CLIMATE PROJECTIONS FOR THE CAPITAL REGION

APRIL 2017*

CRD
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EXECUTIVE SUMMARY

Temperatures in the capital region are warming. Global climate models project an average annual warming of about 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 vulnerability and risk assessments, decision-making, and planning in the capital region, with a goal of improving resilience to climate change. For this reason, this report focuses 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. However, the amount of warming by the end of the century will depend more highly on the amount of greenhouse gases (GHG) emitted and captured over the next few decades.

As our climate warms, our region can expect the number of summer days above 25°C to triple, from an average of 12 to 36 days per year. The 1-in-20 year hottest day's temperature is projected to increase from 32°C to 36°C by the 2050s. These rising temperatures will result in a 22% increase in the growing season length and a 49% increase in growing degree days by the 2050s. This projected warming will have implications for regional ecosystems, watersheds, agriculture and horticulture, and communities. Warmer winters mean the region will experience a 69% decrease in the number of frost days, significantly impacting the natural environment, and heating demand for buildings will decrease. The "new normal" is a climate that is almost entirely frost-free at lower elevations.

Annual precipitation projections are a modest 5% increase by the 2050s and 12% by the 2080s. Projections indicate the fall season will see the greatest increase in precipitation. This precipitation is expected during increasingly extreme events, with about 31% more precipitation on very wet days (95th percentile wettest days precipitation indicator) and 68% more on extremely wet days (99th percentile wettest days precipitation indicator). Despite the projected increased intensity of wet events, the amount of rain in summer is expected to decrease by about 20%, while the duration of dry spells will lengthen by about 20%.

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 the Eastern Region (where the majority of the population and agriculture is situated, and the Southern Gulf Islands), the Western Region (Juan de Fuca Electoral Area), and the Greater Victoria Water Supply Area. In particular, the wettest areas in the mountains on the west coast will become even wetter. However, with warmer temperatures and more precipitation falling as rain, the April 1 snowpack depth, at the higher elevations in the region, is projected to decrease by more than 90% by the 2080s.

This document is intended to support decision making throughout the region and to help community partners better understand how their work may be affected by our changing climate.

CONTRIBUTING AUTHORS

Trevor Murdock and Stephen Sobie from Pacific Climate Impacts Consortium conducted downscaling of climate modelling, analysis, data interpretation, and provided valuable suggestions for the report.

Gillian Aubie Vines from Pinna Sustainability served as a lead writer of this report.

ACKNOWLEDGEMENTS

We would like to acknowledge the effort and input received from CRD staff, municipal staff, and the CRD Climate Action and Integrated Watershed Management Inter-Municipal Working Groups in the development of this report.

Finally, we would like to recognize the support of Lillian Zaremba, Metro Vancouver Regional District, and Kate Miller, Cowichan Valley Regional District. Working together ensures that we build on each other's success and create resilient regions.

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Acronyms

- BCCAQ Bias Correction/Constructed Analogues with Quantile mapping reordering
- CMIP5 Coupled Model Intercomparison Project 5
- CRD Capital Regional District
- ENSO El Niño-Southern Oscillation
- ETCCDI Expert Team on Climate Change Detection and Indices
- GHG Greenhouse Gas
- IPCC Intergovernmental Panel on Climate Change
- PCIC Pacific Climate Impacts Consortium
- PDO Pacific Decadal Oscillation
- RCP Representative Concentration Pathway

Tables

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1. INTRODUCTION

The Capital Regional District (CRD) has undertaken this study to prepare our region for the impacts of climate change. To support this, the Pacific Climate Impacts Consortium (PCIC) has produced high-resolution regional projections to understand the details of how our climate may change by the 2050s and 2080s. Information provided in this report is intended to describe a plausible future and to provide our region's decision makers with an improved understanding of projected local climate change for temperature, precipitation, and related indices of extremes. 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. This document is not intended to offer a holistic analysis of impacts or serve as design guidelines for future planning.

Sea level rise, which does not require the same type of analysis used for temperature and precipitation to examine regional impacts, was not included in this study. A sea level rise planning project was undertaken by the CRD, with local governments, in 2015. The first phase prepared a Coastal Sea Level Rise Risk Assessment Report to further understand regional coastal vulnerabilities to sea level rise. The second phase resulted in the development of the Sea Level Rise Planning Approaches Project Report, a toolkit of prioritized planning, regulatory and site-specified tools specific to the CRD and its local governments. These studies were undertaken to advance local governments' understanding of sea level rise implications and potential planning tools. It is anticipated that, when released, provincial guidelines will provide further guidance to local governments. Due to the connectivity and interactions between marine and terrestrial systems, adaptation planning in our region will require detailed assessments of sea level rise in combination with other local conditions, such as subsidence and wave effects.

A selected number of standard climate indicators are offered in this report as key properties of the regional climate system. Taken together, they tell a story of how our climate is expected to change over time. The first section offers a general description of our changing climate, followed by sections on precipitation, summer temperatures, and winter temperatures. Each section includes a description of each indicator, along with a summary of projected trends.

The second section of this report identifies potential impacts of climate change on different sectors within our region. These include human health, rainwater management and sewerage, water supply and demand, tourism and recreation, our transportation network, ecosystems and species, buildings and energy systems, and food and agriculture. This information on potential impacts will assist those charged with planning for the future and help the community at large to understand their role in preparing for climate change.

2. METHODOLOGY

Climate Scenario Selection

Various future trajectories of GHG emissions are possible, and they depend directly on global political initiatives and socio-economic changes over the coming years. This report presents a recognized roughly "business as usual" GHG emissions scenario for the remainder of the century, known as Representative Concentration Pathway 8.5 (RCP8.5).

Additional information from lower emissions scenarios (RCP4.5 and 2.6) and projections for the 2020s time period are available from the CRD Climate Action Program for sensitivity analysis, and to illustrate the relationship between adaptation and GHG emissions reductions or mitigation. 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 predicted to keep global warming below 2°C above pre-industrial temperatures. The projected global temperature change is illustrated on page 3.

Representative Concentration Pathways (RCP)

RCP describe potential 21st century scenarios of GHG emissions, atmospheric GHG concentrations, aerosols, and land use. These RCP 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 RCP directly relate to the choices made by global society.

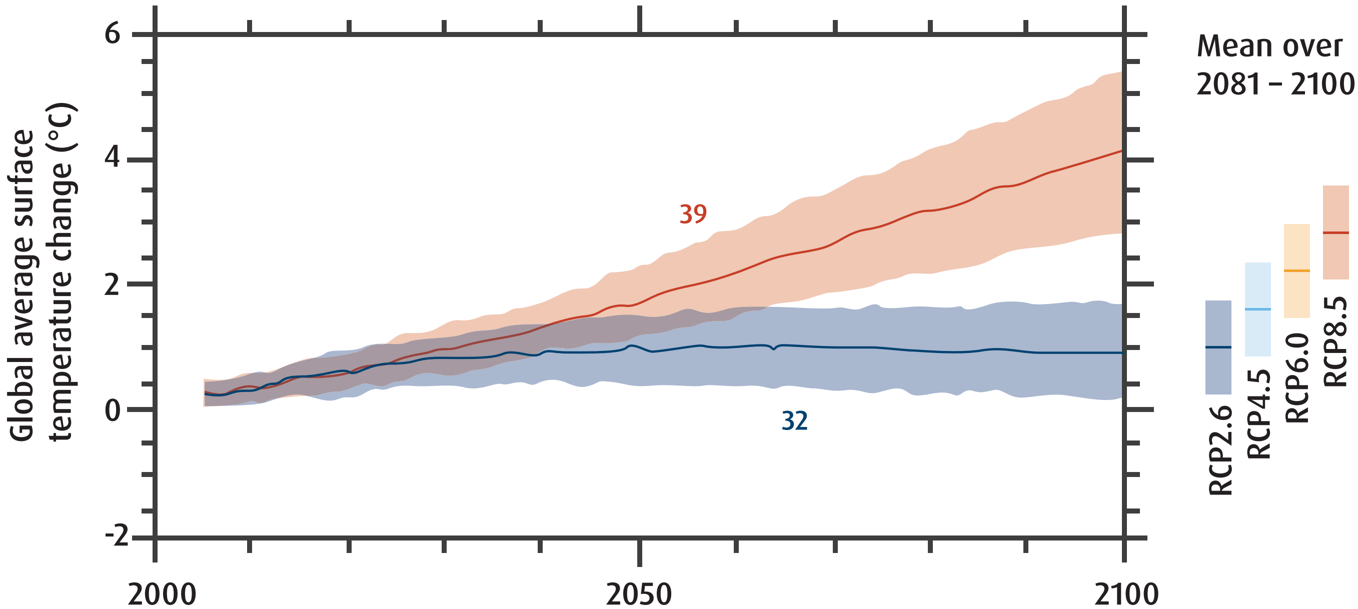


Figure SPM.6(a) from IPCC's Climate Change 2014. Synthesis Report shows modeled global average surface temperature change relative to 1986–2005. The mean of the projections (lines) and a measure of uncertainty (shading) are shown for RCP8.5 (red) and RCP2.6 (blue). The number of climate models used to 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 by PCIC from the Coupled Model Intercomparison Project 5 (CMIP5). The CMIP5 climate models were first screened to remove those that least accurately represented historical data. From the remainder, an ensemble of 12 models was chosen to provide the widest range of projected change for a set of climate parameters.

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

About Climate Models

More information about climate models is available from the Pacific Institute for Climate Solutions' Climate Insights 101 course.

Global climate models: **http://pics.uvic.ca/insights/module1_lesson4/player.html**

Regional climate modelling and impacts in British Columbia: **http://pics.uvic.ca/education/climate-insights-101#quicktabs-climate_insights_101=1**

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 2050s (which is an average of modelled values over the 2041–2070 period) and 2080s (2071–2100). The three RCP scenarios previously described 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.[1] The indicator names in this report have been translated into plain language, with the original CLIMDEX names provided in the tables for reference. 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) monthly values in that season or year.

Average or mean of model ensemble

10th percentile of model ensemble

90th percentile of model ensemble

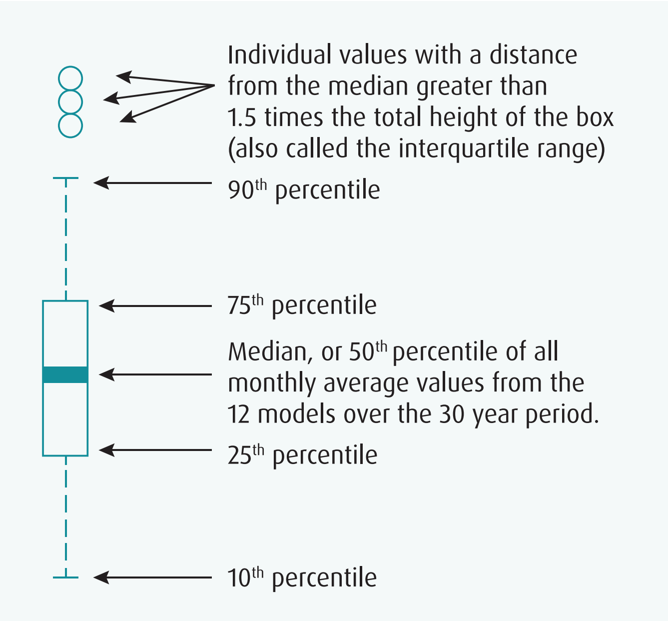
	Past (°C)	2050s Change (°C) Average (Range)	
Winter	5	2.4	(1.3 to 3.0)
Spring	12	2.9	(1.7 to 4.7)

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 mean 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.
- Values in tables are averaged over the entire region (within the regional boundary shown on the maps), unless labelled as Eastern Region (Greater Victoria and Southern Gulf Islands), Western Region (Juan de Fuca Electoral Area), or Greater Victoria Water Supply Area.
- Maps show only the mean 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 A.
- 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. To be precise, 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.

[1] http://www.climdex.org/indices.html



Interpretation

This report tells the story of how we can expect temperature and precipitation to change in the capital 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 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 averages presented in the tables. These values can be obtained by looking at the maps presented in the report body and in Appendix A.

3. GENERAL CLIMATE PROJECTIONS

The capital region can expect noticeable changes to our climate in the coming decades. At a high level, the region can expect:

- Warmer winter temperatures
- Fewer days below freezing
- More extreme hot days in summers
- Longer dry spells in summer months
- More precipitation in fall, winter, and spring
- More intense extreme events

These changes will not always happen consistently over the region or over time, as seasonal and yearly variations will occur. For most variables, projected change appears somewhat different from the past by the 2050s. By the 2080s, projections indicate substantial changes, resulting in a very different lived experience than the capital region of today. This is particularly true for the temperature-related variables, as the projected change is larger, compared to the year-to-year variability, for temperature than for precipitation.

This section of the report presents general projections 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.

Warmer Temperatures

About this Indicator

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

Projections

All models project daytime high and nighttime low temperatures to 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 3.3°C) in summer. By the 2080s, we can expect summer daytime highs to increase by more than 5°C.

Nighttime lows are also projected to rise in all seasons by over 2°C by the 2050s and by more than 4°C by the 2080s, resulting in an average winter nighttime low of approximately 4°C by the 2050s. Summer nighttime lows are also projected to increase dramatically, from 10°C in the past to approximately 15°C by the 2080s.

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

TABLE 1: REGIONAL AVERAGE DAYTIME HIGH TEMPERATURE (TASMAX)

	Past (°C)	2050s Change (°C)		2080s Change (°C)	
Winter	6	2.4	*(1.3 to 3.3)*	4.4	*(2.6 to 6.4)*
Spring	12	2.7	*(1.6 to 4.5)*	4.3	*(2.7 to 7.0)*
Summer	20	3.3	*(2.1 to 4.2)*	5.2	*(3.7 to 7.0)*
Fall	13	2.6	*(1.4 to 3.8)*	4.3	*(2.8 to 5.9)*
Annual	13	2.8	*(1.5 to 3.9)*	4.5	*(2.9 to 6.2)*

TABLE 2: REGIONAL AVERAGE NIGHTTIME LOW TEMPERATURE (TASMAX)

	Past (°C)	2050s Change (°C)		2080s Change (°C)	
Winter	1	2.6	*(1.6 to 3.3)*	4.4	*(3.2 to 5.4)*
Spring	3	2.5	*(1.7 to 3.6)*	4.1	*(2.8 to 5.8)*
Summer	10	2.8	*(1.8 to 4.0)*	4.7	*(3.3 to 6.5)*
Fall	6	2.6	*(1.6 to 3.8)*	4.3	*(2.8 to 5.6)*
Annual	5	2.6	*(1.7 to 3.7)*	4.3	*(3.0 to 5.8)*

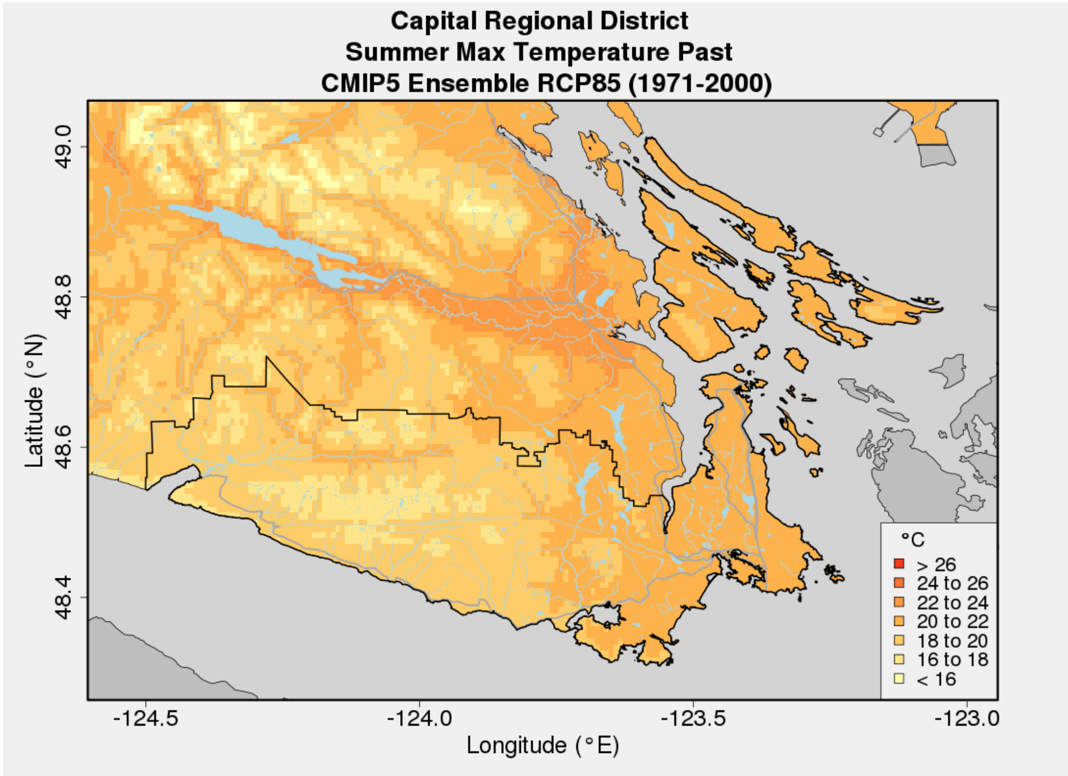


Figure 1: Summer Average Daytime High Temperature – Past

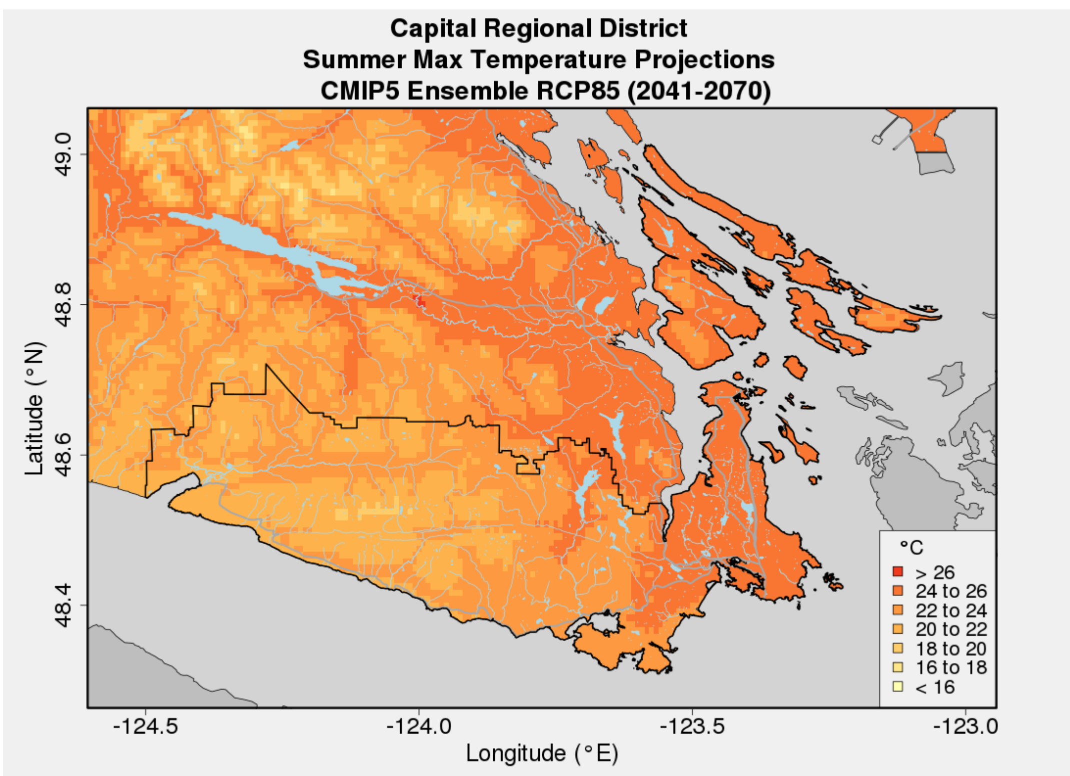


Figure 2: Summer Average Daytime High Temperature – Future (2050s)

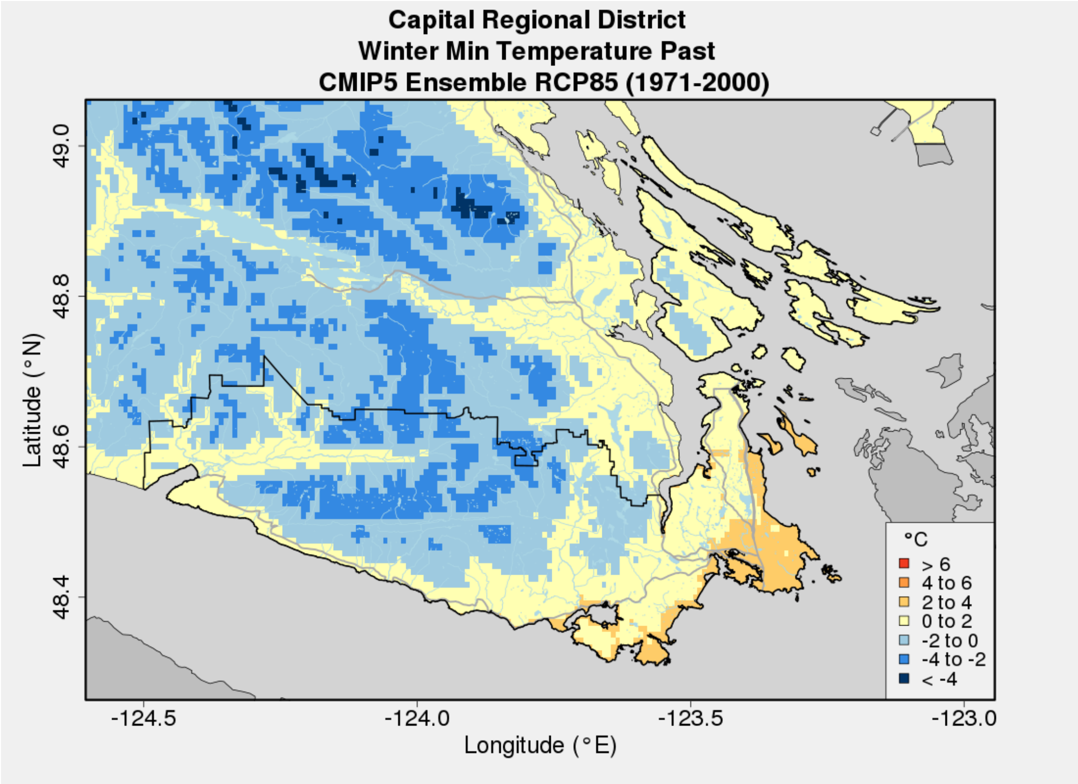


Figure 3: Winter Average Nighttime Low Temperature – Past

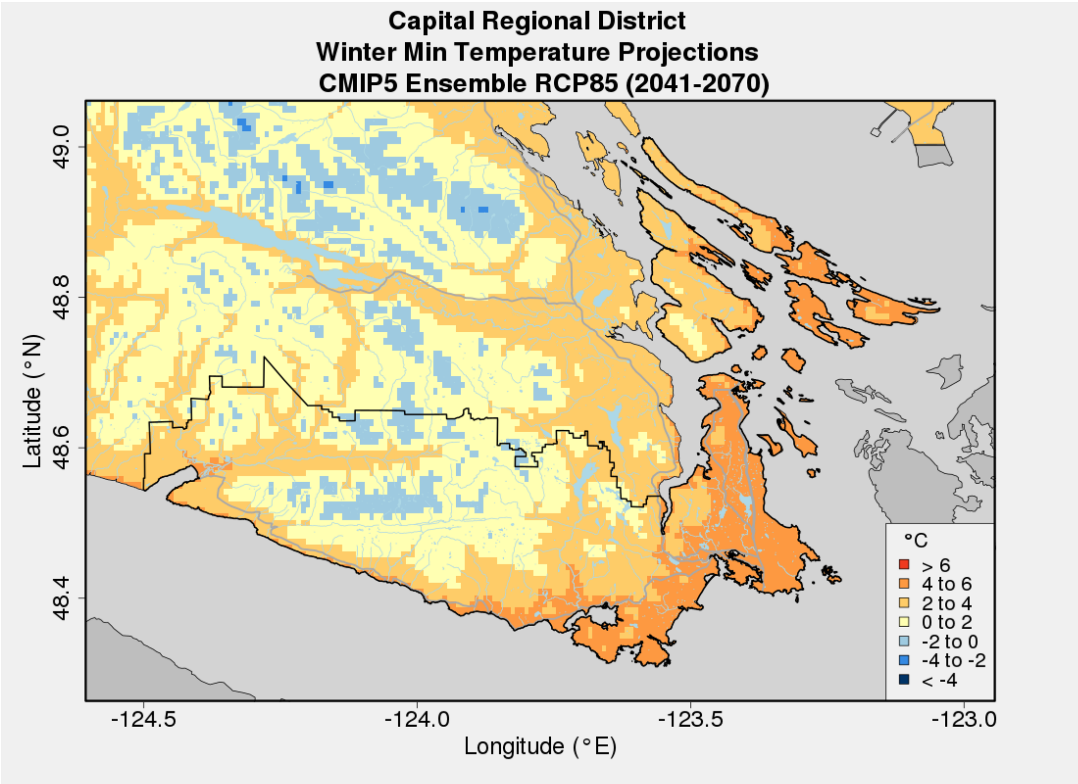


Figure 4: Winter Average Nighttime Low Temperature – Future (2050s)

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 an increase of 12% by the 2080s. While these increases alone are not a dramatic departure from the past, the increase in precipitation will be distributed unevenly over the seasons.

