Climate Projections for the

COWICHAN VALLEY REGIONAL DISTRICT

CVRD

Acknowledgements

This work was developed as a collaboration between the CVRD and regional stakeholders, as represented in the Phase 1 Technical Committee. The Phase 1 Technical Committee met over six months to review climate projections for the region, discuss regional impacts of the projections, and identify recommendations for Phase 2 of this project. This report and process has also benefited from a variety of external partners including Lillian Zaremba with Metro Vancouver and Amanda Broad at the Capital Regional District. Together the work of our combined local governments will ensure we build on each other's successes.

Contributing authors to this report include Trevor Murdock and Stephen Sobie from the Pacific Climate Impacts Consortium (PCIC), who provided regional downscaled climate projections at locally relevant scales, Kate Miller from the Cowichan Valley Regional District, who acted as the project manager, and Gillian Aubie Vines from Pinna Sustainability, who served as the workshop facilitator and lead writer of this report.

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Executive Summary

Temperatures in the Cowichan Valley are warming. Global climate models project an increase in annual average temperature of almost 3°C in our region by the 2050s. While that may seem like a small change, it is comparable to the difference between the warmest and coldest years of the past. The purpose of this report is to quantify, with the most robust projections possible, the related climate impacts (including changes to climate extremes) associated with warming. This climate information will then inform regional risk assessment, decision-making, and planning in the Cowichan Valley region, with a goal of improving resilience to climate change. For this reason, this report focusses on the business-as-usual emissions scenario and the 2050s timeframe. By the end of the 21st century, projected warming and associated impacts are even larger. In addition, the amount of warming by that time depends more highly on the quantity of greenhouse gases emitted in the meantime.

Global climate models project an increase in annual average temperature of almost 3°C in our region by the 2050s.

NEW NORMAL COWICHAN

The Cowichan Valley Regional District (CVRD) is currently working on **New Normal Cowichan**: a multi-phased project to take action on climate change. This work involves 4 phases:

Phase 1: Climate Projections and Impacts Analysis

Phase 2: Vulnerability and Risk Assessments

Phase 3: Adaptation and Mitigation Strategy

Phase 4: Implementation of the Strategy

This report completes the Phase 1 climate projections and impacts analysis to support the next two phases of the planning process, by providing climate projections for the region that illustrate the dramatic changes we can expect in years to come. The projections for the Cowichan Valley are based on highest resolution information about future climate available for our region: daily climate model projections from Global Climate Models, statistically downscaled to 10 km resolution, and then elevation corrected using historical gridded climatology at 800 m resolution. This report also identifies high-level impacts for our region, and sets the stage for further exploration planning and prioritization in Phase 2. In addition to the projections presented here, ongoing work to project future sea level rise and increases to water levels are being completed and will be presented in a separate document.

Projections

As our climate warms, our region can expect more than a doubling in the number of summer days above 25°C, from an average of 16 days per year to 39 days per year. The 1-in-20 hottest temperature is projected to increase from 33°C to 37°C by the 2050s. This projected warming has implications for future water and cooling demands, and translates into changes that are important to our ecosystems, watersheds, and communities, including an overall 28% increase in the length of the growing season and a 49% increase in growing degree days regionally. Warmer winters mean the region will experience a 63% decrease in the number of frost days and heating demand will decrease overall, although both high and low temperature extremes are still possible in a less stable climate.

A modest 5% increase in annual precipitation is projected in our region by the 2050s. Projections indicate that fall will see the greatest increase in precipitation. This precipitation is expected during increasingly extreme events, with about 30% more precipitation on very wet days (95^{th} percentile wettest days indicator) and 65% more on extremely wet days (99^{th} percentile wettest days indicator). Despite the projected increased intensity of wet events, the amount of rain in summer is expected to decrease by 17%, and the duration of dry spells will be lengthened by about 20%, from 22 consecutive days to 26 days.

ROGER WILES

Most of the projected climate changes described in this report will be felt more or less uniformly throughout the region. Certain impacts, however, may differ substantially between low-lying developed areas (where the majority of the population is situated), the water supply areas, and the west coast. A sub-regional analysis has been undertaken for each of those areas to assist in local planning initiatives. Past precipitation values are generally wetter in the water supply watersheds and west coast watersheds, while past temperatures are generally warmer in the developed areas. This is important for temperature indicators like frost days, which illustrate that in the future, only the highest elevations in our region will experience temperatures below freezing. Outcomes from the sub-regional analysis also indicate the wettest areas in the mountains of the west coast will become even wetter, and warmer temperatures will cause more precipitation to fall as rain. April 1 snowpack depth is projected to decrease by 85% by the 2050s.

Regional Collaboration

Preparing for the changes ahead will require provincial and regional governments, local authorities, and agencies to work together in developing a local, regional, and bioregional approach. Emergency preparedness and management will be an increasingly important issue in the planning and delivery of services, programs, and infrastructure. The public will also need to be informed and supported through the range of changes.

Early Recommendations

The technical committee has offered the following early recommendations to be considered as the region continues to prepare and take action on climate change adaptation. Detailed analysis and structured recommendations will follow as a part of the overall adaptation planning exercise.

- Take a “no-regrets” approach when planning for adaptation, as the time for action is now.
- Utilize existing projections in all master planning processes.
- Establish stretch goals and visions in Regional Cowichan 2050 planning process to ensure that adaptation is not an automatic fallback position.
- Incorporate projections and impacts into all engineering and water security planning.
- Conduct additional analysis of drought-related indicators to more fully understand specific impacts to soil, water supply, and ecosystem health at the landscape level.
- Develop long-term community water security plans and update watershed strategies with climate projections to address future conflicts over water use.
- Develop an integrated hydrological monitoring and climate network.
- Identify and map areas affected by increased climate sensitivity (flooding, erosion, landslides) to assist in identifying specific risks.
- Conduct a regional, engineering-based analysis of infrastructure risks to inform asset management.
- Develop IDF curves that reflect climate projections for engineering decision making related to infrastructure.
- Incorporate APEG BC recommendations for additional tolerances above projections.
- Develop sea level rise land use management zones.
- Recognize the rural nature of the region and how this can affect the services provided.
- Work in partnerships with other levels of government to address infrastructure shortages/deficiencies.
- Conduct a full risk assessment of policy and infrastructure in partnership with other levels of government.
- Communicate long-term projections to the general community, stakeholders, and partners, along with other relevant projections concerning sea level rise and forestry http://www.genetics.forestry.ubc.ca/cfcg/BEM.html.

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Introduction

The impacts of climate change are becoming increasingly evident and are challenging all levels of government to develop more resilient communities. Ensuring our region is as prepared as possible is critical to maintaining community well-being, environmental health, and a vibrant local economy over the long term. The 2014–2018 Cowichan Valley Regional District (CVRD) Corporate Strategic Plan has set a mandate to understand our region's climate risks and to complete adaptation plans that strengthen resilience, reduce risks, and take advantage of potentially emerging opportunities.

The first step towards planning is understanding what changes are projected for our region and beginning to build relationships between the community and government to improve our ability to adapt to changes ahead. To support this, the Pacific Climate Impacts Consortium (PCIC) has worked with the CVRD and a multi-stakeholder team to produce high-resolution regional projections to understand how the climate in our region may change by the 2050s and 2080s. This report presents information on temperature, precipitation, and related extreme indicators that, taken together, tell a story of how our climate is expected to change over time. High-level comments on the possible impacts of these changes are also presented as a first step in working collaboratively as a region to understand and prepare for the changes ahead. New approaches to infrastructure, planning processes, and other regional management, require long timelines to change, and this report gives decision makers a clear sign that action is required today to adapt and mitigate further impacts.

The first step towards planning is understanding what changes are projected for our region.

This report offers a general description of our changing climate, followed by an expanded section on precipitation, summer temperatures, and winter temperatures. Each section includes a description of each indicator, along with a summary of the future projected climate. Cases where the results for a particular sub-regional indicator vary substantially from the regional average are noted in the analysis. The second chapter of this report provides a brief narrative describing how these changes could impact our region. These impact themes are broken into the Natural Environment and the Human Environment.

Sea level rise impacts are addressed by utilizing different sea level rise scenarios (1m, 2m, and 3m) along the regions east coast. This work will contribute to and be included in the next phase of the overall "New Normal Cowichan" climate adaption process using detailed coastal mapping.

Information provided in this document is not intended to serve as design guidelines for future planning. Rather it is intended to describe a probable future and enable our region's planners, engineers, policy makers, and community decision makers to make better-informed decisions on how to plan for and adapt to changes ahead.

This report offers a general description of our changing climate, followed by an expanded section on precipitation, summer temperatures, and winter temperatures.

Methodology

Climate Scenario Selection

Various future trajectories of greenhouse gas (GHG) emissions are possible, and depend directly on global political initiatives and socio-economic changes that will occur over the coming years. This report presents the internationally recognized roughly "business as usual" GHG emissions scenario, known as Representative Concentration Pathway 8.5 (RCP8.5). Additional information from lower emissions scenarios (RCP4.5 and RCP2.6) is available for sensitivity analysis and to illustrate the relationship between adaptation and GHG emissions reductions (by request).

In general terms, RCP8.5 corresponds to "business as usual" GHG emissions for the remainder of the century. The RCP4.5 "medium stabilization" scenario represents mitigation efforts that result in about half of the emissions compared to the RCP8.5 scenario. Substantial and sustained reductions in GHG emissions—for example, extensive adoption of biofuels and vegetarianism, along with carbon capture and storage—would be required to achieve RCP2.6, which is the only pathway that would keep global warming below 2°C above pre-industrial temperatures. The projected global temperature change for each pathway is illustrated below.

To date, public policy continues to reflect the RCP8.5 pathway, even though recent aspirational goals, including the 2015 COP21 Paris Agreement, correspond with RCP2.6. It is prudent to plan for an RCP8.5 future until global mitigation actions begin to catch up with commitments.

Representative Concentration Pathways (RCPs)

RCPs describe potential 21st century scenarios of GHG emissions, atmospheric GHG concentrations, aerosols, and land use. These RCPs are used for making projections, and are based on the factors that drive anthropogenic GHG emissions: population size, economic activity, lifestyle, energy use, land use patterns, technology adoption, and climate policy. Each of the RCPs directly relates to the choices made by global society.

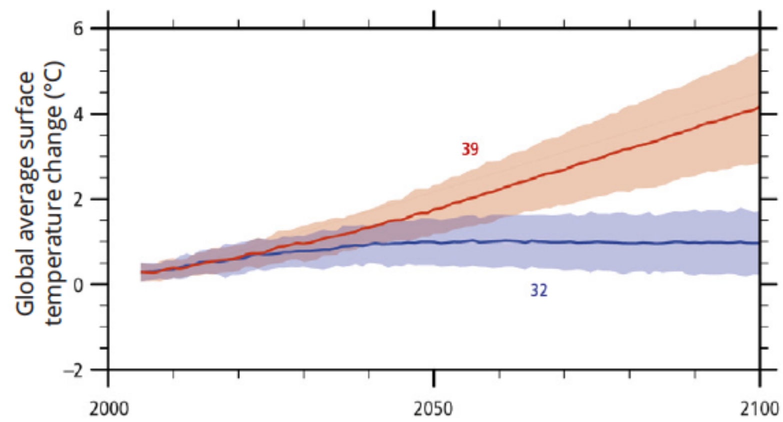


Figure 1: Emissions Scenarios *Figure S SPM.6(a) from IPCC's Climate Change 2014 Synthesis Report shows modeled global average surface temperature change relative to 1986-2005. The mean of the projections (lines) and a measure of uncertainty (shading) are shown for RCP8.5 (red) and RCP2.6 (blue). The number of climate models used to calculate the mean is indicated.*

Climate Model Selection

Many different, highly sophisticated models are used to simulate how the earth's climate will respond to changes in GHG concentrations, each with different strengths and weaknesses. To manage the uncertainty associated with modelling, it is best practice to apply an "ensemble" approach that uses several models to describe the bounds of projected climate change.

The results in this report are based on a subset of climate models selected from the Coupled Model Intercomparison Project 5 (CMIP5). The CMIP5 climate models were first screened according to their ability to replicate historical data, and from them, the ensemble of 12 models was chosen to provide the widest range of projected change for a set of climate parameters.

It is best practice to apply an "ensemble" approach that uses several models to describe the bounds of projected climate change.

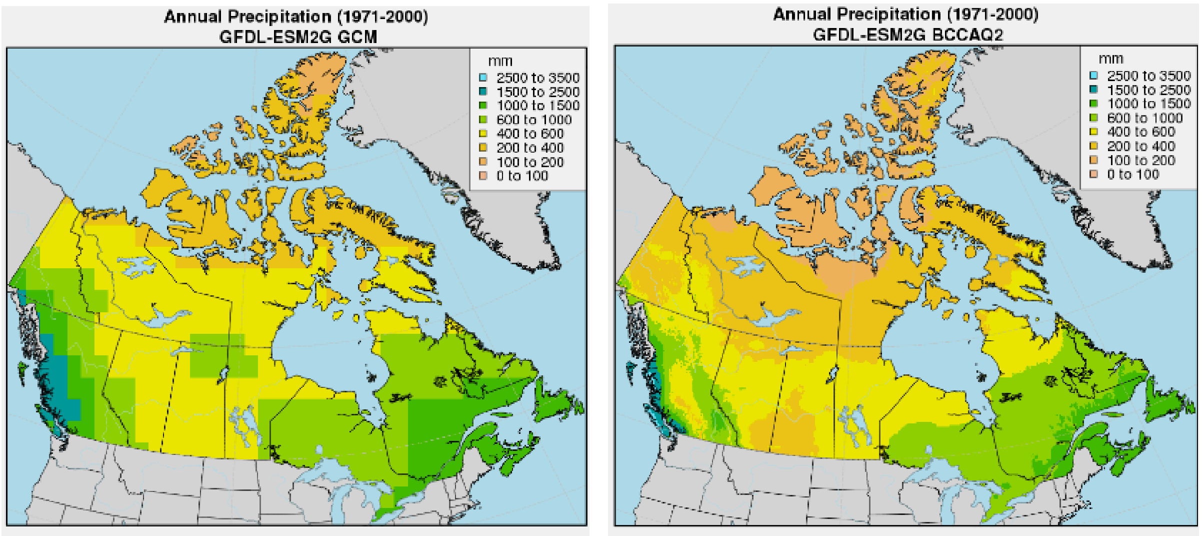


Figure 2: Example of Improved Resolution from Downscaling Climate Models *Climatalogical precipitation for the 1971–2000 period as simulated by the GFDL model, and after applying BCCAQ.*

Acronyms

ANUSPLIN	Australian National University Spline
BCCAQ	Bias Correction/Constructed Analogues with Quantile mapping reordering
CMIP5	Coupled Model Intercomparison Project 5
ETCCDI	Expert Team on Climate Change Detection and Indices
GFDL	Geophysical Fluid Dynamics Laboratory
GHG	Greenhouse Gas
IPCC	Intergovernmental Panel on Climate Change

Information from the large-scale global climate models was translated into predictions at local scales using a procedure called downscaling. The model projections were downscaled to a 10 km grid by making use of a historical daily time series (ANUSPLIN) in conjunction with the climate model projections. BCCAQ statistical downscaling was used, which is a hybrid climate analogue/quantile mapping method. Daily temperature and precipitation observations and future projections at 10 km resolution were then draped over an 800 m grid (PRISM) of 1971–2000 average temperature or precipitation to generate high-resolution maps.

