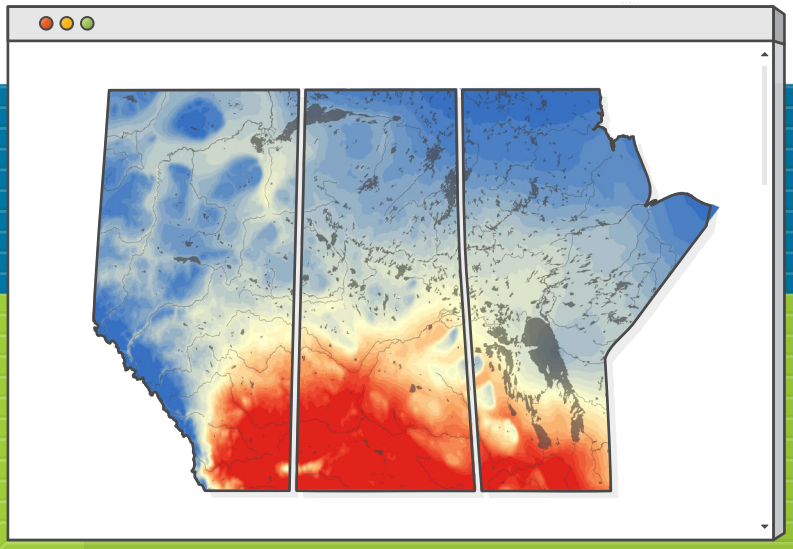
climatewest.ca

ClimateWest

A guide to finding

CLIMATE INFORMATION & DATA



Prepared for ClimateWest
by the Prairie Climate Centre

Prairie Climate Centre

2022

Acknowledgments

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ClimateWest

Building Prairie Resilience

ClimateWest

ClimateWest is the central hub for climate services in Manitoba, Saskatchewan and Alberta. We provide access to regionally-relevant climate information, training and support to address climate risk through planning and action.

- We operate as a network-based non-profit founded with three partner organizations: the Prairie Climate Centre (PCC), the Prairie Adaptation Research Collaborative (PARC) and the International Institute for Sustainable Development (IISD).

- We are a regional climate services hub. We bring together different perspectives and expertise to deliver regionally relevant climate information, tools, guidance and analysis that effectively support adaptation to a changing climate.

- We are a bridge that connects information to action. We convene people from Prairie-based communities, governments, businesses and post-secondary institutions to facilitate the exchange of climate information, research, and lessons for considering climate change in planning and decision-making.

PARC

Prairie Climate Centre

IISD
International Institute for Sustainable Development

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Environment and Climate Change Canada
Environnement et Changement climatique Canada

Alberta
Saskatchewan
Manitoba

To learn more, and for the latest news about our work, please visit
www.climatewest.ca

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List of Acronyms

BCCAQv2	bias correction with constructed analogues and quantile mapping reordering
CCCS	Canadian Centre for Climate Services
CMIP5	Coupled Model Intercomparison Project Phase 5
CMIP6	Coupled Model Intercomparison Project Phase 6
GCM	global climate model
GHG	greenhouse gas
IDF	intensity-duration-frequency
IISD	International Institute for Sustainable Development
PAVICS	Power Analytics and Visualization for Climate Science
PARC	Prairie Adaptation Research Collaborative
PCC	Prairie Climate Centre
PCIC	Pacific Climate Impacts Consortium
RCM	regional climate model
RCP	representative concentration pathway

SECTION 1

Introduction

The climate influences almost all parts of our lives: food, shelter, health, clothing, transportation, recreation – even culture. And this list is not exhaustive. As such, a wide range of people seek out climate information for a variety of reasons and applications. Yet, it is not always easy to find out where the best suited climate information is available, how to access it, and how to interpret it to answer questions about the past, present, and future climate.

ClimateWest is making these steps easier, with a focus on climate information needs within the Prairie provinces of Canada. Intended for people who are looking for information about a changing climate, with an emphasis on climate data, this document is designed to help guide you through the process of finding the appropriate resources for your needs.