In our region, most precipitation occurs during the winter months, and this will continue to occur in the future. The largest percentage increase in rainfall will occur in the fall season, increasing 11% by the 2050s and 21% by the 2080s. Winter and spring precipitation are both projected to increase as well. Summer, already our region's driest season, is projected to experience a decline of 18% 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 AND YEAR (PR)

	Past (mm)	2050s (mm)	2080s (mm)	2050s Change (%)		2080s Change (%)	
Winter	680	714	782	5	*(-3 to 11)*	15	*(3 to 28)*
Spring	328	345	352	5	*(-5 to 14)*	8	*(-6 to 19)*
Summer	125	103	92	-18	*(-41 to 4)*	-26	*(-50 to -6)*
Fall	504	558	605	11	*(-4 to 26)*	21	*(7 to 40)*
Annual	1660	1743	1857	5	*(1 to 10)*	12	*(4 to 17)*

These maps show the amount of precipitation that is projected during the fall season, and indicates that the wetter areas will remain wet, with the largest increases in precipitation expected in the higher elevations of the Western Region.

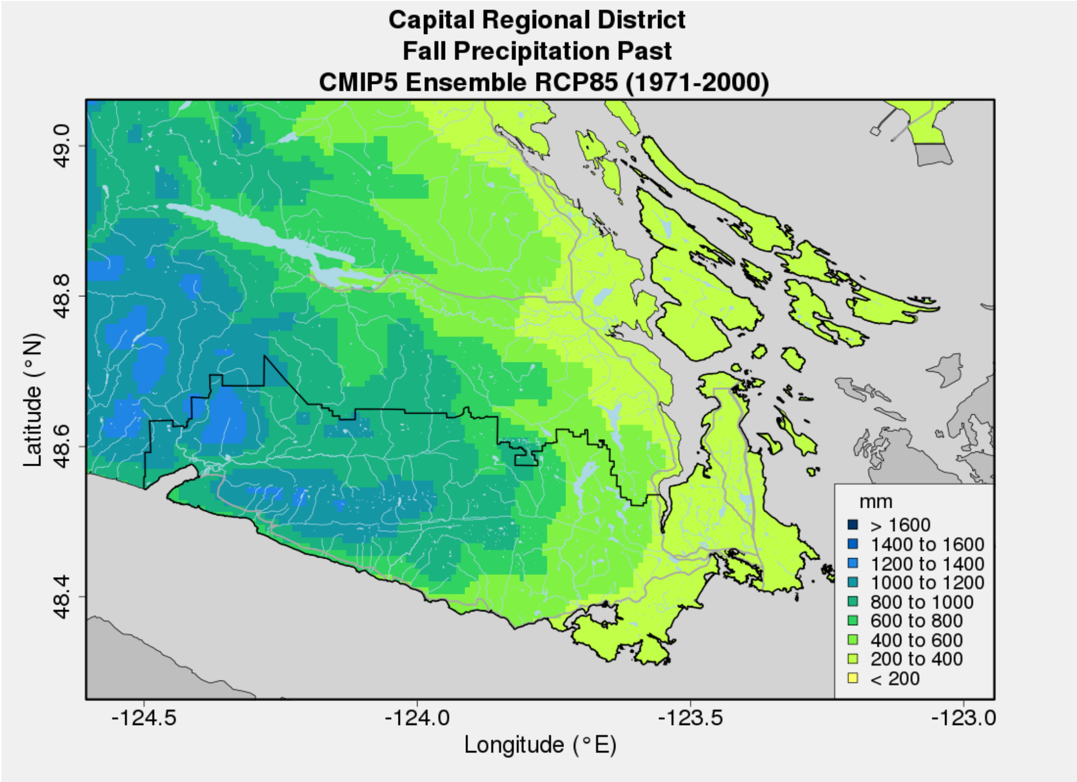


Figure 5: Fall Precipitation – Past

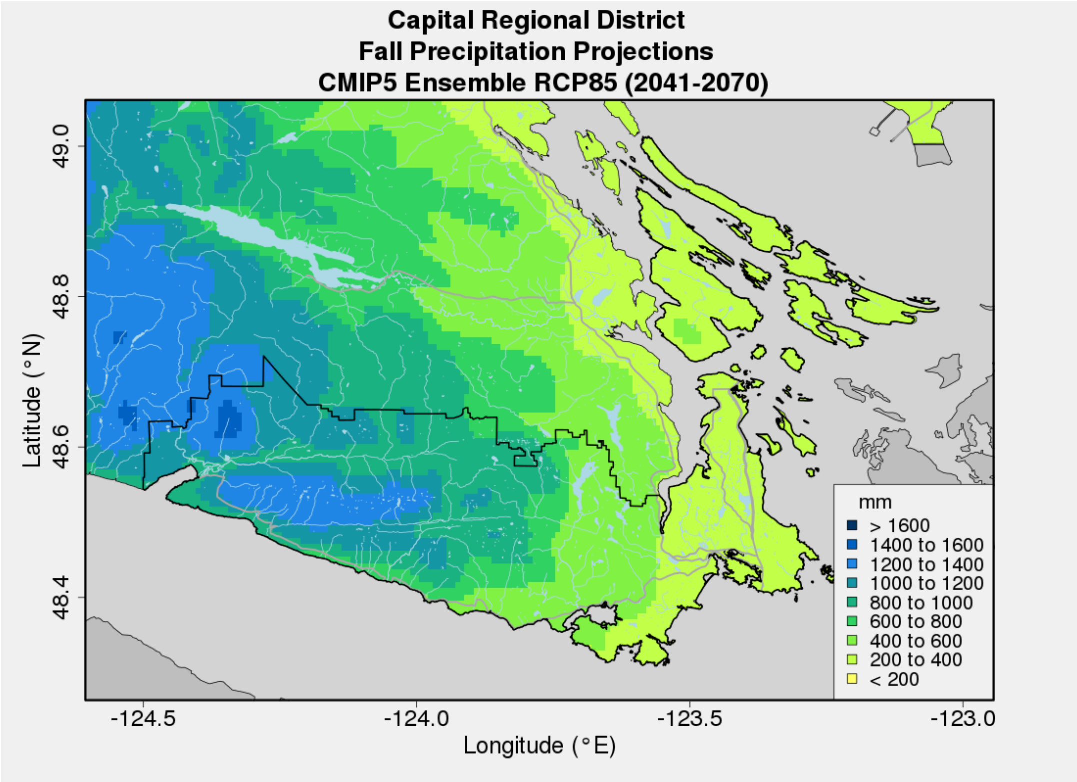


Figure 6: Fall Precipitation – Future (2050s)

Seasonal Variablility in Precipitation

The monthly precipitation values in the plot below suggest that increases within a season will not be uniform across months. For example, October and November show the largest increases in median precipitation for the fall, and December shows the largest increase in winter. The plot also projects much drier summer months than we have ever experienced. September is projected to get drier over time, extending and amplifying the dry season. The models illustrate that we can expect more precipitation in the already wet seasons, less precipitation in already dry summers, and a high level of annual variability, with considerably more precipitation falling in some years, while other years will experience droughts.

In southwestern British Columbia, 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 years that typically mean a warmer and drier winter and spring, and La Niña years that are cooler and wetter.

The range of the natural variability in temperature and precipitation during PDO and ENSO cycles is comparable to the projected changes due to climate change. Because future projections are based on 12 models, the values in the tables reflect 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 Totals in the Capital Region

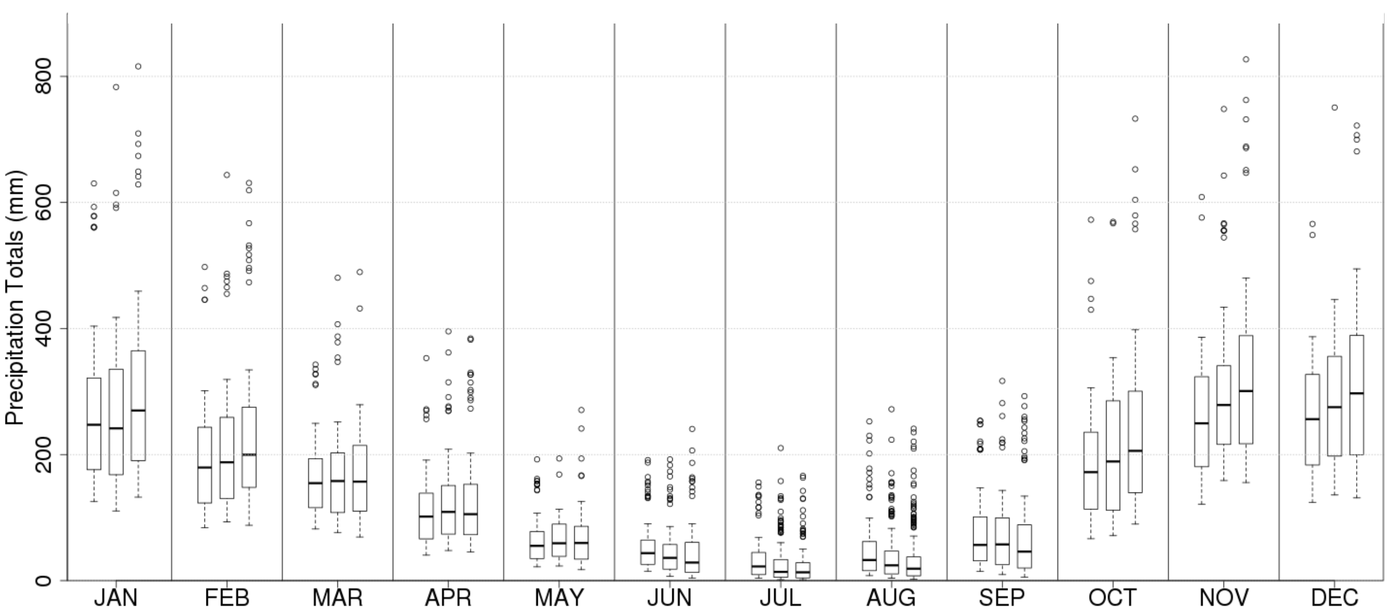


Figure 7: Monthly Total Precipitation – Past, 2050s, and 2080s

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 (Figure 8) shows that the median daytime high in the 2050s will be hotter than the 90th percentile in the past, in all months. Furthermore, in July, August, and September, 75% of these months will be warmer in the future than the 25% warmest of these months in the past. In the 2080s, most September temperatures will be hotter than past August temperatures, and January daytime highs will be similar to past March temperatures.

In terms of nighttime lows monthly temperature, about 50% of past Januarys average temperatures were above freezing for the region as a whole. By the 2050s, 90% of Januarys and Decembers are expected to be above freezing on average. In past summers, cooler nighttime temperatures offered relief from hot days. By the 2050s, over 75% of monthly average nighttime lows in the future are warmer than the warmest 25% in the past, for the months of April through October. These projections indicate a future that has little in common with our current climate in terms of nighttime low temperatures.

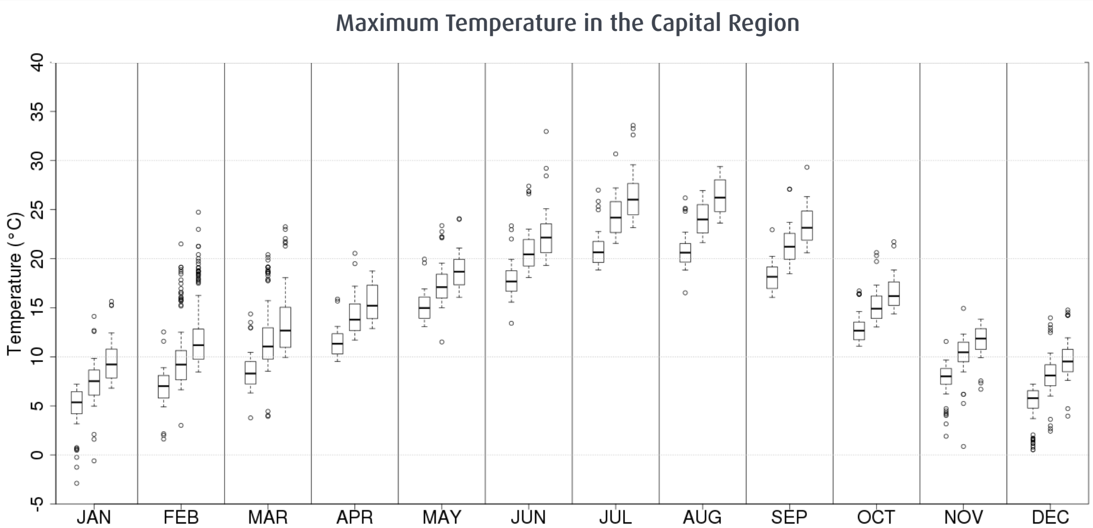


Figure 8: Monthly Daytime High Temperature – Past, 2050s, and 2080s

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 in the Methodology section.

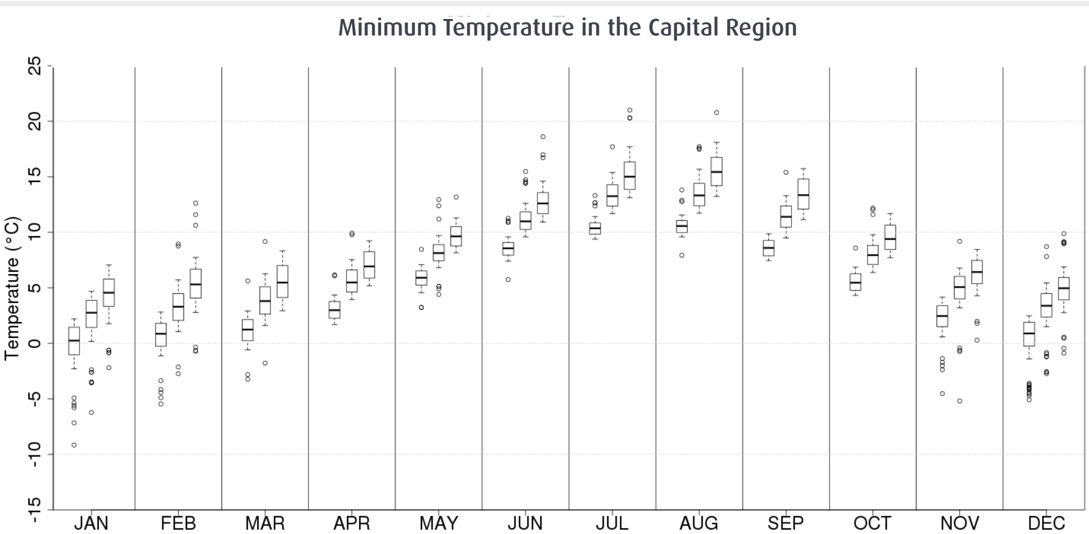


Figure 9: Monthly Nighttime Low Temperature – Past, 2050s, and 2080s

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

4. PRECIPITATION INDICATORS

The downscaled outputs from the climate models project a shift in precipitation patterns, both in seasonality and intensity, with longer dry spells in summer months and more precipitation in fall, winter and spring.

The majority of the region's drinking water comes from surface water reservoirs, with some areas supplied by groundwater wells. Changes in precipitation patterns, accompanied by higher demand for water during summer dry spells, could have impacts on water supply and water quality.

Stormwater infrastructure, both engineered and natural, will need to withstand extreme weather events. As the climate warms, more moisture is held in the atmosphere and released during precipitation events, resulting in more extreme storm events in the future.

Snowpack

Snowfall in the region typically accumulates and persists consistently only at the highest elevations during the winter. There is considerable annual variation in the occurrence, amount, and duration of snow, with low elevations remaining snow-free for most of the winter. Unlike most of British Columbia, snowpack plays a minor role in water supply in the region.

About this Indicator

Snowpack refers to the depth of snow on the ground, either daily depth averaged over a season, or in the case of the April 1 snowpack, the snow depth on that specific date. The snowpack indicator can assist in determining how much snowmelt will be available to flow into our region's watersheds and reservoirs.

Projections

Snowpack is projected to decrease significantly over time. As would be expected, our region's snowpack is highest in the winter months, with average winter snowpack depth measuring 15 cm. Projections indicate a 91% decrease in April 1 snowpack by the 2050s for the region as a whole. The maps illustrate that snow will only be present in the highest of elevations in the region. By the 2080s, projections indicate almost no snowpack at any locations.

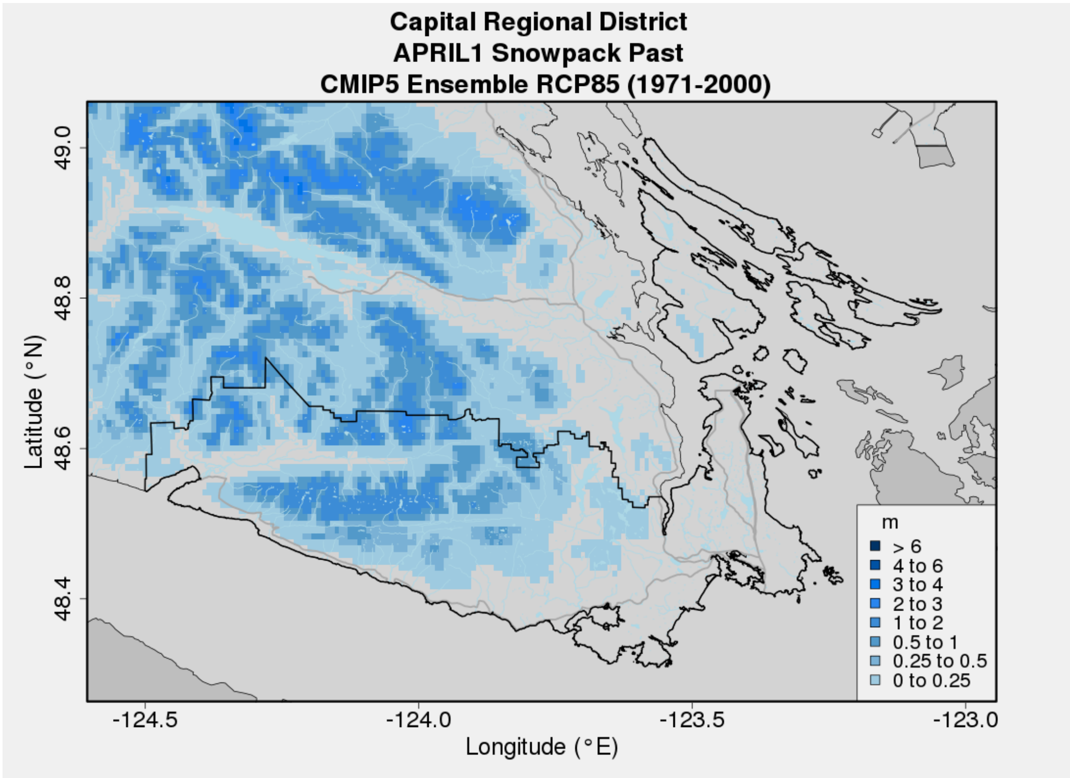


Figure 10: April 1 Snowpack – Past

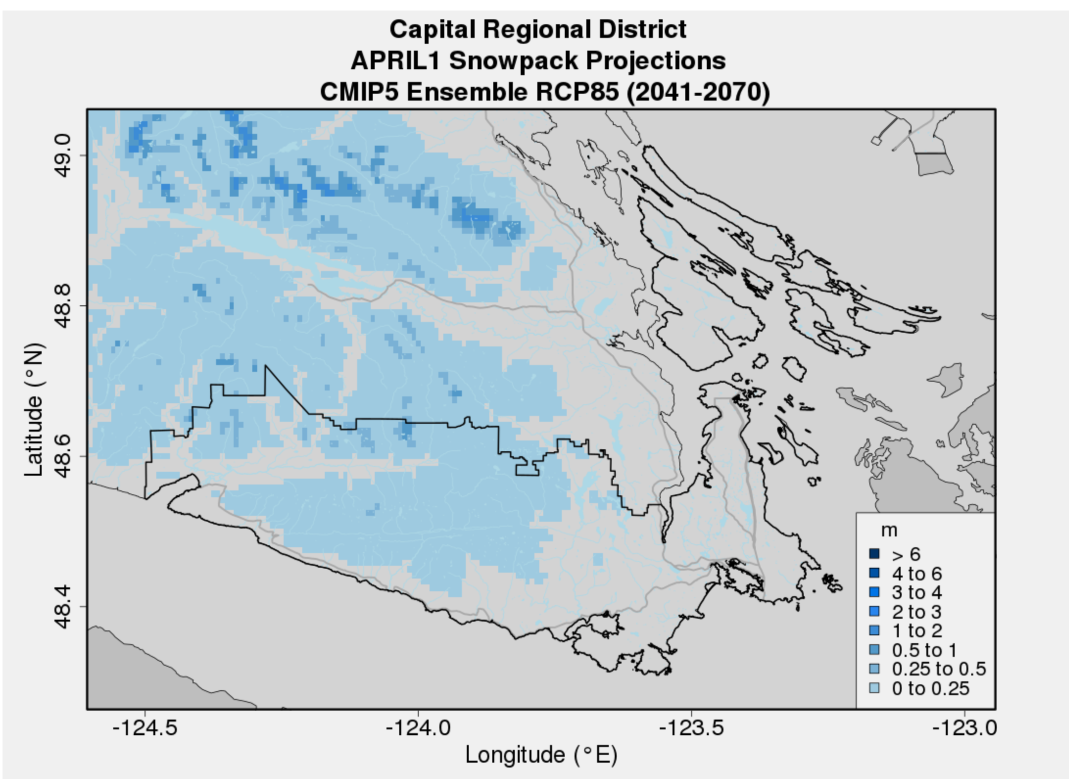


Figure 11: April 1 Snowpack – Future (2050s)

Single-Day Maximum Precipitation

About this Indicator

Single-day maximum precipitation describes the amount of precipitation that falls on the wettest day of the year, on average.