Indicator Derivation

The historical baseline period used for all indicators in the report is 1971–2000. Values are averaged over this 30-year period to smooth out annual variability. The future projections are for the 2020s, 2050s (which is an average of modelled values over the 2041–2070 period), and 2080s (averaged over the 2071–2100 period). The three RCP scenarios have somewhat similar GHG concentrations in the 2050s, but diverge considerably by the 2080s. Indicators of climate change take a similar divergent pattern by the 2080s.

Many of the indicators of extreme events used in this report are derived using the definitions recommended by the Expert Team on Climate Change Detection and Indices (ETCCDI), known as the CLIMDEX indices. The indicator names used in this report have been translated into plain language. Some indicators are defined by ETCCDI on a monthly basis only, such as TXx (monthly maximum daytime high temperature). In some cases, we consider seasonal and annual versions of CLIMDEX indices by taking the corresponding maximum (or minimum) from the highest (or lowest) month in that season or year. The values given as projected changes for the 2050s and 2080s in this report are the average values across all 12 models.

Sub-Regional Analysis

The higher elevations and rain shadow effect from the mountainous regions result in considerable variation in climatic conditions across our region. For example, the west coast of the region receives over three times the annual precipitation compared to the east coast. In order to account for sub-regional variation in climate change, projections for the various indicators have been summarized both for the region as a whole and for three sub-regions. Cases where the results for a particular indicator vary substantially from the regional average are noted in the analysis. These sub-regions were defined using watershed and sub-watershed boundaries to reflect efforts at watershed-based planning within the region. The three sub-regions are defined as follows (also see Figure 3: Sub-Regions):

Developed Area: This sub-region includes the smaller, eastward-flowing watersheds and coastal benchland areas in which the majority of the region's population is located. For the larger Cowichan, Chemainus, and Koksilah River watersheds, only the lower sub-basins are included in this sub-region.

Water Supply Watersheds: This sub-region includes the upper portion of the sub-basins for the Cowichan, Koksilah, and Chemainus River watersheds and consists mainly of resource lands within the privately managed forest landbase.

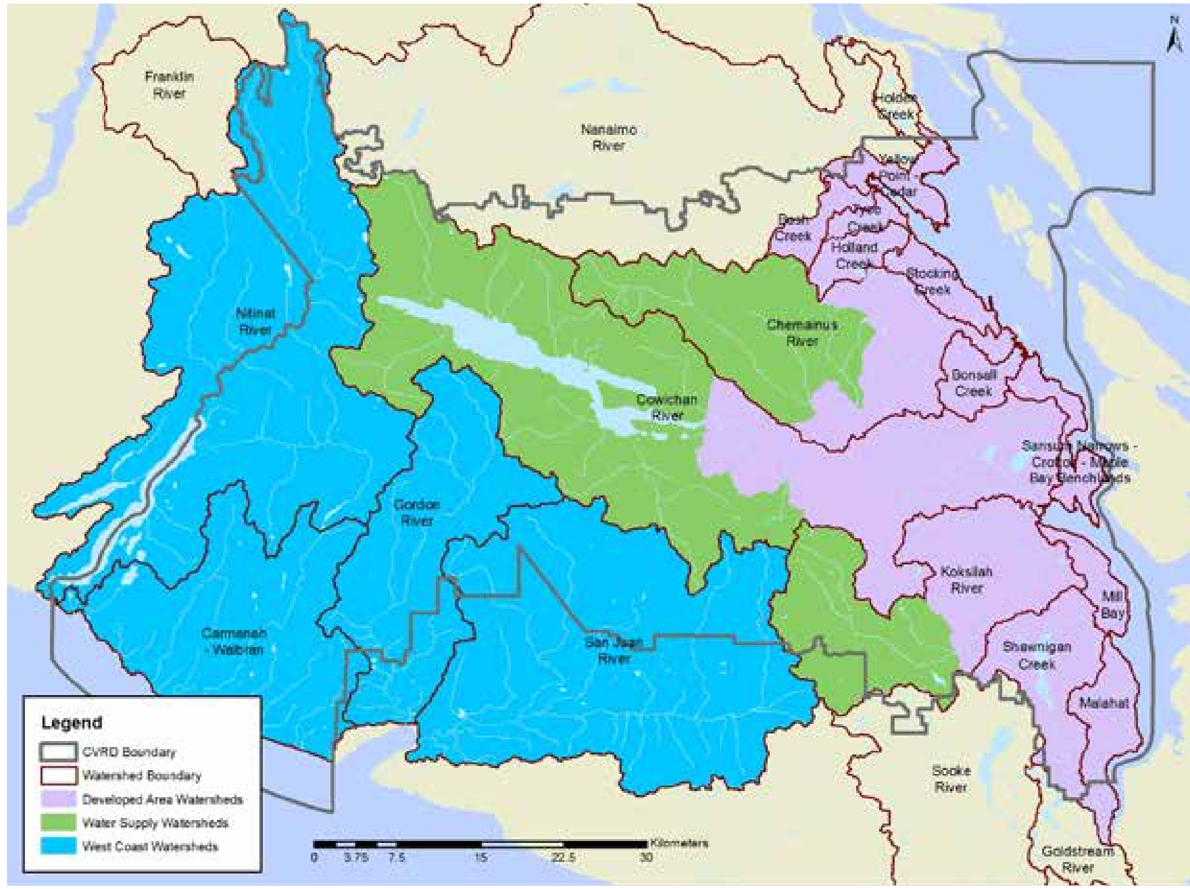


Figure 3: Subregions

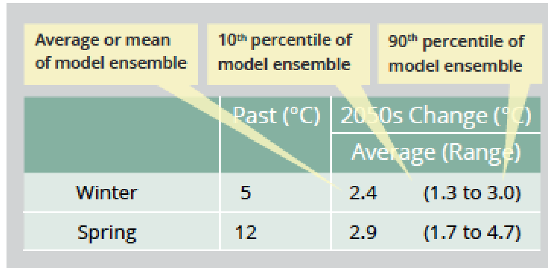
West Coast Watersheds: This sub-region includes the very wet, west-flowing watersheds, which include a mix of parks and resource lands.

While this work provides projections at the regional and sub-regional level, future work will need to consider the impacts of projected climate change and the responses to those impacts at a much finer scale. Differences in hydrological, ecological, social, and other conditions at a watershed or sub-watershed level will play a significant role in determining the extent and nature of the impacts of the projected climate change and the appropriate adaptations to those impacts over time.

How to Read Figures

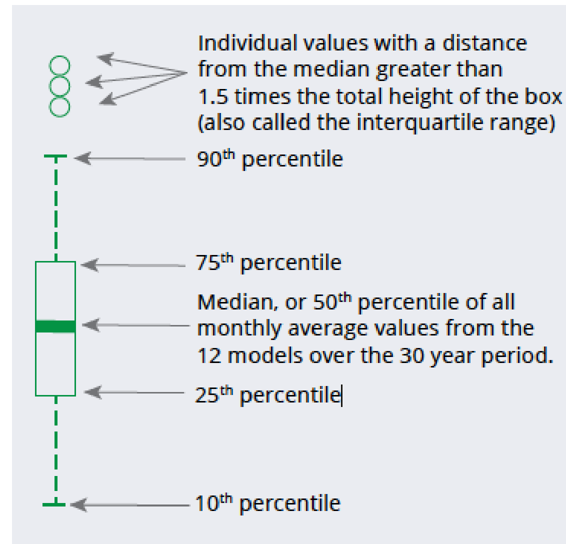
The following methods were used when developing the values shown in the tables, maps, and plots in this report:

- Values for each time period (past, 2050s, and 2080s) are averaged over each 30-year period. The 30-year period used to calculate past values is 1971–2000; the 2050s refer to 2041–2070, and the 2080s refer to 2071–2100.
- Seasons are presented as winter (December-January-February), spring (March-April-May), summer (June-July-August), and fall (September-October-November).
- In tables throughout the document, projected change is given for the average of the model ensemble along with the range (10th to 90th percentile) of the model ensemble. The 10th to 90th percentile range describes the uncertainty among the models and natural climate variability.



	Past (°C)	2050s Change (°C)	
		Average	(Range)
Winter	5	2.4	(1.3 to 3.0)
Spring	12	2.9	(1.7 to 4.7)

- Values in the tables (averages, ranges, percentiles, etc.) are provided for the region as a whole, as well as for the sub-regional geographies where relevant.
- Maps show only the average values of the model ensemble. Maps are provided in the body of the report when they add meaning to data interpretation, with additional maps for remaining indicators presented in Appendix 2.
- For the 1-in-20 events described in this report, the "5% chance of occurrence" is based on an average over each 30-year period. This means that, since climate change will occur throughout that time, there is slightly less than a 5% chance of such an event occurring at the beginning of the period and more than 5% chance at the end of the period, with an average 5% chance per year over the period.
- This report provides several box-and-whisker plots to illustrate year-to-year and model-to-model variability over time. The diagram below illustrates how these plots are to be interpreted.



General Climate Projections

The Cowichan Valley Regional District is already seeing the impacts of climate change and can expect to see increased changes and interrelationships in the years to come. At a broad level, this will mean the following physical changes:

- Warmer temperatures
- Longer dry spells in summer months
- More precipitation in fall, winter, and spring
- A decrease in snowpack
- More intense extreme events

These changes will not always happen consistently over the region or over time because seasonal and annual variations will occur. For most variables, projected change appears somewhat different from the past by the 2050s, and by the 2080s, projections indicate substantial changes, resulting in a very different climate than in the Cowichan region of today. This is particularly true for the temperature-related variables.

This section of the report presents general projections for our region, and is followed by sections with more detailed climate indicators, including indices of extremes for precipitation, summer temperatures, and winter temperatures. Each section includes a definition of the indicator and a summary of projected values.

A Note on Interpretation

This report tells the story of how we can expect temperature and precipitation to change in the Cowichan Valley region. When reviewing the data provided in the tables and figures below, it is important to note the following:

- The 10th to 90th percentile values projected by the ensemble models are important for adaptation planning, as they take into account the range of uncertainty when projecting future climate change. Risk managers may find it appropriate to consider 90th percentile values when planning critical infrastructure investments.
- For some indicators, values for specific geographic areas may be more appropriate than the regional or sub-regional averages presented in the tables. These values can be obtained by looking at the maps presented in the report body or utilizing the associated GIS files.

Warmer Temperatures

ABOUT THIS INDICATOR

Daytime high and nighttime low are averaged over each month, each season, or annually in the tables and plots below.

PROJECTIONS

All models project that daytime high and nighttime low temperatures will rise. While temperature can be expected to increase year round, the greatest increases will occur in the summer months. By the 2050s, daytime high temperatures will be substantially warmer (an increase of 3.2°C on average) in summer. By the 2080s, we can expect summer daytime highs to increase by over 5°C.

Nighttime lows are also projected to warm by almost 3°C in all seasons by the 2050s. In winter, this will mean an average low of 2°C by the 2050s, compared to an average low of -0.6°C in the past, increasing to about 4°C by the 2080s. Summer nighttime lows are also projected to increase dramatically, from 9°C in the past to over 14°C by the 2080s. Similar changes are also seen in each of the three sub-regions.

TABLE 1: REGIONAL AVERAGE DAYTIME HIGH TEMPERATURE

	Past (°C)	2050s Change (°C)		2080s Change (°C)	
		Average	(Range)	Average	(Range)
Winter	5	2.4	(1.3 to 3.3)	4.4	(2.6 to 6.4)
Spring	11	2.7	(1.5 to 4.6)	4.3	(2.7 to 7.1)
Summer	20	3.2	(1.9 to 4.2)	5.2	(3.6 to 7.0)
Fall	13	2.6	(1.3 to 3.8)	4.2	(2.8 to 5.8)
Annual	12	2.7	(1.4 to 4.0)	4.5	(2.9 to 6.2)

TABLE 2: REGIONAL AVERAGE NIGHTTIME LOW TEMPERATURE

	Past (°C)	2050s Change (°C)		2080s Change (°C)	
		Average	(Range)	Average	(Range)
Winter	-1	2.6	(1.6 to 3.2)	4.4	(3.2 to 5.3)
Spring	2	2.5	(1.7 to 3.6)	4.1	(2.8 to 5.8)
Summer	9	2.8	(1.7 to 4.0)	4.7	(3.4 to 6.5)
Fall	5	2.6	(1.6 to 3.7)	4.2	(2.8 to 5.6)
Annual	4	2.6	(1.6 to 3.6)	4.3	(3.0 to 5.8)

Maps indicate that warming is expected to be relatively uniform throughout the region, with the most warming expected in the valleys and low-lying areas. In the past, the average winter nighttime low temperature was below freezing. In future, only the highest elevations will experience nighttime lows below freezing.

Warmer Temperatures, Continued

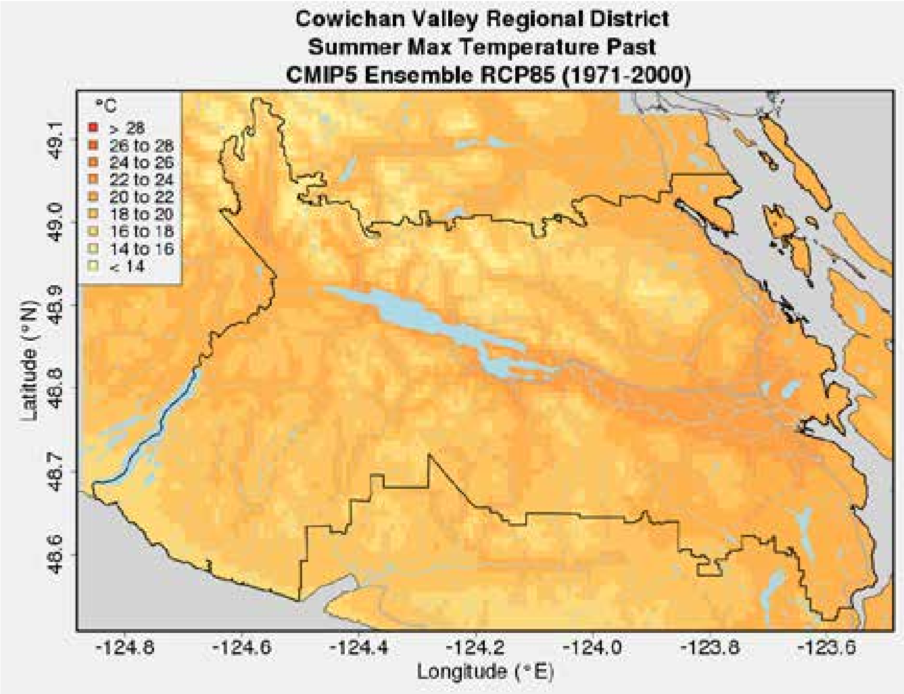


Figure 4: Summer Average Daytime High Temperature – Past

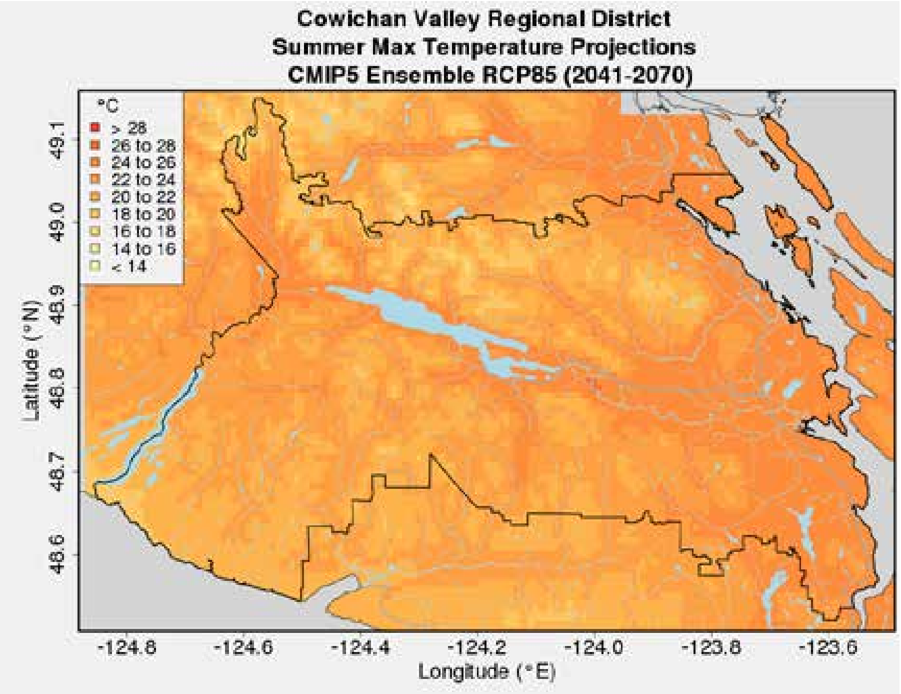


Figure 5: Summer Average Daytime High Temperature – Future (2050s)

Warming is expected to be relatively uniform throughout the region, with the most warming expected in the valleys and low-lying areas.

