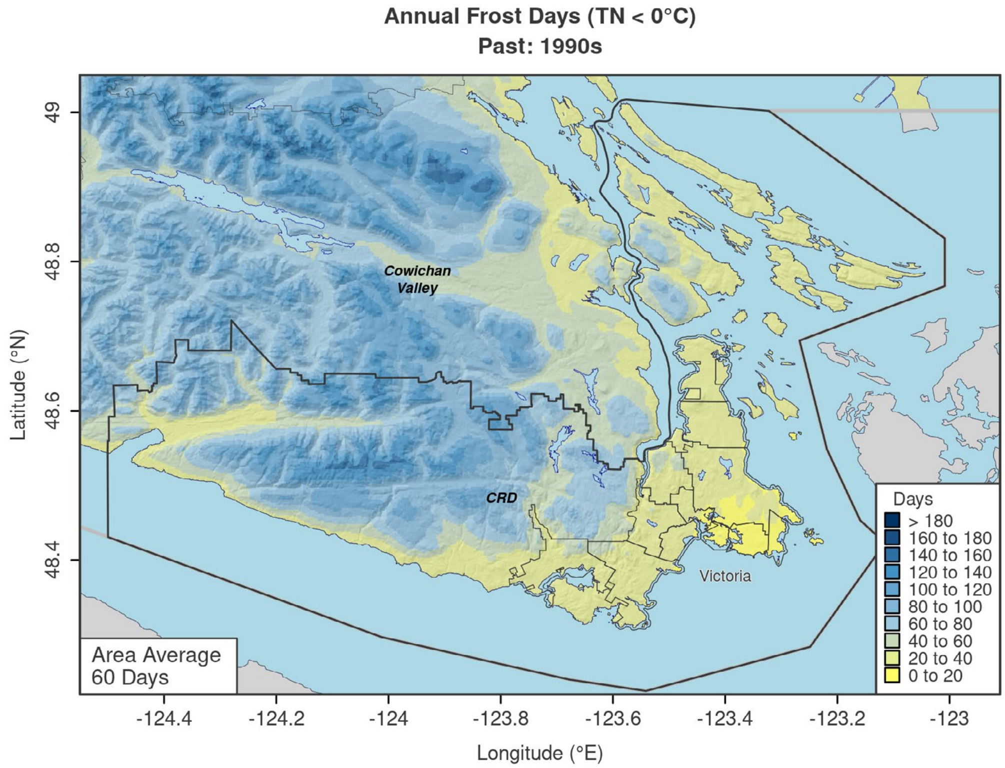


Figure 11a. *Number of annual frost days in the Past.*

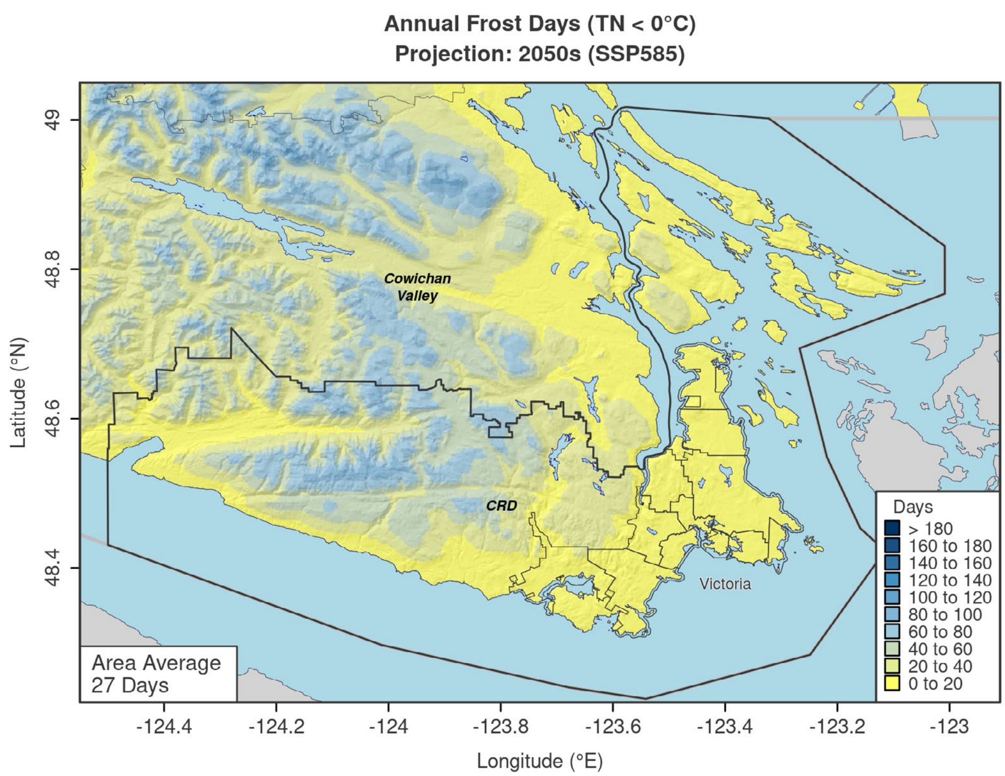


Figure 11b. *Projected frost days in the 2050s.*

4.4 Heating Degree Days

Heating Degree Days (HDD) are calculated by summing the number of degrees that the daily mean temperature falls below 18°C for every day in a year.[9] This measure is commonly used to estimate the heating demand for buildings in the cooler months.

Projections

In the Past, the capital region had a median of roughly 3405 HDD.[10] The median future-projected HDD decreases to 2644 (a 22% decrease) by the 2050s and to 2215 (a 35% decrease) by the 2080s. Due to its cumulative nature, a reduction in HDD is amongst the clearest indicators of warming, both in recent historical observations and in model projections. In addition, it should be noted that HDD varies considerably from west (higher values) to east (lower values) over the region.

Note that while mean winter temperatures will warm throughout the coming decades, the region's continued exposure to easterly polar outflows from Northwestern Canada through the Cascade Range suggests that the potential for multi-day cold snaps will persist in the future, though they should be less frequent. For this reason, building heating systems will still need to be responsive to occasional sub-zero winter temperatures.

Table 6: Heating Degree Days

	Past (°C-days)	2050s (°C-days)	2080s (°C-days)	2050s Change (%)	2080s Change (%)
Region	3405	2644	2125	-22 *(-40 to -19)*	-35 *(-56 to -32)*
Southern Gulf Islands	2836	2114	1755	−25 *(-45 to -22)*	−38 *(−63 to −35)*
Core / Peninsula	2904	2164	1773	−25 *(−44 to −22)*	−39 *(−62 to −35)*
Western Region	3387	2613	2158	-23 *(-41 to -20)*	-36 *(-57 to -33)*

[9] For example, if the daily mean temperature on January 1 is 10°C, followed by one day of 4°C, two days of −1°C and three days of 0°C, then HDD for that week are calculated as: (18−10) + (18−4) + 2 × (18−(−1)) + 3 × (18−0) = 114 degree-days. Note that days with a temperature equal to or greater than 18°C are not counted.

[10] Someone consulting the tables for the National Building Code of Canada (NBCC, 2015) will see different values of HDD listed for Victoria locations than the Past values cited in Table 6. One reason for this is the larger area covered by our Core/Peninsula subregion. Another is the different methodology and period of observations used to calculate HDD in the NBCC. As our estimate depends to some extent on coarse-grained climate models, while the NBCC employs interpolated station data, the NBCC value would normally be considered more reliable in this subregion (which contains several meteorological stations). For those interested in future HDD estimates, the relative differences from Past values can be used for HDD projections, regardless of which baseline value is used.

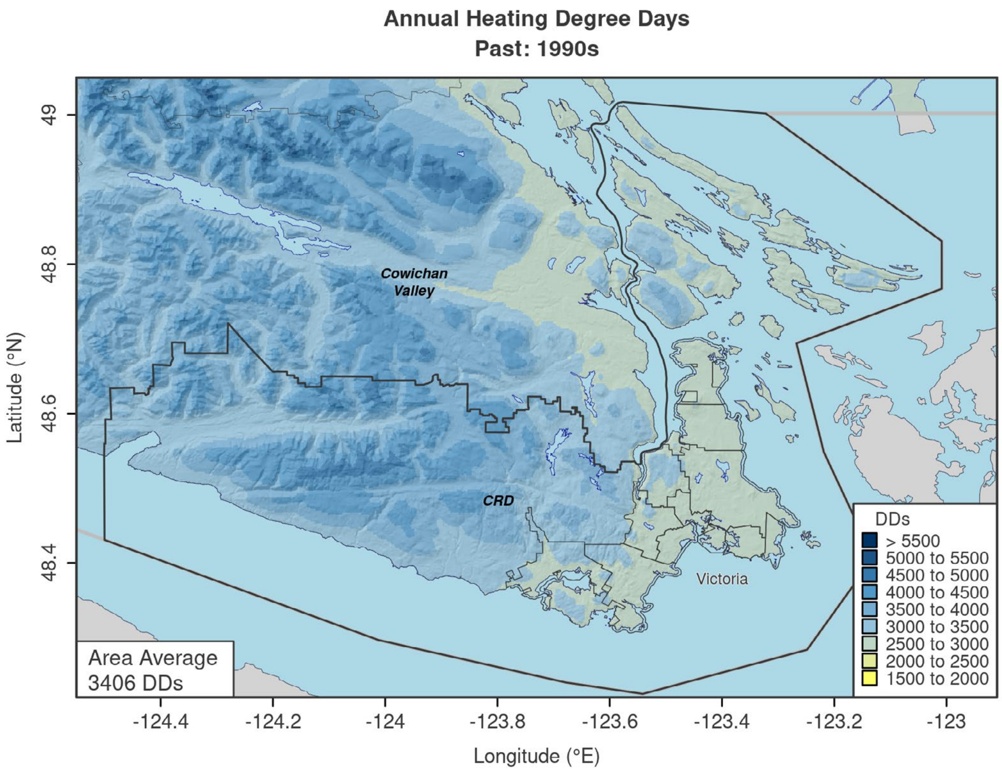


Figure 12a. *Heating Degree Days in the Past.*

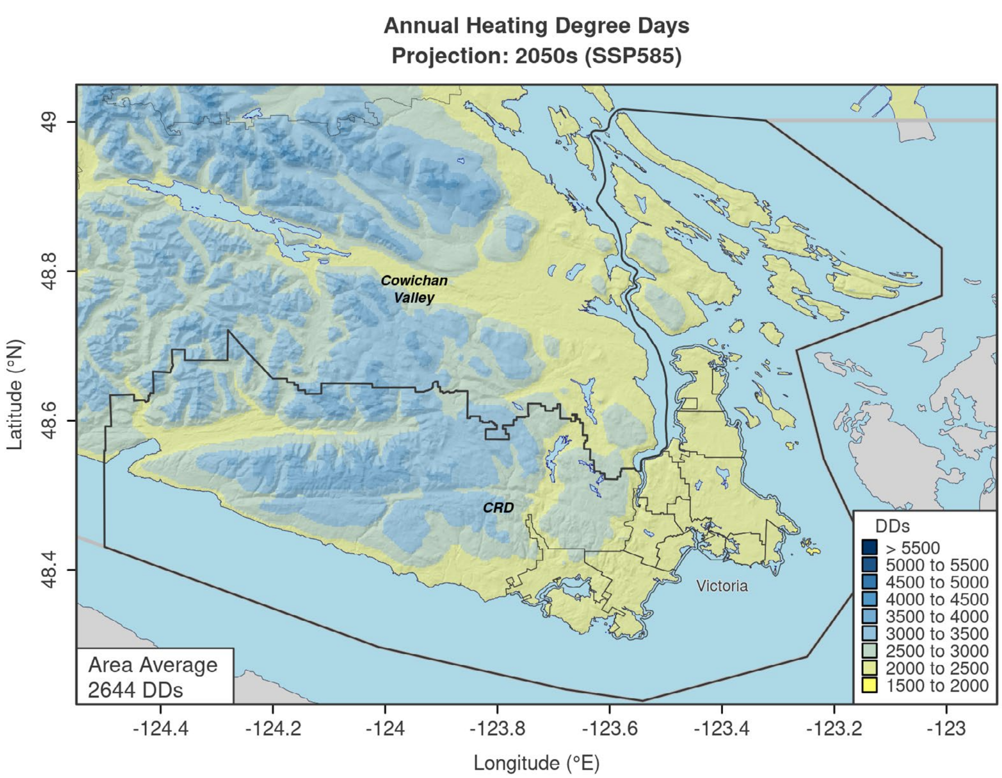


Figure 12b. *Projected (decreased) HDD in the 2050s*

5. SUMMER TEMPERATURE INDICATORS

5.1 Growing Season Length

Growing Season Length (GSL) is an annual measure indicating the period when temperatures are warm enough for most vegetation to grow. The GSL is the number of days between the first span of at least 6 consecutive days with daily average temperatures above 5°C, and the first span, after July 1, of six days with temperatures below 5°C. This measure helps to highlight how urban forests, agricultural and landscaped areas, grasses, weeds (and their pollens) may be affected by climate change.

Projections

In the Past, the growing season lasted roughly 270 days in the region. The median future-projected growing season increases by 47 days to 318 days by the 2050s and by 68 days to 339 days by the 2080s.

Other things being equal, a longer GSL implies potentially more productive vegetation in the future. However, since GSL uses only a lower temperature threshold (and not an upper threshold to account for heat stress) and ignores changes in precipitation (reduced rainfall in the warm season—Section 3.3, Table 3), it should be considered an upper limit for estimates of future productivity.

A related measure to GSL is the length of the frost-free season, which uses a lower threshold of 0°C for minimum daily temperature. As mentioned above, frost days will become increasingly rare in the future, resulting in frost-free conditions nearly year-round in the region by the 2080s.

Table 7: Growing Season Length

	Past (days)	2050s (days)	2080s (days)	2050s Change (days)	2080s Change (days)
Region	271	318	339	47 (*39 to 71*)	68 (*60 to 86*)
Eastern Region	315	348	358	33 (*25 to 42*)	44 (*37 to 49*)
Western Region	283	324	344	41 (*35 to 64*)	61 (*53 to 76*)
Water Supply Area	245	301	329	56 (*45 to 90*)	84 (*75 to 112*)

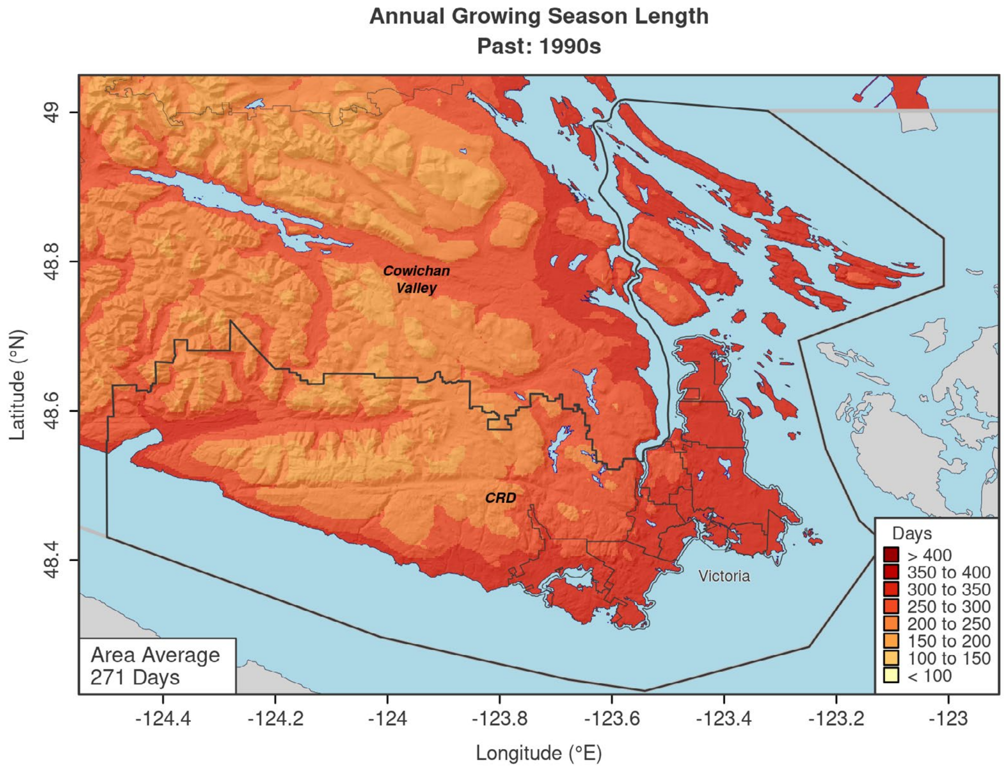


Figure 13a. *Growing season length in the past*

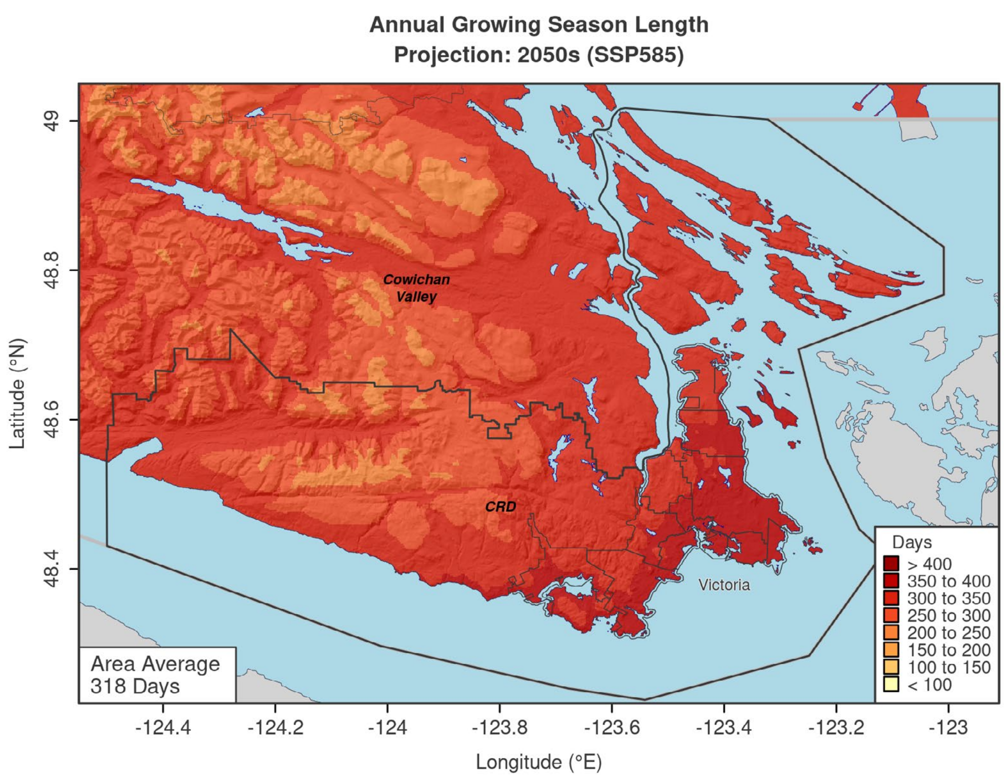


Figure 13b. *Projected (increased) growing season length by the 2050s*

5.2 Cooling Degree Days

The opposite of HDD, *Cooling Degree Days* are calculated by summing the number of degrees that the daily mean temperature exceeds 18°C for every day in a year.[11] This measure is commonly used to estimate the demand for mechanical cooling (i.e., air conditioning) in buildings in the warmer months.