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 will see an average of 20% more rain by the 2050s, and 35% more by the 2080s. The wettest day of the year could occur anytime from September to May, but particularly in the fall season.

5-Day Maximum Precipitation

About this Indicator

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

Projections

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. In the future, we can expect the amount of rain in the wettest 5-day period to increase by an average of approximately 12% by the 2050s, and 26% by the 2080s. The most significant increase in 5-day maximums is projected to take place in the fall season.

TABLE 4: EXTREME RAINFALL

	CLIMDEX Index	Past (mm)	2050s Change (%)		2080s Change (%)	
Single-day maximum precipitation	Rx1day	70	20	*(2 to 37)*	35	*(11 to 54)*
5-day maximum precipitation	Rx5day	156	12	*(1 to 24)*	26	*(6 to 37)*
95th-percentile wettest days precipitation	Rx95day	380	31	*(9 to 63)*	59	*(38 to 87)*
99th-percentile wettest days precipitation	Rx99day	118	68	*(30 to 123)*	126	*(60 to 192)*

95th-Percentile Wettest Days Precipitation

About this Indicator

The 95th-percentile wettest days precipitation indicator describes the total amount of precipitation 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 that exceed the 95th-percentile threshold amount occur, and the total rain during these events.

Projections

The wettest periods in our region are projected to become wetter. The wettest days that exceed the baseline 95th-percentile threshold could produce roughly 31% more rain by the 2050s, and 59% more rain by the 2080s. Most of this increase in precipitation on heavy days is due to those days becoming more frequent in future and the rest is from an increase in the amount of precipitation during each event.

99th-Percentile Wettest Days Precipitation

About this Indicator

The 99th-percentile wettest days precipitation indicator points to the total amount of precipitation 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 that exceed the 99th-percentile threshold amount occur, and the total amount of rain during these events.

Projections

More precipitation is expected to fall during the 99th-percentile wettest days extreme storm events in the future. Precipitation from larger 99th-percentile wettest days events could increase by up to 68% by the 2050s, and 126% by the 2080s. Most of this increase in rain during high rainfall days is due to those days becoming more frequent in future.

1-in-20 Wettest Day Precipitation

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.

Projections

More precipitation is expected to fall during the 1-in-20 (or 5% chance) wettest day extreme storm events in the future. Larger 1-in-20 wettest day events could mean over 30% more rain by the 2050s, and almost 40% by the 2080s.

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, and when vegetation can experience more extreme moisture stress in the dry months.

Projections

The past average longest period of consecutive days without rain (under 1 mm) in our region is 25 days. Dry spells on average are expected to increase to 30 days by the 2050s, and 33 days by the 2080s.

TABLE 5: 1–IN–20 WETTEST DAY PRECIPITATION (RP20 PR)

	Past (mm)	2050s Change (%)		2080s Change (%)	
Region	120	31	*(9 to 59)*	39	*(13 to 69)*

TABLE 6: ANNUAL DRY SPELLS (CDD)

CDD	Past (days)	2050s (days)	2080s (days)	2050s Change (%)		2080s Change (%)	
Dry Spells	25	30	33	22	*(9 to 37)*	33	*(16 to 51)*

5. SUMMER TEMPERATURE INDICATORS

The downscaled outputs from the climate models project increases in average summer (June-July-August) daytime high temperatures that suggest that summer temperatures will be much warmer in the future than in the past. 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. This section provides descriptions of the indicators and values for these projections.

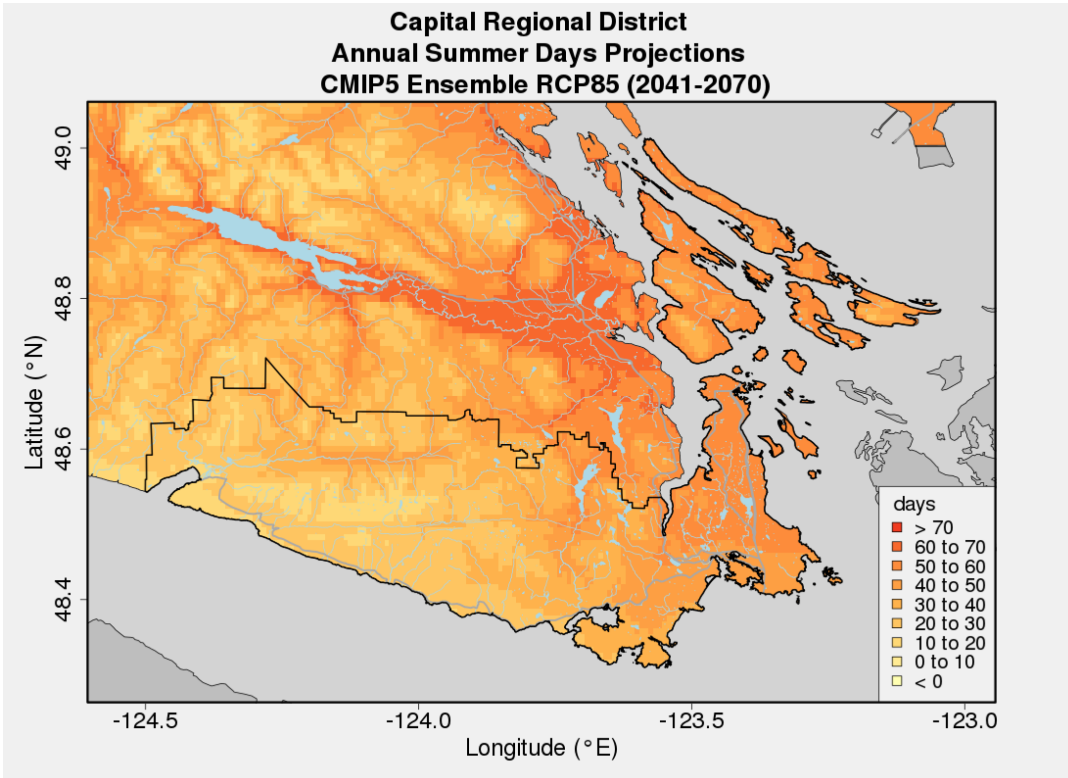


Figure 12: Summer Days – Future (2050s)[12]

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 an average of 12 summer days a year, and we can expect significantly more summer days in the future. The ensemble of models used by PCIC project triple the number of summer days by the 2050s, and 5 times more by the 2080s. This means that future summers may have 36 days above 25°C by the 2050s, and 59 days by the 2080s.

The map for summer days, included above, shows that the number of hot days will be highest in the eastern reaches of the region, with the greatest changes in many areas with the highest populations that already experience warmer temperatures.

Tropical Nights

About this Indicator

Tropical nights refers to the number of days in a year when the nighttime low temperature is greater than 20°C. This measure is important as a series of hot nights can cause heat stress in vulnerable populations (e.g., those with compromised immune systems), and will have an impact on energy used for cooling buildings during warm spells.

Projections

In the past, our region did not experience average nighttime lows warmer than 20°C (referred to as tropical nights). By the 2080s, it is expected that the region may experience an average of 4 tropical nights a year.

[12] Please refer to Appendix A for Annual Summer Days – Past

Hottest Day

About this Indicator

Hottest day refers to the highest daytime high temperature of the year, usually experienced during the summer months. The annual high for each year is an indicator of extreme temperatures and is averaged over a 30-year period here. This measure helps us prepare for a "new normal" for hotter temperatures, and understand how they may impact ecosystems and water supply.

Projections

The past hottest day temperature was 29°C for the region. This will increase to about 32°C by the 2050s, and to 34°C by 2080s. Like summer days (shown above), the highest increases can be expected in our region's populated low lands and valleys.

1-in-20 Hottest Day

About this Indicator

1-in-20 hottest day refers to the day so hot 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 temperatures could reach this magnitude.

Projections

As temperatures increase, so will extreme heat events. Our past 1-in-20 hottest day temperature is 32°C. By the 2050s we can expect this value to increase to 36°C, and to 38°C by the 2080s. The 1-in-20 hottest day temperatures will affect the entire region, and like other hot summer indicators, will most affect our region's valleys and lower elevations.

TABLE 7: HOT SUMMER INDICATORS – REGIONAL AVERAGES

	CLIMDEX Index	Past	2050s	2080s	2050s Change		2080s Change	
Summer days (# of days >25°C)	SU	12	36	59	24	*(16 to 34)*	47	*(31 to 66)*
Tropical nights (# of nights >20°C)	TR	0	1	4	0.5	*(0 to 1)*	4	*(0 to 9)*
Hottest daytime high (°C)	1-yr TXx	29	32	34	3.4	*(2.2 to 4)*	5.5	*(4.0 to 7.2)*
1-in-20 hottest daytime high (°C)	R20 TASMAX	32	36	38	3.8	*(2.4 to 5.0)*	5.9	*(4.2 to 7.4)*

TABLE 8: HOT SUMMER INDICATORS – EASTERN REGION

	CLIMDEX Index	Past	2050s	2080s	2050s Change		2080s Change	
Summer days (# of days >25°C)	SU	11	40	67	29	*(18 to 40)*	56	*(36 to 82)*

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 6 days with a daily average temperature greater than 5°C and the first span after July 1 of 6 days with temperature less than 5°C. It indicates the length of the growing season for typical plants or crops. This measure helps us to understand how opportunities for agriculture may be affected by projected changes.

Projections

In the past, our region had an average of 267 days in the growing season. We can expect 59 days will be added to the growing season by the 2050s, and 83 days by the 2080s, resulting in a nearly year-round growing season of 350 days, on average. In the Eastern Region, the growing season is already 310 days, and increases to nearly year-round growing (350 days) by the 2050s, and 359 growing season days by the 2080s. However, despite this projection, future variability in extreme weather could curtail agricultural opportunities.

TABLE 9: GROWING SEASON LENGTH (GSL)

	Past (days)	2050s (days)	2080s (days)	2050s Change (days)		2080s Change (days)	
Region	267	326	350	59	*(43 to 70)*	83	*(76 to 90)*
Eastern Region	310	350	359	40	*(32 to 36)*	49	*(47 to 52)*
Western Region	268	326	350	58	*(42 to 70)*	82	*(74 to 88)*
Water Supply Area	243	311	343	68	*(52 to 83)*	100	*(91 to 113)*

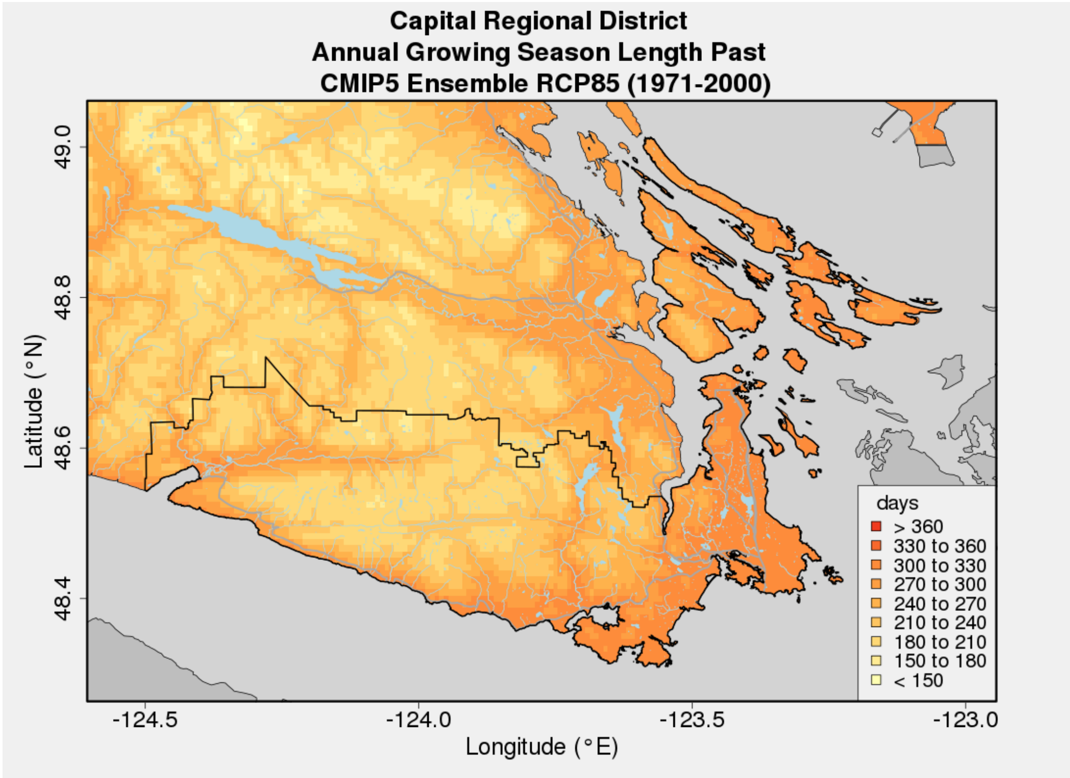


Figure 13: Growing Season Length – Past

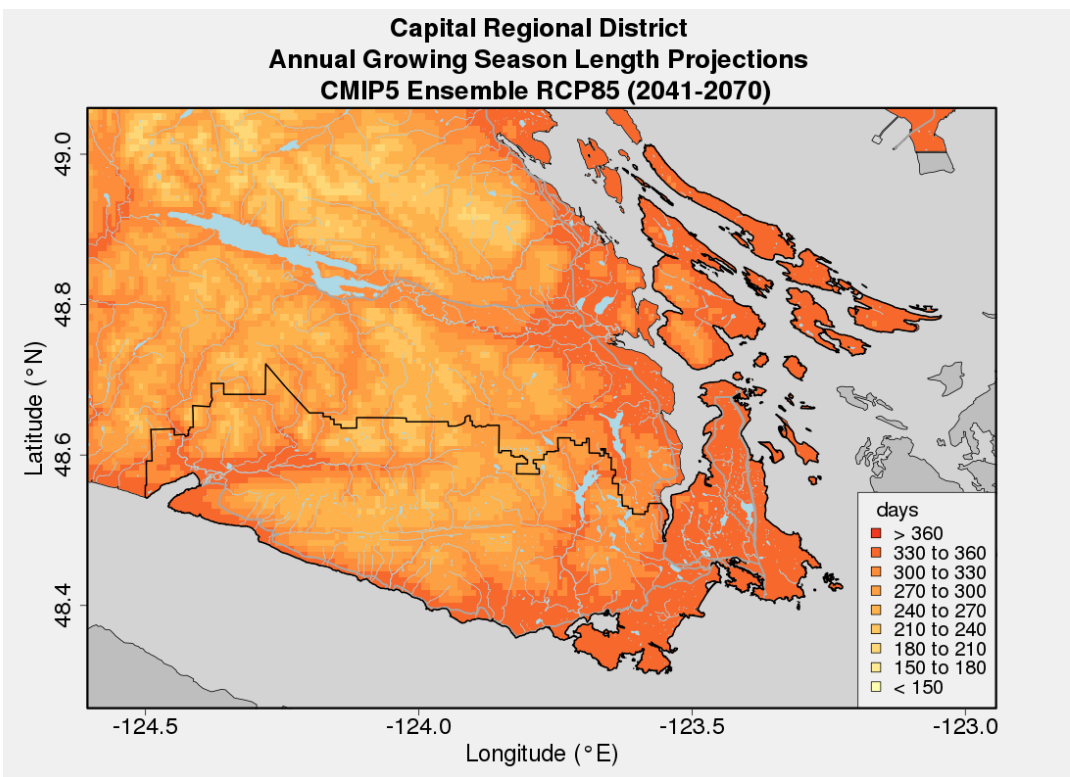


Figure 14: Growing Season Length – Future (2050s)

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 here by how warm daily temperatures are compared to a base temperature of 5°C (although 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 accumulated this way for each day of the year and then summed. This measure is a useful indicator of opportunities for agriculture, as well as the potential for invasive species to thrive due to a longer period of suitable conditions for growth and reproduction.

Projections

In the past, there were 1630 growing degree days in our region. By the 2050s, we can expect almost 50% more growing degree days, and 85% more growing degree days by the 2080s.

While projections indicate increases in growing degree days through the region, regional differences show that the greatest increases are projected for locations that are currently warmer such as the lower elevation locations which are more prevalent in the eastern part of the region (see table below).

TABLE 10: ANNUAL GROWING DEGREE DAYS (GDD)

	Past (Degree days)	2050s (Degree days)	2080s (Degree days)	2050s Change (%)		2080s Change (%)	
Region	1630	2430	3005	49	*(27 to 73)*	85	*(53 to 119)*
Eastern Region	1915	2813	3418	47	*(27 to 67)*	79	*(49 to 109)*
Western Region	1563	2349	2913	50	*(29 to 74)*	86	*(54 to 121)*
Water Supply Area	1508	2272	2836	51	*(27 to 77)*	88	*(54 to 126)*

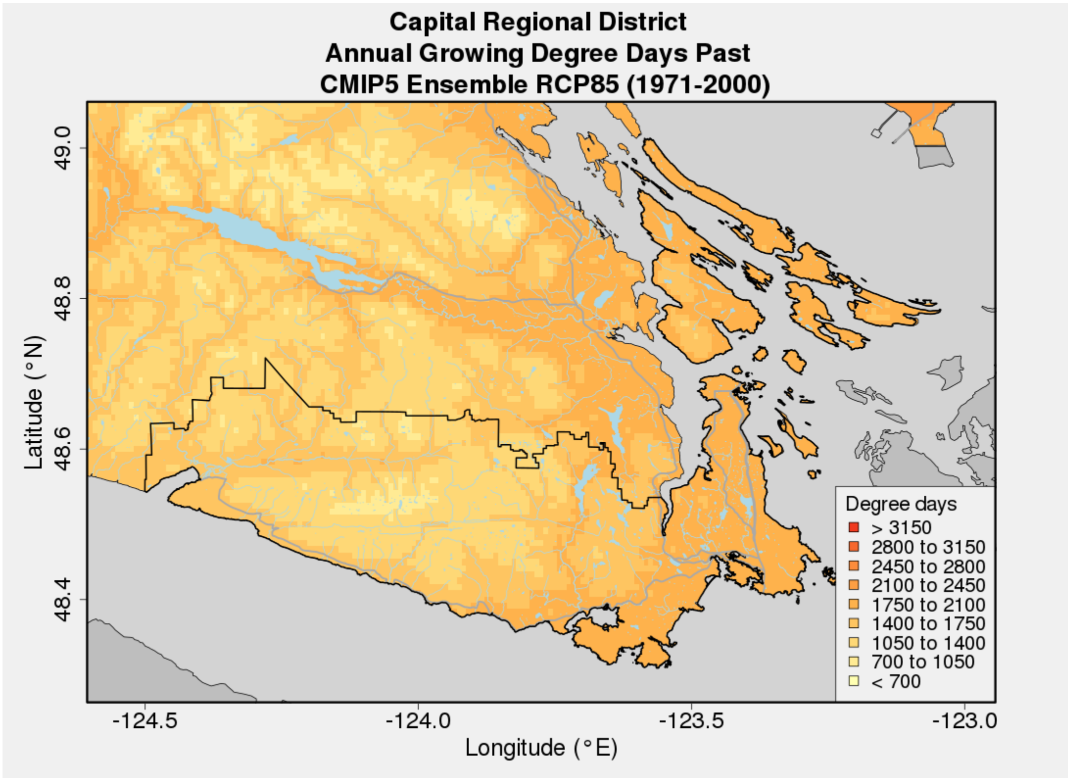


Figure 15: Growing Degree Days – Past

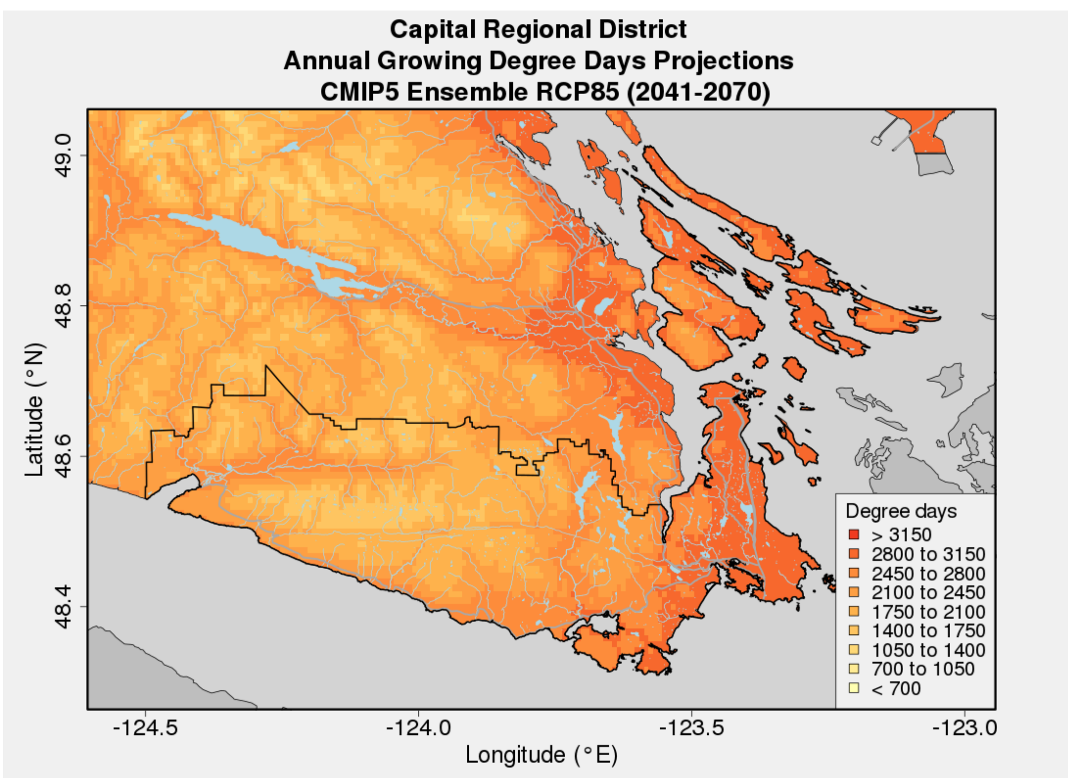


Figure 16: Growing Degree Days - Future (2050s)

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. 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 would be added to give a total value. This measure is used to estimate the use of air conditioning to cool buildings.