Warmer Temperatures, Continued

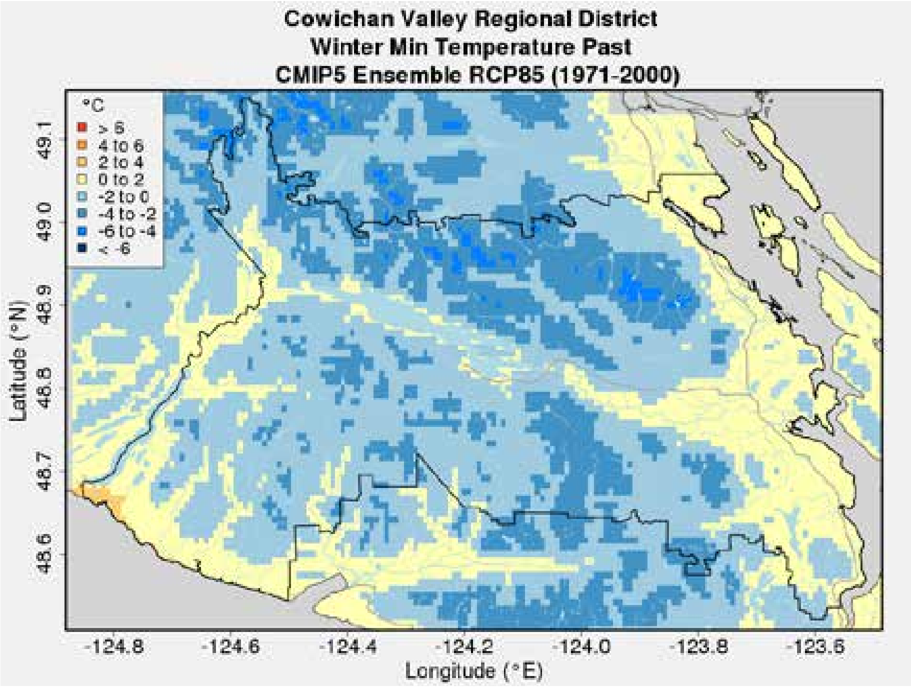


Figure 6: Winter Average Nighttime Low Temperature – Past

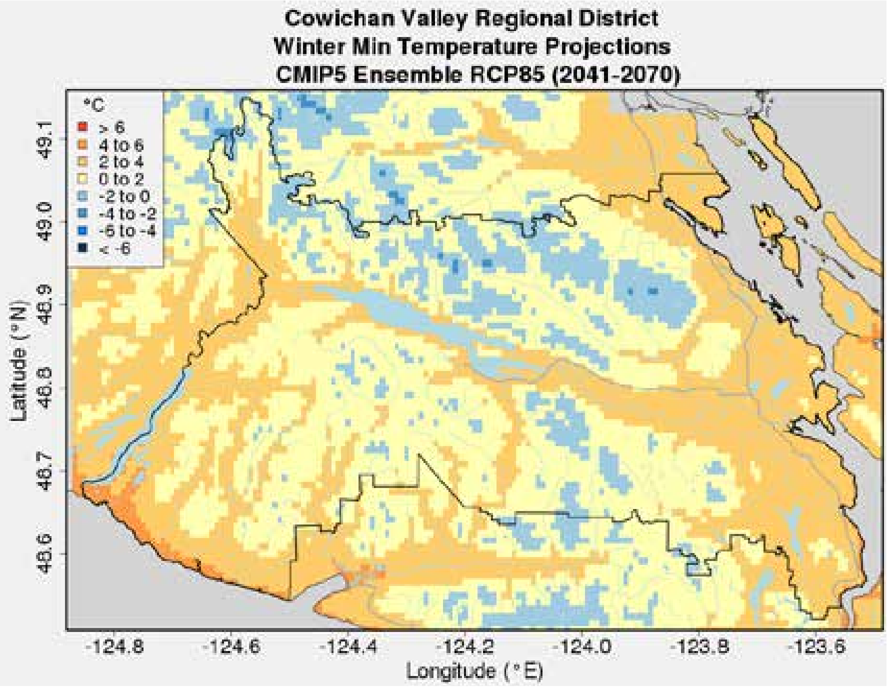


Figure 7: Winter Average Nighttime Low Temperature – Future (2050s)

In the past, the average winter nighttime low temperature was below freezing. In future, only the highest elevations will experience nighttime lows below freezing.

Seasonal Variability in Temperature

The box-and-whisker plots of monthly daytime high and nighttime low temperatures provide a comparison of the year-to-year variability in future to that experienced in the past. This shows that the new normal for the region may be very unlike the past.

The daytime high temperature plot shows that the median daytime high in the 2080s are projected to be hotter than the 90th percentile of warm days in the past in many months and even by the 2050s in some months, with the most notable changes projected for July, August, and September. In the 2080s, most September temperatures can be expected to be hotter than past August temperatures. In the 2080s, January daytime highs are projected to be generally warmer than past March temperatures.

NOTE:

Further explanation of how to read the box-and-whisker plots is provided on page 7 under Methodology.

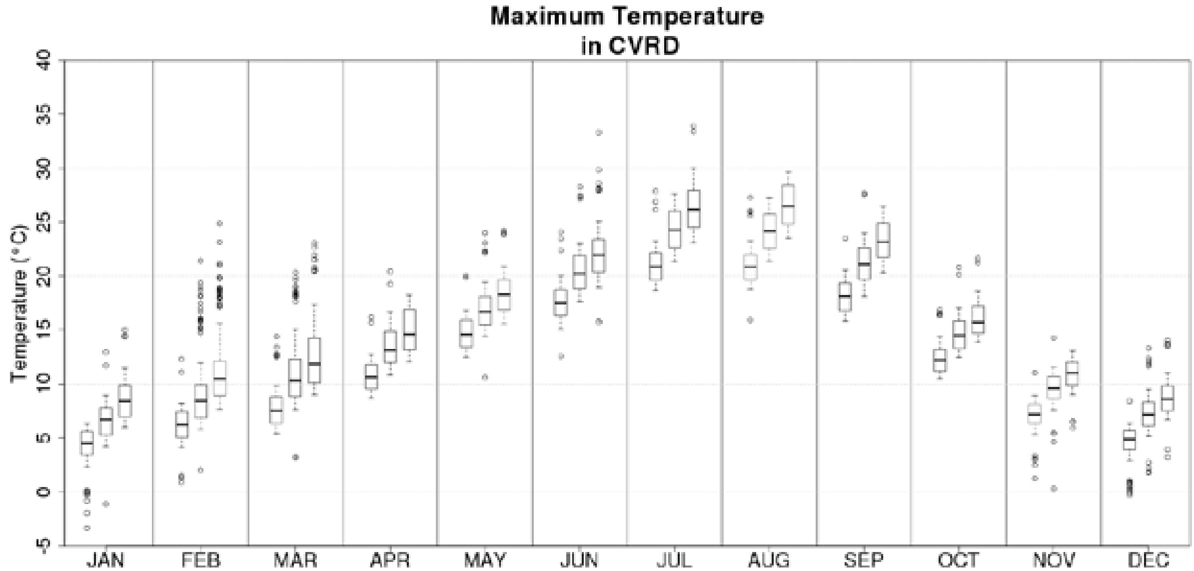


Figure 8: Monthly Daytime High Temperature – Past, 2050s, and 2080s

Boxes from left to right in each month indicate past, 2050s, 2080s.

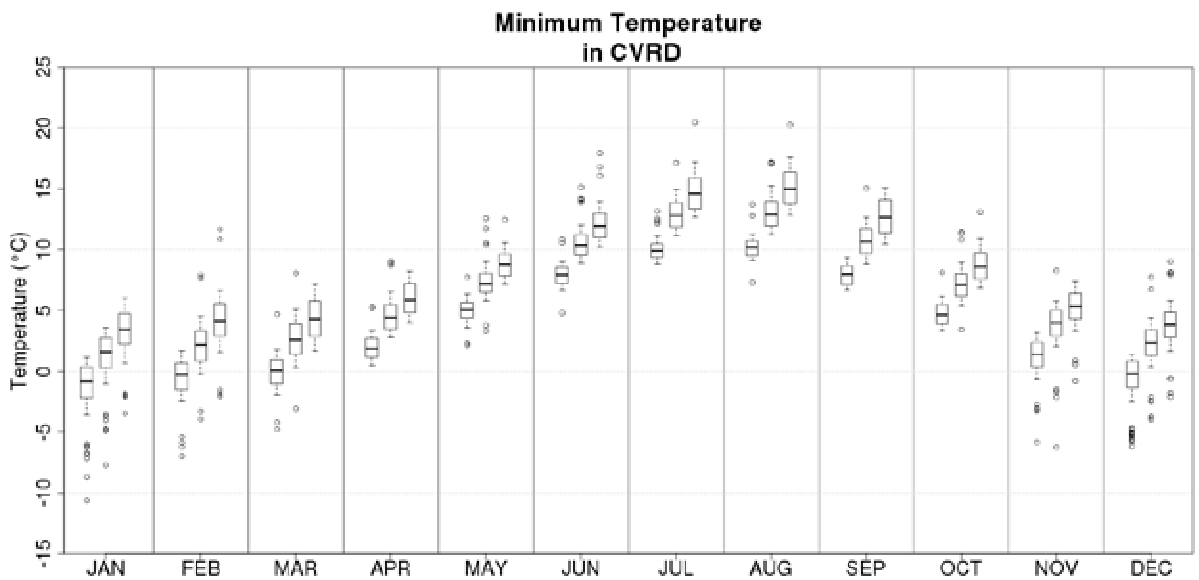


Figure 9: Monthly Nighttime Low Temperature – Past, 2050s, and 2080s

Boxes from left to right in each month indicate past, 2050s, 2080s.

Wetter Winters, Drier Summers

ABOUT THIS INDICATOR

Total precipitation is all precipitation summed over a month, season, or year, including rain and snow water equivalent. This is a high-level indicator of how precipitation patterns can expect to change.

PROJECTIONS

Projections indicate that our region will experience a modest increase in total annual precipitation of 5% by the 2050s and 11% by the 2080s. While these increases alone are not a dramatic departure from the past, the increase in precipitation is expected to be distributed unevenly over the seasons and among extreme events.

Most rain in our region falls over the winter months, and this is projected to continue to occur in the future. The largest percentage increase in rainfall is expected to occur in the fall season, increasing 11% by the 2050s, and 19% by the 2080s. Models indicate winter and spring precipitation will both increase as well. Summer, already our region's driest season, may experience a decline of 17% by the 2050s, and a decline of 26% by the 2080s. While the models indicate a range of possible change, they mostly agree about the direction of change for each season.

TABLE 3: TOTAL PRECIPITATION OVER SEASONS IN A YEAR

	Past (mm)	2050s (mm)	2080s (mm)	2050s Percent Change (%)		2080s Percent Change (%)	
				Average	(Range)	Average	(Range)
Winter	818	856	932	5	(-2 to 11)	14	(2 to 26)
Spring	413	433	442	5	(-6 to 13)	7	(-5 to 17)
Summer	158	131	117	-17	(-41 to 2)	-26	(-49 to -6)
Fall	612	676	727	11	(-3 to 25)	19	(6 to 38)
Annual	2028	2124	2250	5	(1 to 10)	11	(2 to 16)

Wetter Winters, Drier Summers, Continued

The main distinction between the regional and sub-regional numbers is that the baselines for precipitation are different. The seasonal percent changes are similar throughout the region.

By the 2080s, summer precipitation in the Water Supply Watersheds are expected to be similar to summer precipitation in the Developed Area today. Conversely, by the 2080s, winter precipitation in the Water Supply Watersheds will look like winter precipitation in the West Coast Watersheds today. This is important when planning for stormwater management and flood control.

The maps on the following pages show the amount of precipitation projected, and indicate that the wetter areas are expected to experience the largest increases in precipitation.