Projections

In the Past, the capital region typically had around 17 cooling degree days, with the vast majority of such days occurring in summer. The median future-projected cooling degree days increase to about 119 (a 7-fold increase) by the 2050s and to nearly 240 (a 14-fold increase) by the 2080s. While most such days will continue to occur in summer, they will increasingly occur during late spring and early fall.

Like the projected decrease in HDD, an increase in cooling degree days is among the clearest indicators of warming, both in recent historical observations and model projections. Moreover, the magnitude of increase varies strongly from west (lower values) to east (higher values) across the capital region. To the extent that this index correlates with demand for cooling, new buildings may need to be designed differently to maintain thermal comfort.

Table 8: Cooling Degree Days

	Past (°C-days)	2050s (°C-days)	2080s (°C-days)	2050s Change (°C-days)	2080s Change (°C-days)
Region	17	119	237	102 (*62 to 235*)	220 (*176 to 592*)
Southern Gulf Islands	38	227	392	189 (*119 to 385*)	354 (*297 to 820*)
Core / Peninsula	25	169	317	144 (*87 to 310*)	292 (*234 to 716*)
Western Region	10	83	185	73 (*41 to 185*)	175 (*135 to 525*)

[11] For example, if the daily mean temperature on July 1 is 20°C, followed by three days of 21°C, one day of 25°C and two days of 16°C, then the cooling degree days for that week are calculated as: (20−18) + 3 × (21−18) + (25−18) = 18 degree-days.

Note that days with temperature equal to or less than 18°C are not counted.

5.3 Warm Summer Days and Nights, Annual Hottest Day and Heatwaves

These indicators highlight the most extreme warm temperatures occurring in the region. The results in the table below are for the Core/Peninsula subregion (see Figure 1) which has the highest population and therefore the highest exposure to many heat-related impacts (values for the Southern Gulf Islands are very similar). Three single-day extreme heat measures are included in the table: the peak temperature of the hottest day of the year (not necessarily occurring during a heatwave), the number of days with TX > 25°C (*Summer Days*), and the number of nights with TN > 16°C (*Temperate Nights*). Episodes of multi-day extreme heat, which were rare in the Past, are captured by several heatwave (HW) indicators defined in the Appendix. These are partly based on threshold temperatures for emergency health alerts used specifically in BC.[12] As with the variables discussed above, each of the indices describes a typical year within the indicated 30-year period.

Projections

In the Past, there were typically around 12 days per year with a high temperature exceeding 25°C, and rarely did nighttime temperatures rise above 16°C. The median future-projected number of Summer Days increases to roughly 40 per year by the 2050s and 62 per year by the 2080s, while Temperate Nights begin to occur by the 2030s, with a frequency of 15 per year in the 2050s and 52 per year in the 2080s.

When it comes to heatwaves, in the Past, there was usually one HW per year, lasting up to 3 days and having a peak daily temperature of around 30°C. The median future-projected number of HWs increases to roughly 3 per year by the 2050s and 5 per year by the 2080s. HWs are also projected to increase in length in the future (approaching 9 consecutive days or more by the 2080s) and will feature both warmer daytime and nighttime temperatures. It is clear that residents of the area will need to adapt to more frequent, longer, and intense HWs in future.

Table 9: Measures of extreme heat (Core/Peninsula subregion)

Core/Peninsula subregion: Heatwave (HW) Indices, Hot Summer Days and Warm Nights*					
Index	**Description**	**Past**	**2030s**	**2050s**	**2080s**
HWD	HW days (days)	1	4 (*3 to 11*)	10 (*6 to 27*)	23 (*17 to 74*)
HWXL	HW Maximum length (days)[13]	3	4 (*3 to 5*)	4.5 (*4 to 10*)	8.5 (*6 to 43*)
HWN	Annual number HWs	1	2 (*1 to 4*)	3 (*2 to 5*)	5 (*4 to 7*)
TXHX	Avg. TX in most extreme annual HW (°C)	30	31 (*30 to 32*)	31 (*31 to 33*)	32 (*32 to 34*)
TNHX	Avg. TN in most extreme annual HW (°C)	15	16 (*15 to 16*)	17 (*16 to 18*)	19 (*18 to 21*)
TXX	TX on hottest day of year (°C)	29	31 (*30 to 32*)	32 (*32 to 35*)	35 (*33 to 38*)
SU	Number of days reaching TX >25 °C	12	28 (*22 to 41*)	40 (*30 to 70*)	62 (*57 to 111*)
TR16C	Number of nights reaching TN >16°C	0	4 (*3 to 13*)	15 (*9 to 47*)	52 (*36 to 108*)

**Upper values in each table cell are the ensemble median, with values in parentheses giving the 10th to 90th percentile range over the model ensemble.*

[12] See the report, BC Provincial Heat Alert and Response System (BC HARS): 2023, May 2023. Available at: http://www.bccdc.ca/health-professionals/professional-resources/heat-event-response-planning. The lower threshold temperatures used in our HW definition, which is intended for use throughout BC, are TX = 28°C and TN = 13°C. In addition, a HW must: 1) last at least 2 full days; and 2) have TX and TN exceeding their 95th percentile values in the Past.

[13] It may seem strange that HWD < HWXL in the Past, but this is an artifact of small number statistics. Some years in the Past contained no HWs, leading to a mean annual value of 0.4 for HWD (rounded to 1 in the table, since some years had a HW). Nevertheless, one or more years had HW lengths of 2 or 3 days, leading to the mean HWXL = 2.5 days (rounded to 3) over the 30-year period. As the number of HWs increases in future years of the simulations, the expected behaviour HWD > HWXL emerges.

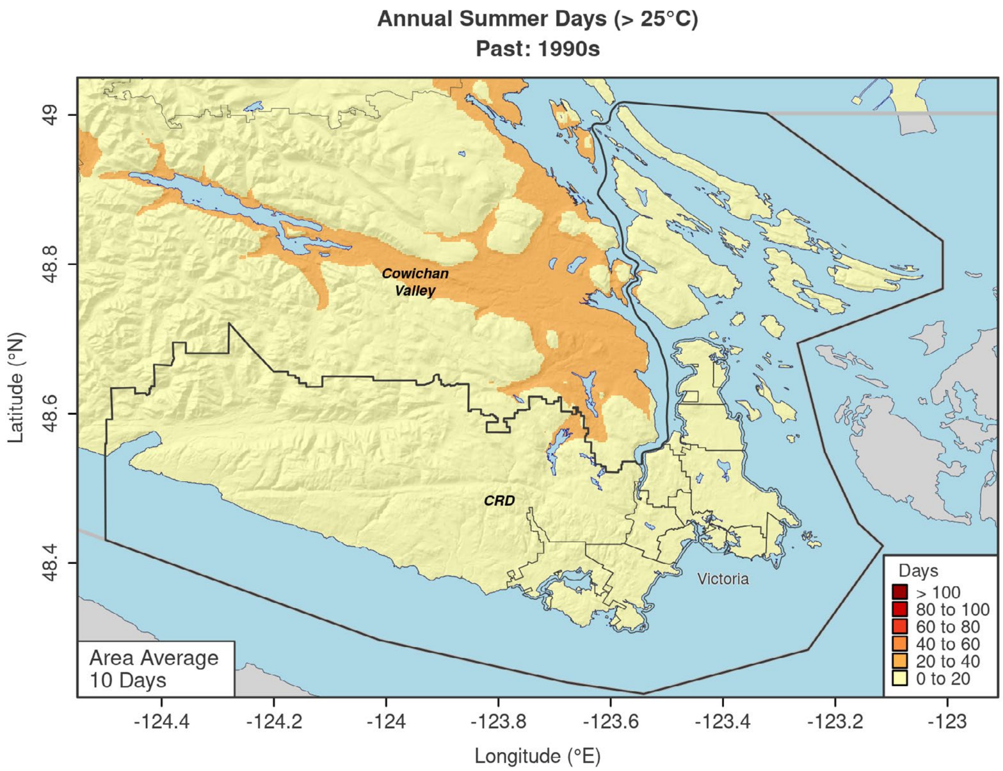


Figure 14a. *Annual count of summer days in the Past*

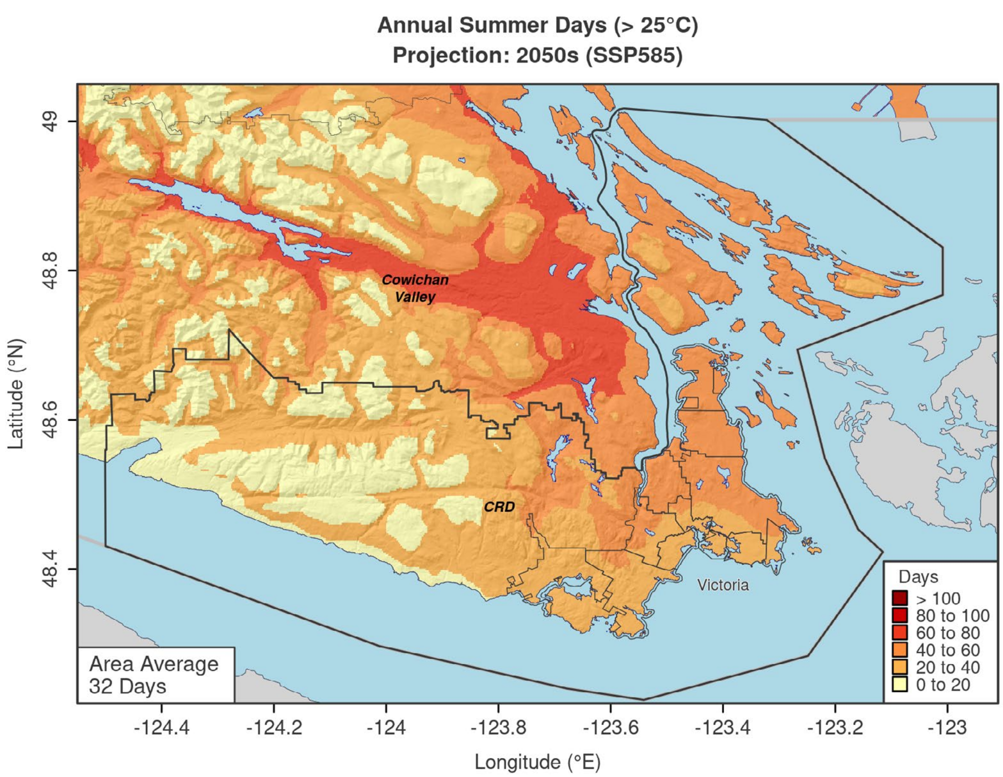


Figure 14b. *Projected number of annual summer days by the 2050s*

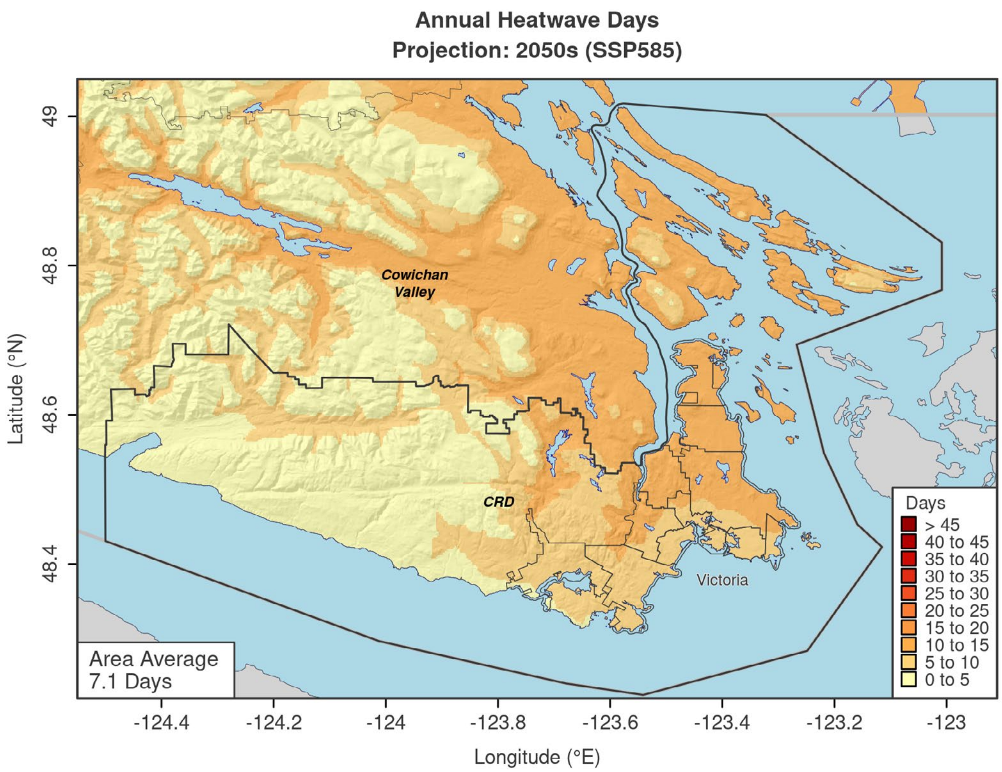


Figure 15a. *Projected annual count of heatwave days in the 2050s.*

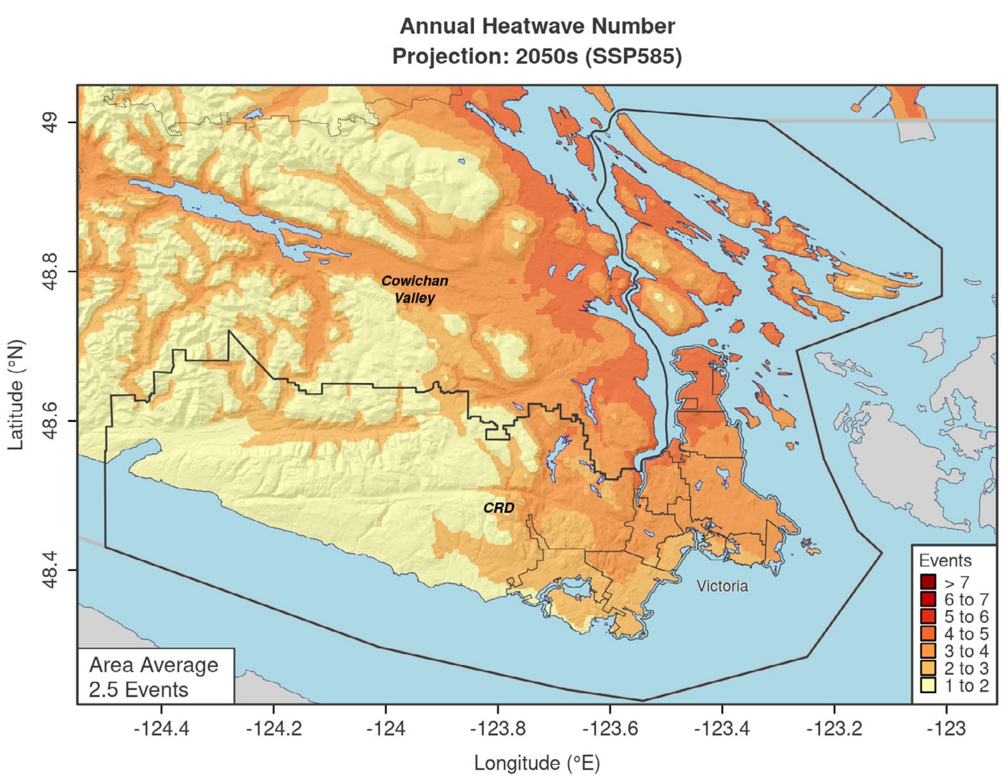


Figure 15b. Projected number of annual heatwaves in the 2050s.

Note that: (i) for both measures, counts in the Past are very low (about 1 per year) and uniform throughout the capital region; and (ii) average values for Core/ Peninsula (Table 9) are larger than capital region averages shown on the maps.

5.4 The 1-in-20-Year Annual Hottest Day

This indicator describes extreme daily high temperatures so warm, they are expected to occur only once every 20 years in the historical climate. In other words, the *1-in-20 Year Hottest Day* presently has a 5% chance of occurring in any given year.

Projections

The figure below shows the projected changes in this type of event in two ways: first, in terms of how frequently an event of the same TX value occurs in the future; and second, in terms of how much TX increases for an event occurring with the same frequency (or annual probability) in the future.

For example, in the Past, a daily maximum temperature of 32°C or higher occurred once every 20 years or so in the capital region, or with a 5% annual exceedance probability (AEP). In the projections for the 2050s, this temperature is exceeded around 8 times in a 20-year period, or with a 40% AEP. Alternatively, one can say based on the same projections that in the 2050s, the magnitude of a 1-in-20 year (5% AEP) event increases to around 35.5°C (see the 'Return Levels' tab in the SSP585 Summary Table).