Projections

Historically, there has been very little cooling demand in our region. This is reflected in the baseline average of 22 cooling degree days in the past. It is projected that there will be an average 520% increase in cooling degree days by the 2050s, and an 1190% increase by the 2080s. These changes are even more substantial in the lower elevations, as shown in the table below. The large relative increases are partly the result of the fact that the historical baselines are so small. These values represent a substantial change from the past.

TABLE 11: COOLING DEGREE DAYS

	Past (Degree days)	2050s (Degree days)	2080s (Degree days)	2050s Change (%)	2080s Change (%)
Region	22	135	281	520 (*280 to 775*)	1190 (*678 to 1911*)
Eastern Region	22	162	339	640 (*343 to 956*)	1451 (*819 to 2362*)
Western Region	14	99	226	617 (*309 to 912*)	1536 (*825 to 2440*)

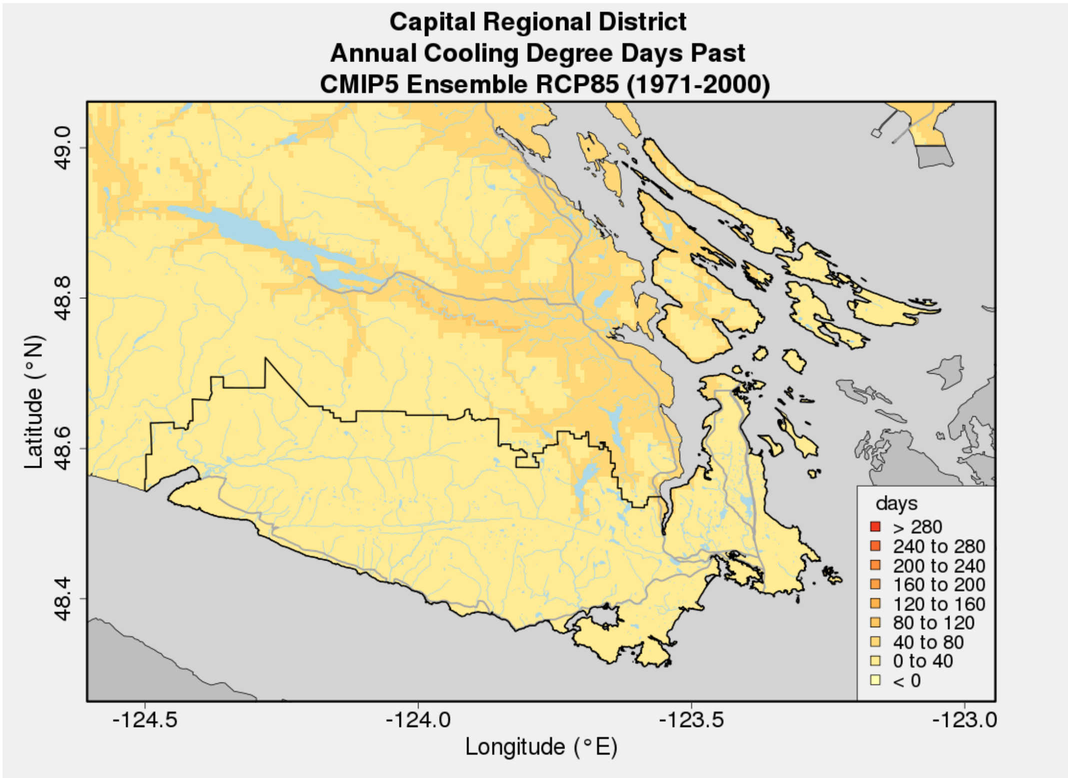


Figure 17: Cooling Degree Days – Past

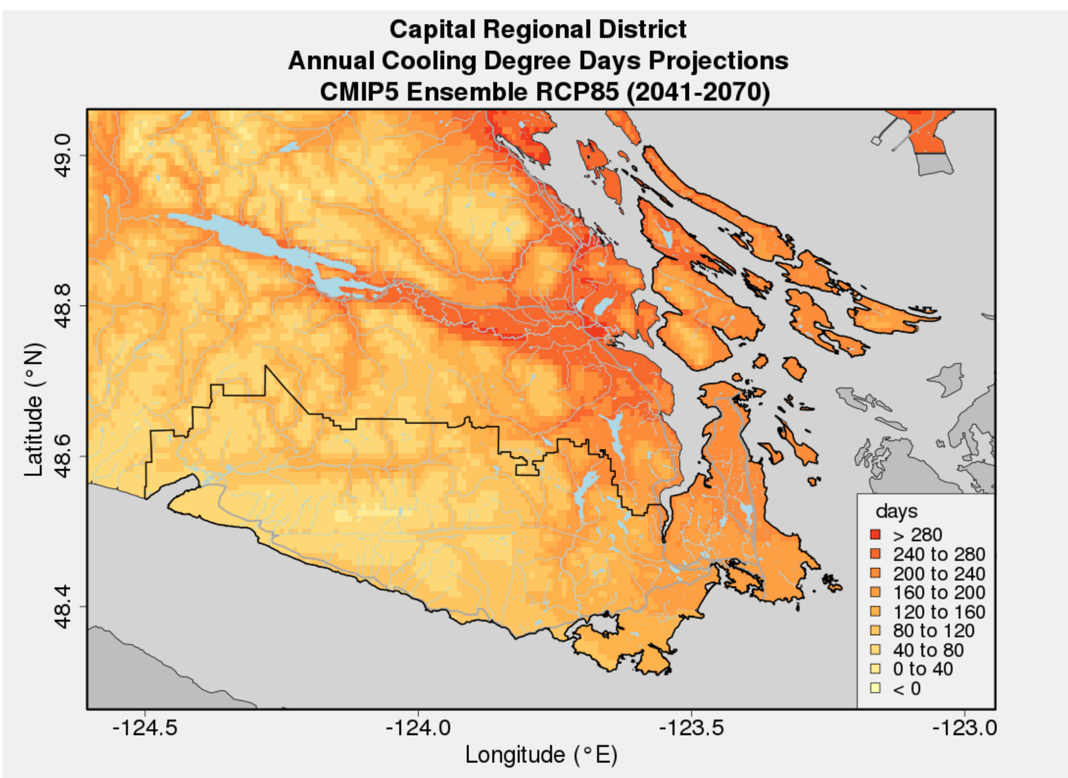


Figure 18: Cooling Degree Days – Future (2050s)

6. WINTER TEMPERATURE INDICATORS

Future climate projections suggest our region will see warmer winter months (December-January-February). These indicators provide insight into the projected changes to winter temperature in our region.

Warmest Winter Day

About this Indicator

Warmest winter day is the highest temperature recorded during the winter months, in an average year. When considered in combination with the night, this indicator is useful to describe the projected "new normal" for winters in our region.

Projections

By the 2050s, we can expect to see the warmest winter day temperature rise from 12°C to about 15°C. This value may increase to about 17°C by the 2080s.

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 winter night had a temperature of -8.6°C. Models project annual lows to increase by roughly 4°C by the 2050s, to -4.5°C, and by 6.6°C by the 2080s, to -2°C. The map below illustrates that in the future, temperatures below freezing will rarely occur anywhere but at the highest elevations.

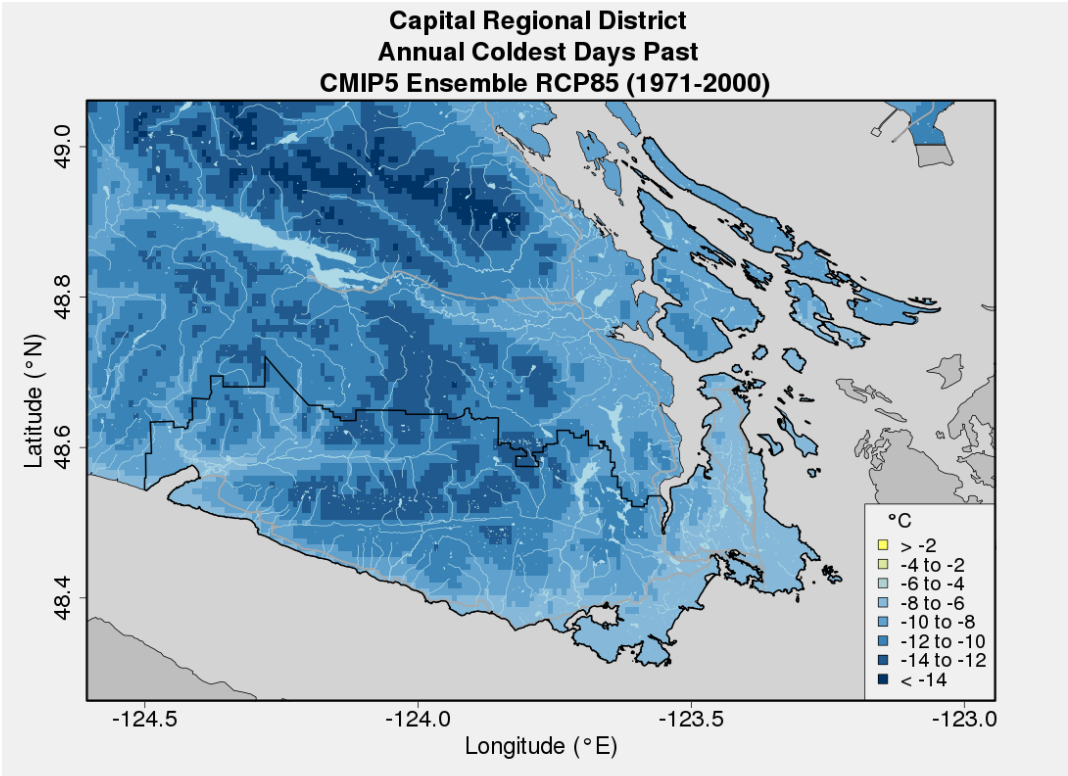


Figure 19: Coldest Winter Night – Past

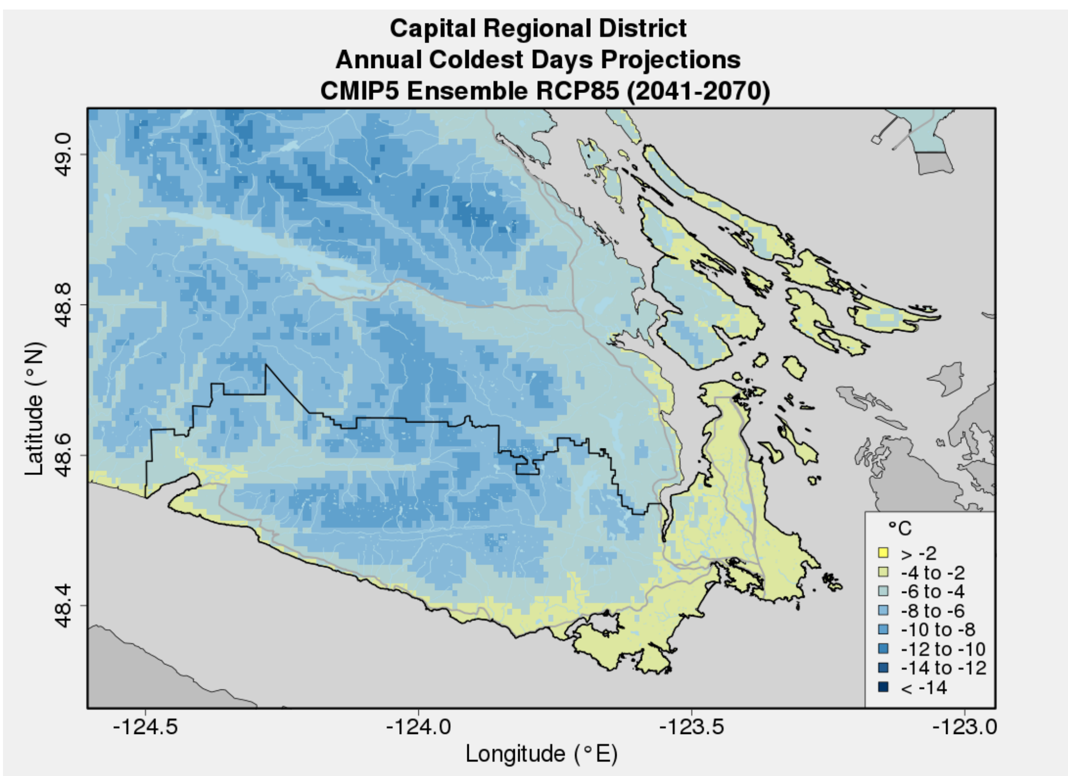


Figure 20: Coldest Winter Night – Future (2050s)

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 1-in-20 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 cold winter temperatures.

Projections

In the past, the 1-in-20 coldest night had a temperature of -15°C. In the future, the 1-in-20 coldest night across the region will increase about 4°C by the 2050s and about 6°C by the 2080s.

TABLE 12: WARMER WINTER TEMPERATURES

		Past (°C)	2050s (°C)	2080s (°C)	2050s Change (°C)	2080s Change (°C)
Warmest winter day	(TXx)	12	15	17	2.9 *(0.4 to 5.2)*	5.3 *(1.9 to 10.4)*
Coldest winter night	(TNn)	-9	-5	-2	4.1 *(2.5 to 5.7)*	6.6 *(4.7 to 7.8)*
1-in-20 coldest nighttime low	(RP20 TASMIN)	-15	-11	-9	3.8 *(1.9 to 5.7)*	6.3 *(4.5 to 8.1)*

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 to help predict how changes in the number of days with minimal temperatures below freezing could affect native and agricultural species.

Projections

In the past, the capital region had an average of 59 frost days while the Eastern Region experienced an average of only 30 frost days. Future projections indicate the region may expect an average of 18 frost days by the 2050s, and only 8 by the 2080s. This will mean that the future will be almost entirely frost-free except for the very highest elevation locations of the region.

TABLE 13: ANNUAL FROST DAYS

FD	Past (days)	2050s (days)	2080s (days)	2050s Change (days)	2080s Change (days)
Region	59	18	8	-41 *(-50 to -31)*	-51 *(-57 to -44)*
Eastern Region	30	7	3	-23 *(-27 to -17)*	-27 *(-30 to -23)*
Water Supply Area	73	24	11	-49 *(-61 to -38)*	-62 *(-70 to -54)*

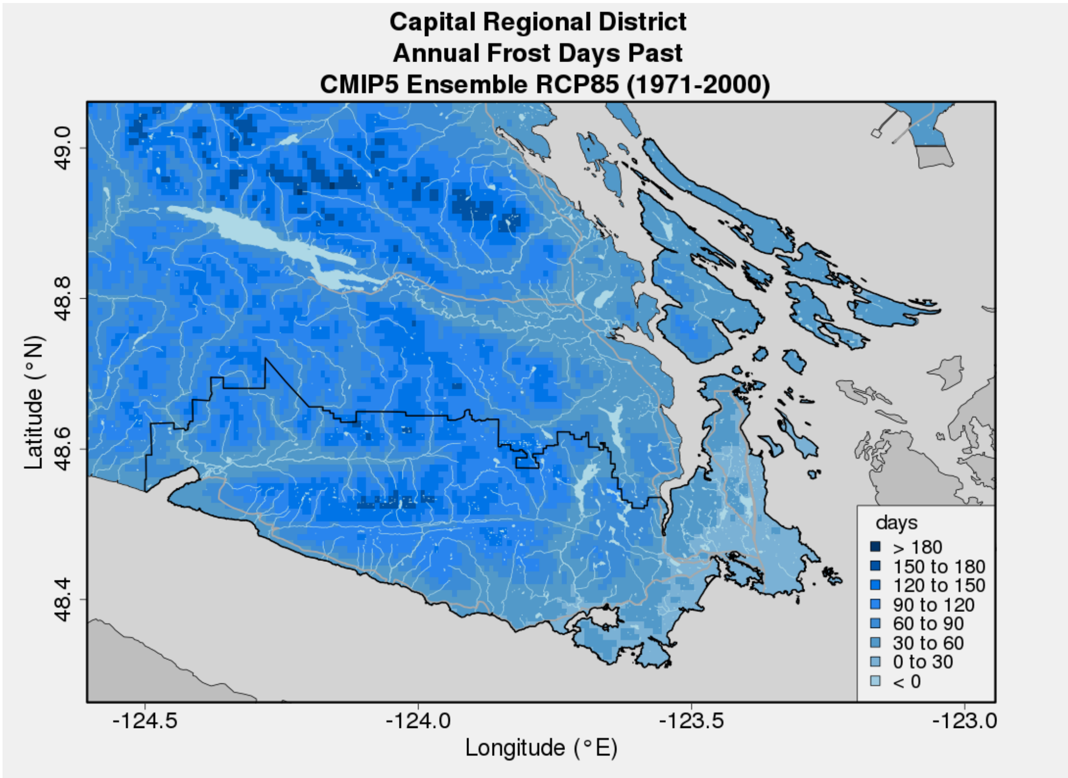


Figure 21: Frost Days – Past

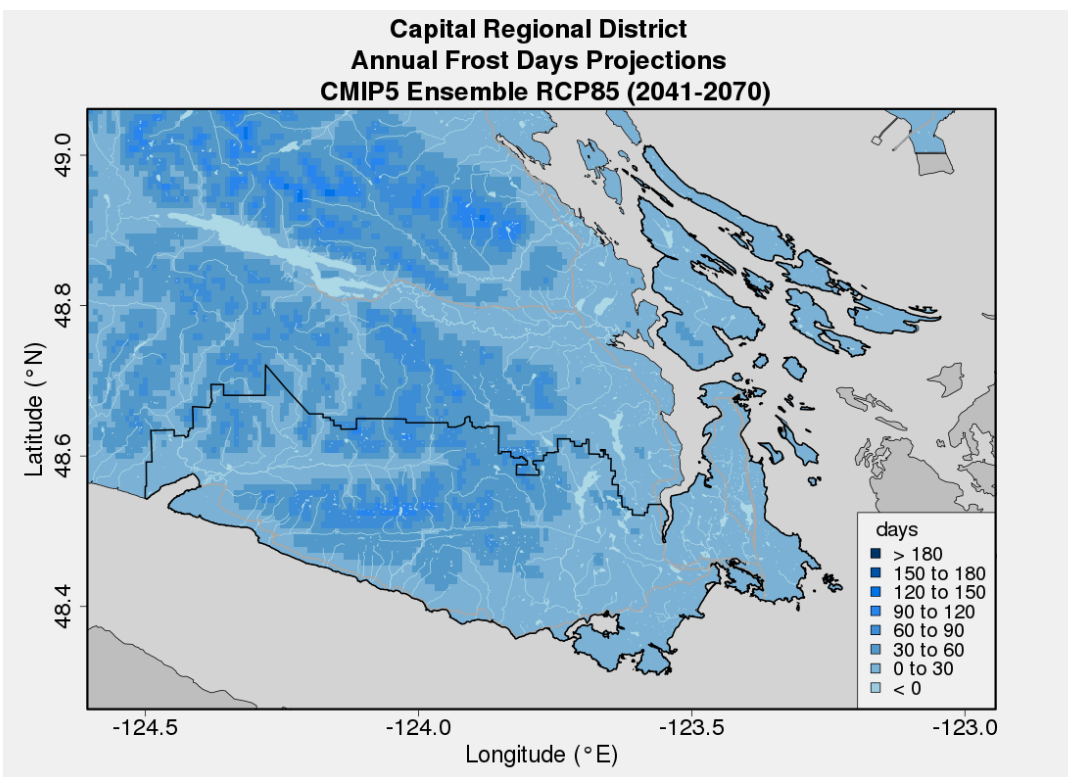


Figure 22: Frost Days – Future (2050s)

Ice Days

About this Indicator

Ice days are days when daytime high temperature is less than 0ºC. This measure offers insight into how changes in the number of days where the temperature does not rise above freezing could affect ecosystems, species, and transportation in the region.

Projections

In the past, our region had roughly 5 ice days per year on average. Future projections indicate a "new normal" where higher elevation areas experience very few, if any, days when the daily high temperature remains below freezing. The region may expect even fewer ice days by the 2050s, and by the 2080s temperatures below freezing will rarely occur anywhere but at the highest elevations, and even these occurrences will also be infrequent.

TABLE 14: ANNUAL ICE DAYS

ID	Past (days)	2050s (days)	2080s (days)	2050s Change (days)	2080s Change (days)
Ice days (# of days >0°C)	5	2	1	-3 *(-4 to -1)*	-4 *(-5 to -3)*

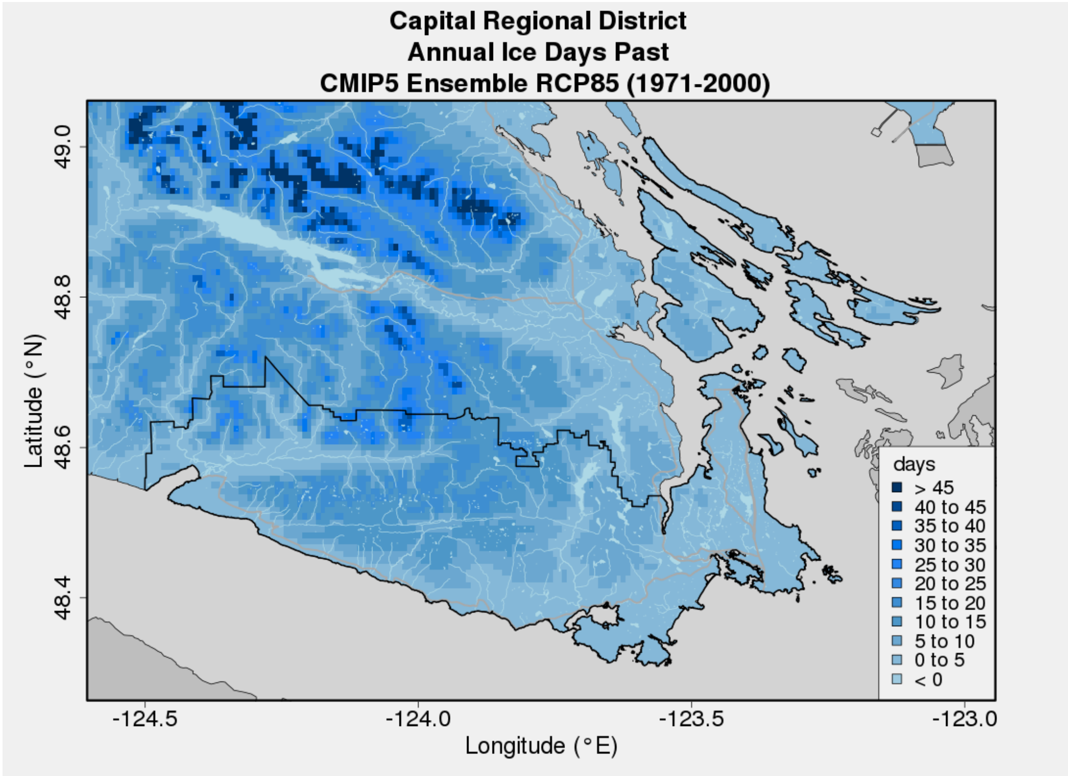


Figure 23: Ice Days – Past

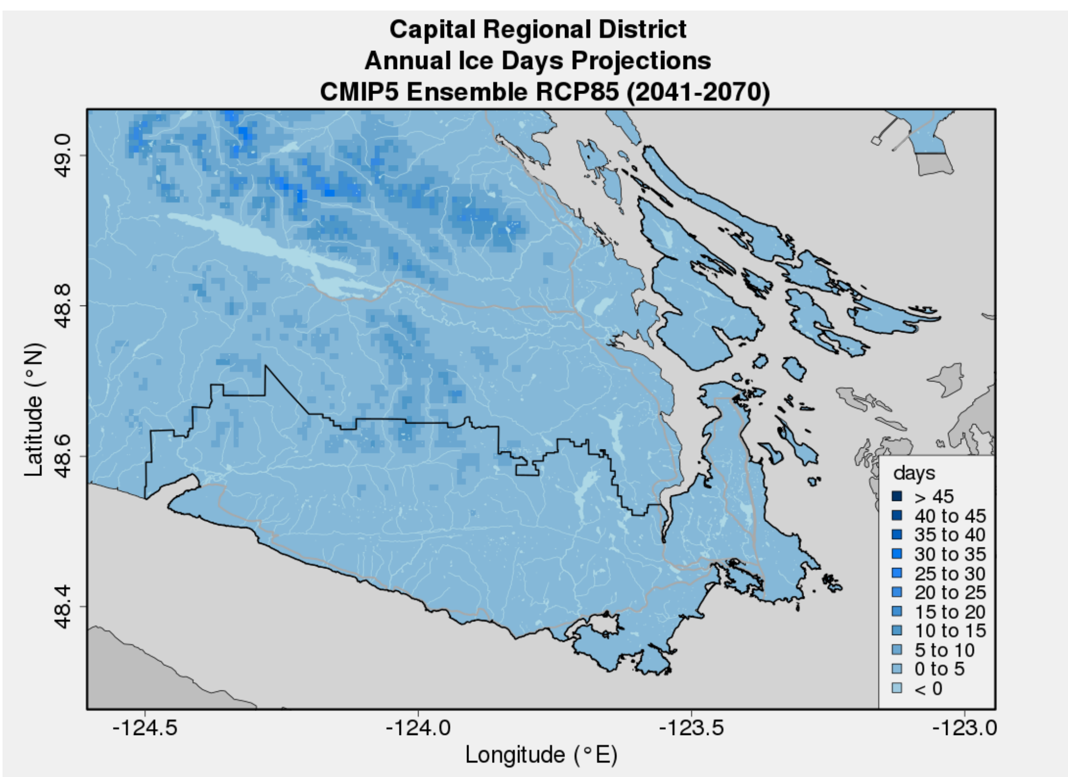


Figure 24: Ice Days – Future (2050s)

Heating Degree Days

About this Indicator

Heating degree days is a derived variable that can be useful for indicating energy demand (i.e., the need to heat homes, etc.). It is calculated by multiplying the number of days that the average daily temperature is below 18°C by the number of degrees below that threshold. For example, if a given day saw an average temperature of 14°C (4°C below the 18°C threshold), that day contributed 4 heating degree days to the total. If a month had 15 such days, and the rest of the days had average temperatures above the 18°C threshold, that month would result in 60 heating degree days.