TABLE 4: SUB-REGIONAL SEASONAL PRECIPITATION

	Developed Area			Water Supply Watersheds			West Coast Watersheds		
	Past (mm)	2050s Change (mm)	2080s Change (mm)	Past (mm)	2050s Change (mm)	2080s Change (mm)	Past (mm)	2050s Change (mm)	2080s Change (mm)
Winter	612	27 (-14 to 68)	88 (12 to 163)	857	40 (-21 to 93)	119 (17 to 221)	968	47 (-24 to 101)	136 (20 to 248)
Spring	279	16 (-17 to 40)	24 (-11 to 60)	435	21 (-25 to 55)	31 (-19 to 76)	506	23 (-27 to 63)	33 (-27 to 81)
Summer	109	-20 (-44 to 3)	-29 (-56 to -5)	169	-30 (-67 to 3)	-45 (-84 to -12)	186	-31 (-74 to 6)	-47 (-91 to -11)
Fall	429	48 (-20 to 11)	89 (32 to 174)	649	67 (-20 to 158)	121 (40 to 236)	736	75 (-19 to 181)	134 (46 to 258)
Annual	1514	74 (-10 to 148)	179 (42 to 264)	2126	102 (11 to 220)	234 (53 to 333)	2403	115 (20 to 262)	257 (52 to 358)

Wetter Winters, Drier Summers, continued

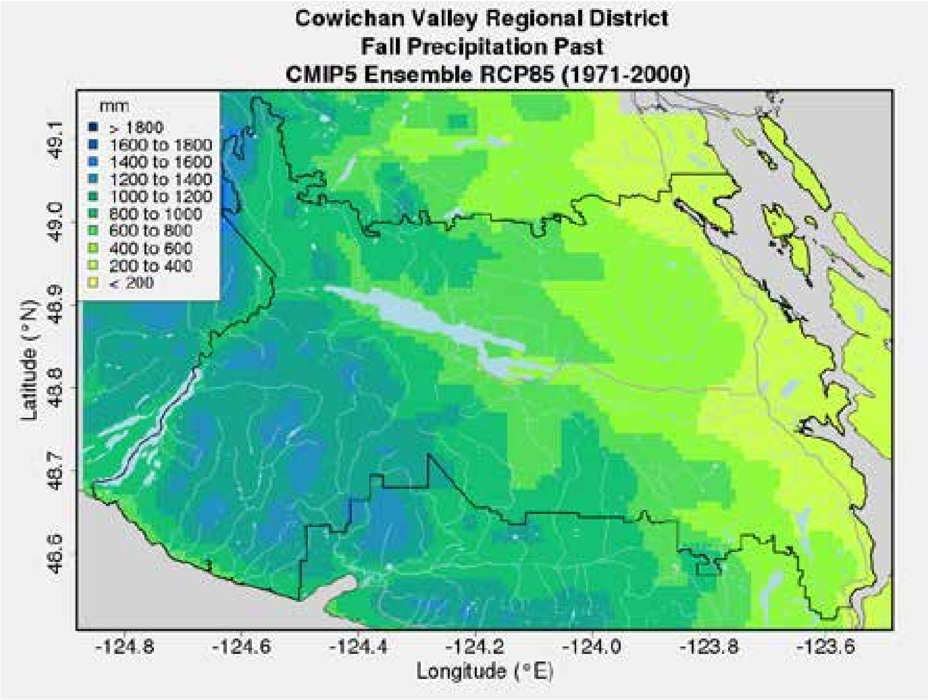


Figure 10: Fall Precipitation – Past

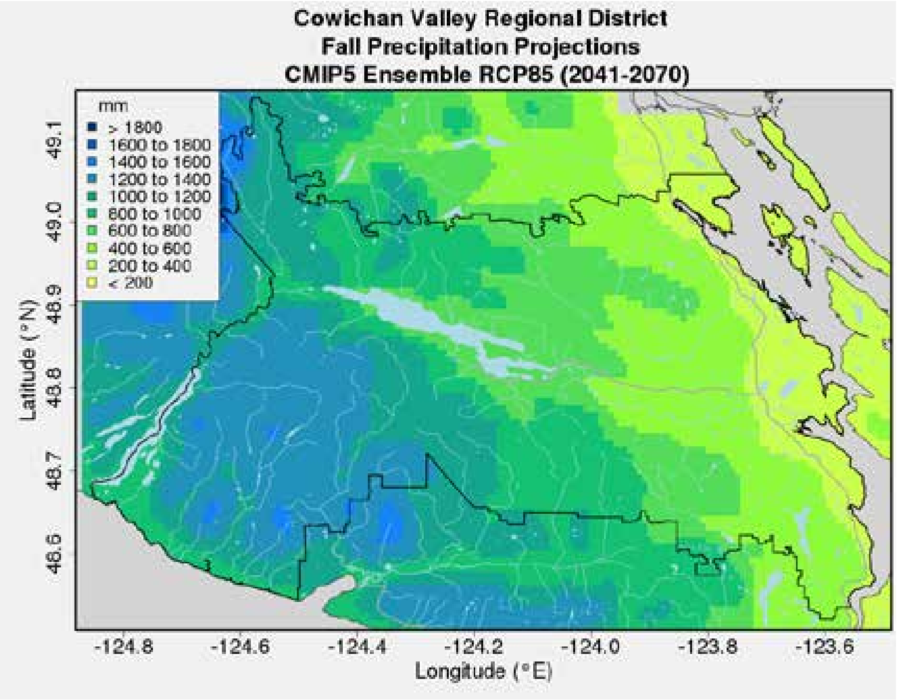


Figure 11: Fall Precipitation – Future (2050s)

Wetter areas are expected to experience the largest increases in precipitation.

Seasonal Variablility in Precipitation

When examining monthly precipitation values in the plot below, we see that the increases within a season are not uniform across months. For example October, November, and December show the largest precipitation increases in both absolute and relative terms. The plot also indicates the potential for drier summer months in the future. September is projected to get drier over time, extending the dry season into fall.

The models illustrate that we can expect more precipitation in the already wet seasons, less precipitation in already dry summers, and considerably more rain falling in some years, while other years will experience droughts.

In southwestern BC, year-to-year precipitation variability is modulated by the Pacific Decadal Oscillation (PDO), which has varied between warm and cool phases a few times over the last century. As well, the El Niño-Southern Oscillation (ENSO) varies between three phases: neutral years, El Niño events that typically mean a warmer and drier winter and spring, and La Niña events that are cooler and wetter.

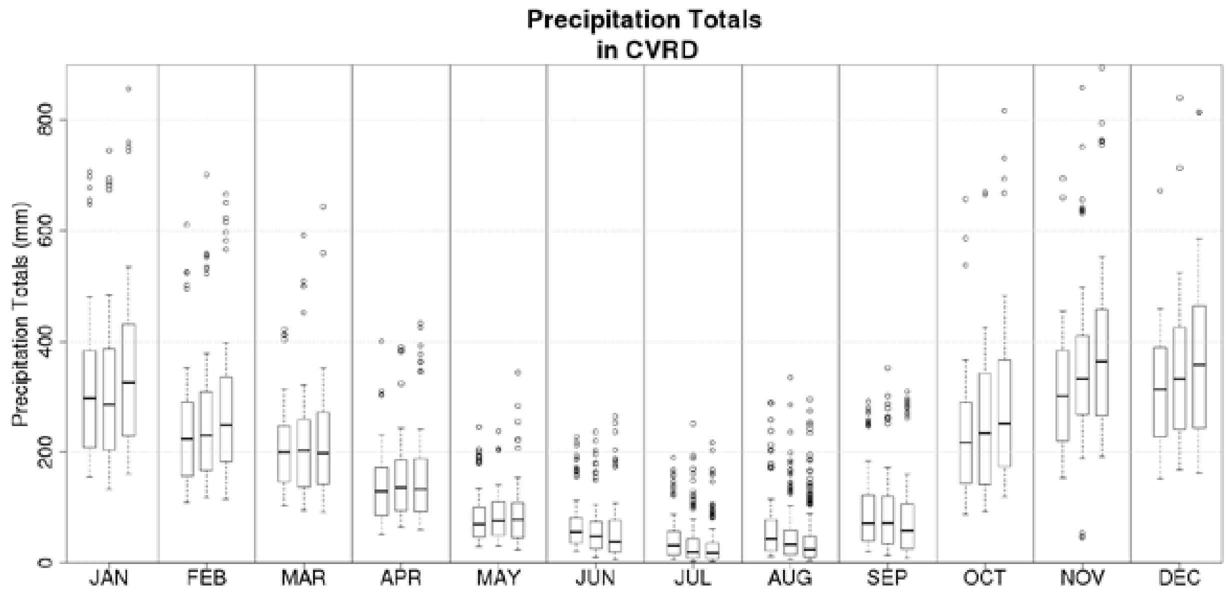


Figure 12: Monthly Total Precipitation – Past, 2050s, and 2080s

Boxes from left to right in each month indicate past, 2050s, 2080s. Further explanation of how to read the box-and-whisker plots is provided above in the Methodology section (page 7).

The range of the natural variability of PDO and ENSO cycles is comparable to the projected changes due to climate change. Because future projections are based on 12 model runs, the values in the tables approximate average conditions in terms of natural variability.

To illustrate the influence of year-to-year variability (including ENSO and PDO contributions) on precipitation, the box and whisker plots below show, for each month of the year, the distribution of values in each 30-year period for all 12 models. As natural variability will still exist in future and projected changes are superimposed on variability, individual precipitation events that are more intense than those experienced in the past are expected to occur.

Precipitation Indicators

Our region's drinking water, as well as water for industry and agriculture, comes from a variety of sources including lakes, rivers, and groundwater. Some utilities in the region have reservoirs, but these are small and have limited capacity for additional storage. Changes in precipitation patterns will have impacts on surface water availability, lake and river system levels, and ultimately on groundwater resources. Changes in precipitation will also have impacts on water quality, both in winter due to increasing sedimentation, and in summer due to algal events driven by water temperature and levels.

The majority of the region outside of municipal boundaries relies on natural drainage infrastructure (wetlands, watercourses, and floodplains) to withstand extreme weather events. The region's network of roads and drainage systems, operated by the provincial Ministry of Transportation and Infrastructure and the municipalities, was designed to withstand past rainfall patterns. As the climate warms, more moisture is held in the atmosphere and released during precipitation events, resulting in more intense future storm events. Also, with changing global climate patterns, weather systems like atmospheric rivers are likely to stall on the coast and, when combined with an increased precipitation intensity, we can expect

to see longer and more intense storm events coming off the Pacific in the future. During these events, new thresholds for extreme weather events are likely to challenge the capacity of the regional sewerage and drainage infrastructure currently in place[1].

We can expect to see longer and more intense storm events coming off the Pacific in the future.

1 For more information, see: https://www.pacificclimate.org/sites/default/files/publications/Atmospheric%20Report%20Final%20Revised.pdf

Dry Spells

ABOUT THIS INDICATOR

Dry spells is a measure of the number of consecutive days where daily precipitation is less than 1 mm. The value denotes the longest stretch of dry days in a year, typically in summer. This indicator reflects times of the year when watersheds/water resources are not recharged by rainfall.

PROJECTIONS

The past average longest period of consecutive days without rain (under 1 mm) in our region is 22 days. Dry spells on average are expected to increase to 26 days by the 2050s, and 29 days by the 2080s. Sub-regional trends align with regional trends.

Single-Day Maximum

ABOUT THIS INDICATOR

Single-day maximum precipitation describes the largest amount of rain that falls on any single day in the year.

PROJECTIONS

As noted previously in the General Climate Projections section, a modest increase (5%) in total annual precipitation is expected by the 2050s. Models project that the increase will be concentrated into the wettest days. The wettest single day of the year is expected to see 17% more rain by the 2050s, and 30% more by the 2080s. The percent changes are similar across the sub-regions. Like the general precipitation numbers, the baseline values for single-day maximum precipitation in the sub-regions are different, while the future percent changes are in line with regional averages.

5-Day Maximum

ABOUT THIS INDICATOR

5-day maximum precipitation describes the largest amount of rain that falls over a period of 5 consecutive days in the year.

PROJECTIONS

Again, as noted earlier, a modest increase (5%) in total annual precipitation is expected by the 2050s, with models projecting the increase will be concentrated into the wettest days. The amount of rain in the wettest 5-day period is projected to increase by 10% by the 2050s, and 23% by the 2080s. Sub-regional percent changes are in line with the regional projections.

TABLE 5: ANNUAL DRY SPELLS

	Past (days)	2050s (days)	2080s (days)	2050s Percent Change (%)		2080s Percent Change (%)	
				Average	(Range)	Average	(Range)
Dry spell duration	22	26	29	20	(4 to 36)	32	(16 to 48)

95th-Percentile Wettest Days

ABOUT THIS INDICATOR

The 95th-percentile wettest days precipitation indicator points to the total amount of rain that falls on the wettest days of the year, specifically on days when precipitation exceeds a threshold set by the annual 95th percentile of wet days during the baseline period (1971–2000). This measure indicates how much total annual precipitation falls during these heavy events, which is a combination of both how often these events occur and the size of these events.

PROJECTIONS

The wettest periods in our region are projected to become wetter. The wettest days that exceed the baseline 95th-percentile threshold are projected to produce 30% more rain by the 2050s, and 57% more rain by the 2080s. Most of this increase in rain is due to those heavy rain days becoming more frequent in the future. Sub-regional percent changes are in line with the regional projections.

TABLE 6: EXTREME PRECIPITATION

	Past (mm)	2050s Percent Change (%)		2080s Percent Change (%)	
		Average	(Range)	Average	(Range)
Single-day maximum precipitation	75	17	(4 to 28)	30	(10 to 40)
Five-day maximum precipitation	177	10	(3 to 20)	23	(8 to 33)
95th-percentile wettest days precipitation	448	30	(9 to 57)	57	(36 to 81)
99th-percentile wettest days precipitation	134	65	(26 to 107)	120	(59 to 161)
1-in-20 wettest day	112	30	(11 to 45)	39	(22 to 57)

99th-Percentile Wettest Days

ABOUT THIS INDICATOR

The 99th-percentile wettest days precipitation indicator points to the total amount of rain that falls on the wettest days of the year, specifically on days when precipitation exceeds a threshold set by the annual 99th percentile of wet days during the baseline period (1971–2000). This measure indicates how much total annual precipitation falls during these heavy events, which is a combination of both how often these events occur and the size of these events.

PROJECTIONS

More precipitation is expected to fall during the 99th-percentile wettest days extreme storm events in the future. Larger 99th-percentile wettest days events could mean up to 65% more rain by the 2050s, and 120% by the 2080s. These projected large increases mean that we can expect more frequent and more intense storms in the future, with more rain falling during extreme downpours. Sub-regional percentile changes are in line with the regional projections.

1-in-20 Wettest Day

ABOUT THIS INDICATOR

The 1-in-20 wettest day is the day so wet that it has only a 1-in-20 chance of occurring in a given year. That is, there is a 5% chance in any year that a 1-day rainfall event of this magnitude will occur. This indicator is useful when planning for future infrastructure and forest production.

PROJECTIONS

More precipitation is expected to fall during the 1-in-20 (or 5% chance) wettest day extreme storm events in the future. 1-in-20 wettest day events could be about 30% more intense by the 2050s, and almost 40% by the 2080s. Sub-regional projections indicate that the wetter areas will become increasingly wetter over time, and indicate we should expect year-to-year variability in precipitation levels.

TABLE 7: EXTREME PRECIPITATION IN THE SUB-REGIONS

	Developed Area			Water Supply Watersheds			West Coast Watersheds		
	Past (mm)	2050s Change (mm)	2080s Change (mm)	Past (mm)	2050s Change (mm)	2080s Change (mm)	Past (mm)	2050s Change (mm)	2080s Change (mm)
Single-day maximum precipitation	61	10 (2 to 19)	18 (6 to 28)	79	14 (2 to 24)	24 (8 to 35)	87	15 (4 to 26)	25 (11 to 34)
Five-day maximum precipitation	139	14 (5 to 29)	33 (8 to 47)	186	20 (4 to 37)	43 (14 to 60)	206	22 (7 to 38)	45 (11 to 34)
95th-percentile wettest days precipitation	329	96 (16 to 185)	193 (129 to 277)	471	139 (44 to 263)	265 (168 to 371)	536	158 (54 to 296)	297 (2015 to 410)
99th-percentile wettest days precipitation	100	63 (26 to 105)	123 (59 to 182)	141	87 (38 to 144)	166 (92 to 219)	158	101 (50 to 163)	183 (107 to 231)
1-in-20 wettest day precipitation	95	23 (8 to 41)	34 (13 to 52)	118	38 (11 to 59)	49 (27 to 70)	128	42 (21 to 60)	48 (30 to 69)

Summer Temperature Indicators

The downscaled outputs from the climate models project warming in average summer (June-July-August) daytime high temperatures. While warmer temperatures may have benefits and be welcomed in some ways, they will also need careful consideration when planning for a growing population in the region. Descriptions of these indicators are offered below, and values for these projections are given in Table 8: Hot Summer Indicators. Sub-regional numbers illustrate that temperatures are generally warmer in the Developed Areas, and cooler in the West Coast Watersheds, while projected changes are relatively uniform across the region. Sub-regional values are given in Table 9: Hot Summers in the Sub-Regions. These indicators are useful when planning for agriculture, and for understanding how ecological systems will change over time, including fish productivity and plant growth.