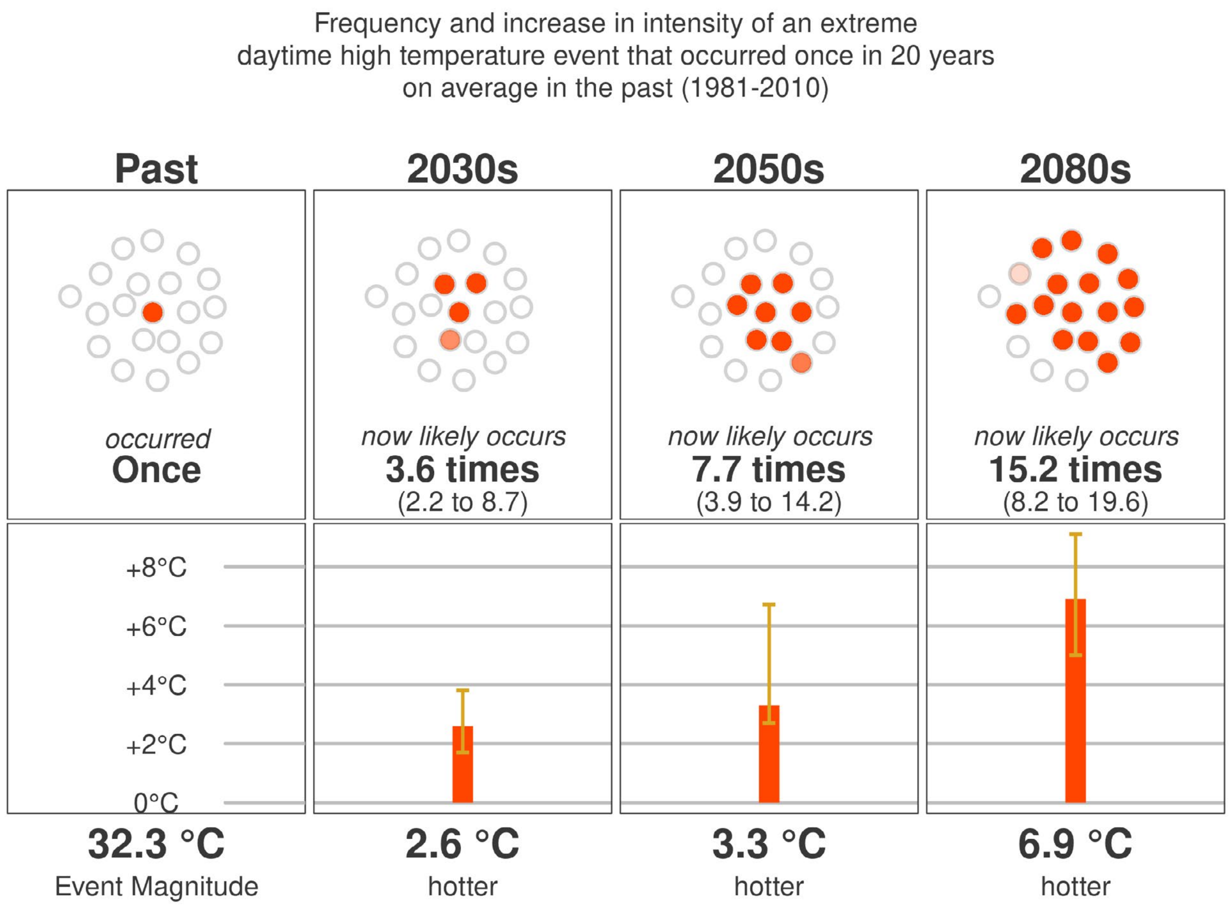


Figure 16. *Upper panels: Frequency of a 1-in-20 year daily maximum temperature (TX) event in the Past and projected frequency of the same magnitude event (i.e. TX = 32°C) in the three future periods. Lower panels: Increase in magnitude of a 1-in-20 year TX event from the Past to Future periods. Figure design is taken from similar infographics in the IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., et al. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 3-32, doi:10.1017/9781009157896.001.*

6. PRECIPITATION INDICATORS

6.1 Dry Spells

The *Consecutive Dry Days* indicator tracks the annual longest string of days with less than 1 mm of precipitation.

Projections

In the Past, the median dry spell length in the capital region was 24 days. The median future-projected dry spell length increases by 8% to 26 days (range 24 - 34 days) by the 2050s and by 21% to 29 days (range 26 - 47 days) by the 2080s.

The increase in dry spell length is consistent with the higher summer temperatures and reduced summer rainfall highlighted in the previous chapters. The map of consecutive dry days (not shown) is quite uniform throughout the region, as are its changes in the future periods.

6.2 Snowfall

Snowfall is inferred from the downscaled total daily precipitation and temperature, using a widely validated empirical relationship.[14]

Projections

In the Past, the median annual snowfall in the capital region was around 275 mm (snow water equivalent, or SWE). The median future-projected snowfall decreases by 60% to around 110 mm (range 32 to 134 mm) by the 2050s and by 85% to just 40 mm (range 7 to 60 mm) by the 2080s. Due to the robust projection of an increase in cold season temperature (Chapters 3 and 4), the expectation of a smaller fraction of precipitation falling as snow in future decades is reasonable, even if its magnitude is somewhat uncertain.

Of more concern is the limited model ability to simulate the unique meteorological conditions that lead to the rare, but sometimes heavy, snowfalls in southwest BC. The CMIP6 models used in this study are probably not able to capture this behaviour very well, meaning that the change in frequency of winter storms resulting in heavy snowfall is largely unknown.

[14] Dai, A. (2008). "Temperature and pressure dependence of the rain-snow phase transition over land and ocean," Geophysical Research Letters, 35(12). Snowfall projections should be taken with special caution, for two reasons. First, the amount of total precipitation that falls as snow is a sensitive function of local temperature, so whatever temperature biases remain after the downscaling procedure result in uncertainty in snowfall. Over time, however, as local temperatures exceed 0°C more often in winter, this uncertainty decreases.

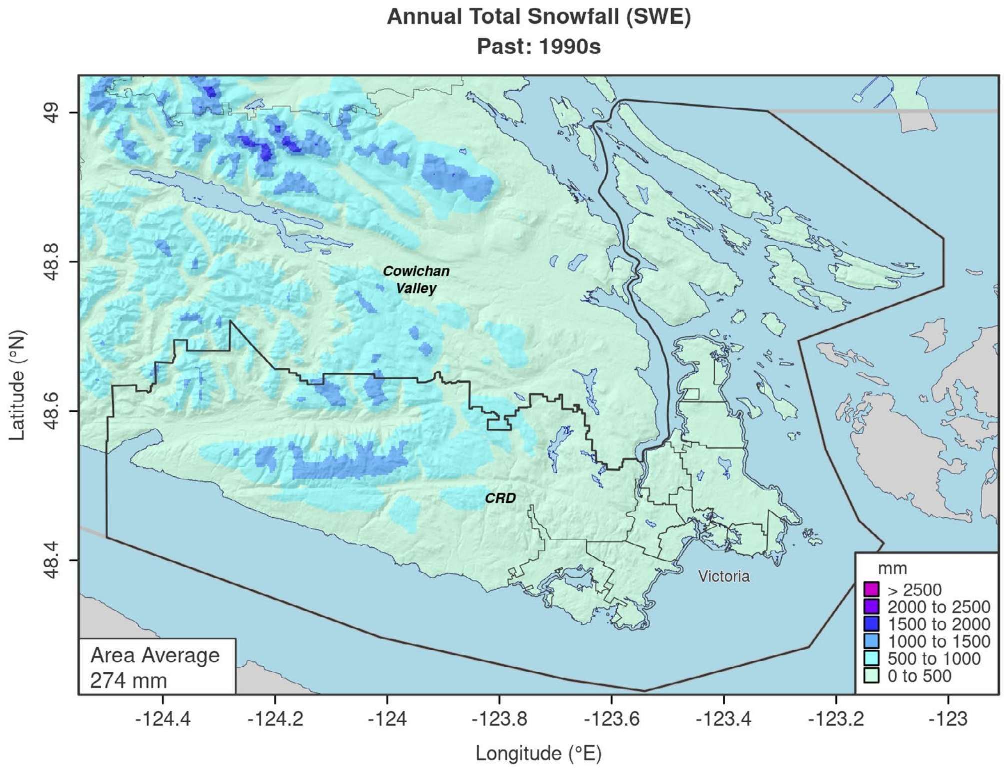


Figure 17a. *Annual total snowfall in the Past.*

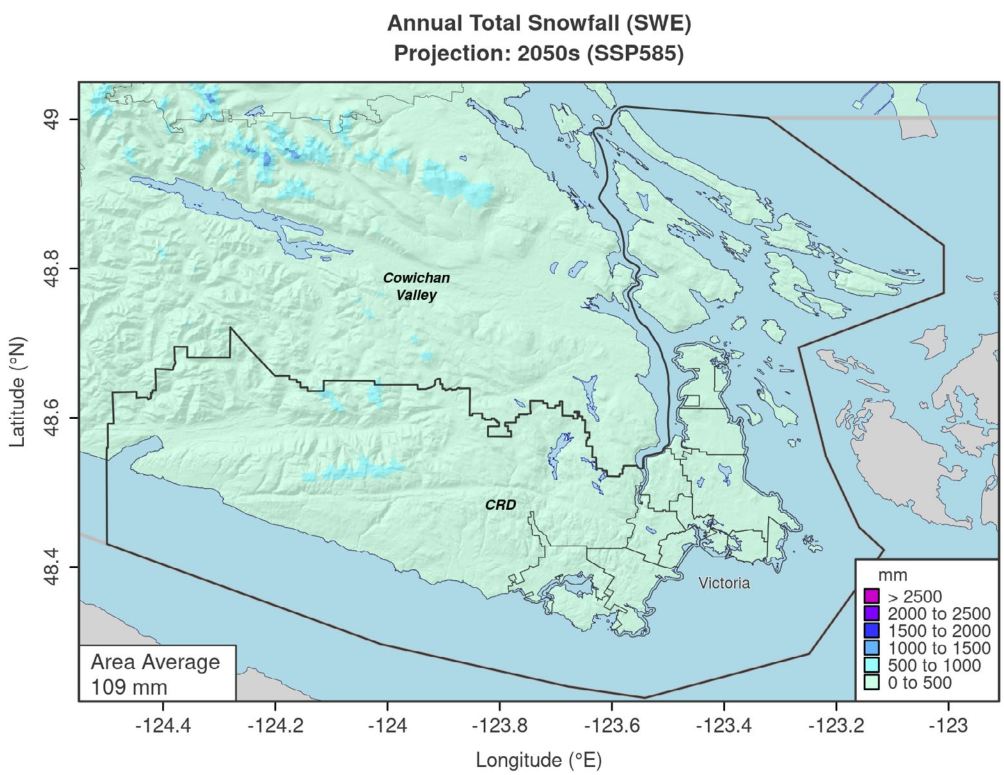


Figure 17b. *Projected snowfall in the 2050s.*

6.3 Annual Maximum One-Day and 5-Day Precipitation and 95th-percentile Wettest Days

These indicators describe the largest precipitation events of the year. The *Annual Maximum One-Day Precipitation* (RX1DAY) is self-explanatory, while the *Annual Maximum 5-Day Precipitation* (RX5DAY) tracks the accumulated amount over consecutive 5-day periods during the year. If we compute the 95th percentile of daily precipitation over all wet days in the Past (i.e. those with a daily amount of at least 1 mm), and then sum the amounts over that threshold that fell on especially wet days, then we obtain the 95th-percentile Wettest Days (R95P) index.

Note that R95P is potentially composed of several large precipitation events in a typical year, and does not (usually) describe single storms.

All amounts in the table below reflect the systematic difference in precipitation amount from west (high) to east (low) across the capital region. Across the region, percent increases for the 2050s differ somewhat for each index: from 10-16% for RX1DAY, to around 10% for RX5DAY to around 30% for R95P. Changes for the 2080s are correspondingly higher, as shown in the table.

Table 10: Annual Extreme Precipitation Indices

	Past (mm)	2050s(mm)	2080s(mm)	2050s Change (%)	2080s Change (%)
One-day maximum precipitation (RX1DAY)					
Region	63	72	77	14 (*4 to 24*)	22 (*17 to 29*)
Western Region*	67	74	80	10 (*4 to 24*)	19 (*17 to 30*)
Eastern Region	37	43	45	16 (*5 to 26*)	22 (*17 to 33*)
5-Day maximum precipitation (RX5DAY)					
Region	163	179	187	10 (*6 to 21*)	15 (*12 to 33*)
Western Region	172	188	197	9 (*6 to 20*)	15 (*13 to 24*)
Eastern Region	88	97	101	10 (*5 to 23*)	15 (*12 to 23*)
95th Percentile Wettest Days (R95P)					
Region	402	527	590	31 (*16 to 46*)	47 (*30 to 77*)
Western Region	423	553	622	31 (*16 to 46*)	47 (*30 to 79*)
Eastern Region	193	245	276	26 (*10 to 41*)	43 (*23 to 64*)

*Values for Water Supply Area and the entire region are slightly lower than those for the Western Region, and well within the spread of model results, so are not shown. Consult the data deliverable spreadsheets for values in all subregions.