Projections

The capital region experiences many more heating degree days compared to cooling degree days. Our past regional annual average of heating degree days is 3413. Heating degree days are projected to decrease by 26% by 2050s, and by 40% by the 2080s.

TABLE 15: ANNUAL HEATING DEGREE DAYS

	Past (Degree days)	2050s (Degree days)	2080s (Degree days)	2050s Change (%)		2080s Change (%)	
Region	3413	2541	2053	-26	*(-35 to -15)*	-40	*(-54 to -28)*
Eastern Region	2991	2128	1672	-29	*(-39 to -18)*	-44	*(-59 to -31)*
Western Region	3468	2586	2090	-26	*(-35 to 15)*	-40	*(-54 to 28)*

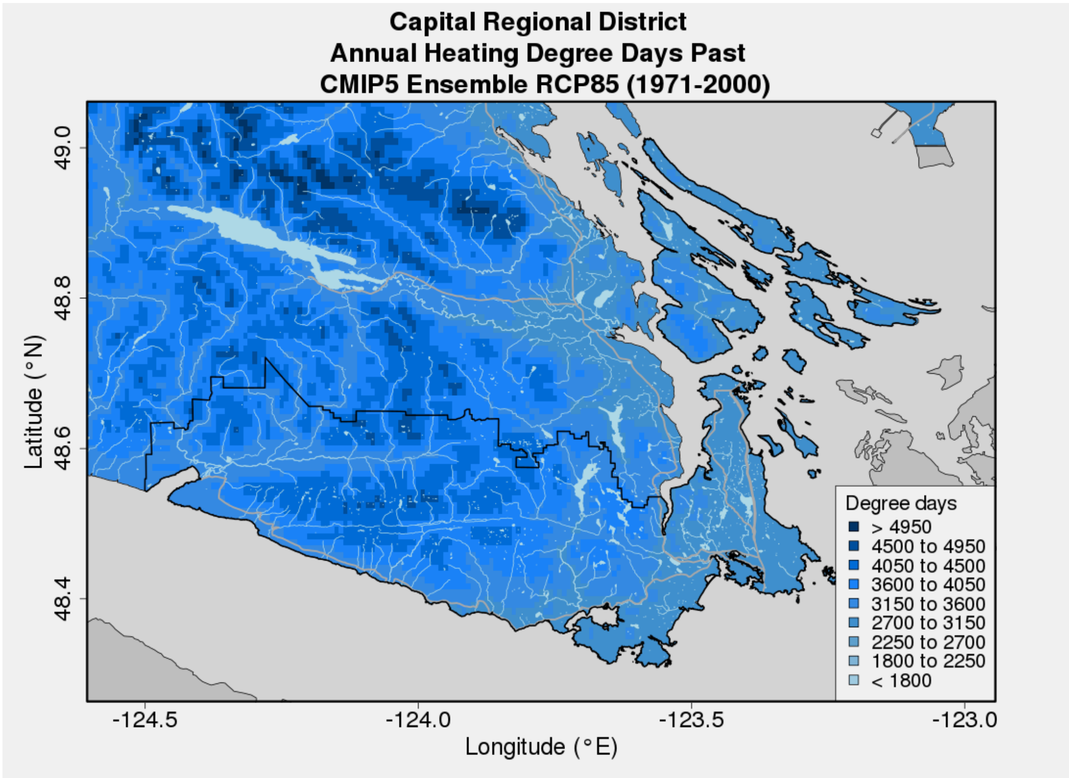


Figure 25: Heating Degree Days – Past

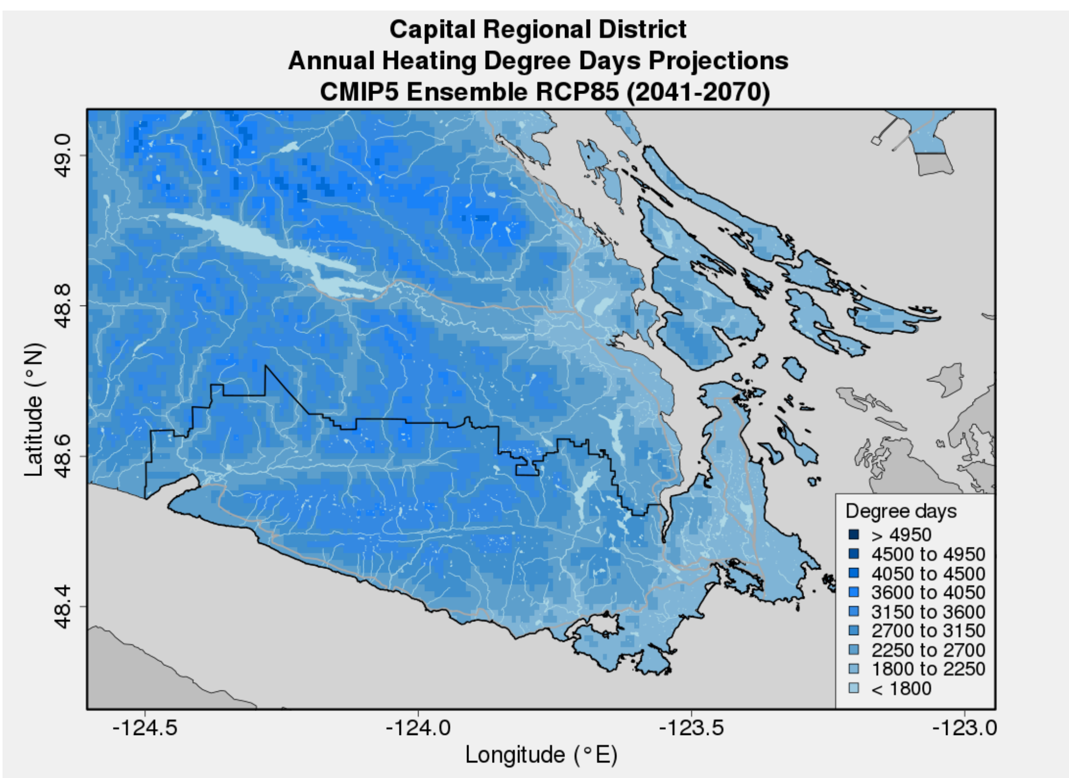


Figure 26: Heating Degree Days – Future (2050s)

7. REGIONAL IMPACTS

Action on climate adaptation has the potential for profound benefits to environmental, economic, and social systems in the capital region. Examples include increased efficiency of energy and water use, improved building design, infrastructure, and transportation systems, along with the recognition of linkages between regional systems. Adaptation offers a positive path towards protecting and enhancing regional ecosystems, reducing our impact on climate change, enhancing human health, and reducing climate-related risk to citizens and infrastructure. New partnerships, technologies, and innovation show significant promise for adapting to climate change in the capital region.

We are on a path towards rising temperatures and increased variability in precipitation, and these changes will be experienced unevenly over the seasons, and from year to year. We can expect some winters will be warm, while others could be cold, and some summers could be wet and cold, while others could be hot and dry. Adaptation measures will need to consider the inherent complexity and variability of projected changes to the climate in the region.

This section provides initial considerations about how climate change can be expected to have an impact in our region. This work provides a direction for decision makers to consider when planning for the future, and will help community partners understand how climate change will affect ongoing and planned initiatives.

Human Health

Potential changes to the climate in the capital region during the summer months can have a number of implications for human health and related social services, especially with an aging population (by 2021 it is projected that 37% of the population will be 55 years of age or older). Respiratory illnesses relating to particulates and compounds in the air can be made worse by periods of heat, an increased incidence in forest fires, and any increase in ground-level ozone levels on days over 25°C. Impacts have the potential to be more significant in urban centres due to urban heat island effect, unless adaptive measures are taken, including air conditioning, cooling stations, and an increase in the urban tree cover.

In general, milder winters should reduce respiratory issues associated with wood burning stoves and fireplaces, however this could be offset if rising temperatures lead to more frequent temperature inversions that can concentrate pollutants near ground level. Due to annual variation, the region may need to maintain the capacity to provide emergency shelter in the winter in years where temperatures dip below critical levels. Increases in year-round temperatures over time could also increase the potential for vector-borne disease transmission.

Rainwater Management and Sewerage

Many of our creeks and wetlands play a role in storm water management. During extreme events in the wetter season (fall, winter, and spring) and during peak runoff, creeks can flood, soils may become over-saturated, increasing runoff and flooding low-lying areas. The combination of increased runoff and rainfall can increase erosion, and lead to slope instability and overfilling of wetlands and lakes. Where streams flow into the ocean, extreme precipitation events combined with sea level rise during periods of high tides can lead to a back-up of flows and expanded flooding of low-lying areas.

Extreme precipitation events can cause inflow and infiltration of rainwater into our sanitary system in crossover areas. This could exceed the capacity of infrastructure and cause highly diluted sewage to enter our waterways. In areas where forest and stream-side vegetation has been removed, stream channels have been straightened, and wetlands have been filled in, property damage associated with floods can be more substantial and extensive. An increase in extreme precipitation events in the fall, winter, and spring can worsen these existing issues. Such events can also be expected to compromise some septic fields.

The projected increase in the intensity, duration, and frequency of rainfall events may be beyond those for which we are currently prepared, and can have a wide range of impacts to natural and built systems dealing with water flows and sewage. It can be assumed that the trends in precipitation and intensity projected in this report will continue past the end-of-century timeframe. This information offers important context for those who design critical rainwater and sewerage infrastructure, and merits further detailed study to inform future Intensity-Duration-Frequency (IDF) curves for our region.

Water Supply and Demand

Drinking water in the capital region is primarily supplied by surface water reservoirs and lakes, with some use of groundwater. The annual recharge of these water supplies is almost entirely from rain in the late fall, winter, and early spring (the wet season). Snowfall and snow accumulations vary considerably among years, and snow in water supply areas typically melts by April.

The CRD supplies 350,000 customers in the Greater Victoria area with water from large supply reservoirs in the Sooke and Goldstream river watersheds. The CRD also provides water to small service areas in the Southern Gulf Islands and the western portion of the region through a combination of 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.

The summer and early fall projections of increased temperatures and longer periods of hot weather, likely mean increases in evapotranspiration, potential increases in wildfire activity, and a reduction in rainfall which can lead to greater water demand during the summer and into September, when supply is lowest. Given the potential for this seasonal decline in water supplies to become more pronounced in some years, water conservation initiatives will remain a priority in the region. It will be important to consider how to better capture and store wet-season precipitation and to improve the efficiency of summer outdoor water use. Efficient water use will likely be especially important in coastal areas supplied by wells, as overdrawing groundwater can reduce available water supply and lead to saltwater intrusion.

The relatively modest projected increase in precipitation in the wet season should increase the likelihood that surface water supply reservoirs will fill and groundwater supplies replenish. However, this increase in precipitation will likely be delivered during more extreme events. In years with extreme rainfall or rain-on-snow events, there is an increased chance that higher stream flows could result in increased turbidity and the input of nutrients into surface water supply systems. Increased turbidity can interfere with water disinfection and treatment, and excess nutrients can cause algal blooms, leading to taste and odour issues. Therefore, the potential for more frequent, intense, and longer-lasting precipitation events will need to be considered in the planning and management of water supply systems.

Tourism and Recreation

With the number of warm days in the summer increasing, the warm recreational season can be expected to start earlier and end later, bringing increased economic opportunities to the area. The longer tourism season over the summer could be offset by declines in winter tourism, with greater precipitation and more severe storms expected in some years.

Increased summer temperatures and years with longer periods of hot, dry weather can put pressure on freshwater lakes, ocean coastlines, and coastal waters used for recreation. With the potential of increased nutrients deposited in freshwater lakes, we can expect to see more algal blooms become a challenge for ecosystems and recreational water users, fishing, and tourism. Longer, hotter, and drier summers trigger more and longer campfire bans in parks and forests. When hot, dry summers are combined with extreme storms in the wet season, we can expect shoreline access, water quality, wildlife habitat, and recreational infrastructure to require ongoing maintenance.

Transportation Network

With the onset of increasingly variable weather conditions, we can expect both positive and negative impacts on our transportation systems. Warmer winter temperatures could reduce annual operations and maintenance costs associated with snow removal and repair of cracked roads from freeze-thaw cycles; however, equipment to effectively deal with severe winter conditions will still need to be maintained. Active transportation, such as cycling, has the potential to become more desirable year round, resulting in increased demand for expanded infrastructure networks. Alternatively, hotter summers and increased storm intensities may discourage people from consistently choosing active transportation modes. While these benefits can improve transportation, the increase in year-to-year variability will mean that equipment and key supplies will need to be maintained to effectively deal with severe winter conditions, and summers may require adequate cooling infrastructure such as shade, trees, benches and water fountains to support active transportation.

Increased fall and winter storm events may impact the reliability of our transportation network, with the Malahat and BC Ferries crossings becoming more dangerous during increasingly intense storms. Projected increases in the intensity, duration, and frequency of winter rainfall, and a consideration of the boundaries of flood plains will need to be factored into a review of existing infrastructure, and also when determining the location and design of new infrastructure.

Ecosystems and Species

Ecosystems, native species, and associated ecological relationships and processes within the region are well adapted to the range of variability that occurs within the existing climate. However, the combination of the magnitude and rate of projected changes to the regional climate has the potential to challenge the capability of ecosystems, species, and ecological processes to adapt. As a result, the distribution and composition of ecosystems could shift across the regional landscape.

The complexity of ecosystems and ecological processes will mean that there will be different responses to projected climate change and considerable uncertainty in the timing, magnitude, and spatial scale of effects. An increase in the length of the growing season, and increases in minimum winter temperatures, will have benefits for some plant and animal species in the region. As overall annual temperature rises, there can be positive effects for key processes such as decomposition and nutrient cycling through much of the year.

However, there are a number of predicted negative impacts to ecosystems and species from a changing climate. Warming temperatures can disrupt biological relationships that rely on temperature threshold cues, such as predator/prey and parasite/host. This could result in population declines in desirable species and/or outbreaks of species that are considered pests. Warmer temperatures could also enhance the potential for invasive species and pathogens to increase across the region, causing additional stress to native species.

Increased air temperatures can also raise water temperatures in surface water bodies and streams. This would negatively affect fish species that need cool water to thrive, such as salmon and trout. In extreme cases, higher temperatures and reduced water levels can lead to low oxygen levels and the mortality of some aquatic species.

It is likely that the extremes associated with projected changes in climate could have the greatest potential to disrupt ecosystems and vulnerable species. An increase in the length and severity of drought conditions, and the reduction in available soil moisture, could cause considerable stress to trees and other terrestrial and riparian (streamside) vegetation. Stressed plants are more susceptible to competition with other plants, and damage from insects and diseases. Some tree species, such as western red cedar, may be particularly susceptible to increases in drought. Drier conditions can also slow decomposition in below-ground communities consisting of bacteria, fungi, and other soil organisms, therefore reducing available nutrients. An increase in seasonal drought conditions can also reduce water levels in the streams in the region that continue to flow in the summer and increase the vulnerability of forests to wildfire.

More severe storm events can also cause issues for ecosystems and species. Flooding of lowland areas in the fall, winter, and spring months can result in tree roots becoming saturated, stressing trees and potentially making them more susceptible to being damaged or blown down by strong winds. High stream flows from major rainfall events can negatively affect fish-spawning habitat through channel erosion, and the deposition of sediment. Such storms can also can wash pollutants from roadways and parking lots into aquatic and marine ecosystems.

Buildings and Energy Systems

As our climate warms and storm events become more intense and frequent, the business case for investing in durable, resilient buildings improves. Buildings provide site-specific opportunities to address challenges, such as heat and drought, through technologies, including rainwater capture and reuse, stormwater detention and management, resilient landscaping, green roofs and walls, and passive shading. In some years, buildings may need to withstand heavier snow loads and precipitation events, higher and more frequent winds, higher temperatures and longer duration of heat waves, and in coastal areas, rising sea levels. Building retrofits (e.g., insulation, heat pumps) to address both heating and cooling demand, and additional climate adaptation measures, including storm-resistant design and materials, should be considered. Future climate projections and energy efficiency will also be important to consider for new construction, as this could result in long-term cost savings and future-proofing.

Concentrating development in already developed areas can create opportunities for natural ecosystems to buffer changes to our climate. Protecting the existing and future flood plains from development can reduce risks of personal injury and damage to property from extreme storm events. Also, avoiding conversion of agricultural land to residential and commercial uses will better enable our region to become more self-reliant as traditional agricultural areas become less arable.

In response to warmer year-round temperatures, seasonal and longer-term energy demands will change across the region. Significant shifts are also anticipated across BC, with an increase in cooling demand and decreasing heating demand over time. These shifts in energy demands can be offset with comprehensive energy retrofits to enhance the energy efficiency of existing buildings using air sealing, insulation, and space and water heating upgrades, and initiatives designed to reduce consumption from baseloads (lighting and appliances). Constructing energy efficient (or net-zero ready) homes and buildings would also substantially reduce energy demand. There may also be opportunities for solar electricity production and other types of renewable energy.

Food and Agriculture

An increase in growing degree days and a reduction of frost days will create a longer growing season in our region. Earlier harvests, and year-round productive growing in some years could bring economic opportunity to food producers. Within the context of a changing global climate, our region could see increased agricultural capacity and opportunities for a larger agricultural economy.

These positive conditions will be challenged by a decrease in summer water levels in ponds, wetlands, and streams used for irrigation, and increases in competition for water, heat stress and sun scald on plants, invasive species, pests, and plant diseases. Increases in summer temperatures and reductions in precipitation will also place greater demand on drinking water supply systems where these are used for irrigation. Warmer temperatures also mean warmer oceans, where red tide and other aquatic pests could compromise aquaculture opportunities. More intense spring storms also cause a delay in spring planting in seasonally-flooded fields, or damage plants and their root systems, requiring secondary planting in some years or resulting in instances of crop failure. Additionally, shifting seasonal conditions could cause pollinators needed for crops to emerge at inappropriate times, limiting potential yields.

The availability of water for agricultural use is likely to become a significant issue in the future. The Water Sustainability Act has minimum environmental flow criteria, which means some farmers will likely not be allowed to draw water from water bodies, wetlands, or streams during summer dry spells. This will likely also increase demands for irrigation from water supply systems. Drought conditions could influence the agricultural sector to look at innovative water management practices, ensuring enough non-treated drinking water is available for livestock and irrigation during a longer growing season.

Agricultural producers can expect to notice a shift in energy costs, as heating demand for greenhouses decreases, and cooling needs for greenhouses and livestock facilities could increase. Producers will also need to consider alternative soil-management approaches, as changes to soil moisture and composition will accompany the new climate trends expected in our region. In some cases, land including agricultural areas could suffer from saltwater intrusion from rising sea levels, or need to be restored as wetlands to manage stormwater across the region.

8. SUMMARY AND RECOMMENDATIONS

This report uses current climate model outcomes to provide a "best estimate" snapshot of how climate change will unfold across the capital region over the coming decades. All models project daytime high and nighttime low temperatures to rise. While temperature can be expected to increase year round, the greatest increases will occur in the summer months. Monthly high and low temperatures show that the "new normal" for the region may be very unlike the past. Rising temperatures will lead to hotter summer days and nights, milder winters with the near loss of frost days and snowpack in all but the highest elevation locations in our region.

Our region will experience a modest increase in annual precipitation by the 2050s, though the increase in precipitation will be distributed unevenly over the seasons. The largest increases will occur in the fall season, while rain will decrease significantly in the summer months. Our region can expect stronger and more frequent extreme rainfall events, longer summer dry spells, and an extension of the dry season into September.

The changes outlined in this report will have multiple impacts on our region, some of which can be accommodated through long-range planning and early adaptation efforts. The Capital Regional District will use these projections in incorporating climate change adaptation into planning cycles and ongoing activities, and will update this resource to ensure its relevance using new regionally downscaled projections after each new Intergovernmental Panel on Climate Change (IPCC) report is released (approximately every 5-7 years).

As the Capital Regional District and its partners plan to adapt to climate change, early action will enable our region to best prepare for the changes ahead and increase resilience. Decision makers need to consider the sensitivity of the systems they manage to the possible range of future climate in the region. Risk management approaches and the development of robust climate adapted tools should be applied to address the uncertainty of climate risks. Vulnerability assessments may be conducted to set priorities for more detailed studies and monitoring, to understand the economic costs of climate impacts, and to inform policy, planning, and implementation of adaptation actions. Adaptation actions should be chosen that perform well across the range of uncertainty, to ensure resilient systems. Flexibility in adaptation planning will allow the region to evolve as the future climate unfolds.