Summer Days

ABOUT THIS INDICATOR

Summer days tells us how many days reach temperatures over 25°C in any one year. This measure indicates how often we can expect "summer weather" to occur in the future.

PROJECTIONS

In the past, our region experienced 16 "summer days" a year, and we can expect significantly more in the future. Models project more than double the number of summer days by the 2050s, and more than triple by the 2080s. This means that future summers may have 39 days above 25°C by the 2050s, and 59 days by the 2080s. The Developed Area, where the majority of the population is concentrated, experienced 23 summer days in the past. By the 2050s, 54 summer days a year are projected, and 78 by the 2080s. This marks a significant change from the past.

The map for summer days included below shows that the number of hot days are projected to be highest in the eastern reaches of our region, with the greatest changes in the Developed Area with the most population that already experiences warmer temperatures.

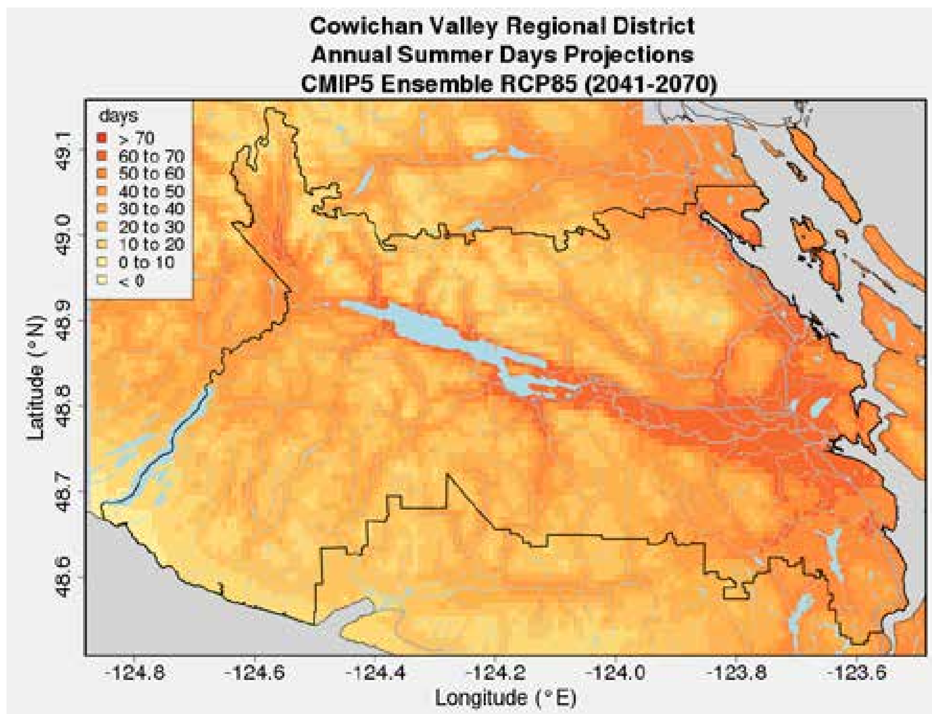


Figure 13: Annual Summer Days – 2050s

Summer Temperature Indicators

TABLE 8: HOT SUMMER INDICATORS – REGIONAL AVERAGES

	Past (days)	2050s (days)	2080s (days)	2050s Change (days)		2080s Change (days)	
				Average	(Range)	Average	(Range)
Summer days (# of days >25°C)	16	39	59	23	(15 to 32)	43	(28 to 62)
	Past (°C)	2050s (°C)	2080s (°C)	2050s Change (°C)		2080s Change (°C)	
				Average	(Range)	Average	(Range)
Hottest daytime high (°C)	30	33	35	3.3	(2.0 to 4.0)	5.5	(3.9 to 7.2)
1-in-20 hottest daytime high (°C)	33	37	39	4.1	(2.6 to 5.2)	6.0	(4.1 to 7.9)

TABLE 9: HOT SUMMERS IN THE SUB-REGIONS

	Developed Area			**Water Supply Watersheds**			**West Coast Watersheds**		
	Past (days)	2050s Change (days)	2080s Change (days)	Past (days)	2050s Change (days)	2080s Change (days)	Past (days)	2050s Change (days)	2080s Change (days)
Summer days (# of days >25°C)	23	31 (19 to 42)	55 (35 to 78)	16	21 (13 to 30)	40 (27 to 57)	10	18 (11 to 26)	36 (25 to 48)
	Past (°C)	2050s Change (°C)	2080s Change (°C)	Past (°C)	2050s Change (°C)	2080s Change (°C)	Past (°C)	2050s Change (°C)	2080s Change (°C)
Hottest daytime high (°C)	31	3.5 (2.2 to 4.4)	5.7 (3.9 to 7.7)	30	3.3 (2.0 to 4.0	5.5 (3.9 to 7.3)	29	3.1 (1.9 to 3.6)	5.2 (3.8 to 6.7)
1-in-20 hottest daytime high (°C)	34	4.3 (2.6 to 5.8)	6.3 (4.3 to 8.6)	33	4.2 (2.8 to 5.3)	6.0 (4.3 to 8.1)	33	3.8 (2.5 to 4.7)	5.6 (3.8 to 7.0)

Hottest Day

ABOUT THIS INDICATOR

Hottest day refers to the highest daytime high temperature of the year, usually experienced during the summer months. The maximum for each year is an indicator of extreme temperatures and is averaged over a 30-year period.

PROJECTIONS

The past hottest day temperature was 30°C for the region. We can expect increases to over 33°C by the 2050s, and almost 36°C by the 2080s. Like summer days (shown above) the highest increases can be expected in our region's Developed Area. An increase in hottest day temperatures is projected to cause up to one week of tropical nights (nights when temperatures do not decrease below 25°C) in the future. These warming trends are similar in the sub-regions.

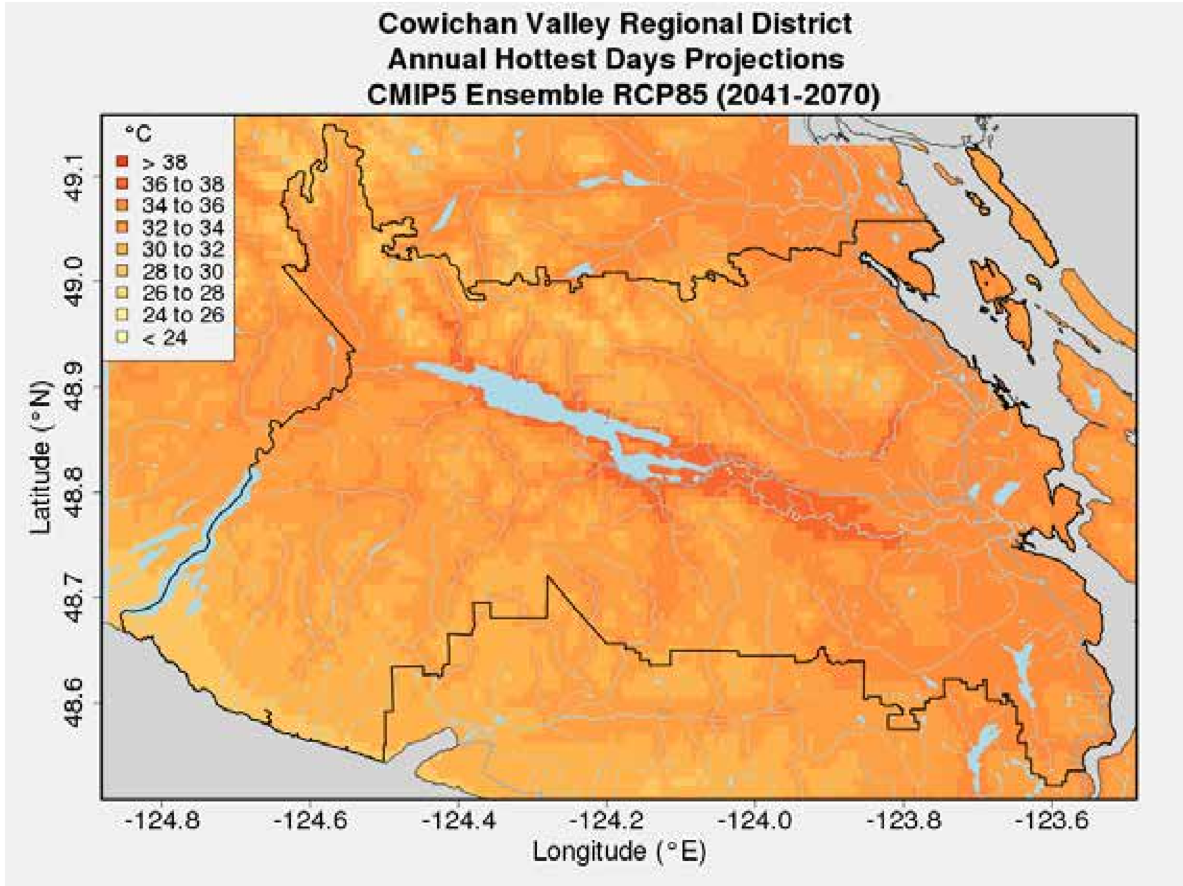


Figure 14: Annual Hottest Days – 2050s

1-in-20 Hottest Day

ABOUT THIS INDICATOR

1-in-20 hottest day refers to the day so hot that it has only a one-in-twenty chance of occurring in a given year. That is, there is a 5% chance in any year that temperatures could reach this magnitude.

PROJECTIONS

As temperatures warm, so will extreme heat events. Our past 1-in-20 hottest day temperature is about 33°C. By the 2050s we can expect this value to increase to over 37°C, and to over 39°C by the 2080s. In low-lying areas where the population is centered, like Duncan the past event is about 34°C and we can expect 1-in-20 hottest day temperatures to rise by 4°C to 38°C by the 2050s, and to over 40°C by the 2080s. This is a significant departure from what the region is accustomed to experiencing.

The 1-in-20 hottest day temperatures are projected to affect the entire region, and like other hot summer indicators, are mostly likely to affect valleys and eastern reaches.

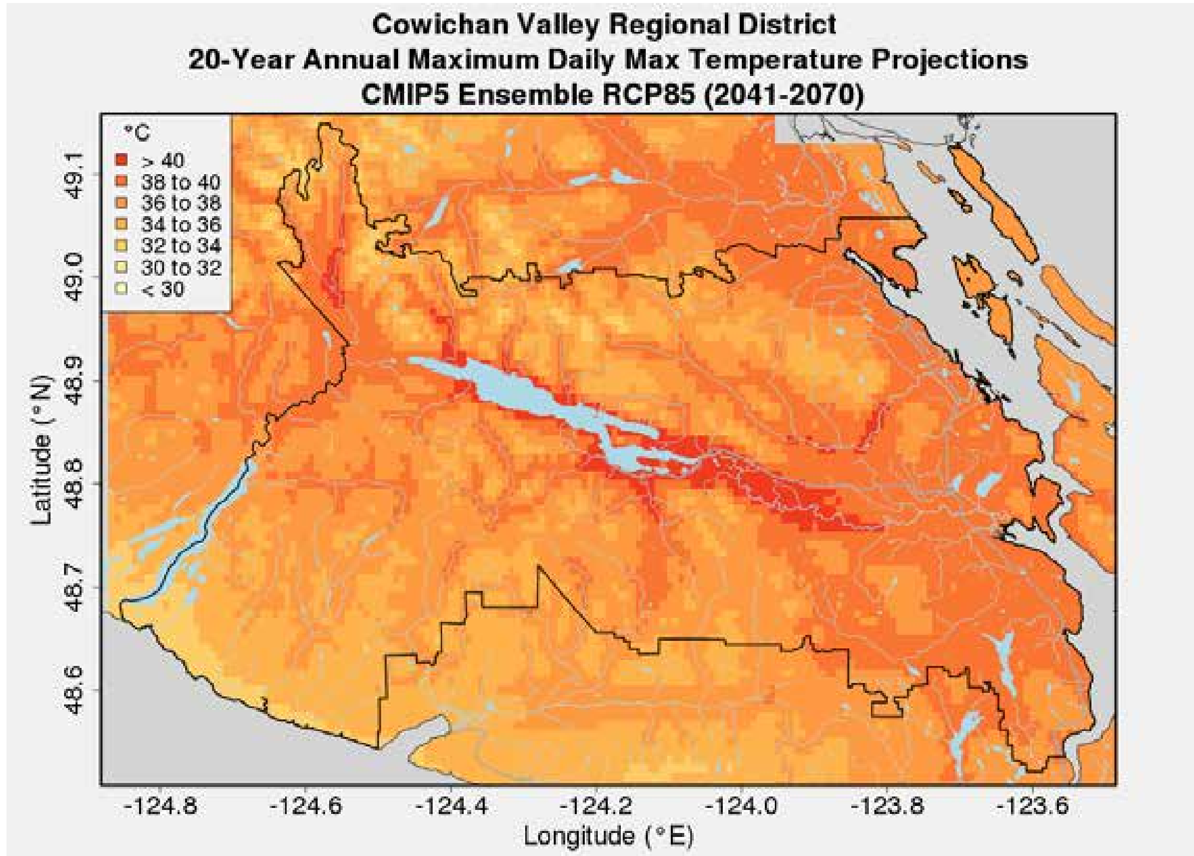


Figure 15: 1-in-20 Hottest Day – 2050s

Cooling Degree Days

ABOUT THIS INDICATOR

Cooling degree days refers to the number of degrees that a day's average temperature is above 18°C, and is used to estimate the use of air conditioning to cool buildings. To determine the number of cooling degree days in a month, the number of degrees that the daily temperature is over 18°C for each day is added to give a total value.

PROJECTIONS

Historically there has been very little demand for cooling in the Developed Area of our region. This is reflected in the baseline average of 47 cooling degree days in the past. In the future it is projected that there will be an over 300% increase in cooling degree days by the 2050s, and an over 700% increase by the 2080s. The large relative increases are partly due to a low historical baseline.

TABLE 10: COOLING DEGREE DAYS

	Past (degree days)	2050s (degree days)	2080s (degree days)	2050s Percent Change (%)		2080s Percent Change (%)	
				Average	(Range)	Average	(Range)
Region	28	136	272	387	(213 to 575)	868	(512 to 1387)
Developed Area	47	208	387	342	(198 to 515)	720	(439 to 1172)

Historically there has been very little demand for cooling in the Developed Area of our region. The large relative increases are partly due to a low historical baseline.