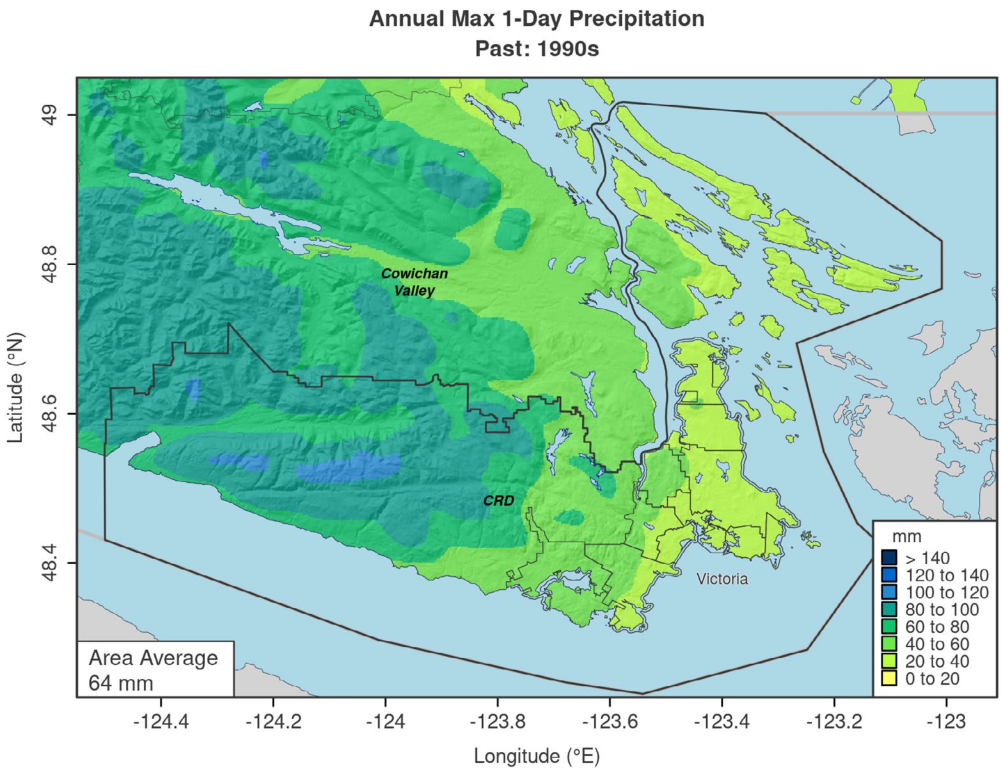


Figure 18a. *Annual maximum 1-day precipitation in the Past.*

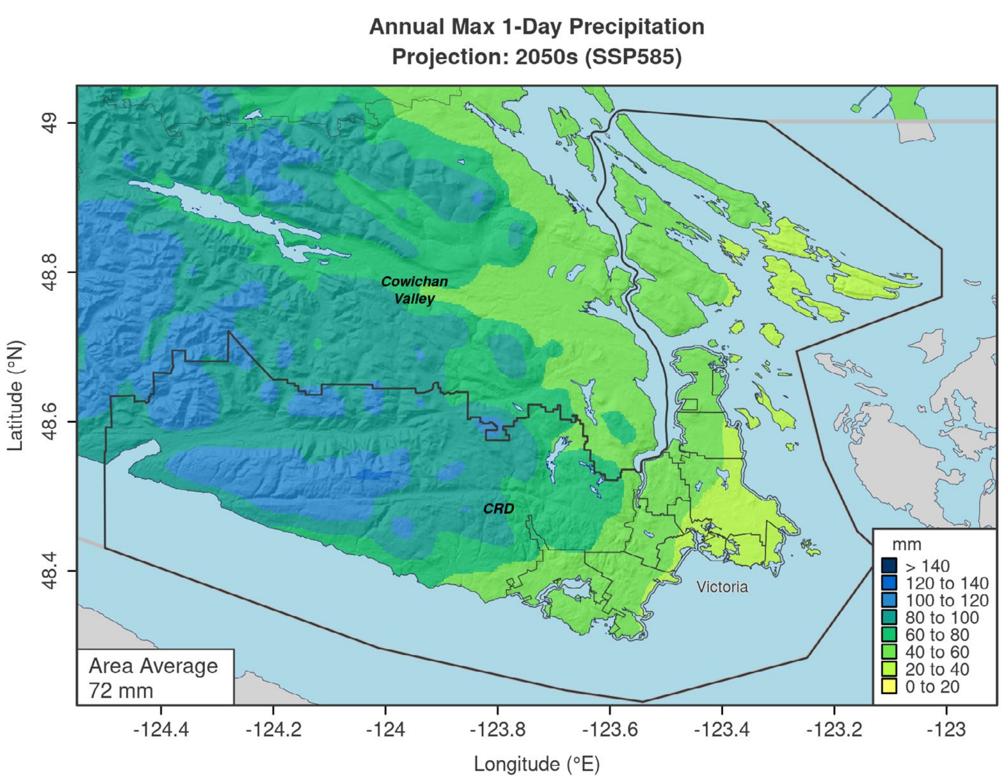


Figure 18b. *Projected Annual maximum 1-day precipitation in the 2050s.*

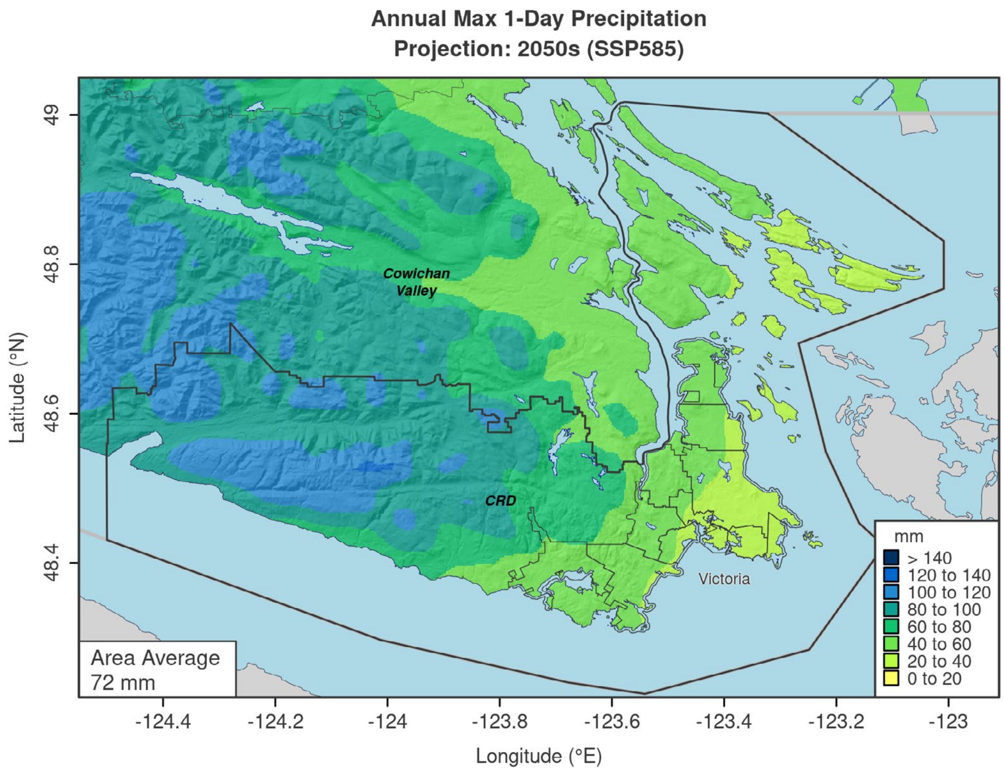


Figure 19a. *1-in-20 year, maximum 5-day rainfall in the Past.*

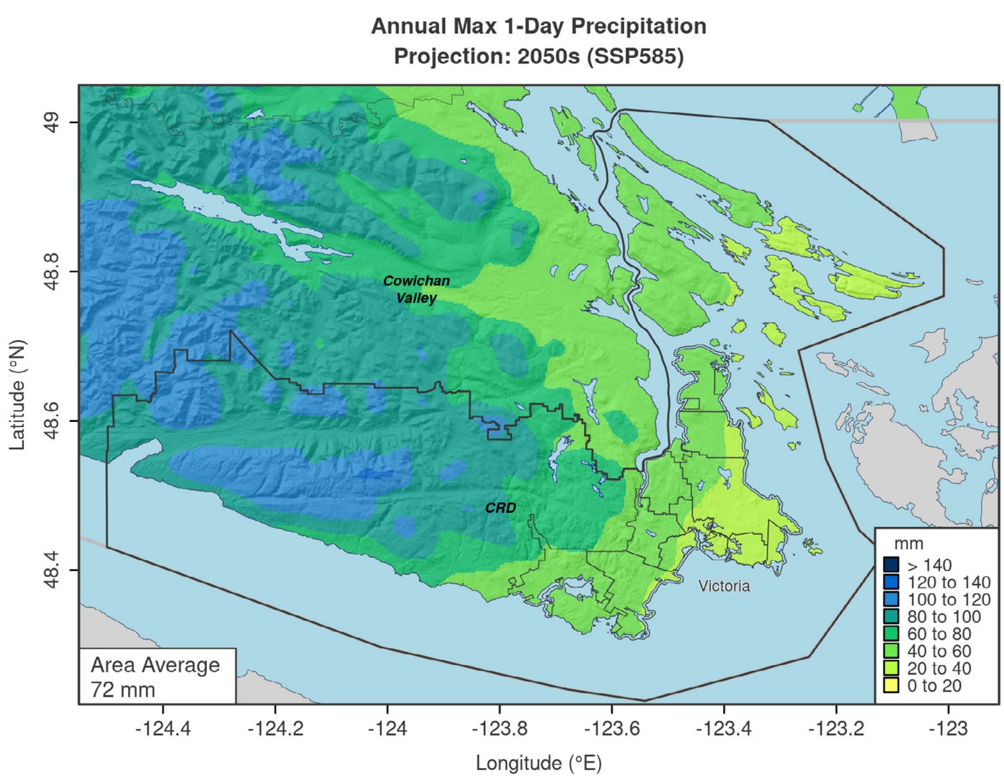


Figure 19b. *1-in-20 year, maximum 5-day rainfall in the 2050s.*

6.4 The 1-in-20 Year Wettest Day and 1-in-20 Year Wettest 5-Day Period

These indicators describe rainfall events so extreme, they are expected to occur only once every 20 years in the Past climate. In other words, the *1-in-20 Year Wettest Day* and *Wettest 5 Days* have a 5% chance of occurring in any given year in the Past.

Projections

In the Past, the median 1-in-20 Year, single-day rainfall in the capital region was around 100 mm, while the median 1-in-20 year, 5-day rainfall was about 230 mm. The median Future-projected 1-in-20 year, single-day rainfall increases by 15% to around 115 mm by the 2050s and by 25% to about 125 mm by the 2080s. The median future-projected 1-in-20 year, 5-day rainfall increases by 15% to around 270 mm by the 2050s and by 20% to about 280 mm by the 2080s. As shown in the maps above, the absolute rainfall amounts for both indices are considerably larger in the west of the region compared to the east.

By comparing these results with those shown in Table 3 of Chapter 3, it is evident that the relative changes in extreme rainfall indices are larger than those for seasonal or annual mean rainfall. Table 12, which gathers relevant results from other tables above, reinforces this point. This behaviour occurs due to the different mechanisms that control how extreme (e.g., daily) and average (e.g., monthly to annual) precipitation respond to warming.

As in the case of rare temperature events, one may express these changes in extreme rainfall in a more visually compelling way, as in the diagram on the following page.

Table 11: 20-Year Return Level Rainfall

	Past (mm)	2050s (mm)	2080s (mm)	2050s Change (%)	2080s Change (%)
1-in-20 Year Maximum One-Day Rainfall					
Region	101	116	124	15 (*9 to 30*)	24 (*22 to 42*)
Western Region[1]	105	122	129	16 (*9 to 28*)	23 (*21 to 39*)
Eastern Region	62	72	79	16 (*10 to 23*)	27 (*23 to 42*)
1-in-20 Year Maximum 5-Day Rainfall					
Region	232	268	281	14 (*3 to 31*)	21 (*11 to 27*)
Western Region	243	274	297	13 (*2 to 32*)	22 (*11 to 27*)
Eastern Region	132	155	159	17 (*0 to 32*)	20 (*10 to 27*)

Table 12: Change in various precipitation indices: Means versus extremes

	Region		Western Region		Eastern Region	
	2050s Change (%)	2080s Change (%)	2050s Change (%)	2080s Change (%)	2050s Change (%)	2080s Change (%)
Annual Mean	4	11	2	8	5	11
RX1DAY	14	22	10	19	15	22
RX5DAY	10	15	9	15	11	15
R95P	31	47	31	47	26	43
1-in-20 RX1DAY	15	24	16	23	16	27
1-in-20 RX5DAY	14	21	13	22	17	20

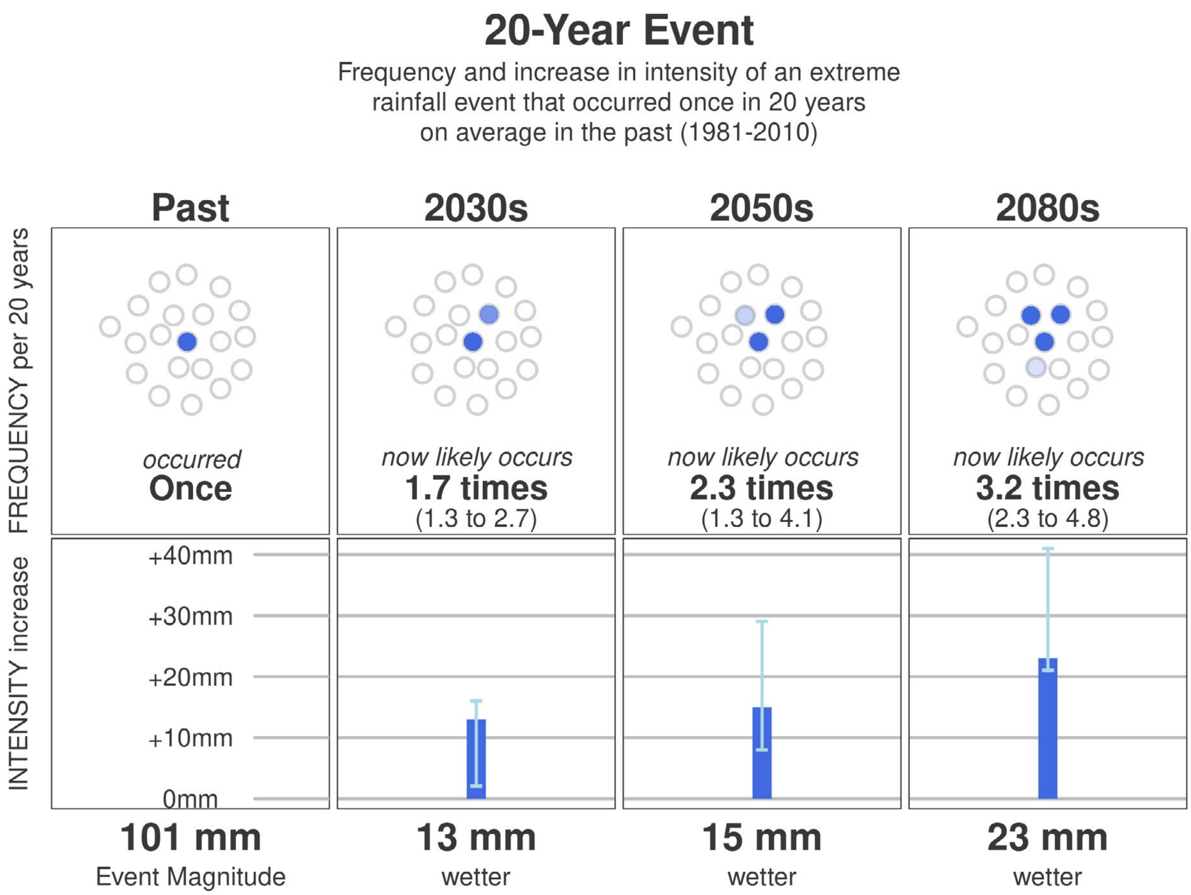


Figure 20. *Upper panels: Frequency of a 1-in-20 year daily maximum rainfall event in the Past and projected frequency of the same magnitude event (i.e. 101 mm) in the three future periods. Lower panels: Increase in magnitude of a 1-in-20 year single-day rainfall event from the Past to Future periods. Figure design is taken from similar infographics in the IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., et al. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 3-32, doi:10.1017/9781009157896.001.*

7. REGIONAL IMPACTS

Communities across the capital region are already witnessing and experiencing impacts from climate change. These impacts are likely to persist and, in many cases, intensify over the coming decades based on projected global GHG emissions trajectories. Collective efforts to reduce emissions and thereby slow the rate of global warming will be necessary to lessen the severity of these impacts. Equally important will be action on climate adaptation and preparing for the environment as it will be in the future, not as it was in the past.

Investing in climate adaptation has the potential to support thriving communities and economies for generations to come. Adaptation actions can safeguard communities and their critical infrastructure from extreme weather events, protect and sustain natural ecosystems, increase the resiliency of food systems, and improve the efficiency of energy and water use. Importantly, there is no "one-size-fits-all-solution"; adaptation can take many forms depending on the unique context of the community.

By the 2050s, the capital region can expect a climate that has diverged from that of the past, with warmer year-round temperatures, shifting precipitation patterns, and more noticeable climate extremes. Due to climate variability, these changes may not occur evenly from one year to the next. Although winters will generally become warmer and wetter, it's important to be prepared for some winters in the future to be colder and drier, especially in the near term. Similarly, while summers will become increasingly hot and dry, there will be summers that are cooler and wetter than the average summer in the future. Adaptation strategies must consider the inherent complexity and variability of projected changes to the regional climate.

This section provides a brief overview of the multiple, intersecting climate impacts expected across various sectors in the capital region. **It is not a comprehensive assessment of the impacts that can be expected from the projected changes outlined in this report.** Rather, this chapter reflects a discussion of regional climate impacts that took place among local government staff, emergency planners and environmental scientists in October 2023. It is intended to spark deeper discussion that explores how to prepare for the interrelated climate impacts facing the region.

While the development of this report did not actively involve First Nations in the capital region, it's crucial to recognize that Indigenous Peoples and their traditional territories bear a disproportionate impact from climate change compared to other groups in Canada.[15] Indigenous knowledge systems play a pivotal role in comprehending ecological resilience, monitoring local and regional impacts, and effectively responding to climate change challenges. Future initiatives aimed at exploring and mitigating the impacts of climate change should prioritize meaningful engagement with First Nations throughout the region.

> The case for investing in climate adaptation is clear: for every $1 spent on adaptation measures today, $13 to $15 is estimated to be returned in future years through direct and indirect benefits.[16]

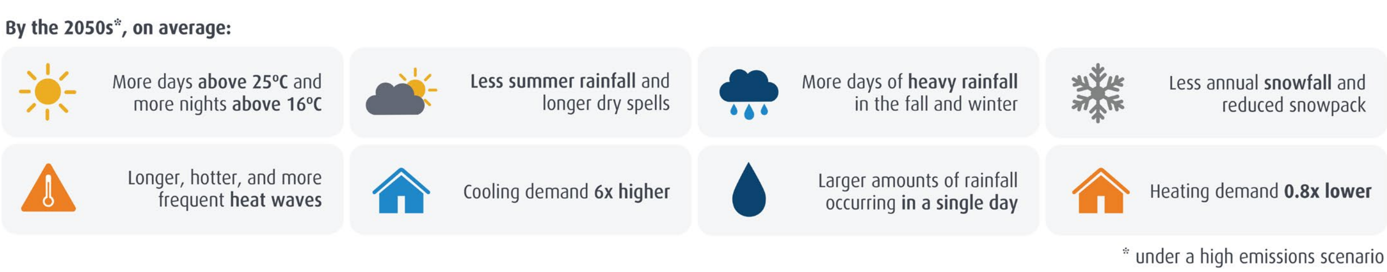


Figure 21. *Infographic summarizing key projections for the 2050s time period.*

[15] BC Centre for Disease Control. Climate Change and Health. http://www.bccdc.ca/health-info/prevention-public-health/climate-change-health

[16] Swayer, D., Ness, R., Lee, C., and Miller, S. (2022). Damage control: Reducing the costs of climate impacts in Canada. Climate Risk Institute.

Climate Equity

The impacts discussed in this chapter will not be experienced the same way by all residents of the region. People facing the greatest economic and social challenges are often the ones most affected by climate change, particularly for impacts that are compounding (see below). During and after climate-related events, some people and communities experience disproportionate impacts because of existing vulnerabilities that often overlap, including:[15]

- People who experience poverty, colonization, racism, inadequate housing, and a lack of access to health care,
- People who are most likely to be exposed to climate impacts because of where and how they live and work,
- People living with disabilities, chronic diseases, and mental illnesses, and
- Babies in the womb, pregnant people, infants, children, and older adults.

Climate equity can be woven into broader efforts to address the socioeconomic, sociocultural, and physical impacts of climate change. This will require collaboration across various sectors to understand where climate change intersects with other crises (e.g., housing, mental health), and to address these issues holistically.

Climate equity[17] is the goal of recognizing and addressing the unequal burdens made worse by climate change, while ensuring that all people share the benefits of climate action efforts. Achieving climate equity means that all people in our region have access to a safe, healthy, and fair environment.

Impacts

The impacts examined in this chapter occur within a dynamic and increasingly complex global system. As a result, the impacts from projected climate change may be more severe due to the collective impact of multiple drivers. Examples of compounding interactions include, but are not limited to:

- In the warmer months, high temperatures combined with less rainfall can make drought conditions more likely. [18]
- Extended periods of drought can change soil conditions and reduce infiltration of heavy rainfall, exacerbating localized flooding.[19]
- Warmer water temperatures and increased stormwater runoff can promote conditions for algal blooms year-round.[19]
- Wildfire smoke during extreme heat events can aggravate pre-existing health conditions and cause exposure to poor air quality for residents seeking relief from the heat outdoors.[19]
- Ongoing emergency response associated with consecutive extreme events can overwhelm staff capacity and deplete emergency management resources.

[17] United States Environmental Protection Agency. Climate Equity. https://www.epa.gov/climateimpacts/climate-equity

[18] Intergovernmental Panel on Climate Change [IPCC]. 2023. Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, pp. 35-115, doi: 10.59327/IPCC/AR6-9789291691647

[19] Yumagulova et al. 2022. Lived experience of extreme heat in BC: Final report to the Climate Action Secretariat. Government of BC.

Health and Well-Being

The capital region has a growing and aging population. By 2038, the population is expected to grow by 20% and the number of people aged 65+ is expected to increase by over 50%.[20] Historically, the region has had excellent air quality and comfortable temperatures, with nights cooling off in the summer. In recent years, wildfire smoke and periods of extreme heat during the warmer months have forced residents to seek refuge indoors. Higher temperatures are typically experienced in the eastern parts of the region and in urban areas further from the coast. Developed areas are typically hotter due to the urban heat island effect, which describes how closely packed buildings and widespread paved surfaces in urban areas absorb and re-emit heat more effectively than natural ecosystems and areas shaded by trees and vegetation.[21]

Impacts

In recent years, extreme weather events made worse by climate change have negatively impacted human health and well-being in the capital region. Climate change has the potential to undermine health determinants such as air quality, water supply, food security, cultural practices, and access to a safe environment. Climate change can also place additional strain on healthcare and social systems that are necessary for good health and well-being.

By the 2050s, the capital region can anticipate more multi-day extreme heat events that become longer and more intense by mid-century. The region can also expect hotter summer temperatures, with more days exceeding 25°C and more "temperate nights" where the temperature stays above 16°C.[22] These projected changes will increase the risk of heat-related illnesses and mortality and worsen pre-existing health conditions, particularly among equity-denied populations who do not have access to a cool indoor environment. Notably, these risks are heightened for the region's growing population of older adults.