APPENDIX A: FIGURES

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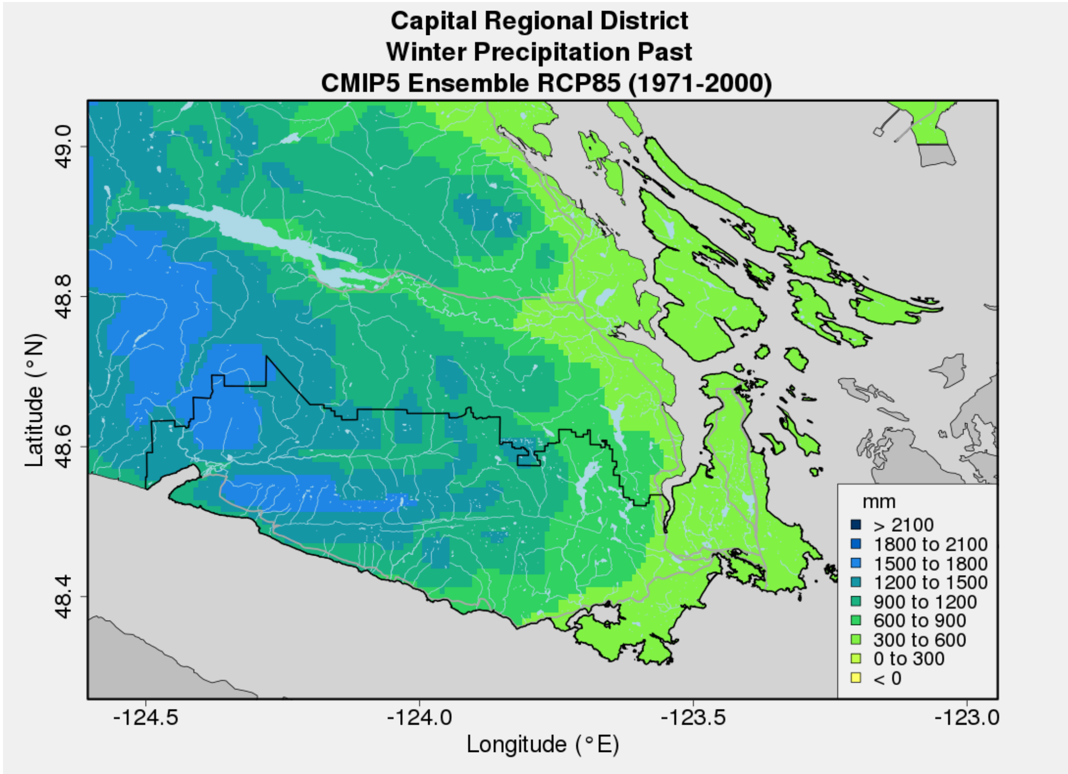
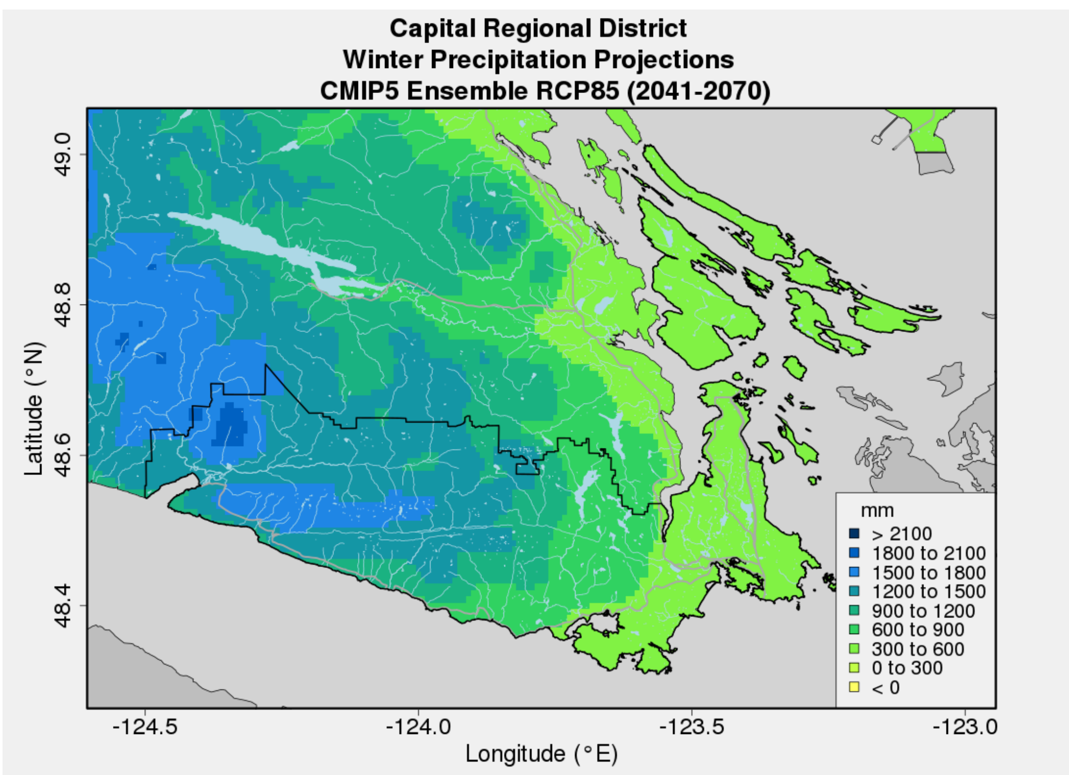


Figure 27: Winter Precipitation – Past



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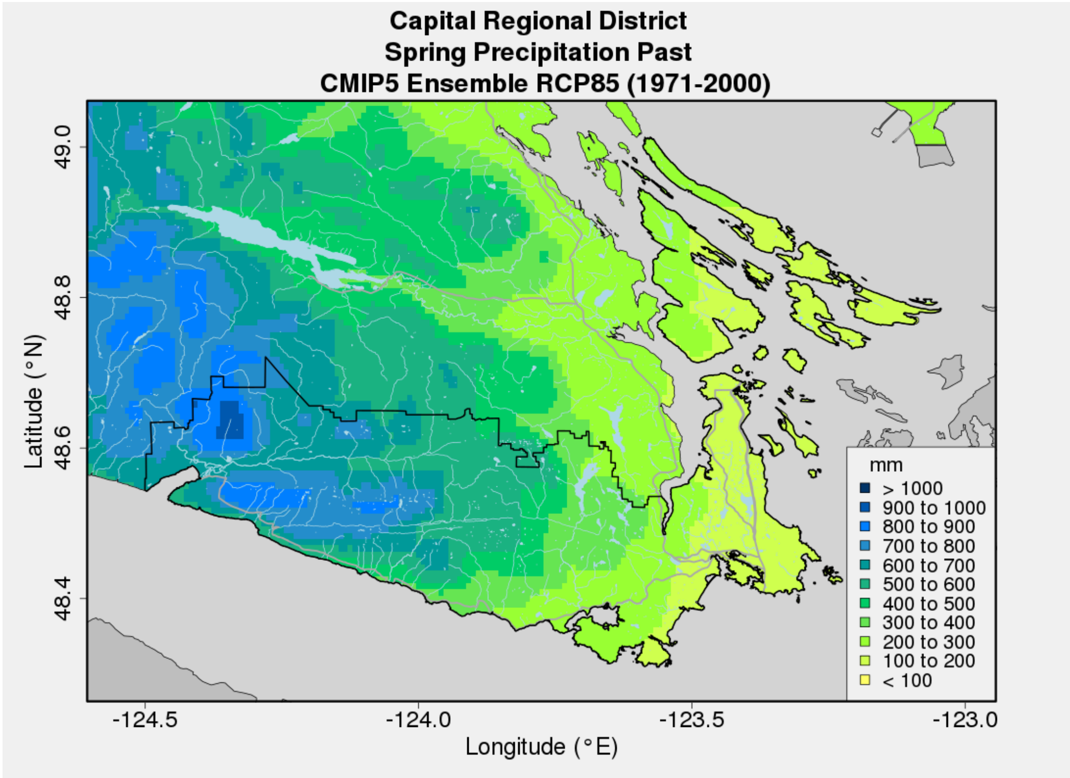

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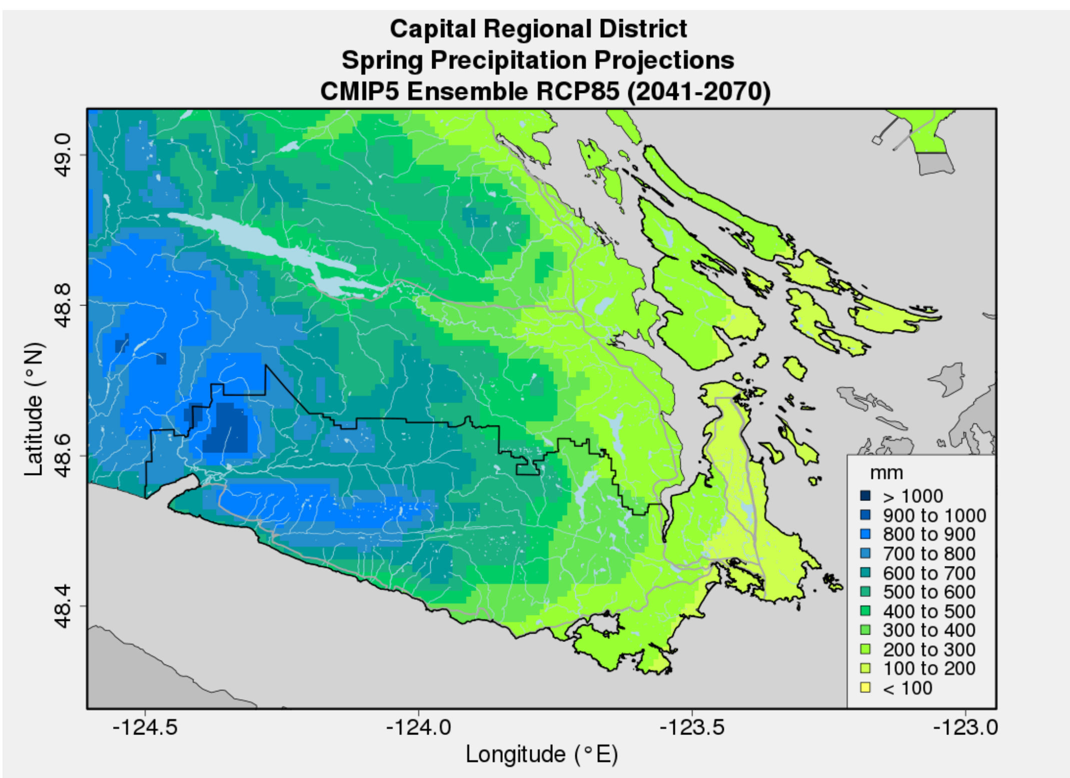

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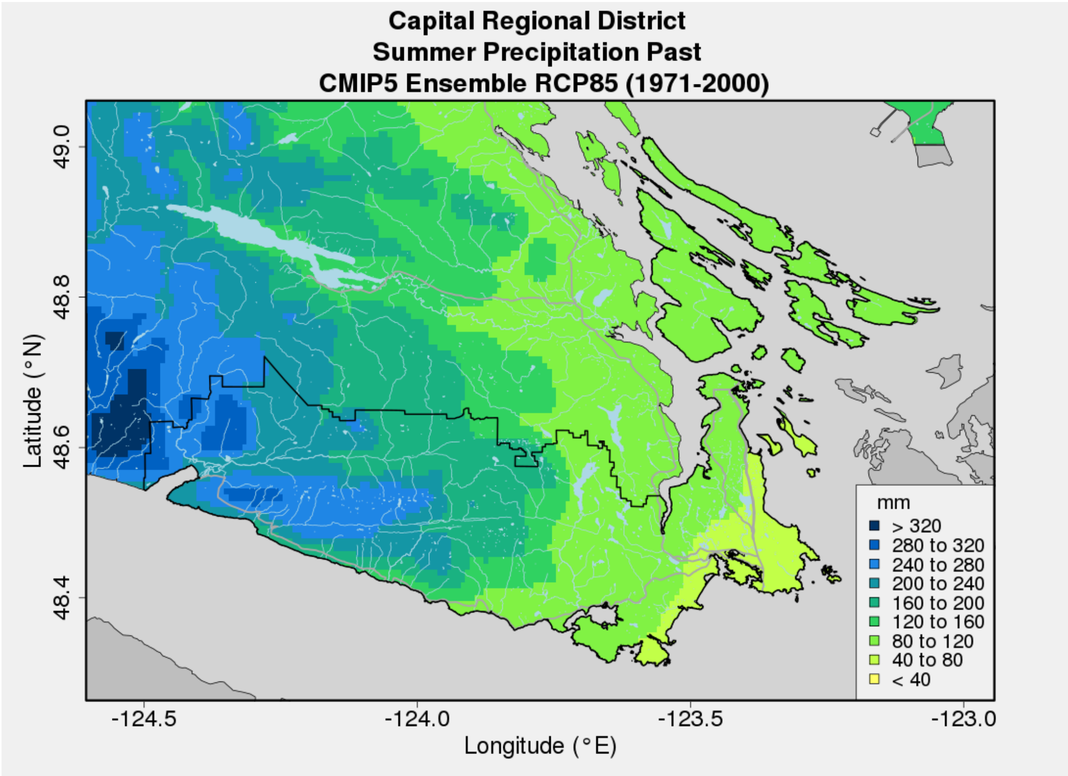

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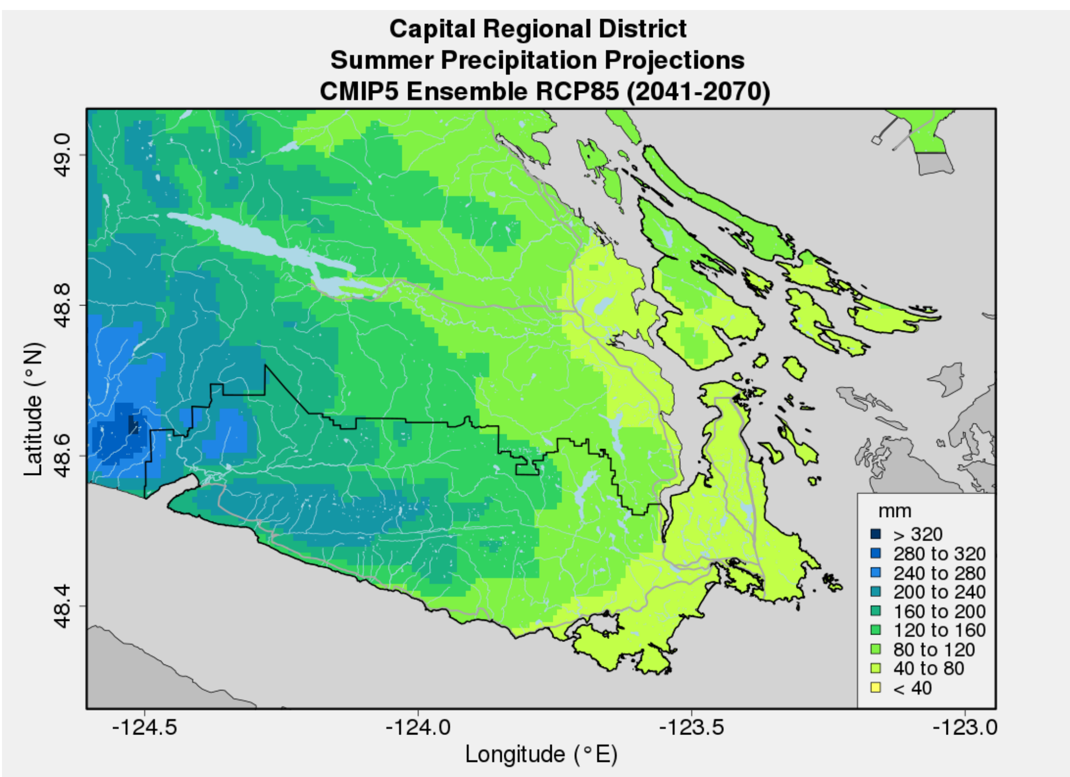

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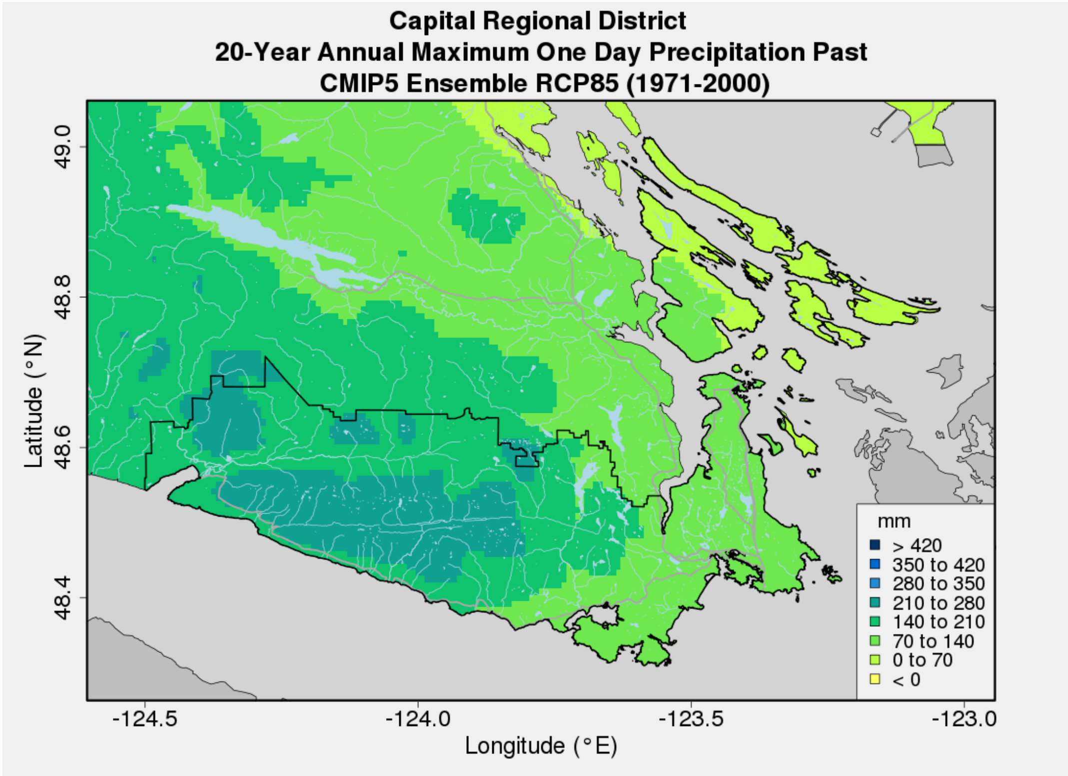

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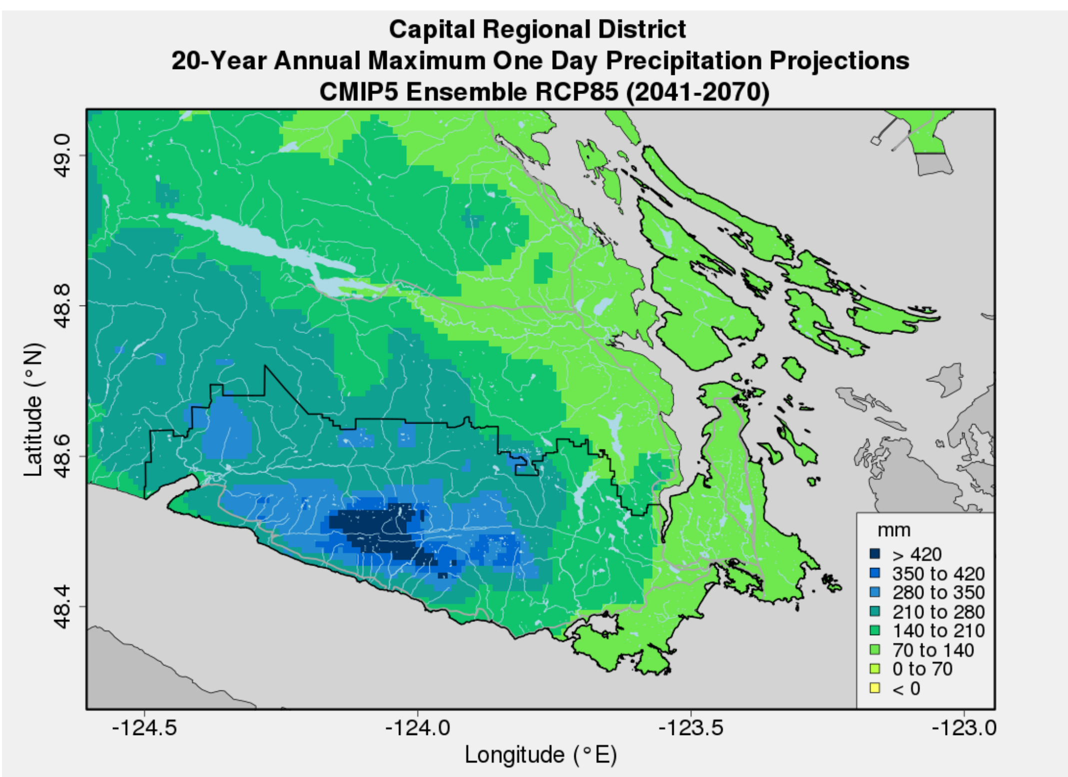

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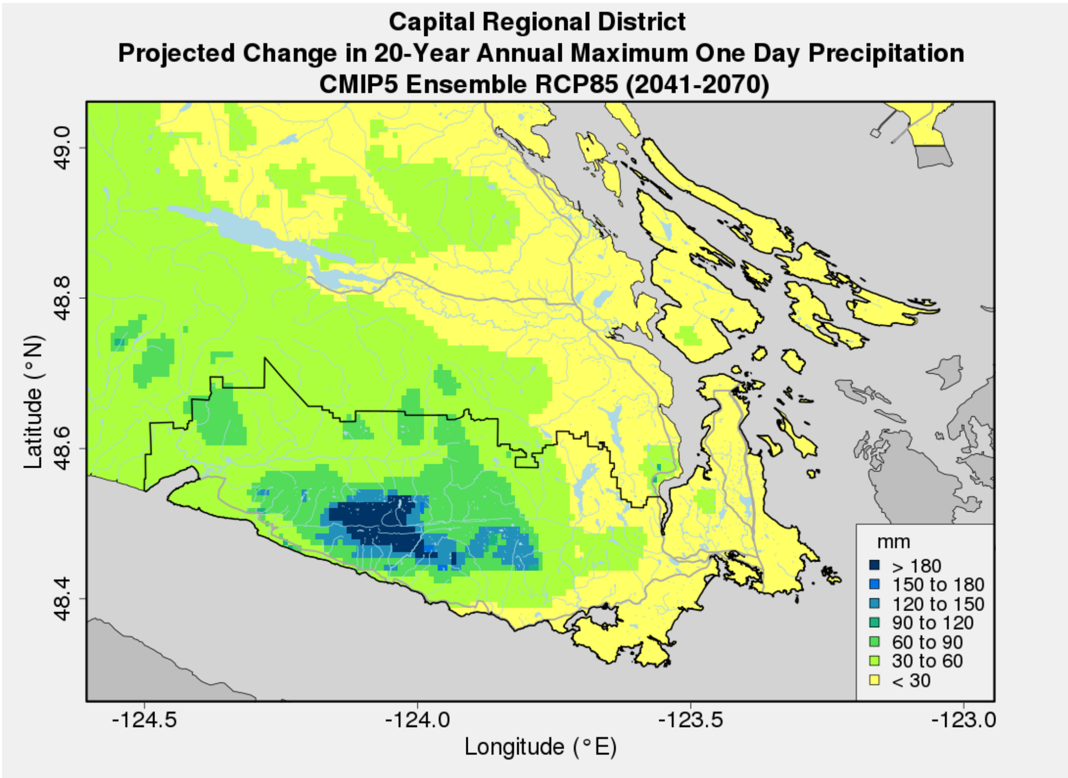