Cooling Degree Days, Continued

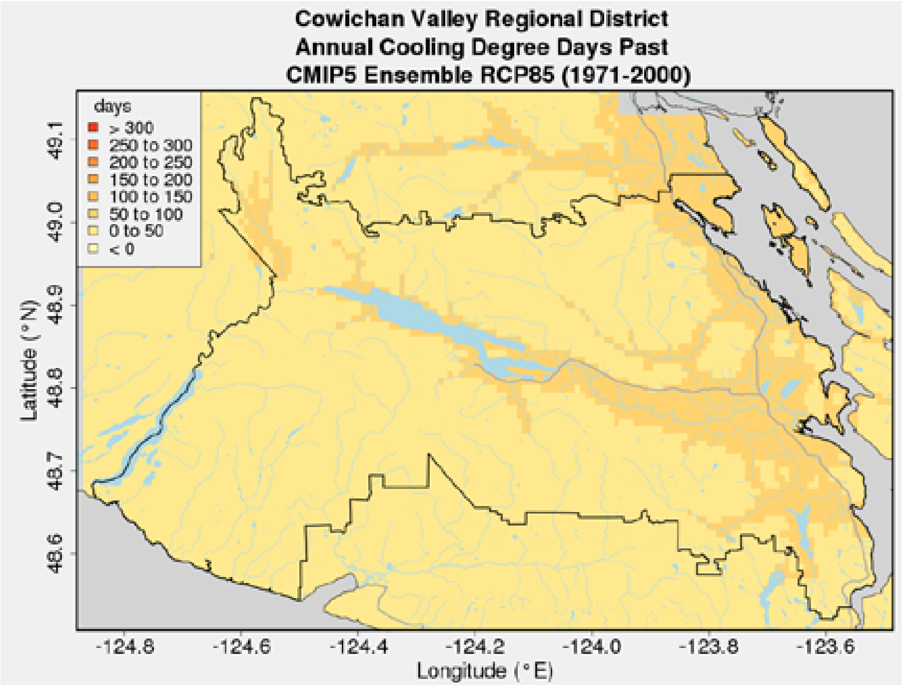


Figure 16: Cooling Degree Days – Past

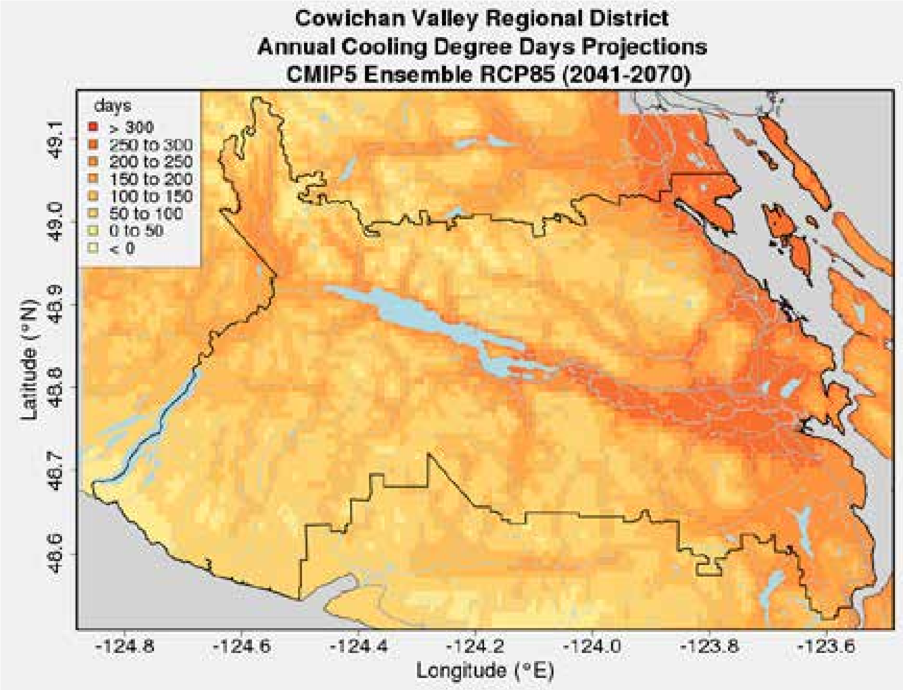


Figure 17: Cooling Degree Days – 2050s

Cooling degree days refers to the number of degrees that a day's average temperature is above 18°C, and is used to estimate the use of air conditioning to cool buildings.

Growing Season Length

ABOUT THIS INDICATOR

Growing season length is an annual measure that counts the number of days between the first span of at least six days with a daily average temperature greater than 5°C and the first span after July 1 of six days with temperature less than 5°C. It indicates the length of the growing season for typical plants or crops.

PROJECTIONS

In the past, our region had an average of 237 days in the growing season. We can expect 66 days will be added to the growing season by the 2050s, and 100 days by the 2080s, resulting in nearly a year-round growing season of 337 days on average. In forest ecosystems at higher elevations, the growing season will lengthen by more days as higher temperatures creep up the mountains and more days tip over the 5°C threshold. By the 2080s, we will see a growing-season length at higher elevations similar to that projected for the Developed Area (337 days and 349 days respectively).

TABLE 11: GROWING SEASON LENGTH

	Past (days)	2050s (days)	2080s (days)	2050s Change (days)		2080s Change (days)	
				Average	(Range)	Average	(Range)
Region	237	303	337	66	(46 to 80)	100	(85 to 113)
Developed Area	262	322	349	60	(47 to 71)	87	(78 to 94)
Water Supply Watersheds	218	287	328	69	(46 to 86)	110	(89 to 126)
West Coast Watersheds	232	301	337	69	(49 to 85)	105	(92 to 118)

Growing Season Length, Continued

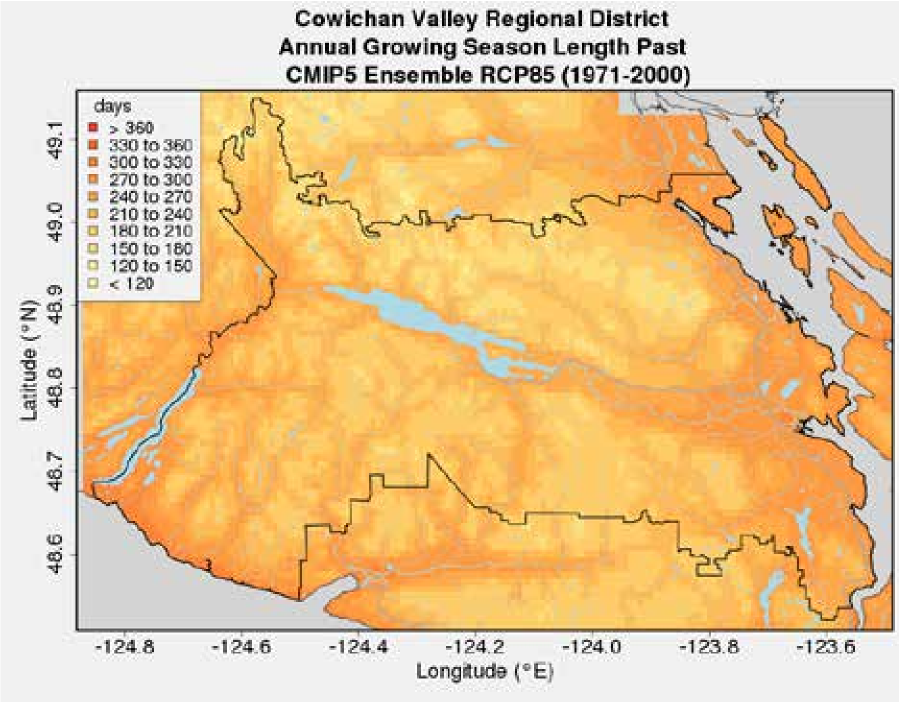


Figure 18: Growing Season Length – Past

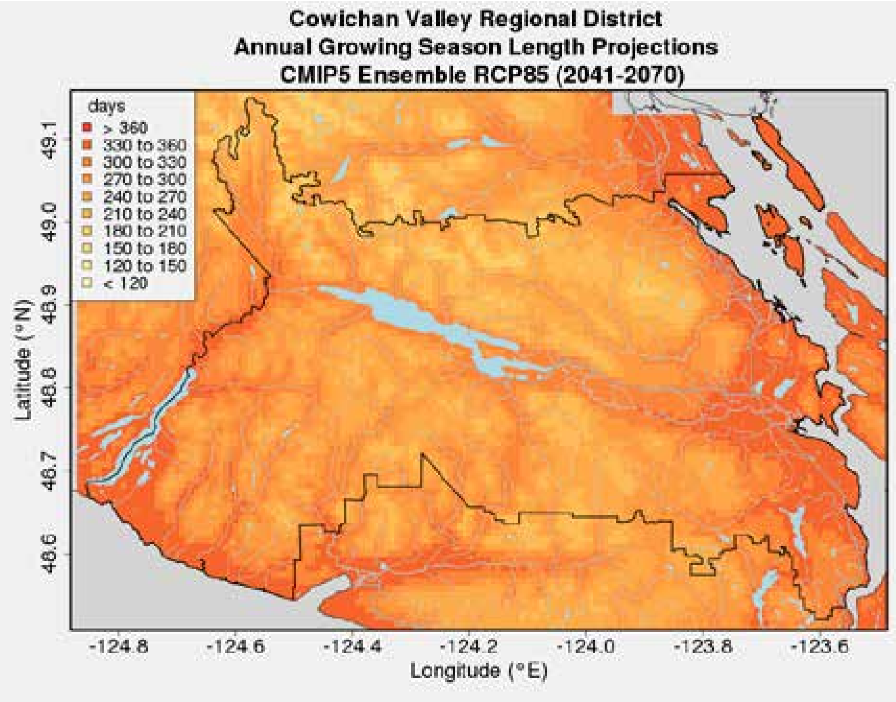


Figure 19: Growing Season Length – 2050s

We can expect 66 days will be added to the growing season by the 2050s, and 100 days by the 2080s.

Growing Degree Days

ABOUT THIS INDICATOR

Growing degree days are a measure of heat accumulation that is useful for agriculture and horticulture. Growing degree days are calculated by how much warmer daily temperatures are compared to a base temperature of 5°C (note: 5°C is used for this report, though different base temperatures may be used for different crops). For example, if a day had an average temperature of 11°C, that day would have a value of 6 growing degree days. Annual growing degree days are the total of adding this for each day of the year. This measure is useful for determining future agricultural opportunities, and to understand drivers of change in ecological systems, for example fish productivity.

PROJECTIONS

In the past, there were 1505 growing degree days on average in our region. Projections indicate increases in growing degree days throughout the region. By the 2050s, we can expect 49% more growing degree days, and 85% more growing degree days by the 2080s. Similar to the growing season length, trends in the sub-regions are in line with regional projections, with slightly more increases in higher elevations.

TABLE 12: GROWING DEGREE DAYS

	Past (degree days)	2050s (degree days)	2080s (degree days)	2050s Percent Change (%)		2080s Percent Change (%)	
				Average	(Range)	Average	(Range)
Region	1505	2238	2807	49	(26 to 74)	85.3	(53 to 121)
Developed Area	1772	2588	3177	46	(25 to 69)	79.4	(48 to 113)
Water Supply Watersheds	1380	2074	2605	51	(26 to 78)	88.8	(54 to 127)
West Coast Watersheds	1384	2079	2611	50	(28 to 77)	88.8	(55 to 126)

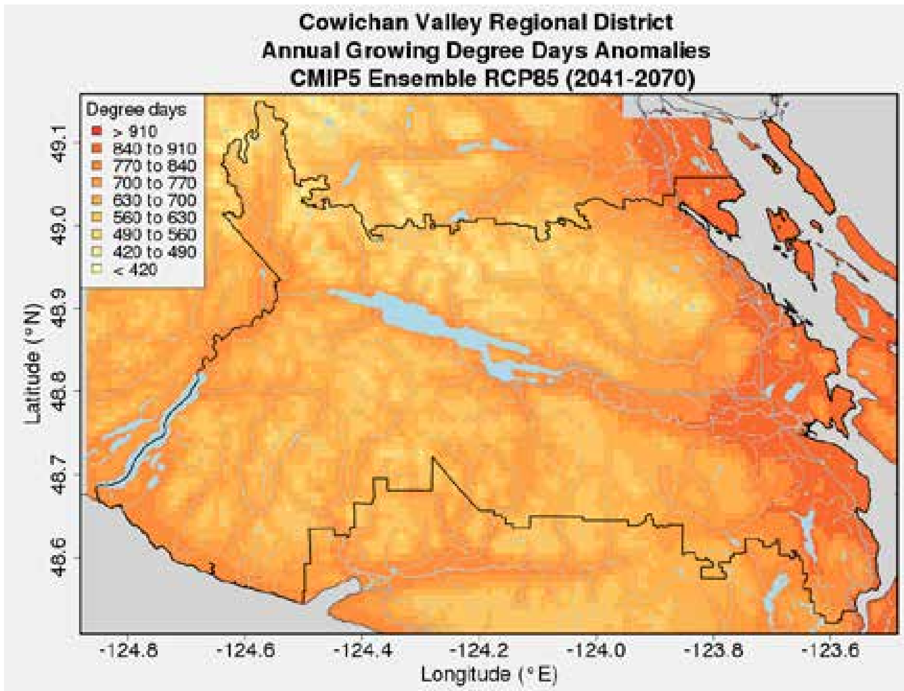


Figure 20: Growing Degree Days – Anomaly

Winter Temperature Indicators

Future climate projections suggest our region can expect to see warmer winter months. These indicators provide insight into the "new normal" for winter temperatures in our region, and are useful when trying to determine how local ecological systems will change over time.

Warmest Winter Day

ABOUT THIS INDICATOR

Warmest winter day is the highest temperature recorded during the winter months, in an average year. This indicator is helpful to understand winter temperature trends when considered in combination with the coldest winter night temperatures below.

PROJECTIONS

By the 2050s, we can expect to see the warmest winter temperature to rise from 12°C to about 14°C. This value may increase to about 17°C by the 2080s (projections range from 14°C to 22°C, depending on the model). Sub-regional trends are similar to regional trends.

TABLE 13: WARMER WINTER TEMPERATURES

	Past (°C)	2050s (°C)	2080s (°C)	2050s Change (°C)		2080s Change (°C)	
				Average	(Range)	Average	(Range)
Warmest winter day	12	14	17	2.7	(0.2 to 5.2)	5.2	(1.8 to 10.3)
Coldest winter night	-10	-6	-3	4.1	(2.3 to 5.7)	6.7	(4.8 to 7.9)
1-in-20 coldest night	-17	-13	-10	3.8	(1.8 to 5.5)	6.5	(4.5 to 7.9)

Coldest Winter Night

ABOUT THIS INDICATOR

Coldest winter night refers to the lowest temperature of the year, usually experienced at nighttime during the winter months.

PROJECTIONS

In the past, the coldest night had a temperature of -10°C. Models project the annual minimum temperature to warm by roughly 4°C by the 2050s, to -6°C, and by about 7°C by the 2080s, to -3°C. In the future, temperatures below freezing will rarely occur anywhere but at the highest elevations. Sub-regional changes are similar to regional projections.

TABLE 14: WARMER WINTER TEMPERATURES IN THE SUB-REGIONS

	Developed Area			Water Supply Watersheds			West Coast Watersheds		
	Past (°C)	2050s Change (°C)	2080s Change (°C)	Past (°C)	2050s Change (°C)	2080s Change (°C)	Past (°C)	2050s Change (°C)	2080s Change (°C)
Warmest winter day	12	2.9 (0.4 to 5.5)	5.5 (2.0 to 10.5)	11	2.7 (0.0 to 5.4)	5.3 (1.8 to 10.7)	11	2.6 (0.1 to 4.8)	5.0 (1.7 to 10.0)
Coldest winter night	-10	4.3 (2.5 to 5.8)	6.8 (4.8 to 8.1)	-11	4.2 (2.3 to 5.8)	6.8 (4.8 to 8.1)	-10	3.9 (2.2 to 5.5)	6.4 (4.6 to 7.6)
1-in-20 coldest night	-16	3.9 (1.8 to 5.8)	6.3 (4.6 to 8.1)	-18	3.8 (1.8 to 5.7)	-6.6 (4.5 to 8.2)	-16	3.5 (1.1 to 5.4)	6.4 (4.3 to 7.9)

1-in-20 Coldest Night

ABOUT THIS INDICATOR

1-in-20 coldest night refers to a nighttime low temperature so cold that it has only a one-in-twenty chance of occurring in a given year. That is, there is a 5% chance in any year that a minimum temperature of this value will occur. This indicator is a marker of extreme winter cold temperatures.