Warming temperatures and shifting precipitation patterns may worsen air quality in the region. Across the Pacific Northwest, hotter and drier conditions can increase the likelihood of wildfire ignition. This may cause more frequent episodes of wildfire smoke in the capital region, which can irritate the lungs, cause inflammation, and alter immune function, particularly for people with pre-existing conditions.[24] The projected changes in temperature, precipitation and heat wave occurrence may also exacerbate other air pollutants that influence human health such as pollen, mould, and ground-level ozone.

Living through an extreme weather event, or grappling with uncertainty about the future, can impact mental health and wellbeing, often manifesting as stress, anxiety, fear, and exhaustion. During and after an extreme event, people who face property loss or displacement may endure significant and lasting trauma.

In June 2021, an unprecedented[23] "heat dome" event in the Pacific Northwest caused extended periods of record-breaking high temperatures that had severe implications for health and well-being. Over 600 heat-related deaths were recorded across BC, particularly among people with pre-existing medical conditions (including schizophrenia), older adults, people living alone, and people living in socially deprived areas[21]. In response to this event, numerous projects have been launched across the capital region to better understand extreme heat vulnerability and to build resilience towards extreme heat in the future. For more information, see Appendix D: Further Resources.

[20] BC Statistics. 2019. Capital Regional District 2019-2038 Population, Dwelling Units and Employment Projection Report.

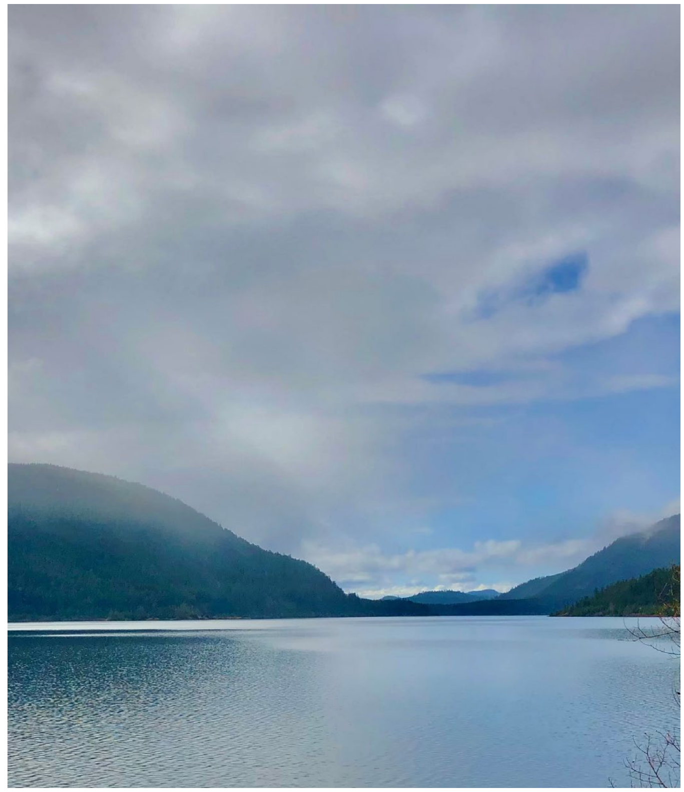
[21] British Columbia Coroners Service. 2022. Extreme heat and human mortality: A review of heat-related deaths in BC in Summer 2021.

[22] The number of temperate nights is an important public health measure that reflects the lower temperature threshold for emergency health alerts used in the capital region. For more, see: Government of British Columbia. 2023. BC Provincial Heat Alert and Response System (BC HARS).

[23] The unprecedented nature of the June 2021 heat dome makes it difficult to estimate its return period (or annual probability of occurrence). Based on analysis of historical data, it was estimated as a 1-in-300-year (or 0.3% annually) at Seattle-Tacoma Airport to a 1-in-1000-year event (or 0.1% annually) in New Westminster (Philip et al., 2022; doi: 10.5194/esd-13-1689-2022). While the capital region can expect more frequent extreme temperatures in the future, estimates for how often an event of this magnitude will occur are difficult because historical records are far shorter than the estimated return periods for this event.

[24] Berry, P., and Schnitter, R. 2022. Health of Canadians in a changing climate. Government of Canada.

Water Supply and Demand



The CRD supplies drinking water to over 390,000 customers from large reservoirs in the Sooke, Leech and Goldstream watersheds that make up the protected Greater Victoria Water Supply Area (GVWSA). The CRD also provides water to small service areas in the Southern Gulf Islands and the western portion of the region through surface water and groundwater systems. Similar privately owned systems provide water in other areas. In some rural and less developed areas, residents rely on groundwater wells on their properties. Residential water use accounts for the largest portion of water use in the region (60%). Water supplies across Southern Vancouver Island are almost entirely replenished from rainwater in the late fall, winter, and early spring (the wet season). Snow melt runoff contributes to groundwater recharge and is needed to sustain summer flows.

Impacts

By the 2050s, less summer rainfall and longer dry spells will increase the risk of drought during the summer and into the early fall. At the same time, hotter temperatures and more extreme heat events will intensify water demand as residents consume more water to keep cool and stay hydrated. Hotter and drier conditions will also increase evaporation and evapotranspiration, raising outdoor watering demand. Water conservation initiatives will remain a priority in the region, given the growing population and the potential for the seasonal decline in water supplies to become more pronounced in the future. Greater densification and anticipated increases in peak demand may also trigger the need for more storage, supplements to existing water supplies, larger capacity infrastructure, and balancing reservoirs in water distribution systems.

> Hotter and drier summer conditions will be particularly challenging for those who rely on groundwater wells or small reservoirs that may not recharge sufficiently. In some instances, these systems may reach dangerously low levels or may even deplete completely. In coastal areas, overdrawing groundwater can lead to saltwater intrusion – an impact that is compounded by rising sea levels.

Hotter and drier conditions also increase the threat of wildfire in the GVWSA and other forested areas that supply water to residents of the region. Although fire is a natural and essential process in forest ecosystems, severe wildfire occurring in water supply areas can affect water quality and supply by increasing erosion during the following rainy season.[25] As the threat of wildfire increases in rural areas, water needs for wildfire protection will gain increasing importance in water conservation planning.

During the wet season, heavier rainfall may increase erosion of saturated slopes, leading to more fine sediment and organic material in streams entering water supply reservoirs. Increased turbidity from fine sediment can interfere with water disinfection and treatment, while excess organic material can promote algal blooms that produce cyanotoxins, cause taste and odour issues, and compromise disinfection and filterability. Where unprotected water supply catchment areas have been developed, more intense rainfall and runoff can lead to greater undesirable substances (pollutants) entering wells and surface reservoirs. Heavy rainfall and increased water inflows also pose a risk to dam safety. To support safe and resilient water supply through a changing climate, the potential for more intense rainfall events (see next section) will need to be considered in the planning and management of water supply systems.

[25] Brown et al. 2019. Long-term climate, vegetation and fire regime change in a managed municipal water supply area, SAGE Journals, 29(9), 1411-12.

Rainwater Management and Sewerage

A myriad of rainwater management and sewerage infrastructure aims to protect quality of life, property, and aquatic ecosystems across the capital region. Local governments in British Columbia are responsible for managing drainage; as a result, much of the region's drainage infrastructure (hard and soft) is integrated into local land use and infrastructure planning and processes. Historically, stormwater infrastructure was designed to move water away from the built environment, channeling high volumes of rainwater into creeks and streams. Recently, local governments are shifting towards the use of green infrastructure, which mimics natural drainage systems that play a crucial role in rainwater management. Natural drainage systems (i.e., creeks and wetlands) slow runoff through water retention, helping to reduce flood magnitude and filter out substances that impact water quality. The use of green infrastructure is particularly important in areas with increasing urbanization and development, where greater impermeable surfaces (i.e., roads, parking lots and buildings) contribute to additional runoff.

Impacts

In the past, flooding from extreme events has occasionally overwhelmed stormwater and sanitary systems in the region. With extreme precipitation events becoming wetter in the future, the region can expect aging and undersized infrastructure to continue to be overwhelmed, amplifying stressors on the receiving environment. During high intensity rain events, creeks may overflow and soils may become saturated, intensifying runoff, and increasing the chance of flooding in low-lying areas. This combination can increase erosion, decrease slope stability, and flood wetlands and lakes, impacting public infrastructure, drinking water quality, and surrounding aquatic ecosystems. Heavy rainfall events can also cause inflow and infiltration of rainwater into the sanitary system in crossover areas, increasing the likelihood of highly diluted sewage entering waterways.

When heavy rainfall occurs after prolonged periods of dry weather, the "first flush" of surface runoff typically contains high levels of contaminants that have accumulated on hard surfaces. This runoff makes its way into surface waters that are home to aquatic ecosystems. When paired with warmer water temperatures, increased stormwater runoff of nutrients can make conditions more favorable for algal blooms year-round – a growing issue in that region – that impacts water quality, ecosystems, recreation, and human health.

Malahat washout during November 2021 extreme rain event (Credit: Emcon Services Inc.)

Certain areas in the region are at increased risk of flooding during heavy rainfall events due to flat terrain and proximity to the ocean, particularly when these events occur simultaneously with high tides and onshore winds. The CRD Coastal Flood Inundation Mapping Project (2021) may be used in conjunction with the projected changes outlined in this report, to understand how these factors, along with sea level rise, will influence future flood risk for lower-lying areas near the coast.

The projected increase in heavy rainfall may lead to a higher volume of runoff than the current capacity of infrastructure is able to handle. Green infrastructure, low impact development and multijurisdictional watershed management approaches will remain important strategies for reducing the flooding, runoff and pollution associated with extreme precipitation events. Designers of stormwater infrastructure (i.e., culverts, storm drains, etc.) will also need to plan for higher single- and multi-day rainfall amounts. For more information about how future precipitation is estimated using climate model projections, including the adjustment of Intensity-Duration-Frequency (IDF) curves in a future climate, see Appendix D: Further Resources.

Ecosystems and Species

The capital region is home to various ecosystems, including Douglas-fir forests, Garry oak meadows, riparian zones, wetlands, estuaries, shorelines, and more. The diversity in the region brings with it a wide range of flora and fauna, including many species at risk that need protection. Natural assets providing connectivity and ecosystem services are essential for supporting climate resilience. Forests in the GVWSA contribute to the high quality of water in supply reservoirs, and green spaces in urban and suburban areas provide natural cooling capacity, stormwater retention, and help reduce air and water pollution.

Impacts

Warming year-round temperatures and seasonal changes in precipitation will have important impacts on the ecosystems, native species and associated ecological relationships and processes existing in the capital region. Because ecological systems are highly complex, it will be difficult to make specific predictions for how they will be impacted by a changing climate. In general, the speed and scale of climate change may threaten the capability of many species to adapt, altering the ecological landscape. Shifting seasonal patterns, characterized by an earlier onset of spring or a later start to fall, may threaten processes that rely on temperature cues, including predator/prey, parasite/host, and pollinator dynamics. This may cause population declines for certain species, and/or outbreaks of species that are considered pests. Specialist species may be particularly vulnerable, which may threaten regional biodiversity and create new opportunities for invasive species to thrive.

Climate change not only impacts ecosystems and species directly; it also interacts with environmental changes from human development.[26] Impacts from climate change may be amplified for ecosystems where land-use changes have caused fragmentation and, as a result, weakened resiliency. For example, the Bowker Creek watershed – covering 1,028 hectares of the capital region – historically supported coho and chum salmon and cutthroat trout. Today, Bowker Creek is highly urbanized, with roughly 50% now composed of impervious surfaces that cause low summer base flows and reduced water quality for aquatic ecosystems. Long range, multijurisdictional efforts are in place to protect its natural characteristics and reduce impacts from a changing climate.[27]

In the summer, hotter and drier conditions will continue to stress trees and other terrestrial and riparian (streamside) vegetation, particularly for species that are sensitive to drought such as the Western red cedar. Drought conditions can slow decomposition in below-ground communities consisting of bacteria, fungi, and other soil organisms, thereby reducing available nutrients. When plants undergo stress, they become more susceptible to competition with other plants and to damage from insects and diseases.

Warmer year-round temperatures will also raise water temperatures in aquatic ecosystems, which may be problematic for species that require cool water to thrive. In extreme cases, warm water can cause low oxygen levels and mortality, particularly when these conditions are compounded by low water levels and occur during critical life stages such as spawning, rearing, or hatching. Heavy rainfall can also disrupt critical ecological processes. For example, during an atmospheric river event in November 2021, increased channel erosion and sediment deposition resulting from high stream flows severely impacted salmon spawning beds.[28]

[26] IPCC. 2022. Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group, II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. [H.-O. Pörtner et al. (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, 3056 pp., doi: 10.1017/9781009325844.59327/IPCC/AR6-9789291691647

[27] Bowker Creek Initative. 2012. Bowker creek blueprint: A 100-year action plan to restore Bowker Creek Watershed.

[28] CBC. 2021, 21 November. For B.C.'s salmon, floods represent another challenge to survival.

Buildings and Energy Systems

Energy use in buildings accounts for roughly one third of GHG emissions in the region. In the past climate, most buildings and homes in the capital region did not require active cooling capacity. During the 2021 heat dome, 98% of heat-related deaths in BC occurred in private residences, highlighting an urgency to implement cooling measures in homes across the region.[21] Retrofit programs and new building policies not only support the transition to renewable energy and energy efficient technologies but are leading to building envelope considerations and a greater adoption of low emission heat pumps that support thermal comfort. In both urban and rural communities across the region, many homes and other buildings are in coastal and riverine areas where flooding may be a concern.

Impacts

As the climate warms and precipitation patterns change, the case for investing in well-designed, resilient buildings improves. Heavier rainfall events may increase the risk of flooding in the fall and winter, which can cause property damage, personal injury, and economic losses, particularly where development is located on flood plains. More episodes of multi-day extreme heat can also stress foundations and building materials, and potentially affect the functioning of heating, ventilation, and air conditioning (HVAC) systems.

Across the region, warmer year-round temperatures and more days going above 25°C in the summer will shift seasonal and long-term energy demands. Whereas heating demand is expected to decrease in the colder months, hotter temperatures and more multi-day extreme heat events during the warmer months will generate cooling demand where it did not exist previously. In the past, buildings and homes have relied on the region's cool summer nights to support thermal comfort during the warmer months. In the future, an increasing number of "temperate nights" (i.e., nights when the temperature stays above 16°C) will heighten the risk of buildings overheating.

Adaptive design strategies, such as passive cooling, outdoor shading, rainwater capture and reuse, green roofs, resilient landscaping, and rain gardens, can help address challenges from heat, drought, and overland flooding. In addition, concentrating development in already developed areas, balanced with access to urban greenspace, can protect opportunities for the surrounding natural ecosystems to buffer changes to our climate.

The projected increase in cooling degree days by mid-century will require that most buildings have some form of active cooling to maintain thermal comfort and prevent overheating. Certain units, such as older, multi-unit residences, often lack air conditioning and are not designed to handle hot temperatures, leaving occupants at greater risk of heat-related illnesses and mortality. The use of energy efficient technologies like heat pumps will play an important role in aligning with efforts to reduce GHG emissions while avoiding additional costs to residents. Authorities with jurisdiction over building codes should consider how to proactively integrate future climate considerations into the design of new and existing buildings.

Transportation

The region's transportation network includes many local and arterial corridors, three major highway corridors (Highways 1, 14 and 17), two provincial and two international ferry corridors, a regional transit network, international and harbour airports, cruise ship and ferry terminals, and many active and multi-use trails. Regional transportation priorities include full realization of a multi-modal transportation network to help shift away from private vehicles to public transport, walking and cycling. As a coastal community, the capital region is vulnerable to significant transportation disruptions that complicate responses to emergencies and extreme events, and can interrupt the local supply chain.

Impacts

The projected increase in heavy rainfall may intensify flooding across the region, potentially causing more frequent road closures, vehicle collisions and construction delays. Some communities, such as Sooke, have already seen recurrent road closures due to flooding and may be particularly vulnerable to heavy rainfall.[29] Extreme precipitation events may also impede the reliability of major transportation corridors. In November 2021, extreme rainfall and runoff from a landfalling atmospheric river caused extensive damage to the Malahat Highway (Highway 1), prompting its temporary closure. This disruption reverberated through the local supply chain, resulting in shortages of fuel and other essential goods and services across the region. Like flooding from heavy rainfall events, wildfires also pose risk to the closure of regional highways and roads. In the future, hotter temperatures and less rainfall occurring in the warmer months will increase fire danger. Wildfire damage along hillslopes near roadways may also heighten the risk of landslides during the subsequent rainy season.

> The effects of extreme weather on transportation may be particularly challenging for some equity-denied groups. Residents may find themselves unprepared to leave their homes, hindering their ability to access essential supplies and services.

By the 2050s, a shorter winter season characterized by less snowfall and fewer freezing days may lower the costs associated with snow removal and the repair of cracked roads from freeze-thaw cycles. However, equipment to manage severe winter conditions will need to be maintained as changes to the frequency of heavy snowfall events remains largely unknown because they are driven by "Arctic outflow" events from Northern BC.

Warming temperatures may enhance the appeal of active transportation (walking, cycling and transit use) during the colder months. Conversely, high temperatures, multi-day extreme heat events, and poor air quality from wildfires in nearby regions may deter residents from choosing active transportation methods in the summer and early fall. Active transportation routes may also be interrupted by heavy rainfall, which can cause localized flooding and erosion along trails and pathways.

To safeguard transportation across the region, projected changes to temperature and precipitation should be considered in the design and retrofit of transportation infrastructure. These changes should also be considered against the backdrop of other existing weather hazards that will continue to affect the region (e.g., windstorms). Efforts to reduce GHG emissions across the region will rely on a resilient active transportation network. Strategies to support active transportation may involve installing adequate cooling infrastructure (i.e., trees, benches, shade structures, misting stations and water fountains) and supporting nature's capacity to buffer climate impacts through stewardship and community engagement.

[29] Chek News. 2021. Heavy flooding and road closures forces Sooke into temporary isolation.