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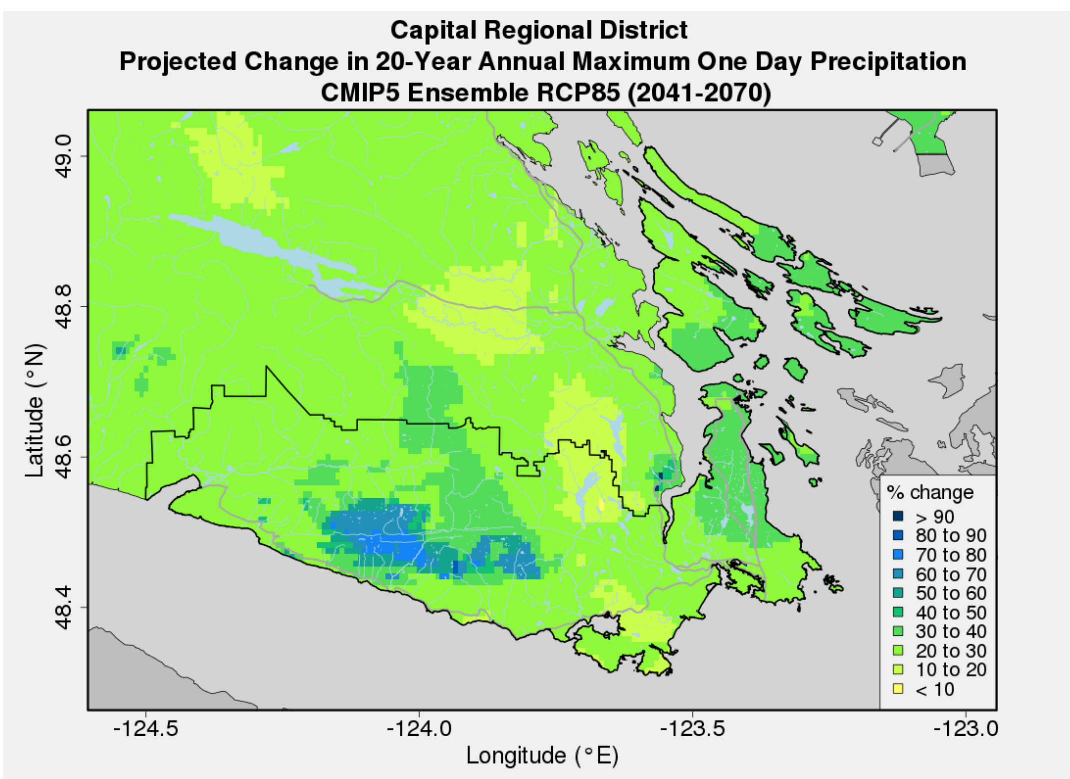

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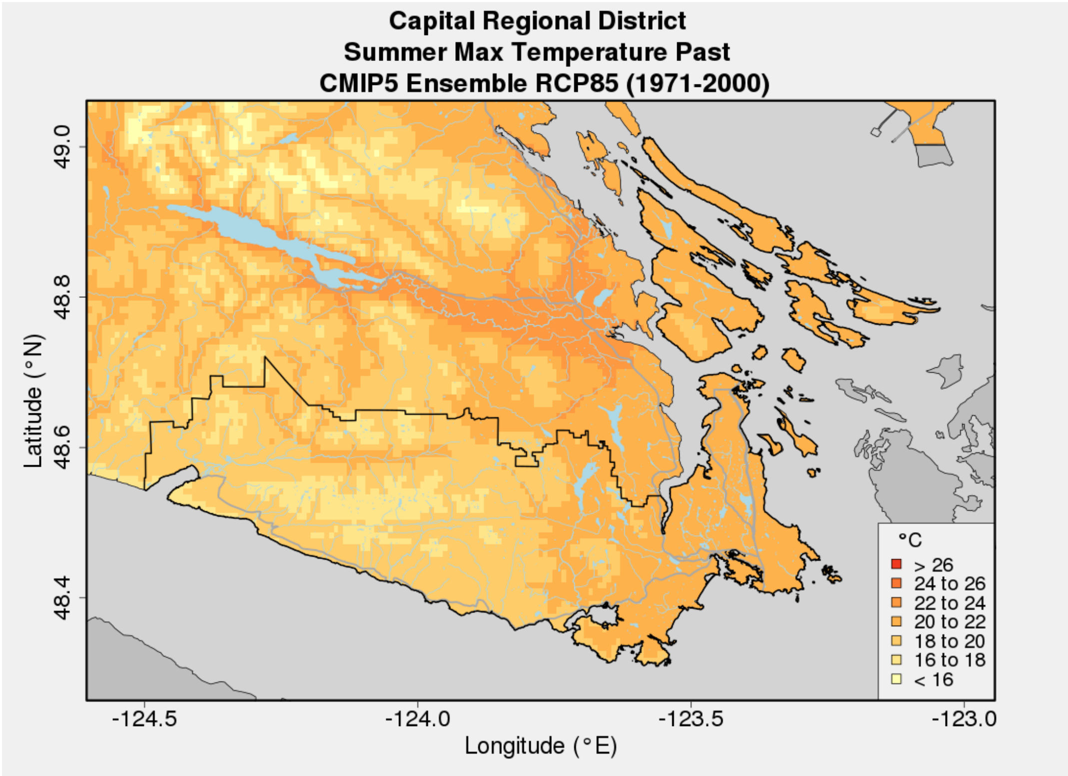

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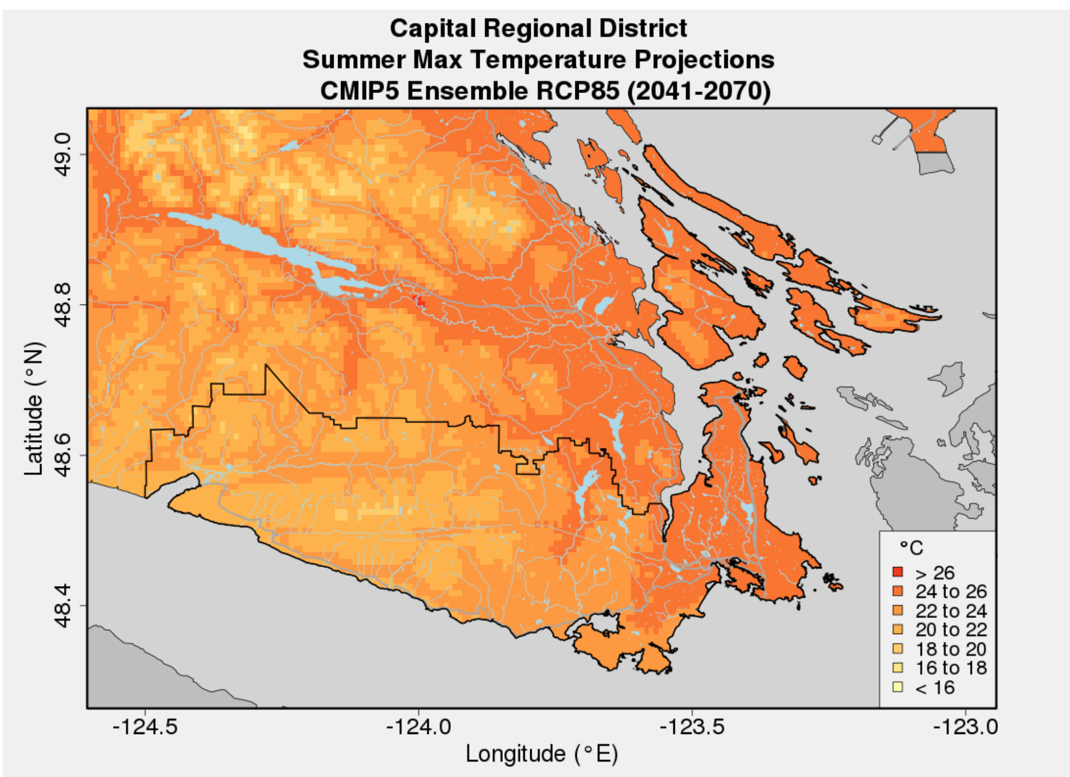

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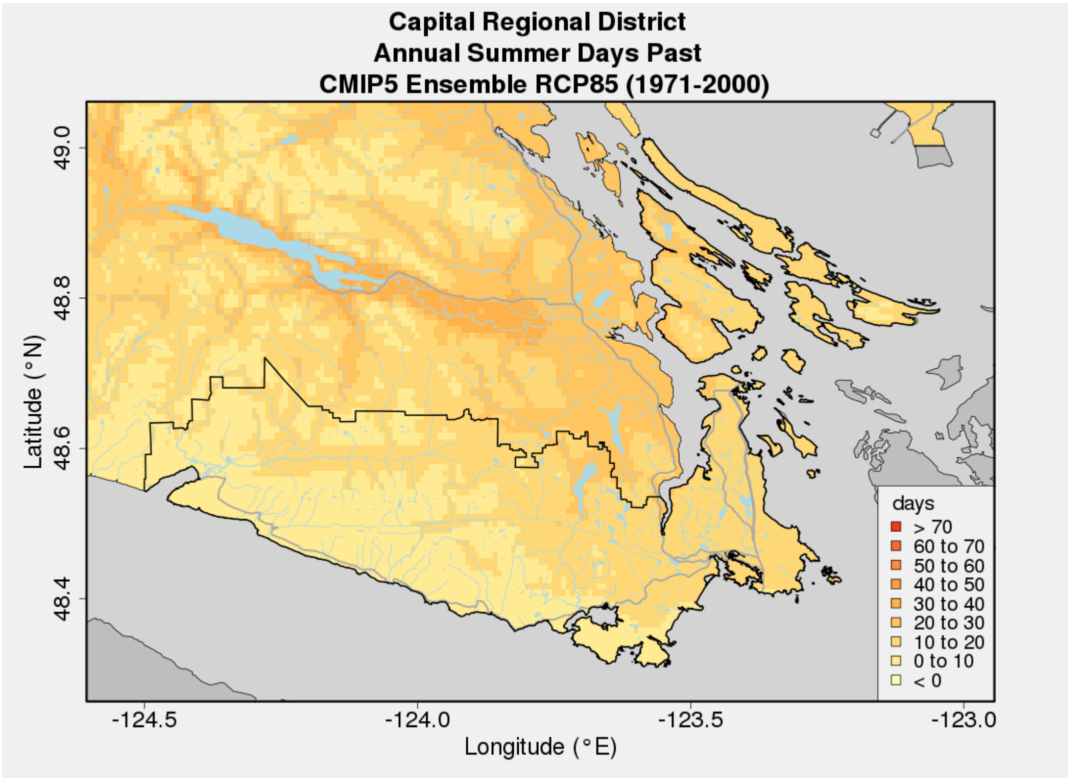

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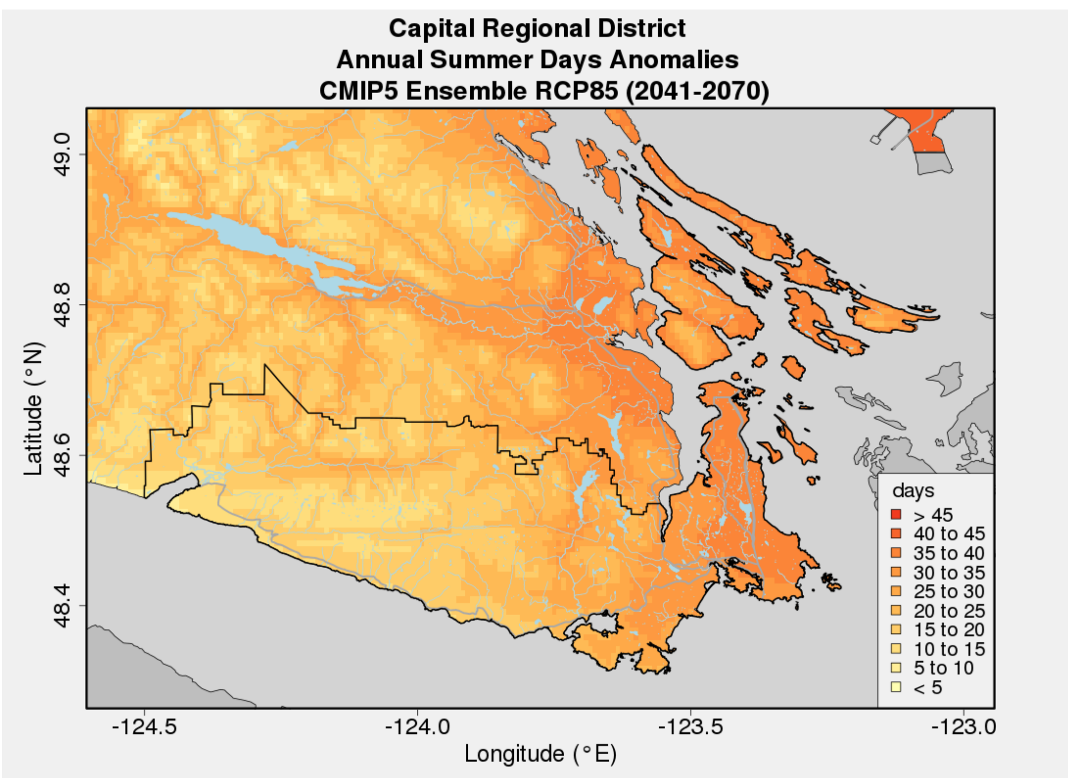

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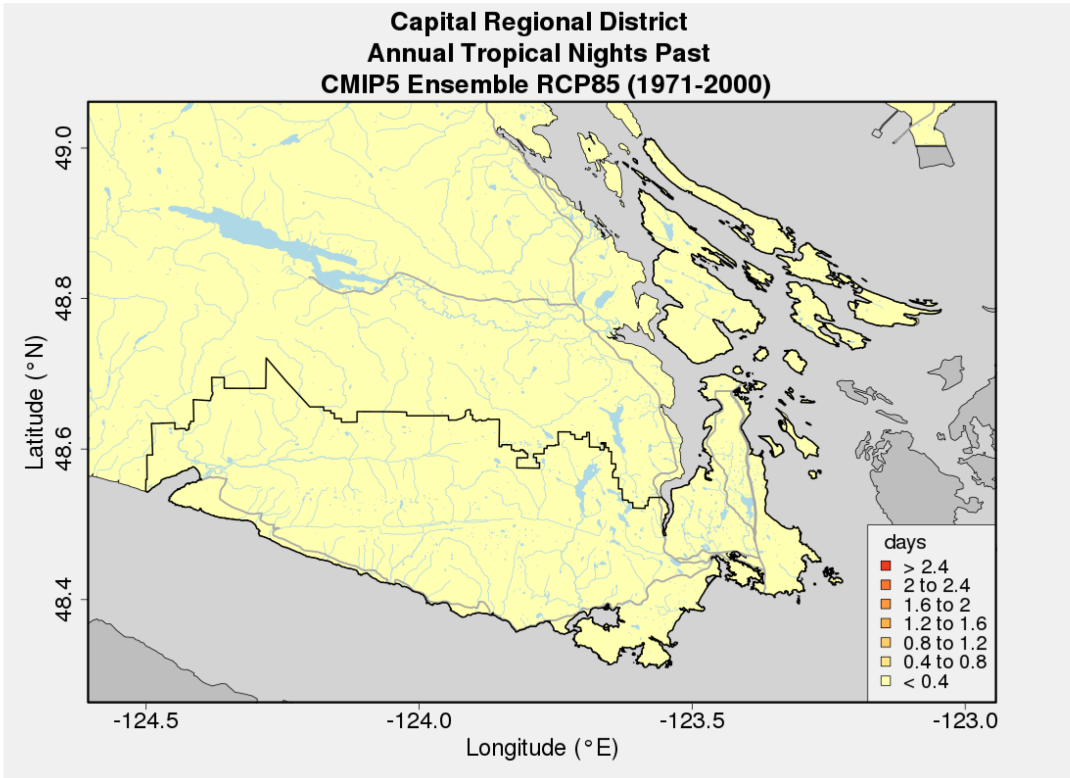

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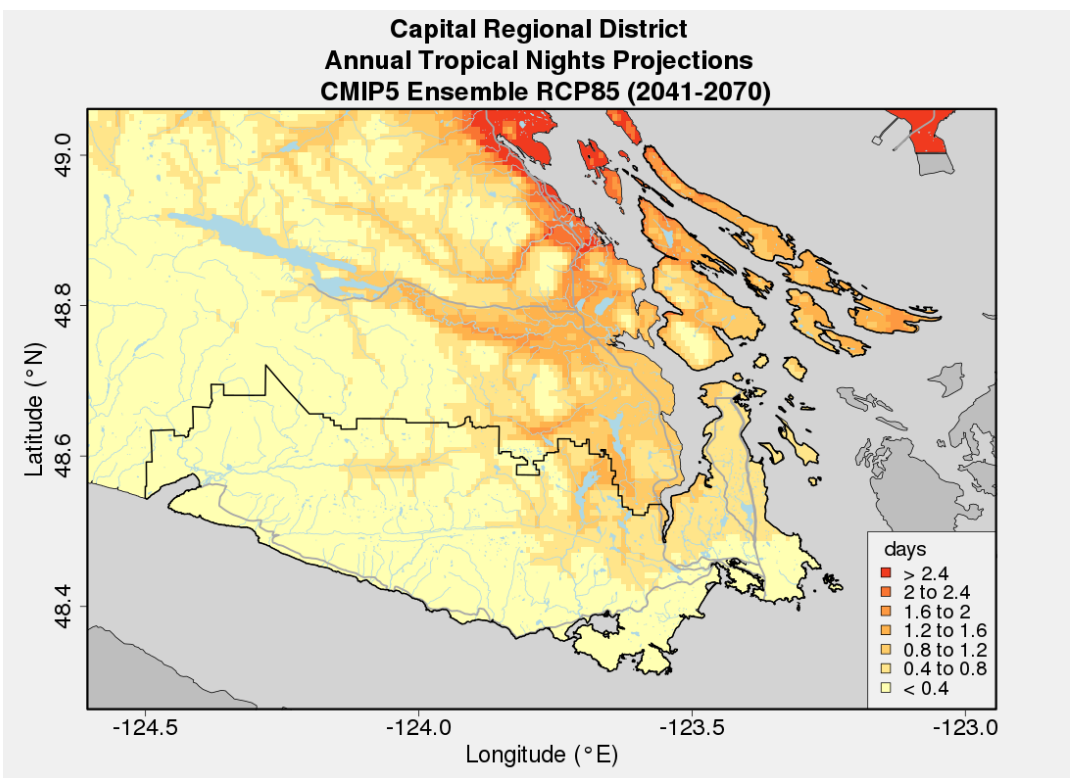

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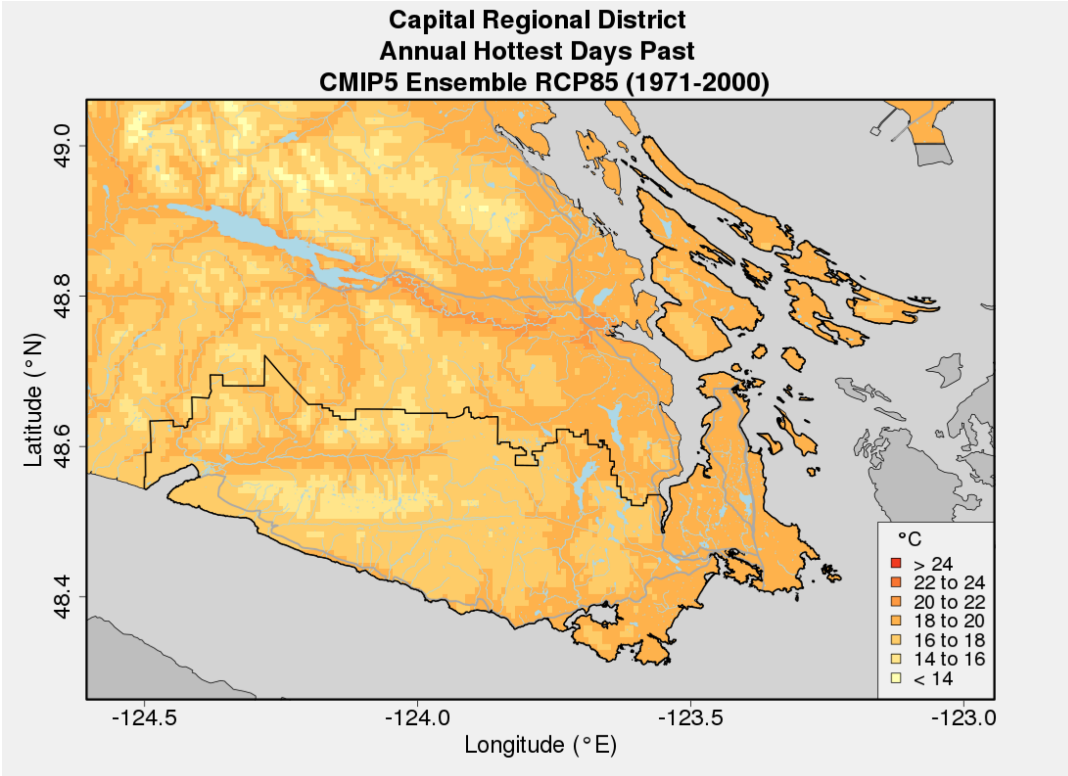