PROJECTIONS

The 1-in-20 coldest night across the region is projected to increase by almost 4°C by the 2050s to -13°C, and over 6°C by the 2080s to -10°C. Sub-regional changes are similar to regional projections.

TABLE 15: ANNUAL HEATING DEGREE DAYS

	Past (degree days)	2050s (degree days)	2080s (degree days)	2050s Percent Change (%)		2080s Percent Change (%)	
				Average	(Range)	Average	(Range)
Region	3659	2793	2290	-24	(-33 to -14)	-37	(-51 to -26)

Heating Degree Days

ABOUT THIS INDICATOR

Heating degree days refers to the number of degrees that a day's average temperature is below 18°C, and is used to estimate the amount of energy used to heat buildings. To determine the number of heating degree days in a month, the number of degrees that the daily temperature is below 18°C for each day would be added to give a total value.

PROJECTIONS

Our region experiences many more heating degree days compared to cooling degree days. Our past regional annual average of heating degree days is almost 3700. Heating degree days are projected to decrease by 24% by 2050s, and by 37% by the 2080s. Sub-regional percent changes are similar, with decreases of 23% to 26% by the 2050s.

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Heating Degree Days, Continued

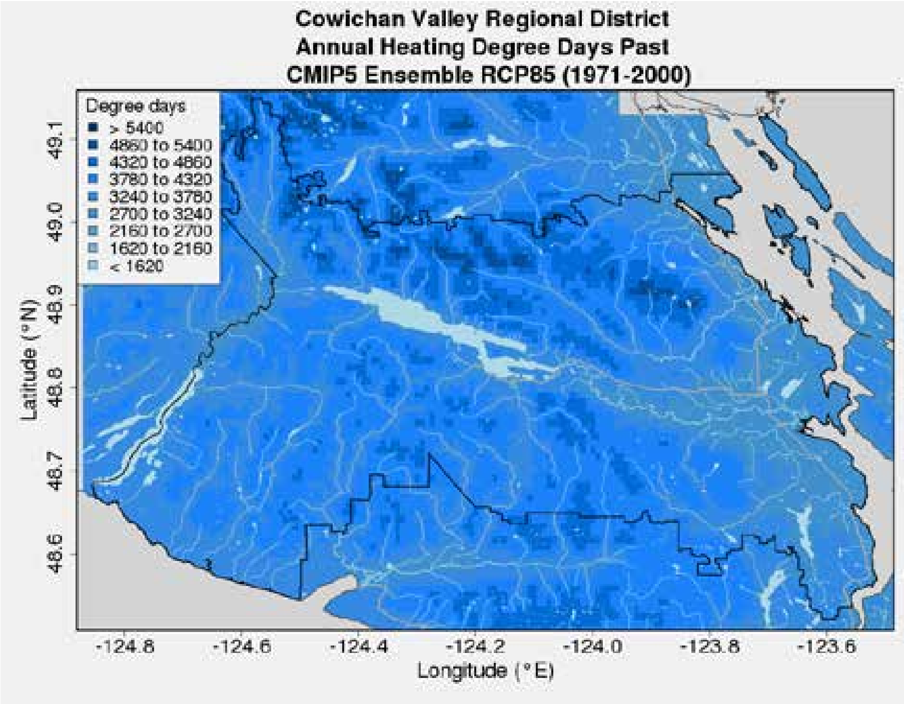

Figure 21: Heating Degree Days – Past

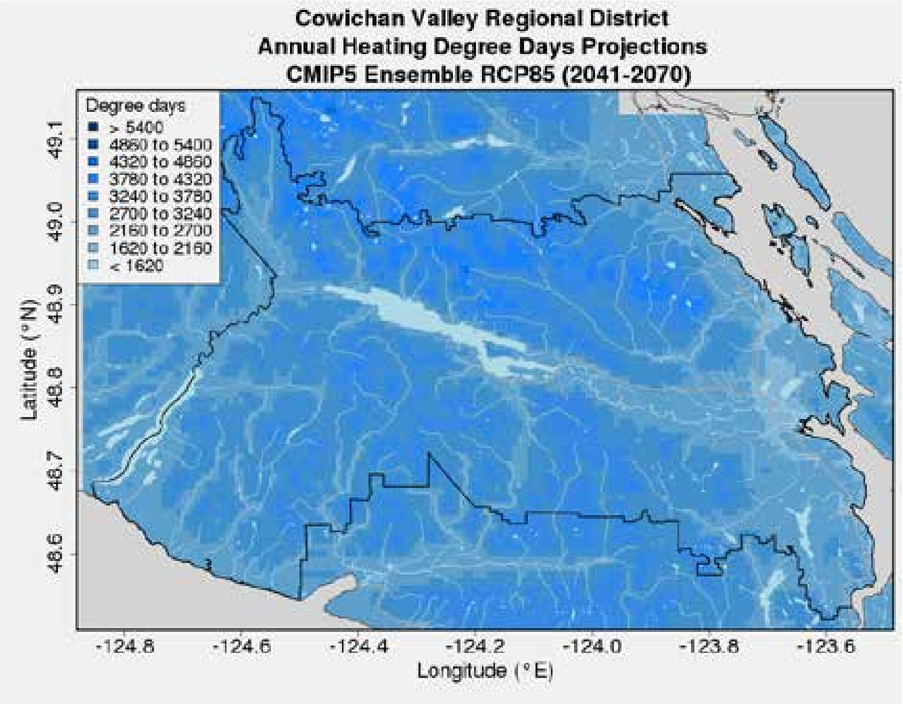

Figure 22: Heating Degree Days – 2050s

Frost Days

ABOUT THIS INDICATOR

Frost days is an annual count of days when the daily minimum temperature is less than 0°C, which may result in frost on the ground. This indicator is useful when predicting which species may thrive in our shifting ecosystem.

PROJECTIONS

In the past, our region had 86 frost days a year. Lower elevations experienced only 66 frost days, while there were 101 days in the Water Supply Watersheds. Future projections indicate the region may expect 32 frost days by the 2050s, and 15 by the 2080s. Changes are relatively uniform across the region. By the 2080s, the "new normal" is a climate that is almost entirely frost-free in lower elevations, with higher elevations experiencing only two to three weeks of frost days a year.

TABLE 16: ANNUAL FROST DAYS

	Past (days)	2050s (days)	2080s (days)	2050s Change (days)		2080s Change (days)	
				Average	(Range)	Average	(Range)
Region	86	32	15	-54	(-66 to -41)	-71	(-80 to -60)
Developed Area	66	20	8	-46	(-56 to -35)	-58	(-63 to -50)
Water Supply Watersheds	101	41	19	-60	(-75 to -46)	-82	(-93 to -68)
West Coast Watersheds	88	33	15	-55	(-69 to -42)	-73	(-82 to -62)

Frost Days, Continued

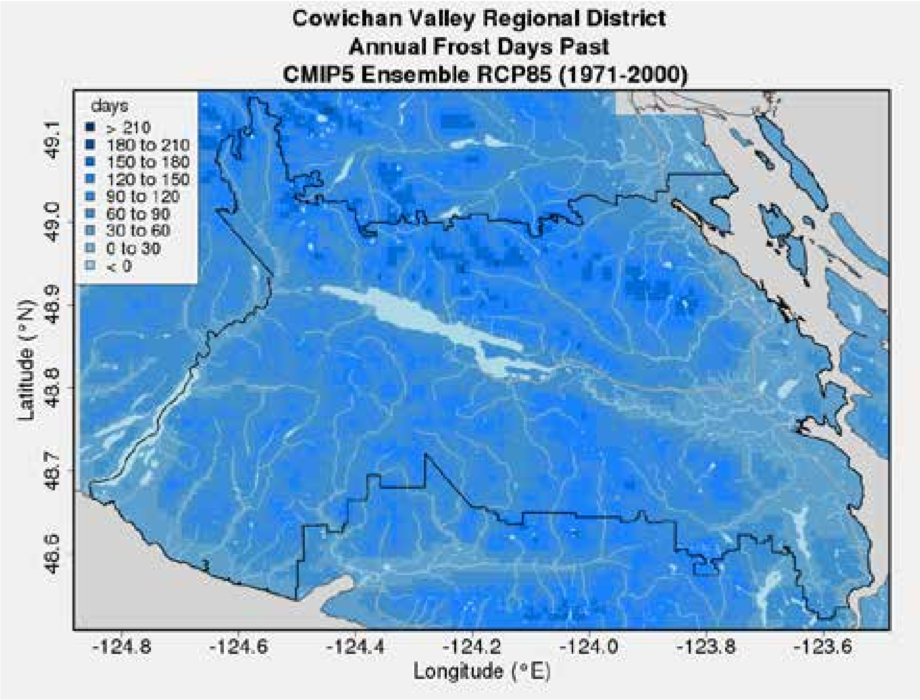

Figure 23: Annual Frost Days – Past

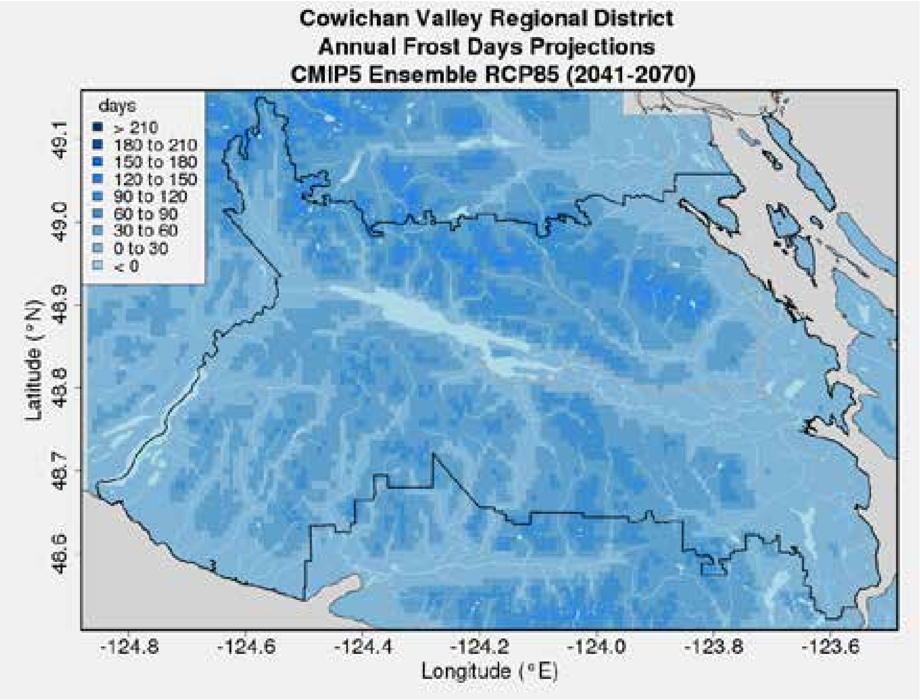

Figure 24: Annual Frost Days – 2050s

Ice Days

ABOUT THIS INDICATOR

Ice days are days when daytime high temperature is less than 0°C.

PROJECTIONS

In the past, our region had on average 6 ice days per year, mainly in areas of higher elevation. Future projections indicate a "new normal" where higher elevation areas experience very few days, if any, when the daily high temperature remains below freezing. The region may expect 2 ice days by the 2050s, and by the 2080s temperatures below freezing will rarely occur anywhere but at the highest elevations, as shown in the plots below.

TABLE 17: ANNUAL ICE DAYS

	Past (days)	2050s (days)	2080s (days)	2050s Change (days)		2080s Change (days)	
				Average	(Range)	Average	(Range)
Ice days (# of days < 0°C)	6	2	0	-4	(-6 to -2)	-6	(7 to -5)

Ice Days, Continued

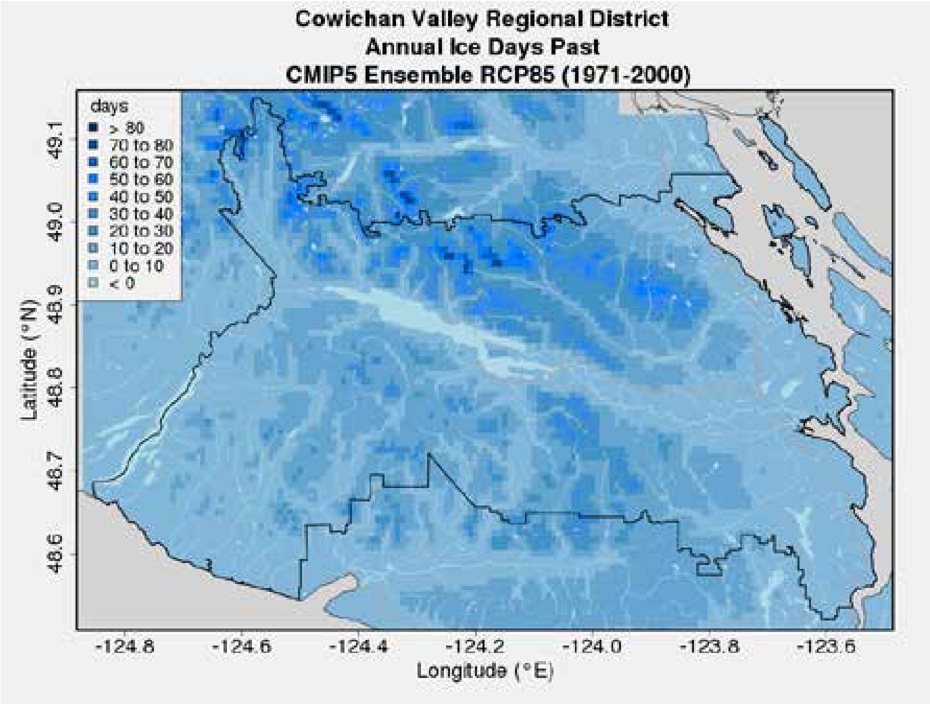

Figure 25: Annual Ice Days – Past

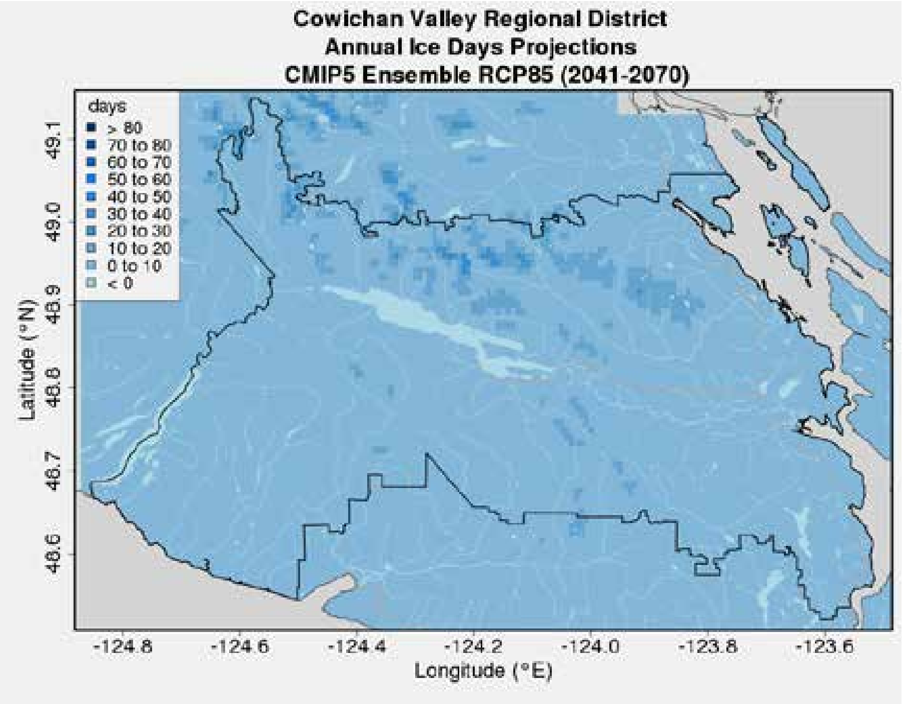

Figure 26: Annual Ice Days – 2050s

Future projections indicate a “new normal” where higher elevation areas experience very few days, if any, when the daily high temperature remains below freezing.