Food and Agriculture

Food and agriculture are fundamental elements of the long-term sustainability, resilience and health and wellbeing of the capital region. In recent years, changes in climate, energy costs, water availability and agricultural production have drawn attention to the ongoing resilience of the region's food system. Ensuring a stable local food system requires management of changing wildlife populations, flooding and drainage concerns, water availability, as well as the amount of agricultural land in food crop production. The average age of farmers in the capital region remains higher than the Canadian average and represents a warning sign for the future of food production in the region.[30]

Impacts

Increasing year-round temperatures will lead to fewer frost days, an earlier start to spring, and extended summer-like weather into the fall. These changes will result in a longer and warmer growing season that could enhance agricultural productivity in the region. However, climate change is also expected to introduce greater uncertainty for growers, as temperatures become hotter in the warmer months and precipitation patterns change. The projected increase in growing season length by 2050 (estimated to be roughly 17%) should be considered an upper limit for estimates of future productivity. This measure uses only a lower temperature threshold and does not account for reduced summer precipitation, which increases the risk of drought. In addition, shifting seasonal conditions from warming temperatures may cause pollinating species to emerge at misaligned times, limiting potential crop yields.

During the growing season, reduced water availability and extended dry periods leading to drought could have significant impacts on agriculture in the region. Less total rainfall in the summer will reduce water levels in ponds, wetlands and streams used for irrigation, while hotter temperatures will promote further evaporation and evapotranspiration. These conditions can increase heat stress and sun scald, competition for water resources, and may create opportunities for invasive species, pests, and plant diseases to flourish. Increased demand for irrigation strains water supply systems with competing demands, and negatively impacts ecosystems in water bodies, wetlands, and streams. Addressing these challenges will require innovative strategies that improve the efficiency of agricultural irrigation and transition to crops requiring less water. Growers may need to consider alternative soil-management approaches, as changes to soil moisture and composition may accompany the projected changes to the region.

In the fall, heavy rainfall events may impact crop harvest by increasing the risk of flooding and creating more opportunities for diseases and pests. Extreme precipitation can also lead to more runoff onto and off agricultural land, leading to erosion, soil nutrient leaching, and crop loss and damage. For low-lying agricultural areas near the coast, these impacts may be compounded by high tides, storm damage, and saltwater intrusion from rising sea levels.

[30] Capital Regional District. 2018. Regional Growth Strategy.

Recreation and Tourism

With its mild climate, beautiful coastlines, and abundant ecosystems, the capital region continues to be a sought-after destination for visitors from across the globe and tourism remains a key local industry. Tourism is an estimated $1.9 billion dollar industry in Greater Victoria with more than three million visitors to the region annually.[31] The region boasts plenty of outdoor recreation, with more than 26,000 hectares of national, provincial, regional, and municipal parks and ecological reserves and four regional trails on southern Vancouver Island and the Gulf Islands.[32] In 2021, regional trails received over 3.7 million visits and regional parks received over 5 million visits from local residents and tourists. These areas contribute to the cultural, social, and economic vitality of the region.

Impacts

By the 2050s, warmer year-round temperatures could lead to a longer season for summer recreation, providing more opportunities for outdoor activities and potentially boosting economic productivity. However, the rise in the number of hot summer days and multi-day extreme heat events may encourage more people to seek relief near lakes and coastlines, which can place additional stress on freshwater, marine and shoreline ecosystems. Careful protection and monitoring of recreational sites will be important to ensuring ecological health in areas where visitor use may increase.

The projected changes in temperature and precipitation may also influence the access and safety of recreation and tourism across the region. Less summer rainfall and longer dry spells may result in longer and more frequent campfire bans. Increasing fire danger may also result in the closure of parks and campgrounds due to wildfire risk. During the wet season, heavier rainfall may impact trail access and safety, and increase the costs associated with the maintenance of recreational infrastructure. At all times of the year, the potential increase in algal blooms may pose challenges to recreational water users, fishing, and tourism. Ensuring climate-resilient design of new and existing infrastructure and supporting ecosystem health and integrity through a changing climate can benefit both the economy and the physical, mental, and spiritual health of people across the region.

[31] Greater Victoria Chamber of Commerce. Destination Greater Victoria. https://www.tourismvictoria.com/

[32] Capital Regional District. 2023. Regional Parks and Trails Strategic Plan.

Summary and Recommendations

This report uses the most up-to-date climate model projections to examine how climate change may unfold across the capital region in the coming decades. The region can expect an increase in daytime and nighttime temperatures throughout the year. In the summer months, this implies hotter daily highs, warmer nights, and more numerous and longer multi-day heatwaves. By the 2050s, winters will become milder overall with a steep reduction in frost days and snowfall.

The capital region can expect a modest increase in annual precipitation by the 2050s that will be distributed unevenly across the seasons. Whereas rainfall is projected to increase notably in the colder months, summers will become drier. Warmer cold season temperatures will result in less snowfall and increased rainfall, especially in winter. In the warmer months, longer dry spells are expected due to the combination of less rainfall and warmer temperatures. The magnitude and character of these changes will vary locally across the region.

Early action on climate adaptation will enable the region to best prepare for the changes ahead and increase climate resilience. The information provided in this chapter is intended to guide further discussion among decision makers and community partners across the region. Importantly, adaptation can take many forms depending on the unique context of each community. The regional impacts outlined in this report should be considered a starting point for further analysis of climate impacts and adaptation planning that engages relevant stakeholders and is tailored to the local context.

The CRD will continue to use these projections to incorporate climate change adaptation into planning cycles and ongoing activities. Adaptation planning is complex and requires consideration of multiple factors and compounding drivers. As such, continued data collection and monitoring will be important to establish baselines, monitor changes and ensure that adaptation actions are appropriate to the local context. Some examples of how the future climate projections provided in this assessment can be used to support climate adaptation include:

- Raising awareness about how climate change will impact the region
- Informing strategic and long-range planning
- Informing strategic planning for emergency responses to extreme events
- Conducting vulnerability and risk assessments to inform policy, planning, research, and monitoring
- Designing infrastructure that considers the future climate

This report highlights regional projections for the 2050s under a high emissions scenario, but alternative scenarios were also considered for this project. The complete data package includes information for low, moderate, and high emissions scenarios for the 2030s, 2050s and 2080s. It also includes separate assessments for four smaller sub-regions within the capital region. The report Appendices point to further online resources and general guidance for understanding and using climate projections.

Appendix A

BACKGROUNDER ON FUTURE CLIMATE DATA

The Earth's climate is changing due to the burning of fossil fuels, which emit greenhouse gases (GHGs) and aerosols into the atmosphere. Over the past century, these emissions have raised atmospheric GHG concentrations well above preindustrial levels, which has led to widespread warming over Earth's surface.

The global average temperature has increased by over 1°C to date, and Canada is warming even faster (Figure A1). This warming has resulted in widespread impacts in Canada and across the globe, and it is directly proportional to the total amount of GHGs emitted since the beginning of the industrial era. While a 1°C temperature change at your location may not feel like much, changes of only 1 or 2°C on a global scale are very substantial because they are averaged over the globe and a long period of time.

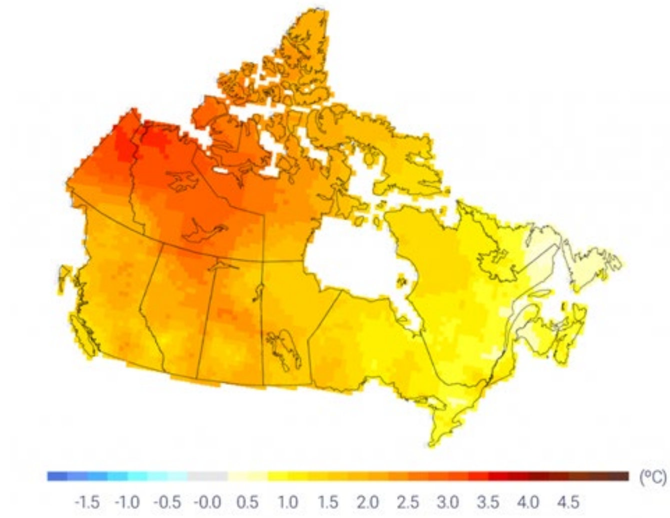


Figure A1. *Warming in Canada between 1948-2018.*

Understanding Weather, Climate, Natural Variability and Climate Change

To understand climate change, it is important to distinguish between weather and climate, and the natural and human influences that affect the climate on different time scales:

- Weather is what we experience when we step outside. It consists of short-term (minutes to days) variations in the atmosphere.
- Climate is the general state of weather, including its extremes, over periods ranging from months to many years. Climate can be thought of as the statistics of weather. Descriptions of normal climate conditions at a particular location are often derived from nearby weather observations and collected over long time periods – typically 30 years or more.
- Natural climate variability causes fluctuations in climate conditions that can span a few months to a few decades or longer. Natural climate variability is not influenced by human activity, but its influence can either mask or enhance human-induced climate change for the periods over which it occurs. Natural climate variability can also affect seasonal weather (e.g., El Niño/La Niña cycles).
- Climate change refers to changes in the state of the climate that persist over an extended period. Both natural processes and human influence can result in changes in climate. Climate science indicates that human influence is the unequivocal cause of the global warming that has been observed since the beginning of the 20th century.

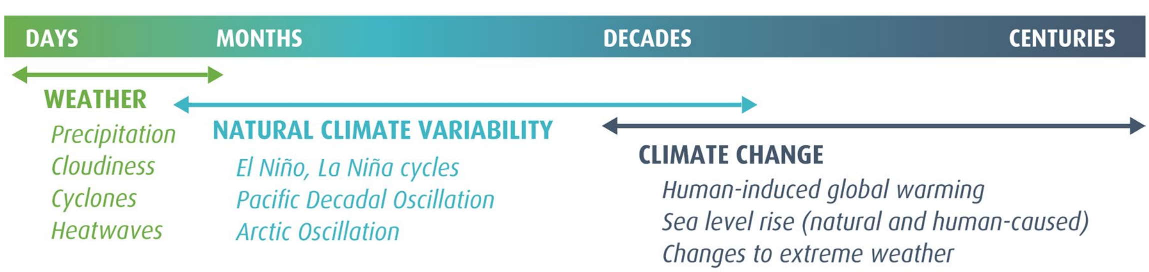


Figure A2. *Timescales for weather, climate, natural climate variability, and climate change.*

What is Future Climate Data?

In the context of a changing climate, historical climate observations are no longer suitable for assessing future climate-related risks. As a result, engineers, planners, and decision-makers are increasingly using future climate data to estimate the growing risks associated with climate change. Practitioners and decision-makers want to know how much climate change (and risk associated with that change) they can expect to encounter over the coming decades.

The extent of further warming depends on how global emissions change in the future. Unfortunately, it is impossible to predict the exact societal conditions of the future that will directly influence global emissions. Therefore, a range of potential futures, or scenarios, can be used to plan for the changes associated with rising global temperatures. These scenarios are based on assumptions about population growth, climate policy, land use changes, energy intensity, economic activity, and more, that lead to different levels of global GHG emissions. The scenarios used in this assessment are known as Shared Socio-economic Pathways, or SSPs for short – but more on that later.

To understand the future climate, scientists develop global climate models (GCMs) to simulate Earth's future climate in detail under each of the various scenarios. GCMs are extensively tested against historical observations and compared to one another. Through the Coupled Model Intercomparison Project (CMIP), we can construct an ensemble of different GCMs that describes a range of plausible climate futures. In Figure A2 below, each red line represents an individual GCM projection, developed by research groups from around the world. The solid black line in this case represents the ensemble median, with the lower and upper dotted lines showing the 10th to 90th percentile range of the model ensemble.

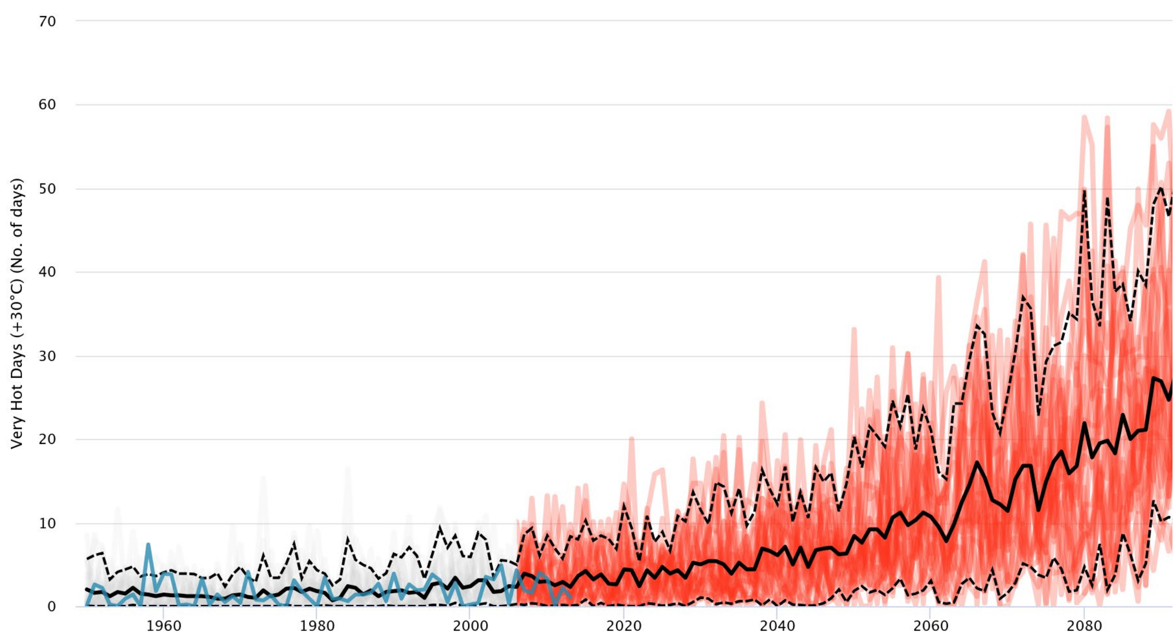


Figure A3. *Example of a GCM ensemble.[1] Each red line represents a single GCM projection for the number of annual days with a maximum temperature exceeding 30°C in British Columbia. The solid black line is the median and the dotted lines are the 10th (lower range) and 90th (upper range) percentile values across all GCMs in the ensemble.*

[1] Retrieved from ClimateAtlas.ca, using modeled data from PCIC.

Understanding Shared Socio-Economic Pathways

As noted above, to project the future climate, GCMs need input about the amount of future industrial emissions. Shared socio-economic pathways (or SSPs, Figure A3a) are such inputs, providing emissions scenarios based on assumptions of various societal decisions, including:

1. How population, education, energy use, technology – and more – may change over the next century, and;
2. The level of ambition for mitigating climate change globally.

The SSPs used in CMIP6 simulations are a set of five main socioeconomic pathways (SSP1 through SSP5) that illustrate different ways in which global societies may develop. They are the successors to the previous emissions scenarios used in CMIP5 called Representative Concentration Pathways, or RCPs. Figures A4a and A4b illustrate projections for GHG emissions and temperature under various SSPs. Here, it is important to note that global temperature projections for the near future are similar across different SSPs. The projections begin to diverge more meaningfully around 2050 (Figure A4b).

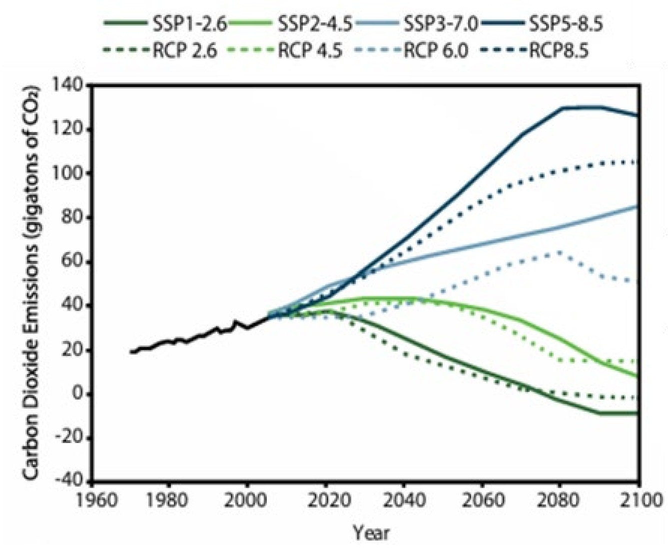


Figure A4a. *SSP scenarios used by CMIP6 models for global CO2 emissions by the end of this century. The scenarios used for CMIP5 (RCPs) are also shown.*

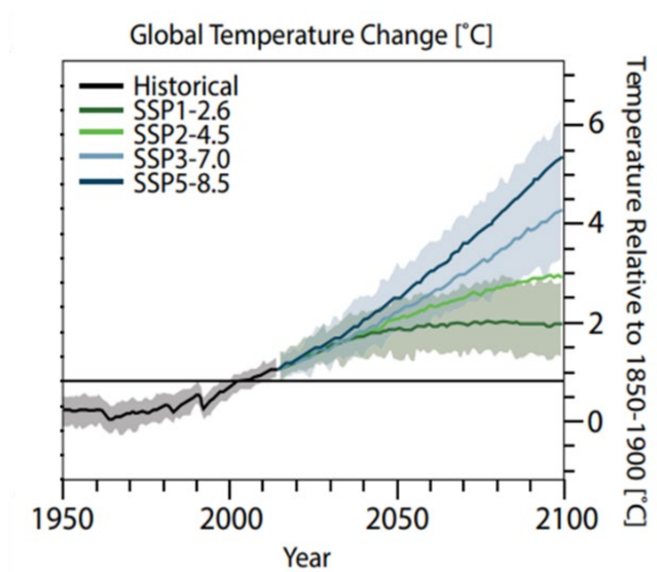


Figure A4b. *Historical and future temperature change from 1950-2100, relative to 1850-1900. After 2014, models are driven by the SSP scenarios indicated, with ranges shown for SSP1-2.6 and SSP3-7.0. The horizontal line shows temperature change that has occurred up to 1995-2014 (about +0.85°C).*

Future Climate Uncertainty

While we know the future climate will be different from the climate of the past, we cannot precisely predict what the future climate will look like. There are three main sources of uncertainty inherent in future climate data: natural climate variability, model uncertainty, and scenario uncertainty. In the following sections, we provide support for making decisions in the presence of scenario uncertainty.

- **Natural climate variability** (as discussed above) refers to climatic fluctuations that occur without any human influence (i.e., independent of GHG emissions). Natural climate variability is largely unpredictable and can mask or enhance human-induced climate change.
- **Model uncertainty** arises because models can only represent the climate and earth system to a certain degree. Although they are highly sophisticated tools, GCMs can differ from reality. Furthermore, not all models represent the system processes in the same way, nor do all include the same processes. To help address model uncertainty, it is best practice to use an ensemble (i.e., a set of multiple GCMs), to display a range of possible futures. PCIC uses an ensemble of 9 GCMs that are best suited to analyses focused on British Columbia.
- **Scenario uncertainty** arises because different emissions scenarios lead to different levels of climate response, and it is not possible to know what global emissions will be in the future. The emissions pathway of the future depends on a wide range of policy decisions and socioeconomic factors that are impossible to predict. To help address scenario uncertainty, it is best to evaluate future projections under more than one emissions pathway.