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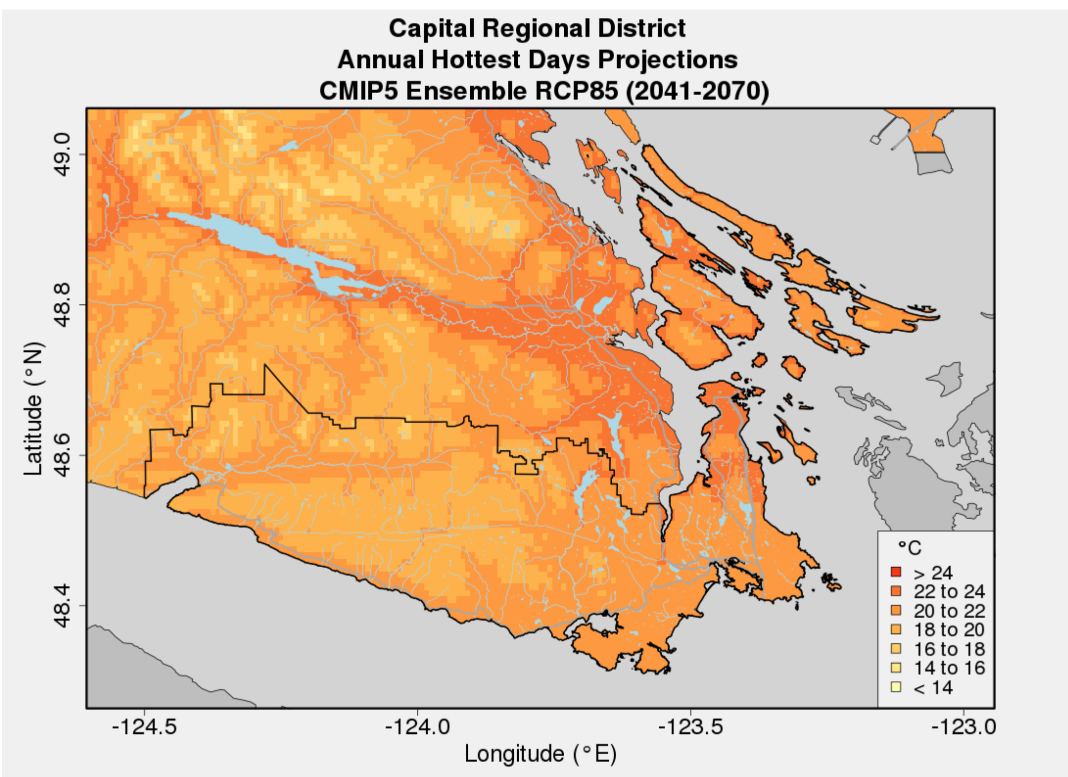

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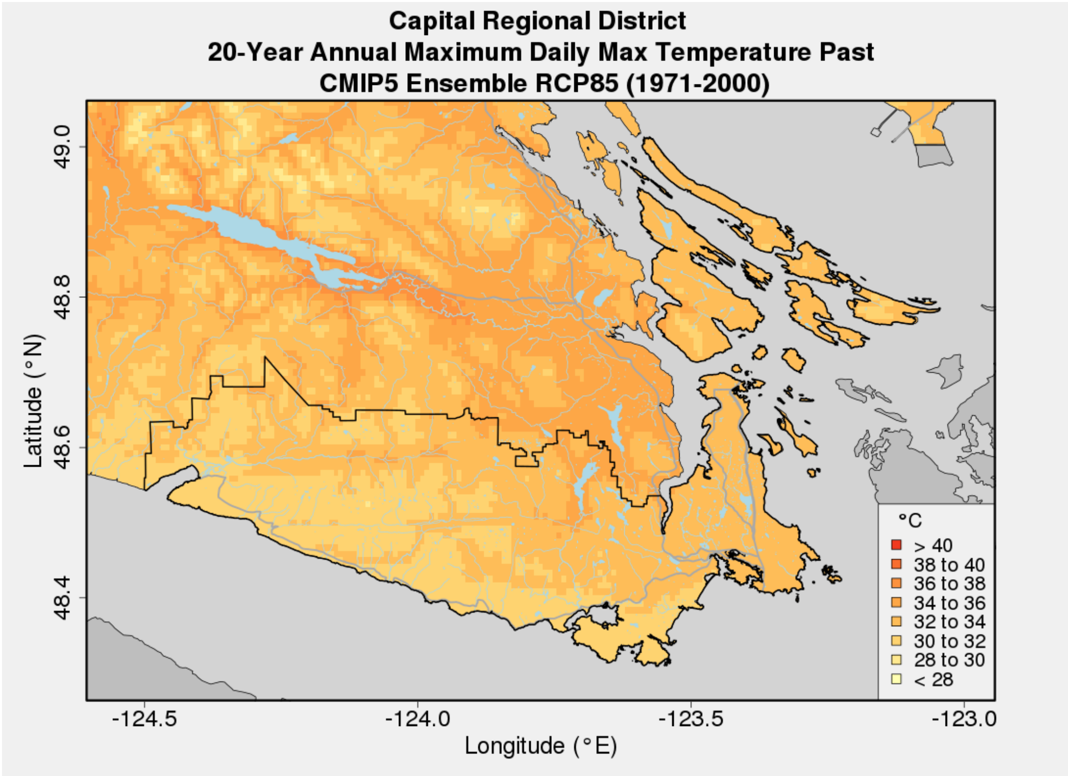

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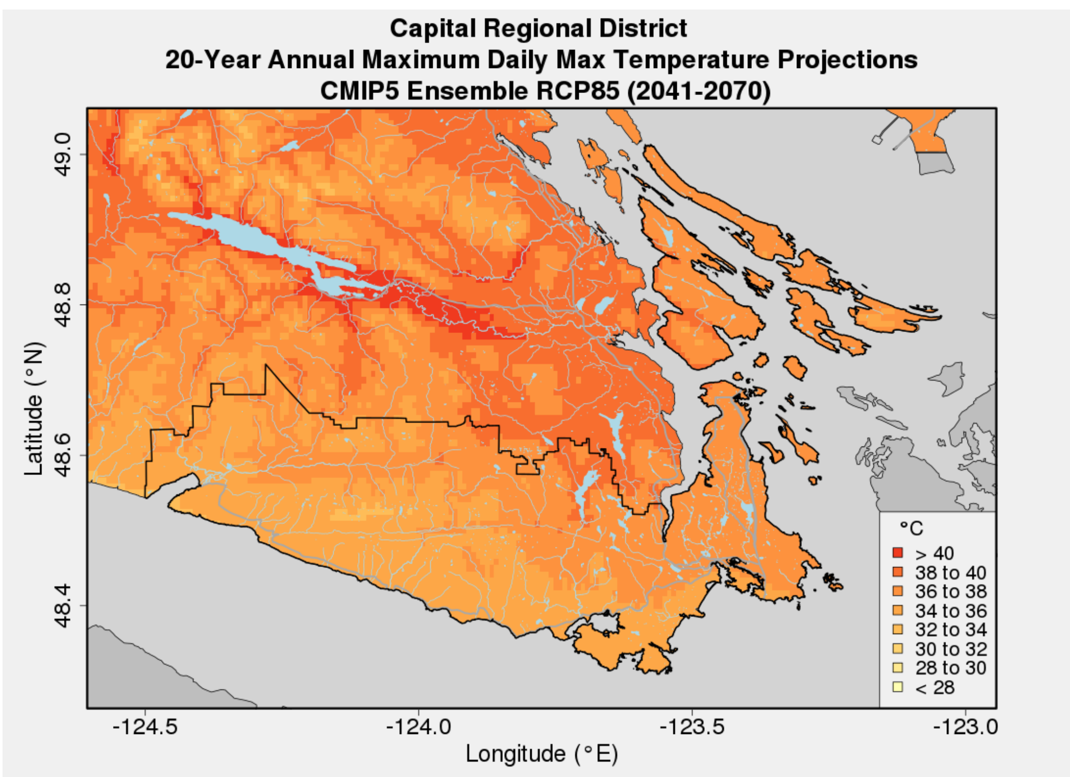

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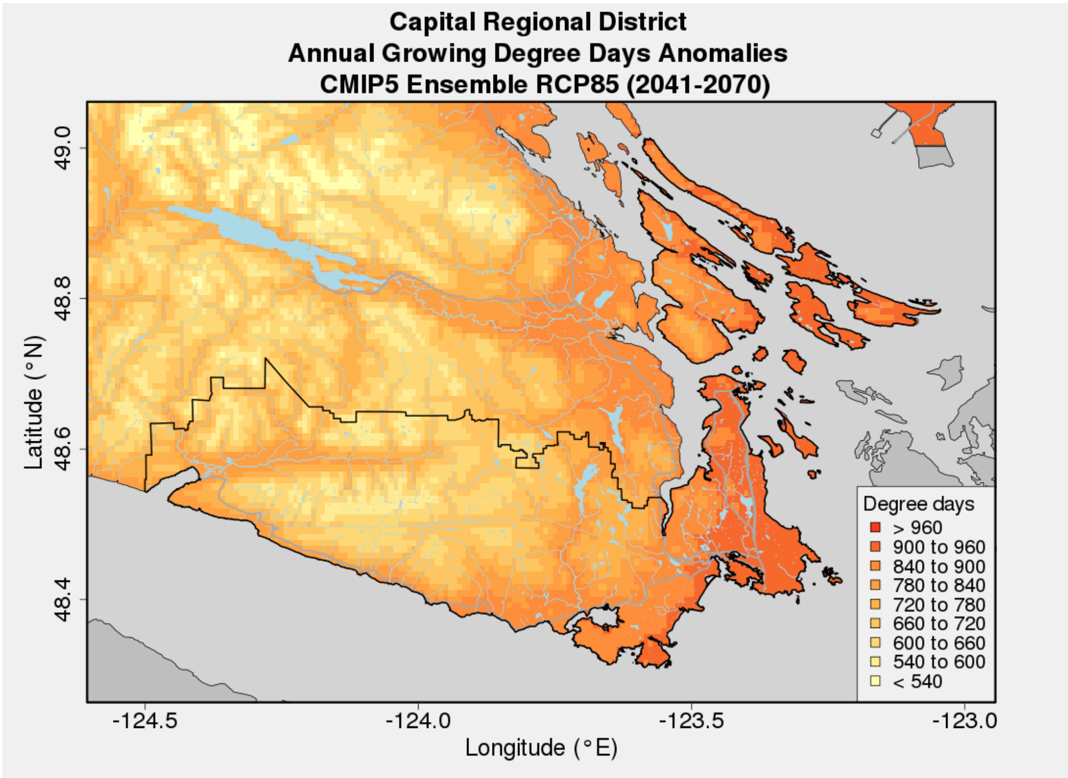

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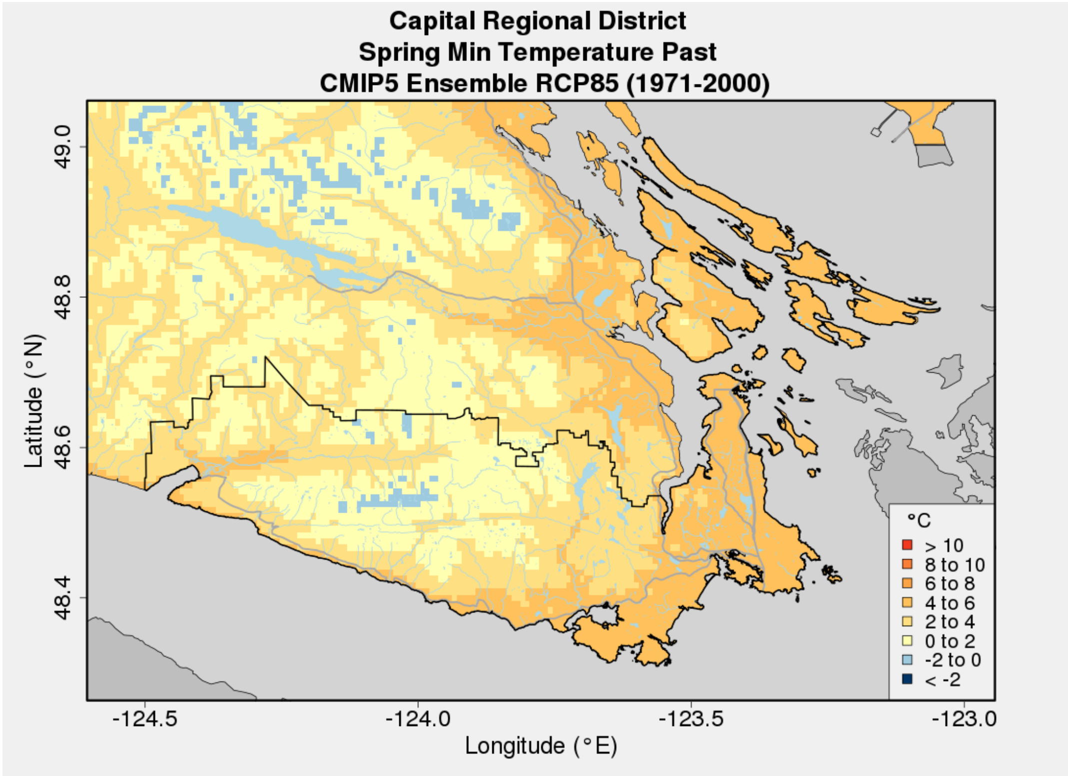

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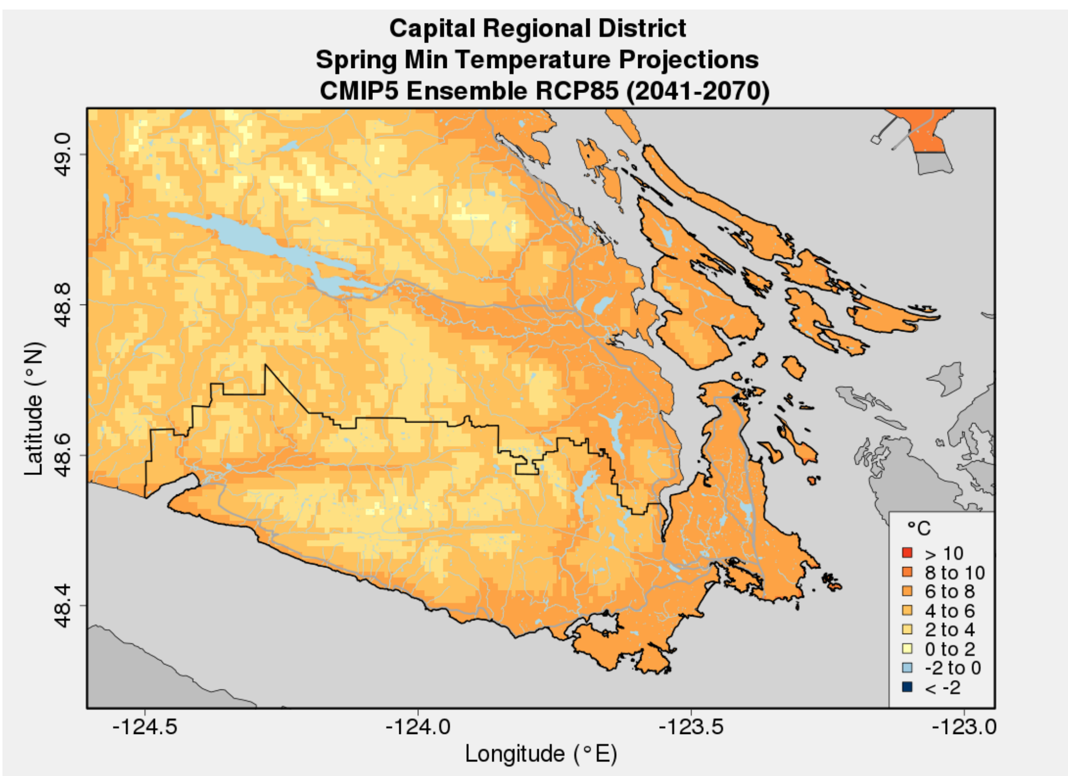

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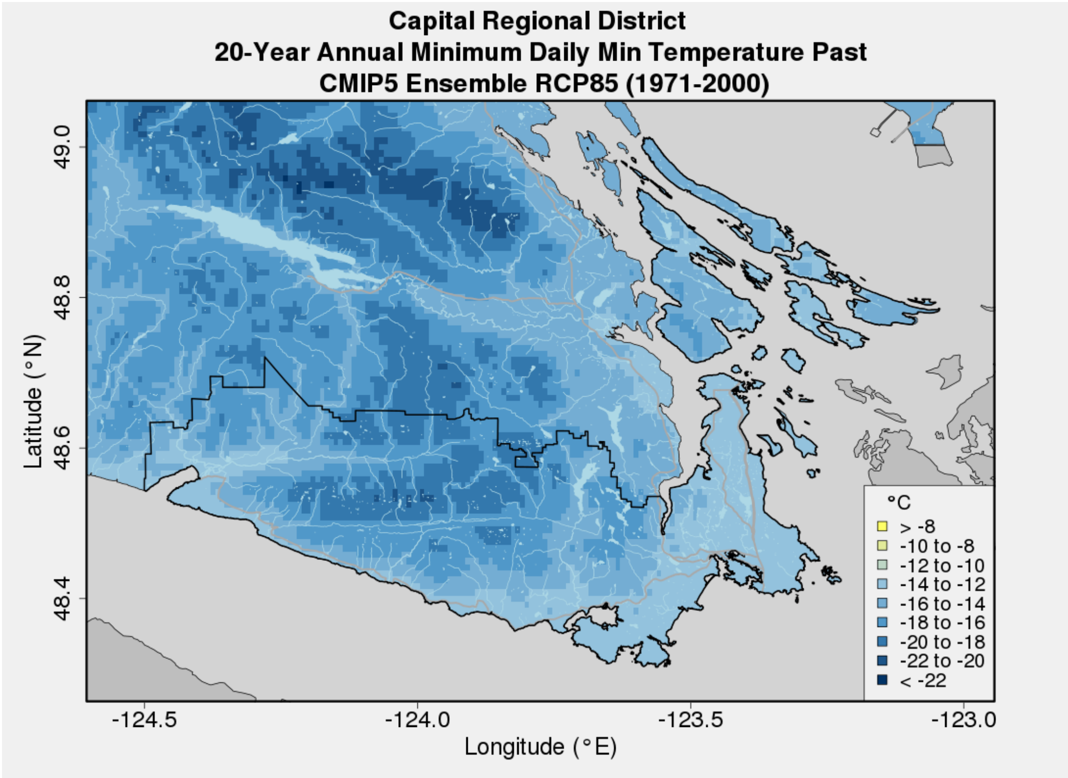

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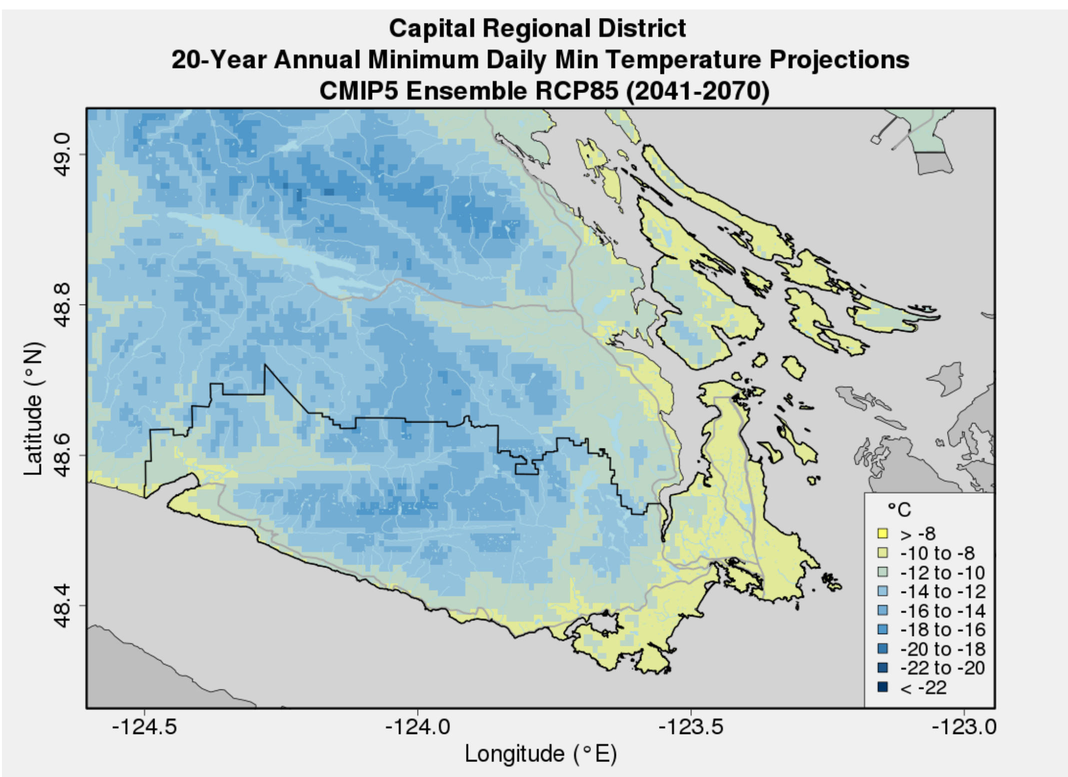

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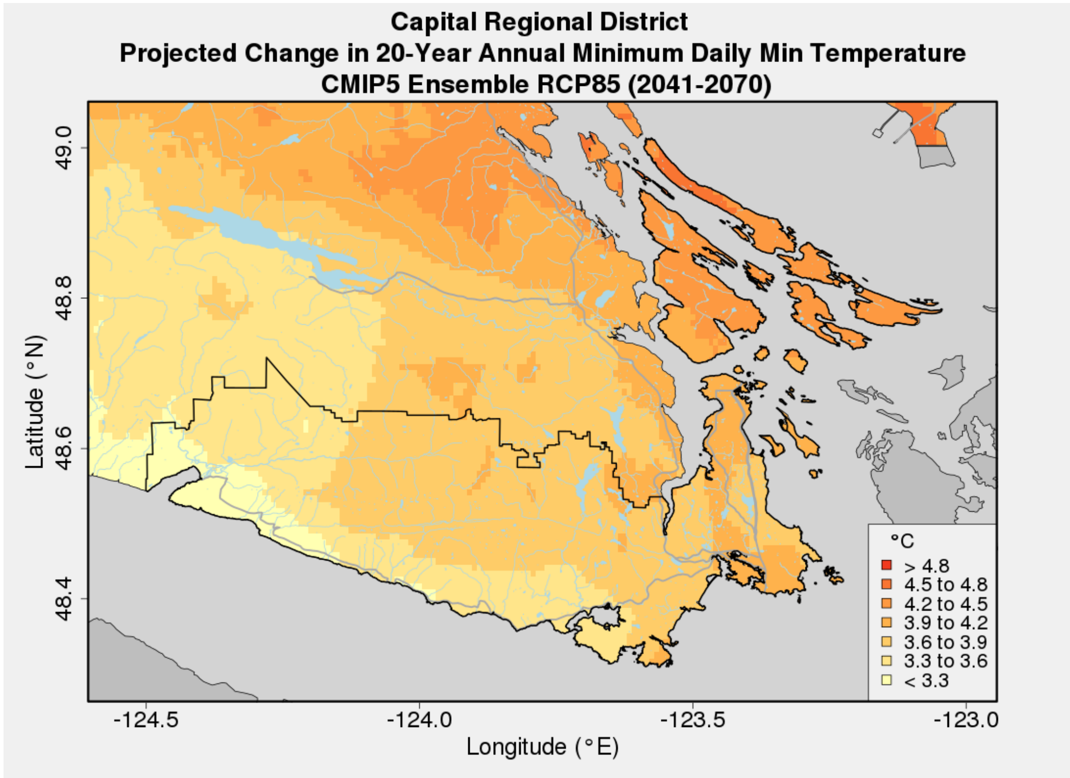

Figure 52: 1-in-20 Coldest Night - Anomalies

NOTES

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