Regional Impacts

The projected changes to our climate discussed in this report will have multiple impacts in our region, and on the land- and water-based ecosystems on which we depend. Temperature rise, and the dramatic increase in variability, or "unusual weather for this season," can expect to cause stress to some and create opportunities for others. This section provides a brief overview of the types of impacts we can expect in various sectors. A more in-depth analysis of these impacts will be the focus of the next phase of New Normal Cowichan, which will explore these in more detail and develop a suite of actions. This report is intended to spark a deeper discussion among community leaders involved in conducting land-use planning, managing and designing safe and sustainable infrastructure, managing the health of our population and ecosystems, and anticipating the economic challenges and opportunities ahead. This will be further examined in the following phases of New Normal Cowichan.

The impacts of climate change are complex and interrelated. For the purposes of this high-level scan they are organized into the following categories:

- Ecosystems and Biodiversity
- Watershed and Groundwater Health
- Health and Well-being
- Infrastructure
- Economic Development
- Bioregional Carrying Capacity

Ecosystems and Biodiversity

As climate change occurs, ecosystems and species can be expected to experience stress, resulting in changes to biological diversity. At a high level, we can predict warmer temperatures and increased variability to upset the timing of biological cycles and strain sensitive habitat. Warmer temperatures will also enhance the potential for invasive species, pests, and pathogens to increase across the region, which are likely to compromise native species.

TERRESTRIAL ECOSYSTEMS (FORESTS, WETLANDS, CONNECTIONS TO AQUATIC ECOSYSTEMS)

While some terrestrial species may thrive in our future climate, others may decline. Longer drought periods, coupled with more intense precipitation at other times, is likely to have an impact on soil chemistry and the soil's capacity to absorb and retain water, which may lead to increased risk of slope failure, overland flooding, stream collapse, and transport of silt to water bodies. Compromised soil conditions and root systems may increase the risk of trees being blown down. An increase in the risk of wildfires can also be expected, further stressing upland forest water-holding capacity, exposing soils directly to the elements, and causing further erosion.

RYAN HETSCHKO

Earlier springs and a longer growing season may cause some species' reproductive and biological cycles to be out of sync with the new climate. Early leaf development could shade the understory of deciduous forests, which could cause species loss and impacts throughout the food chain. We can expect Cedar, a sentinel species to the region already under stress, to reduce in range, while Garry Oak, a rare and imperiled ecosystem, may have the potential to expand in range. New species seeking refuge from a warming south may migrate to our region through a variety of means. With warmer, drier summers, we can expect an increasing scarcity of water, changes to plant growth rates, heat stress, and reduced quality of forage crops.

AQUATIC ECOSYSTEMS AND SPECIES HEALTH

Temperature increases and changes in precipitation over the seasons can be expected to affect our regional water-based ecosystems. Aquatic habitat and species may be stressed in summer by decreasing streamflow, warmer water temperatures, and an earlier freshet. In the fall/winter/spring, aquatic habitat and species will be stressed by increased erosion bringing silt and sediments into watercourses and estuaries. These changes may affect salmon migration and their long-term survival in many of the region's watersheds. Loss of salmon as a key nutrient driver would affect the long-term viability of forest ecosystems particularly with increased rainfall further reducing nutrient levels. Fish species in upland water bodies, and those that migrate between fresh water and the ocean would also be affected by the expected changes to habitat described above. Warmer water also enhances the potential for algal blooms, invasive weed growth, and low oxygen levels that would further stress these sensitive ecosystems.

Watershed and Groundwater Health

WATER SUPPLY AND DEMAND

The majority of our region's drinking water supply comes from groundwater wells, and in some cases regional lakes and rivers, fed by rainfall and snowmelt. With warmer winter weather, more rainfall is expected during extreme events, while snowpack may be compromised, as well as the ability of watersheds, wetlands, lakes, and groundwater wells to hold and store water for summer use. Based on studies undertaken in the Cowichan Valley, existing groundwater recharge rates vary across the region's aquifers. Changes to precipitation patterns and snow will affect the region's groundwater resources unevenly, with some aquifers experiencing lower recharge values and some potentially becoming more productive.

At current levels of water use in our region, we can expect our water supply to be strained during times of the year when temperatures are high and water is in greatest demand. As our population grows, overall groundwater extraction rates can be expected to increase and water conservation will increasingly become a priority. Regional watershed and supply management will be necessary to balance competing water needs with diminishing surface and groundwater supplies.

WATER QUALITY

With warmer temperatures, decreased summer precipitation, and extreme rainfall at times, we may see a decrease in water quality throughout the region. Erosion of upland soils would introduce nutrients, silt, organic materials, and contaminants into our water systems. We may also see a decrease in water quality due to algal blooms, turbidity arising from flash floods and extreme events, and chemical and microbiological contaminants introduced during first flush events. Additionally, drawing down surface reservoirs can be expected to change the natural conditions and will likely have negative effects on water quality. With reduced water quality, surface drinking water systems may be compromised, and existing water treatment facilities may not be adequate.

Health and Well-Being

PHYSICAL

Temperature and precipitation have a direct relationship with air quality and human health. Hotter, drier summer conditions, combined with decreased snowpack, may lead to an increase in wildfire and slash-burning activity. Smoke contributes a significant amount of particulate matter into our air, which is a known human carcinogen. Uncertainty around future wind patterns and temperature inversions may compound this issue. Also, warmer summer temperatures cause increases in ground-level ozone, which can cause breathing problems, trigger asthma, reduce lung function, and cause lung disease, particularly in children, older adults, and people who are active outdoors. Warmer winters could result in less use of fireplaces and wood stoves for heating, potentially improving winter air quality and reducing human exposure to smoke from wood-burning appliances.

> Temperature and precipitation have a direct relationship with air quality and human health.

Hotter, drier summers also cause heat stress and have an impact on human health. Although heat stress may appear less threatening than in areas that already experience hot summers, stress levels may be high because much of the population is accustomed to mild temperatures and is less prepared to accommodate high temperatures. Increased heat stress may require local governments to provide infrastructure to support cool-down areas. In extreme cases, we may see increased allergies and hospitalization of vulnerable populations due to poor air quality, heat stroke, and increases in environmental and vector-borne diseases. Also, as water quality is compromised, it will likely be more difficult to supply clean drinking water to regional citizens.

SOCIAL (SOCIAL NETWORK STRESS, MENTAL HEALTH)

With warmer temperatures, decreased summer The uncertainty posed by our changing climate, and the associated changes in how we are used to living in the region can lead to an increased level of stress and compromised mental

health for individuals in our region. Vulnerable populations who do not have the resources to adapt to heat stress, loss of income, property damage, and other stresses that may come with a changing climate require increased social support. It is prudent to prepare for an increase in at-risk populations requiring assistance and support to protect public health in the future.

EMERGENCY MANAGEMENT

Emergency managers can plan for increased incidence of forest fires, floods, and landslides. Enhanced communications on the expected outcomes of climate change in the region, paired with information on the public's role in emergency preparedness is critical to improving our resilience during future increases in "natural disasters". It is also important for emergency managers to work closely with regional planners to ensure plans are not dependent on critical infrastructure that may be stressed during future extreme events.

Infrastructure

We can expect extreme precipitation events, more intense storms (including increases in localized storms), hotter temperatures, longer dry periods, and year-to-year variability of these conditions to put a strain on existing infrastructure and buildings. With increased flooding, drought, episodic snow events, and heat waves, the business case for "future-proofing" infrastructure will become stronger.

The extreme rainfall indicators illustrate future extreme events may be beyond the frequency and intensity of events for which we are currently prepared. It can be assumed that the trends projected (and their relative intensity) will continue past the end-of-century timeframe presented in this report. This information offers important context for those who design critical infrastructure in our region, and merits further detailed study to inform future Intensity-Duration-Frequency (IDF) curves and other design criteria, especially for infrastructure that is expected to last for many decades.

STORMWATER SYSTEMS

Increases in storm intensity are expected to put significant pressure on our region's stormwater management and drainage systems. Extreme precipitation and an increase in 5-day events may cause drainage systems and streams to overflow, soil saturation, and flooding in low-lying areas.

These impacts may also combine to affect slope stability, leading to increased risk of landslides. This can be expected to cause damage to personal property and public infrastructure.

SEWAGE AND WATER TREATMENT

Our sewage and water treatment facilities will likely struggle to keep up with increased flows during storm events. Increased rainwater inflows to sewage treatment facilities leads to a reduction in system efficiencies, resulting in a higher potential of overflow and impacts to the environment and public health. Overall turbidity in the surface water supply during storm events reduces water quality, resulting in increasing costs of treatment, maintenance, and boil-water orders affecting the community.

ROADS AND TRANSPORTATION

Preparing our transportation networks for the changes ahead requires an updated approach to design, materials, and maintenance programs. Changes to freeze-thaw cycles, shifting precipitation patterns, more frequent flooding events, and increased summer temperatures all have an impact on annual operations and maintenance plans, and long-range planning decisions. Warmer winters may provide more opportunities for year-round active transportation (cycling and walking), and may improve safety at certain times of the year for all road users.

HOUSING AND BUILDINGS

There are opportunities to adapt housing to climate change on a building-by-building scale. The business case for technologies including onsite renewable generation, water capture and reuse, onsite stormwater detention and management, resilient landscaping, green roofs and walls, passive shading, and other alternative building approaches and materials will improve. Other siting parameters will likely become more critical, including the need for compact development in village centres, preservation of natural areas to buffer settlements from future extreme events, and avoiding new infrastructure in areas at risk of flooding. New buildings will likely need to withstand heavier snow loads in some years, higher and more frequent wind speeds, higher temperatures and duration of heat waves, higher maximum rainfalls, and rising sea levels. Additionally, a milder climate may increase indoor air humidity, leading to better conditions for mould and house dust mites, and decrease indoor air quality in some buildings.

There are opportunities to adapt housing to climate change on a building-by-building scale.

ENERGY USE AND DISTRIBUTION

Substantial shifts in energy demand are anticipated as a result of increasing temperatures, with heating demands decreasing and cooling demands increasing over time. Currently, residential buildings are largely cooled by night air. As cooling degree days increase along with the introduction of tropical nights in the Developed Areas, the ability of buildings to cool without mechanical systems will decrease, and energy use for air conditioning may increase. With more buildings requiring energy for cooling, summer energy supply may become a challenge for our region and province. Long-term planning of provincial energy infrastructure could be significantly affected by the projected major shift in province-wide heating and cooling requirements, improving the feasibility of local renewable energy production.

Economic Development

A changing climate brings challenges and opportunities. It is thought that the biggest impacts in economic development will be in the agriculture and forestry industries, while tourism may also be affected. Warmer temperatures and prolonged summer drought, combined with extreme out-of-season storm events can be expected to bring uncertainty to the forestry, agricultural, and tourism sectors.

AGRICULTURE

More growing degree days, along with a reduction of frost days would create a longer growing season in our region. Agricultural producers can expect earlier harvests, and potentially year-round productive growing. This benefit may be challenged by an increase in heat stress, sun scald, invasive species, pests, and plant diseases, which can threaten plant health and crop productivity. An increase in the intensity of spring storms may also damage young plants and their vulnerable root systems, requiring secondary planting some years. Additionally, increased competition for water resources in the region, and inappropriate timing of pollinators, may limit the ability of traditional crops and species to grow.

While some agricultural production may experience challenges, opportunities for diversity and higher crop productivity are also possible. Agricultural managers who are experiencing challenges may need to consider alternative crops, new irrigation systems, enhanced drainage, rainwater capture, nutrient management, livestock management, and soil conditioning techniques. Agricultural producers can expect to feel a shift in energy costs, as heating demand for greenhouses will likely decrease, and cooling needs for greenhouses and livestock facilities will likely increase. Additionally, food security may become an increasingly important issue as global food systems adapt to climate change, and local crop production may vary year to year due to the stressors mentioned above.

FORESTRY

Decreases in snowpack, frost days, and summer precipitation, combined with increasing temperatures, may cause tree growth to decline and mortality rates in vulnerable species to rise. Increased risk of extreme rain events in winter, with their increased erosion potential, can be expected to challenge harvest opening sizes, cut-block orientation, road-building and de-activation practices, slope-stability practices, blow-down prevention, rotation lengths, and commercial viability.

Certain tree species in our region's mountains may migrate to different elevations in search of suitable temperature and precipitation conditions. Forestry managers can expect to consider increased risk of forest fires, lower growth rates, stress to forest health posed by disease and pests, maintenance of infrastructure, and the introduction of new planting patterns and species that will be resilient in our new climate. Water shortages during the dry spells, and associated increases in water cost may have a significant impact on the viability of forestry in our region over the long term.

TOURISM

Like other industries, climate change will likely bring a variety of benefits and challenges to the tourism industry. Warmer temperatures and drier summers may benefit tourism opportunities by attracting visitors in the warmer seasons, though drought conditions and increased temperatures may negatively impact the ability of people to enjoy summer tourism opportunities. Over time, we may see traditional winter sports becoming more difficult to sustain year over year, and these may be replaced by shoulder season or summer recreation activities all year round. Also, as our ecosystems experience stress, some recreation venues may become less attractive, while new economic opportunities may emerge associated with extended "summer-like" conditions.

Bioregional Carrying Capacity

The bioregional carrying capacity refers to the provision of key services for the health and well-being of our population. These services include clean drinking water, clean air, waste management, food security, and the generation of energy.

REGIONAL GROWTH (AND LIMITATIONS TO GROWTH)

Future water supply should be a central consideration when developing strategies to support changing regional demographics and populations. Long-range planners are advised to consider our region's future carrying capacity when planning for regional growth, ensuring substantial additional investments in supporting infrastructure in high-impact areas, and/or potentially limiting growth in these areas. Also, hazards including flooding, landslides, and others will need to be included in future planning frameworks.

MIGRATION TO THE ISLAND (CLIMATE REFUGEES)

Although projections indicate a significant departure from the past, the regional climate is projected to be mild relative to global climate changes, and may lead to new interest in human migration to our region. Our region may need to prepare for an increase in climate refugees, some with means, and others who will likely need support services.

Preparing for the changes ahead will require provincial and regional governments, local authorities, and agencies to work together in developing a local, regional, and bioregional approach.