1.1 A GUIDE TO FINDING CLIMATE INFORMATION AND DATA

A vast amount of information about climate change is available online. The purpose of this document is to present an overview of several key climate service organizations and climate data portals in Canada that can serve as credible sources of climate information and climate data. While the focus of ClimateWest is the Prairie provinces, and the sample applications of climate data are Prairies-based, much of the guidance offered in this document is relevant to any region in Canada.

Section 1 introduces this ClimateWest guide and some key concepts. Section 2 describes the various climate services where you can find downscaled climate projection data and additional climate information applicable to the Prairie region. An overview of the differences and similarities between the different climate information websites is found in Section 3. Examples of how climate projections have been used for different purposes are provided in Section 4. Finally, answers to some frequently asked questions can be found in Section 5, references are listed in Section 6, and glossary terms (bolded throughout this document) are defined in Section 7.

This document is a complement to A Guidebook on Climate Scenarios (Charron, 2016), developed by Ouranos, which provides guidance on using climate information for decision-making. Between these two resources, you should be able to identify what information you need and where to find it. ClimateWest has several other complementary resources available, including a Help Desk which provides individualized support to answer your questions.

1.2 KEY CONCEPTS

1.2.1 What is the difference between climate information and climate data?

Climate information, as used in this document, is a broad term that encompasses a wide variety of sources including datasets, fact sheets, guides, briefing notes, case studies, research reports, presentations, webinar recordings, and more. In short, anything that seeks to share information about climate change with a basis in scientific evidence can be considered climate information.

In this guide, climate data is a narrower term that focuses on measures of the observable climate and the indices that can be calculated from these variables. Such measures capture biophysical qualities of climate, such as precipitation, the first frost day of the year, etc. Climate data can include:

- ***observed historical data,*** ***which is collected by weather stations across the country.***
- ***simulated historical data,*** ***meaning data about the past climate generated from climate models.***
- ***simulated projected data,*** ***which is data about the future climate generated from climate models.***

1.2.2 Why use climate information?

Climate information and climate data can be used for a variety of purposes. Whether you are an educator, planner, researcher, or just wondering how the climate is projected to change in your region, climate information can help answer your questions and prepare for the future. For example, many communities across the Prairie region are already using climate information as the basis for adaptation planning (City of Edmonton, 2018; City of Saskatoon, 2019; City of Selkirk, 2019). Educators are bringing climate data and stories into the classroom to teach students about climate change (Climate Change Connection, 2020).

Observational climate records help us to understand the historical and current climate, and we use climate models to explore how the climate may evolve in the future. Understanding how the climate is likely to change in the future is the first step in planning for it, and climate information contributes to that process.

1.2.3 What are global climate models?

Global climate models (GCMs) are complex numerical models that represent interactions between different components of the Earth, including the atmosphere, ocean, land surface, and the frozen components of the Earth such as sea ice, glaciers, and permafrost (Taylor et al., 2012). By representing these processes, GCMs are a tool for climate scientists to better understand the Earth's climate system. GCMs are also used to create climate projections of how the Earth's climate system may change, and are used to understand how climate change may impact different systems and sectors, such as water availability (Kienzle et al., 2012), ecosystems (Thorpe, 2011), and agriculture (Carew et al., 2017).

1.2.4 How is climate model data developed?

Climate models are typically generated at the global scale using global climate models, or GCMs. To enable global models to generate regional climate insights, downscaling techniques are used. Downscaling techniques include both dynamical methods, such as regional climate models (RCMs) run at a finer scale, and statistical methods, which combine observed climate information with climate model simulation outputs to obtain information at a higher spatial resolution. Greater detail about this process is discussed later in this guide.