Uncertainty should not stand in the way of action. Decision makers should use climate projections as a guide to the future but should not discount the possibility of changes occurring outside the projected range when managing risk. In the following sections, we provide support for making decisions in the presence of scenario uncertainty.

Appendix B

WHAT DATA SHOULD I USE?

The decision tree shown in Figure B1 can help determine which data and information from this assessment might be most useful for a given application. Before using climate projections, it is important to do appropriate background reading, identify relevant stakeholders and determine the appropriate level of stakeholder engagement. Stakeholder engagement is important for ensuring that the projected changes are both meaningful and well-suited to your context.

Users accessing the complete data package should reference the Data Descriptor Document. Contact climateaction@crd.bc.ca for more information.

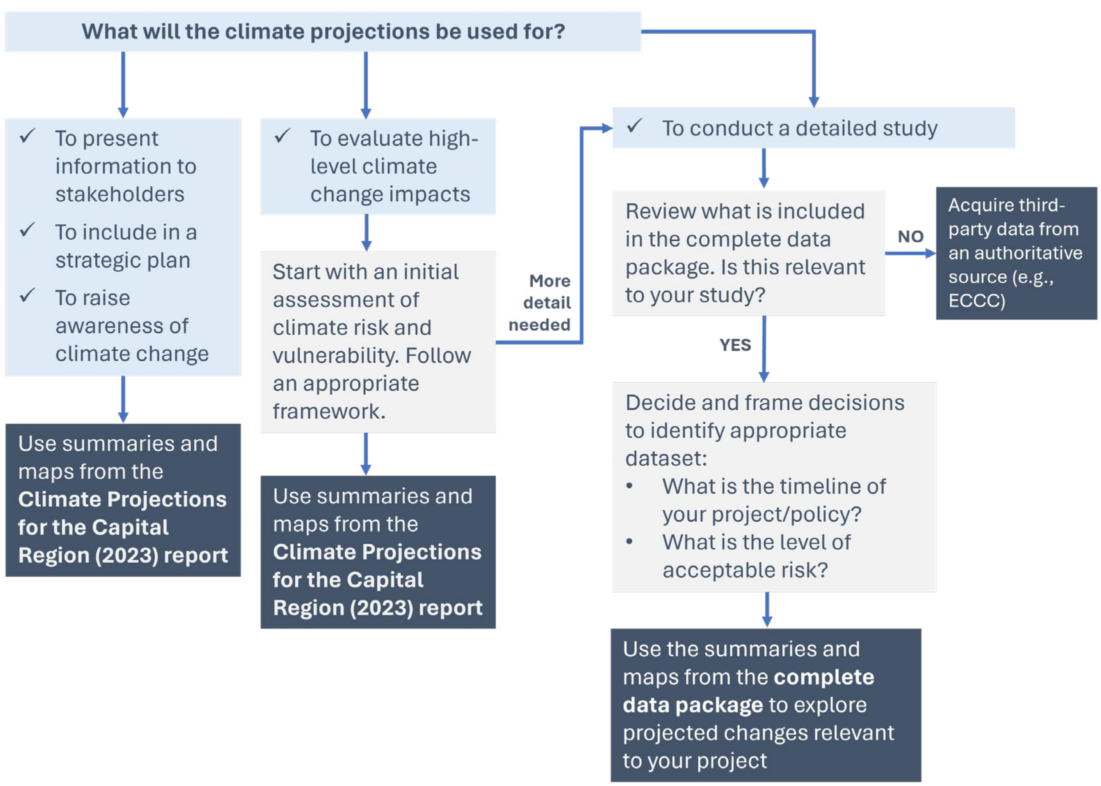


Figure B1. *Decision tree for using climate projections data. This decision tree has been adapted from the Victoria (Australia) Climate Projections 2019 Technical Report (Clarke et al., 2019).*

What is Provided in the Complete Data Package?

The Climate Projections for the Capital Region 2023 report highlights projected changes for a host of indices derived from temperature and precipitation under the highest emissions scenario (SSP5-8.5), mostly for the 2050s. The complete data package contains summary tables (Excel XLSX) and maps (PNG) for the following additional time periods, scenarios and sub-regional breakdowns:

The capital region and four smaller sub-regions.

(see Figure B2 below)

- “Core/Peninsula” (Green)
- “Western Region” (Red)
- “Southern Gulf Islands” (Yellow) and
- “Greater Victoria Water Supply Region” (Blue)

Four time periods.

- 1981-2010 or “1990s” (baseline period)
- 2021-2050 or “2030s”
- 2041-2070 or “2050s”, and
- 2071-2100 or “2080s”,

Three emissions scenarios.

- Low: SSP1-2.6
- Moderate: SSP2-4.5, and
- High: SSP5-8.5.

77 indices derived from temperature and precipitation. *(see Appendix F for a complete list)*

Gridded data (NetCDF) is also available for all 77 climate indices projected to the 2050s under a high emissions scenario (SSP5-8.5). Contact climateaction@crd.bc.ca to access the complete data package and/or the gridded data.

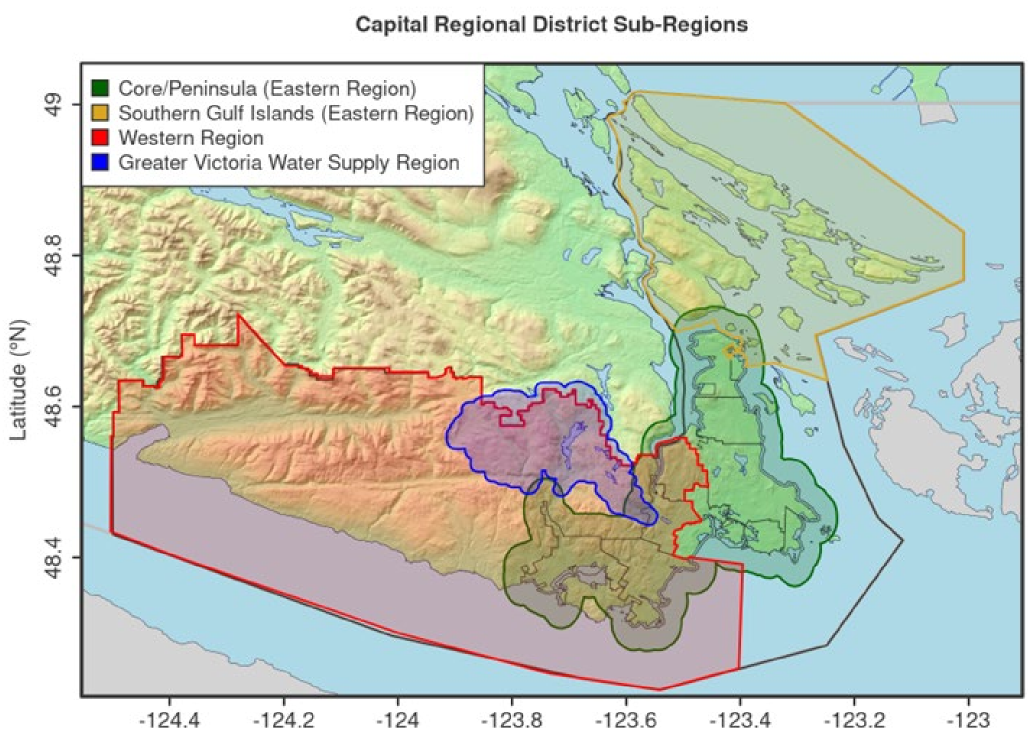


***Figure B2**. The capital region and four sub-regions. Separate Excel files are available for each sub-region and for the region as a whole.*

Appendix C

GUIDANCE FOR USING CLIMATE PROJECTIONS

Key Messages

- ✓ Projections of future climate are complex, and you will likely need advice and guidance from experts in the field. Allow adequate time for consultation.
- ✓ The climate has always been naturally variable. This variability now occurs on top of greenhouse-gas/aerosol forced trends. Over shorter time scales, climate variability can mask long-term trends.
- ✓ Since we do not know what future global emissions will be, climate projections are produced for a number of possible scenarios. In the CMIP6 ensemble, near-term projections are similar and diverge more clearly by the middle of this century (e.g., the 2050s).
- ✓ This assessment provides downscaled climate projections for variables derived from temperature and precipitation only. Variables related to other climate-related hazards, such as sea level rise or windstorms, are not provided. For supplemental resources, see Appendix D: Further Resources
- ✓ While climate models are run under different emissions scenarios, there is no such thing as a 'most likely' scenario. Selecting an emissions scenario is highly context-dependent and will depend on considerations such as risk tolerance and the life cycle of your project or policy.
- ✓ Consider multiple climate variables or indices to get a more complete picture for different manifestations of change. Review annual and seasonal projections to get a sense of how projections vary depending on the time of year.
- ✓ In many cases, using only the median climate projections will not be appropriate. Ensure the ranges of projected change (10th and 90th percentiles) are adequately accounted for in your assessment. Do not entirely discount changes above or below the projected range when managing risk – especially for high-impact, low-likelihood events.

Understanding Climate Risk

As shown in Figure C1, climate risk depends on the complex interaction between hazards affected by climate change and natural climate variability, exposure to these hazards, and the vulnerability of the exposed elements. For example, a hazard (e.g., extreme heat) may impact a community more due to its exposure (e.g., occurring in a densely populated area) and/or vulnerability (e.g., demographic factors influencing heat sensitivity).

While future climate data can support the assessment of hazards affected by future climate change, there are different approaches to understanding climate risk. Decision-making about climate risk often involves a combination of top-down and bottom-up approaches.

Top-down approaches start with an analysis of potential climate change that can be used to guide actions and decisions.

Bottom-up approaches start with the project, policy or activity of interest and analyze the factors and conditions that impact the exposure, vulnerability and resilience of systems. These approaches look for pathways to reduce exposure and vulnerability while increasing the capacity to cope (irrespective of the future climate hazard).

Hence, **future climate data can be used to inform a top-down approach** to assessing climate risk.

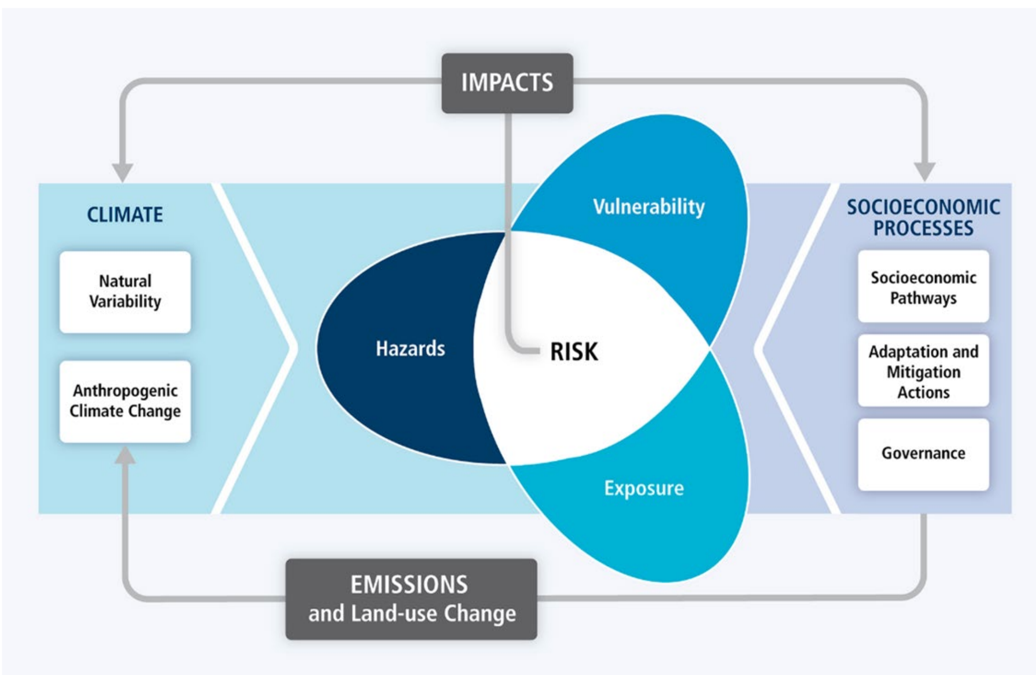


Figure C1. *Climate risk envisioned as the overlap of hazard, exposure, and vulnerability.*[2]

[2]IPCC, 2014: Summary for policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1-32.

Which Emissions Scenario(s) Should I Use?

Climate projections are generated by different climate models and using a range of emissions scenarios. Differences in the projections due to the use of different climate models reflect the fact that we still have an incomplete understanding of how the climate system functions, and differences due to the choice of emissions scenarios reflect the fact that we have only imperfect knowledge of how society, its land use practices, and its emissions may change in the future. Given these diverse sources of uncertainty, it is best to examine a range of possible futures as represented by different climate models and emissions scenarios.

To reduce climate model uncertainty, PCIC has selected a range of climate models that are best suited to regions in BC. Ultimately, deciding on which emissions scenario(s) to assess will depend on the context of your project or policy, including your risk tolerance and time horizon, as discussed next.

Time Horizon

Users of climate projections should consider the time horizon, or life cycle, relevant to their project or policy before selecting a future scenario. This could be the expected lifetime of a given piece of infrastructure, or a policy that needs to be responsive to changing external conditions. As highlighted above in Understanding Shared Socioeconomic Pathways, in the near term – up to a few decades into the future – climate projections do not differ meaningfully across SSP scenarios. This is true at both the global regional scales. Hence, if there is a recurring opportunity to review a given decision every two to three decades, then the choice of emissions scenario may be less relevant. An example of a recurring decision might be the choice of paving material to use when repaving a roadway.

On the other hand, if an infrastructure element is expected to last 50 to 75 years, the choice of scenario becomes more critical because projected changes from different scenarios will differ substantially by the end-of-life of the structure. An example of a long-term infrastructure design decision might be determining the capacity of an upgraded storm sewer. Hence, planners and designers may be able to minimize the role of scenario uncertainty in adaptation planning by first determining the decision-making time-frame.

Level of Acceptable Risk

Climate scientists can help practitioners and decision makers understand how climate-related hazards that affect the assets they are responsible for (i.e., systems, infrastructure, or policy) may change in the future. This requires dialog among practitioners, decision makers and climate scientists to understand and describe the potential impacts of projected climate change under different emissions scenarios. Because climate scientists are not experts on how risk to assets will materialize, it remains the responsibility of practitioners and decision makers to manage future climate-related risks to their assets.

When assessing future scenarios, decision makers should consider four questions:

1. "What components of my project are vulnerable to climate change?"
2. "How likely is it that society will follow a future emissions pathway that will intensity the hazards to which my assets will be exposed?"
3. "What level of risk am I comfortable assuming?"
4. "What is the trade-off between risk and cost?"

Regardless of the rationale used, understanding the level of risk that is appropriate to your work is complex. It will undoubtedly require engagement with diverse partners and stakeholder groups to understand the range of potential impacts.

Scenario Choice

Ideally, public assets should be managed in a way that limits their vulnerability to plausible future hazards. Climate science has not yet ruled out the plausibility of any of the main socio-economic pathway scenarios that were considered in the most recent IPCC assessment. The choice of scenario will depend critically on the climate hazards that would affect the asset of interest. This is because some hazards will likely decline, such as extreme snow loads on buildings that could cause building collapse, while others, related to heat stress, intense rainfall, and flash flooding, will increase. If an asset is affected by both decreasing and increasing hazards, then the approach that would most completely limit vulnerability to future hazards would involve using a no change (historical climate) scenario for declining hazards, and a rapid change, high emissions scenario (e.g., SSP5-8.5) for increasing hazards.

Tips for Using Climate Data

✓ View multiple variables (indices) within each category

To get a more complete understanding of projected changes, users should consider multiple climate variables. For example, if you want to know how precipitation will change in your region, review both a frequency-based variable (e.g., Number of Wet Days > 20 mm) and a volume-based variable (e.g., Total Precipitation). The Hazard Reference Tables (Appendix E) can help users identify which climate variables may be best suited to a particular context or application.

✓ Review both annual and seasonal data

Annual mean changes can mask important seasonal behaviour. For example, a small annual mean precipitation projection might contain a substantial reduction in the summer along with a projected increase in the fall, winter, or spring. Therefore, users should assess both annual and seasonal projections for certain climate variables.

✓ Select a relevant time period

The complete data package offers projections for the "2030s" (2021-2050), "2050s" (2041-2070) and "2080s" (2071-2100). As highlighted above, users should select the period that is most appropriate to the entire life cycle of their project or policy.

✓ Determine an appropriate emissions scenario(s)

There is no right or wrong emissions scenario to use in decision-making: all scenarios represent possible futures and decision-making is highly context dependent. Selecting a scenario requires consideration of risk tolerance, sensitivity to climate impacts and extreme events, the time horizon of the project, and more. It can be useful to remember that planning for a high emissions scenario can help ensure that adaptation measures are resilient for a longer period of time if, in fact, a lower emissions scenario were to play out.

✓ Examine both means and extremes

The median, 10th percentile, and 90th percentile values have been provided in all summary tables for this assessment. Depending on the application, one, two or all three of these values may be important. For instance, if one were designing a building for general use (e.g., retail space, detached home) with an anticipate lifetime of 50 years or so, then the change in the median of Cooling Degree Days (CDDcool18C) under SSP5-8.5 might be appropriate to consider. Alternatively, if the building were classified as critical, long-lived infrastructure (e.g., a hospital, or power plant) then it might be more appropriate to design to the 90th percentile value for that climate index, to capture the upper range of possibility.

Appendix D

FURTHER RESOURCES

There are a growing number of guidance materials, learning resources, and data tools available to support the use of climate projections for regional assessments. Below is a non-exhaustive list of open access resources suited to a broad range of users. For additional guidance, contact PCIC (climate@uvic.ca) or the CRD Climate Action Program (climateaction@crd.bc.ca).

Additional Climate Projections Tools and Resources

ClimateData.ca

User-friendly tool for exploring climate projections and related data

Developed and maintained by the Canadian Centre for Climate Services, a team of information and outreach specialists at Environment and Climate Change Canada (ECCC), ClimateData.ca is an online, user-friendly data portal providing future climate projections for regions across Canada. Users can explore gridded data at small scales or aggregated by watershed, census subdivision, or health region. ClimateData.ca provides plain language descriptions for all climate variables and has various options for visualizing and analyzing climate data. Temperature and precipitation-based variables (the same as those provided by PCIC) as well as humidex, relative sea level change and climate change-scaled IDF data are available.

ClimateData.ca also includes a comprehensive learning zone (climatedata.ca/learn) that is regularly updated to support climate data users in a variety of applications, including some sector-specific information, as well as a Climate Services Support Desk for general or technical inquiries. The site is continuously evolving with more content and features in development.

PCIC Climate Explorer

Useful for intermediate or advanced users analyzing a specific location

PCIC Climate Explorer (PCEX) is an online map-based tool for viewing gridded historical climate data and future projections at any location of interest across Canada. Users can select an arbitrary region on the map, compare climate variables for that region, and download the results in Excel formats. Additional variables for extreme precipitation and streamflow are also available.

ClimateAtlas.ca

Useful for creating communications materials and learning more about climate adaptation

ClimateAtlas.ca is an interactive tool combining climate projections (again using PCIC's data), mapping, and storytelling to inspire local, regional, and national action and solutions. Users can explore videos, articles, educator resources, and various topic including Indigenous knowledges, agriculture, and health.

Spatial Analogues Tool* (ClimateData.ca)

Useful for visualizing the future climate at a target location

With this tool, starting with a target city of interest**, users can search for other cities whose historical climate closely matches the future-projected climate of the target city. Users can search for spatial analogues under a low or high emissions scenario and considering up to four different climate indices. For example, one combination of indices suggests that by the 2050s, Quebec City may have a climate similar to present-day Boston. By examining how Boston has adapted to its current climate, planners in Quebec City might gain insights on how to prepare and adapt to climate change.

*This tool is a beta app, meaning it is a new tool being carefully monitored and is still under development.

**Target cities for British Columbia are presently limited to: Victoria, Vancouver, Abbotsford, Kelowna, and Prince George.

Infrastructure Design Resources

PCIC Design Value Explorer (DVE)

Engineering design professionals can access future-projected climatic design values

The DVE is an online, open-access technical tool for assessing 19 climate design values based on observed data and projections of how they may change in the future. It provides engineers, architects, planners, and other professionals with quantitative, fine-scale historical and future-projected climate information for designing buildings and infrastructure.

PCIC Future-Shifted Weather Files

Energy Modelers can access future-projected weather files

Weather data adjusted for climate change has been produced for three time periods (2020s, 2050s, and 2080s) using the high emissions pathway RCP8.5 (CMIP5). Data are available for several hundred weather stations across Canada. Future-shifted weather files can help building designers simulate building performance under a changing climate, supporting resilient design. Further work is underway to update the weather files for CMIP6-SSPs and to create weather files that capture both mean change and extreme events.

CSA PLUS 4013-19: Development, interpretation, and use of rainfall intensity-duration-frequency (IDF) information: Guideline for Canadian water resource practitioners*

Guidance for Canadian water resource practitioners to better incorporate climate change into IDF information

Technical guidance from the Canadian Standards Association (CSA)—informed by scientists at ECCC and other subject matter experts—for the development, interpretation, and use of rainfall intensity-duration-frequency (IDF) information. Chapters 5 and 6 include guidance for how to incorporate climate change into the formulation and application of IDF information.

*Access fee required

Short-Duration Rainfall IDF Data (ClimateData.ca)

Users can explore historical and climate change-scaled IDF information for weather stations across Canada

ClimateData.ca offers easy access to historical short-duration rainfall IDF data (from 1 to 24 hours) and projected rainfall amounts under low, moderate, and high emissions scenarios at locations across Canada (12 locations within the capital region). This IDF information is consistent with the above-mentioned CSA guidance. Users can download a zip file containing all the historical and future estimated values.

In addition, the Learning Zone on ClimateData.ca has a topic dedicated to using IDF rainfall data to account for a changing climate. For more information on this product and about designing future-ready buildings, visit ClimateData.ca/learn/

Appendix E

HAZARD REFERENCE TABLES

The Hazard Reference Tables help users identify which climate variables included in the complete data package may be best suited to a particular context or application. Users should use the short name (left column) to navigate to the appropriate variable in the complete data package.

Seasonal Patterns and Climate Change

- ✓ Increasing temperatures year-round
- ✓ Fewer frost days and a longer growing season
- ✓ Shifting heating and cooling demands

Key sectors: Agriculture, Biodiversity, Parks, Infrastructure

Temperature	
TX	Daytime high temperature, averaged over all days in a year or season
TM	Mean daily temperature, averaged over all days in a year or season
TN	Daytime low temperature, averaged over all days in a year or season
Seasonal	
FD Frost Days	Number of days in a year when the minimum temperature is below 0°C
ID Ice Days	Number of days in a year when the maximum temperature is below 0°C
GSL Growing Season Length	Number of days between: (i) the first span of 6 or more days in the year with a daily minimum temperature > 5°C and (ii) the first span after July 1st of 6 or more days with a daily minimum temperature < 5°C.
WSDI Warm Spells	A "warm spell" is defined as 6 or more consecutive days when the daily maximum temperature exceeds the 90th percentile value of the historical baseline. This index measures the number of days in a typical year that a warm spell occurs. (A warm spell can occur at any time of year).
CSDI Cold Spells	A "cold spell" is defined as 6 or more consecutive days when the daily minimum temperature is less than the 10th percentile value of the historical baseline. This index measures the number of days in a typical year that a cold spell occurs. (A cold spell can occur at any time of year).
Design	
HDDheat18C Heating Degree Days	Number of degree days below 18°C in a year. A rough estimate for the energy demand needed to heat a building in a typical year.
CDDcold18C Cooling Degree Days	Number of degree days above 18°C in a year. A rough estimate for the energy demand needed to cool a building in a typical year.

Increasing Temperatures and Extreme Heat

- ✓ Hotter daytime temperatures
- ✓ Warmer nighttime temperatures
- ✓ Heat waves becoming hotter and more frequent

Key sectors: Emergency Management, Health, Biodiversity, Watershed

Daytime Temperatures	
TX	Daytime high temperature, averaged over all days in a year or season
TXx	Hottest daytime high temperature in a year or season
SU Summer Days	Number of days in a typical year when the daytime high is above 25°C
SU30 Hot Summer Days	Number of days in a typical year when the daytime high is above 30°C
Nighttime Temperatures	
TN	Daily minimum temperature in a typical year or season
TNx	Warmest nighttime low temperature in a typical year or season
TR16C Temperate Nights	Number of days in a year when the nighttime low stays above 16°C
TR Tropical Nights	Number of days in a year when the nighttime low stays above 20°C
Heat Extremes	
HWD Heat Wave Days	Number of days in a typical year classified as a "heat wave"
HWN Heatwave Number	Number of distinct heat wave events in a typical year
HWXL Heatwave Length	Length (in days) of the longest heat wave in a typical year
TXH Heatwave Intensity (Day)	Daytime high temperature averaged across all heat waves in a typical year
TNH Heatwave Intensity (Night)	Nighttime low temperature averaged across all heat waves in a typical year
TXHX	Daytime high temperature during the most extreme heat wave in a year
TNHX	Nighttime low temperature during the most extreme heat wave in a year
Return Periods (various)	The data package provides return levels and return period changes for the 5-, 10-, 20-, and 30-year Hottest Day.

Extreme Precipitation and Flooding

In this data package, there are no direct indices for flooding.
Rainfall extremes may trigger flooding under certain circumstances.

- ✓ More precipitation occurring over short time periods
- ✓ More days with heavy rainfall

Key sectors: Public Works/Engineering, Infrastructure, Biodiversity, Health, Agriculture, Watershed

Precipitation	
PR Total Precipitation	Total precipitation in a typical year or season
Rain Total Rainfall	Total rainfall in a typical year or season
Snow Summer Days	Total snowfall in a typical year or season
Rainfall Extremes	
RX1DAY	Maximum amount of precipitation (in mm) occurring in a single day in a typical year
RX5DAY	Maximum amount of precipitation (in mm) occurring over a 5-day period in a typical year
R10MM	Number of days in a typical year that receive more than 10mm of total precipitation
R20MM	Number of days in a typical year that receive more than 20mm of total precipitation
R95P / R95DAYS	Amount of precipitation over the year that exceeds the 95th percentile of historical (baseline) daily precipitation / Number of days in a typical year that exceed this amount.
R99P / R99DAYS	Amount of precipitation over the year that exceeds the 99th percentile of historical (baseline) daily precipitation / Number of days in a typical year that exceed this amount.
Return Periods (Various)	The data package provides 5-, 10-, 20-, 30-, and 50-year return periods for annual wettest 1-, 2-, and 5-day rainfall events. It also provides changes to rainfall return periods for an event of given magnitude.

Drought

In this data package, there are no direct drought variables. Hotter temperatures, less rainfall and reduced snowpack may lead to drought conditions in the warmer months.

Key sectors: Agriculture, Biodiversity, Health, Watershed

Precipitation	
PR – Summer Total Precipitation in Summer	Total precipitation in a typical summer (may also be important to consider PR for spring and fall)
SNOW Total Snowfall	Total snowfall (fall-winter-spring)
CDD Consecutive Dry Days	Number of days comprising the longest “dry spell” in a typical year. Dry spells are defined as consecutive days with less than 1mm of total precipitation.
Temperature	
TX	Daytime high temperature in a typical year or season
TXx	Hottest daytime high temperature in a typical year or season
SU Summer Days	Number of days in a typical year when the daytime high is above 25°C

Wildfire and Air Quality

In this data package, there are no direct wildfire variables. Hotter temperatures and less rainfall in the warmer months may lead to more favourable conditions for wildfire.

Key Sectors: Health, Biodiversity, Infrastructure, Agriculture

Variables listed under Drought (see above) can also be considered as informative for Wildfire. Additional variables such as humidity, wind speed, and wind direction must also be considered in order to establish favourable conditions for Wildfire. The Canadian Forest Service has analyzed such historical data to develop Fire Weather Normals, which provide insight into how “fire weather” varies spatially and throughout the year. See https://cwfis.cfs.nrcan.gc.ca/ha/fwnormals for more.

Future-projected temperature and precipitation conditions that may be favourable to increased incidence of Wildfire may be obtained from other regional climate projections reports in BC, including:

- Climate Projections for BC Northeast Region
- Climate Projections for the Okanagan Region
- Climate Projections for the Cowichan Valley Regional District
- Climate Projections for Metro Vancouver

Appendix F

COMPLETE LIST OF CLIMATE INDICES

Name	Variable	Definition	Units
		Standard	
PR	Precipitation	Annual/seasonal precipitation totals	mm
RAIN	Rainfall	Annual/seasonal rainfall portion of precipitation using temperature-based rain-snow partitioning	mm
SNOW	Snowfall	Annual/seasonal snowfall (snow water equivalent) portion of precipitation	mm (H2Oeq)
TM	Daily Average Temperature	Annual/seasonal daily average temperature	°C
TX	Daily Maximum Temperature	Annual/seasonal average daily maximum temperature	°C
TN	Daily Minimum Temperature (usually overnight)	Annual/seasonal average daily minimum temperature	°C

Name	Variable	Definition	Units
		CLIMDEX: Temperature Based	
TXX	Maximum TX	Annual/seasonal maximum of TX	°C
TNN	Minimum TN	Annual/seasonal minimum of TN	°C
TXN	Minimum TX	Annual/seasonal minimum of TX	°C
TNX	Maximum TN	Annual/seasonal maximum of TN	°C
TX90P	Hot Days	Annual percentage of days with TX > 90th historical percentile	%
TX10P	Cool Days	Annual percentage of days with TX < 10th historical percentile	%
TN90P	Warm Nights	Annual percentage of days with TN > 90th historical percentile	%
TN10P	Cold Nights	Annual percentage of days with TN < 10th historical percentile	%
DTR	Diurnal Temperature Range	Annual/seasonal diurnal temperature range, TX – TN	°C
SU	Summer Days	Annual number of days with TX > 25 °C	days
SU30	Hot Summer Days	Annual number of days with TX > 30 °C	days
TR	Tropical Nights	Annual number of days with TN > 20 °C	days
TR16C	Temperate Nights	Annual number of days with TN > 16 °C	days
ID	Ice Days	Annual number of days with TX < 0 °C	days
FD	Frost Days	Annual number of days with TN < 0 °C	days
CSDI	Cold Spells	Annual count of days with at least 6 consecutive days when TN < 10th historical percentile	days
WSDI	Warm Spells	Annual count of days with at least 6 consecutive days when TX > 90th historical percentile	days
GSL	Growing Season Length	Growing season length (number of days between first span of at least 6 days with TM >5°C and first span after July 1st of 6 days with TM <5°C)	days

Name	Variable	Definition	Units
		CLIMDEX: Precipitation-Based	
CDD	Consecutive Dry Days	Annual maximum length of consecutive dry days (PR < 1 mm)	days
CWD	Consecutive Wet Days	Annual maximum length of consecutive wet days (PR ≥ 1 mm)	days
SDII	Simple Daily Precipitation Intensity Index	Annual average PR on days with PR ≥ 1 mm	mm
R1MM	Precipitation ≥ 1 mm	Annual count of days with PR ≥ 1 mm	days
R10MM	Precipitation ≥ 10 mm	Annual count of days with PR ≥ 10 mm	days
R20MM	Precipitation ≥ 20 mm	Annual count of days with PR ≥ 20 mm	days
RX1DAY	Maximum 1-Day PR	Annual/seasonal maximum 1-day PR	mm
RX2DAY	Maximum 2-Day PR	Annual/seasonal maximum 2-day PR	mm
RX5DAY	Maximum 5-Day PR	Annual/seasonal maximum 5-day PR	mm
RN1DAY	Maximum 1-Day RAIN	Annual/seasonal maximum 1-day rainfall	mm
RN2DAY	Maximum 2-Day RAIN	Annual/seasonal maximum 2-day rainfall	mm
RN5DAY	Maximum 5-Day RAIN	Annual/seasonal maximum 5-day rainfall	mm
R95P	Very Wet Day PR	Annual total PR when PR > 95th percentile of daily PR in historical period	mm
R95DAYS	Very Wet Days	Annual number of days when PR > 95th percentile of daily PR in historical period	days
R99P	Extreme Wet Day PR	Annual total PR when PR > 99th percentile of daily PR in historical period	mm
R99DAYS	Extreme Wet Days	Annual number of days when PR > 99th percentile of daily PR in historical period	days
Name	Variable	Definition	Units
		Degree Days	
CDDcold18C	Cooling Degree Days	Annual, cumulative TM difference above 18 °C	°C-days
GDDgrow5C	Growing Degree Days	Annual, cumulative TM difference above 5 °C	°C-days
HDDheat18C	Heating Degree Days	Annual, cumulative TM difference below 18 °C	°C-days
FDDfreeze0C	Freezing Degree Days	Annual, cumulative TM difference below 0 °C	°C-days
Name	Variable	Definition	Units
		Heatwave Indices	
HWD	Heatwave (HW) days	Annual count of HW days, where a HW is defined as both TX and TN exceeding: 1) their 95th percentiles (historical), AND; 2) BC HARS thresholds[3] for at least 2 consecutive days.	days
HWN	HW number	Annual number of distinct HWs	#
HWXL	HW duration	Annual maximum HW length	days
TNH	HW intensity (night)	Average TN over all HWs in a year	°C
TXH	HW intensity (day)	Average TX over all HWs in a year	°C
TNHX	Maximum TNH	Average TN during most extreme HW in a year	°C
TXHX	Minimum TNH	Average TX during most extreme HW in a year	°C
HWDD	HW degree days	Annual, cumulative TM difference above HW threshold	°C-days

[3] The lower threshold temperatures used in our HW definition, which is intended for use throughout BC, are TX = 28°C and TN = 13°C. These are the lowest temperatures found in any region of the map in Figure 3, page 14 of the 2023 report, BC Provincial Heat Alert and Response System (BC HARS): 2023, May 2023. Available at: http://www.bccdc.ca/health-professionals/professional-resources/heat-event-response-planning.

Name	Variable	Definition	Units
		Return Levels	
TX_RP5	5-Year return level of TX	5-Year return level of TX	°C
TX_RP10	10-Year return level of TX	10-Year return level of TX	°C
TX_RP20	20-Year return level of TX	20-Year return level of TX	°C
TX_RP25	25-Year return level of TX	25-Year return level of TX	°C
TX_RP30	30-Year return level of TX	30-Year return level of TX	°C
TN_RP5	5-Year return level of TN	5-Year return level of TN	°C
TN_RP10	10-Year return level of TN	10-Year return level of TN	°C
TN_RP20	20-Year return level of TN	20-Year return level of TN	°C
TN_RP25	25-Year return level of TN	25-Year return level of TN	°C
TN_RP30	30-Year return level of TN	30-Year return level of TN	°C
RN1_RP5	5-Year return level of RN1DAY	5-Year return level of RN1DAY	mm
RN1_RP10	10-Year return level of RN1DAY	10-Year return level of RN1DAY	mm
RN1_RP20	20-Year return level of RN1DAY	20-Year return level of RN1DAY	mm
RN1_RP30	30-Year return level of RN1DAY	30-Year return level of RN1DAY	mm
RN1_RP50	50-Year return level of RN1DAY	50-Year return level of RN1DAY	mm
RN2_RP5	5-Year return level of RN2DAY	5-Year return level of RN2DAY	mm
RN2_RP10	10-Year return level of RN2DAY	10-Year return level of RN2DAY	mm
RN2_RP20	20-Year return level of RN2DAY	20-Year return level of RN2DAY	mm
RN2_RP30	30-Year return level of RN2DAY	30-Year return level of RN2DAY	mm
RN2_RP50	50-Year return level of RN2DAY	50-Year return level of RN2DAY	mm
RN5_RP5	5-Year return level of RN5DAY	5-Year return level of RN5DAY	mm
RN5_RP10	10-Year return level of RN5DAY	10-Year return level of RN5DAY	mm
RN5_RP20	20-Year return level of RN5DAY	20-Year return level of RN5DAY	mm
RN5_RP30	30-Year return level of RN5DAY	30-Year return level of RN5DAY	mm
RN5_RP50	50-Year return level of RN5DAY	50-Year return level of RN5DAY	mm