The GCMs are the best tool available to understand and plan for future projected changes in regional climate conditions. The climate projection data hosted by the Canadian Centre for Climate Services (CCCS), ClimateData.ca, and the Climate Atlas of Canada have been developed using datasets produced by the Pacific Climate Impacts Consortium (PCIC). These datasets are comprised of data from an ensemble of Coupled Model Intercomparison Project, phase 5 (CMIP5) GCMs that have been statistically downscaled. This guide provides an overview of where to find statistically downscaled climate projections relevant to the Prairies. The next generation of climate data from the sixth phase of the Coupled Model Intercomparison Project (CMIP6) is now available online via PCIC's website, and will be rolled out across different Canadian portals in 2022. Given this will take time, CMIP5 data remains the focus of this guide.

1.2.5 What other types of climate information is available besides data?

While much of this guide is focused on online sources of Prairie-relevant climate data, the organizations that host climate projections also have other climate information, too.

- The Canadian Centre for Climate Services maintains a library of climate resources, featuring projects from across Canada.
- ClimateData.ca has sector modules which provide examples of using climate information for different sectors, including adaptation in the health sector.
- The Climate Atlas of Canada explores the impacts of climate change through documentary videos, articles, and reports.
- ClimateWest offers a curated library of climate change research in the Prairie region.
- The Pacific Climate Impacts Consortium hosts technical publications, science briefs, and software.
- Ouranos provides several reports on their projects in different sectors and communities.
- The Prairie Adaptation Research Collaborative is an additional Prairie focused organization that provides past research project reports and unique climate datasets on their website.

SECTION 2

Finding Climate Information Online

2.1 PUBLIC RESOURCES FOR CLIMATE INFORMATION AND CLIMATE DATA IN CANADA

This guide cannot cover every website in Canada that offers climate information or climate data – there are too many. Instead, this guide focuses on the growing network of government and nonprofit climate services providers with a common mandate to make reliable climate information and climate data more accessible for a wide base of people and organizations. The information and data provided by these climate services organizations adhere to high standards of scientific credibility. The climate data portals and climate services organizations include:

- *National climate service provider*
  The Canadian Centre for Climate Services, part of Environment and Climate Change Canada in the Government of Canada
- *The Canadian continuum of climate data portals*
  ClimateData.ca
  The Climate Atlas of Canada
  Power Analytics and Visualization for Climate Science (PAVICS)
- *Regional climate service providers, all independent nonprofits*
  ClimateWest in the Prairie region
  CLIMAtlantic in the Atlantic region
  Pacific Climate Impacts Consortium (PCIC) in the Pacific and Yukon region
  Ouranos in Québec
- *Prairie-focused climate information*
  Prairie Adaptation Research Collaborative

This guide provides an overview of the information available from the resources listed above, with the exception of PAVICS and CLIMAtlantic. CLIMAtlantic is a newly announced regional climate service provider that has yet to launch formally. PAVICS provides a greater ability to analyze data than the other sites described in this document and is targeted towards a highly technical user base that is familiar with climate data and a Python programming environment. PAVICS provides options to directly access several types of climate and weather datasets, analyze and visualize climate data, and run hydrologic models through the Raven hydrologic modelling framework. More information on the analytical tools and datasets available through PAVICS can be found at https://pavics.ouranos.ca/.

ClimateWest and Ouranos do not provide Prairie-focused climate model data at this time, but both host several reports and other resources that may be of interest, depending on what you are looking for. The Prairie Adaptation Research Collaborative (PARC) provides an overview of climate change data in the Prairies by drawing on their unique RCM and paleoclimate datasets.

2.2 FINDING CLIMATE INFORMATION FOR THE PRAIRIE REGION

A wide range of climate model data and adaptation resources are available for the Prairies. Sources of climate information for the Prairies consist of national and regional climate information websites.

Table 1: Climate information available for the Prairies.

	GCM data for the Prairies	Climate information resources relevant to the Prairies
Canadian Centre for Climate Services	✓	✓
ClimateData.ca	✓	✓
Climate Atlas of Canada	✓	✓
ClimateWest		✓
Pacific Climate Impacts Consortium	✓	✓
Ouranos		✓
Prairie Adaptation Research Collaborative		✓

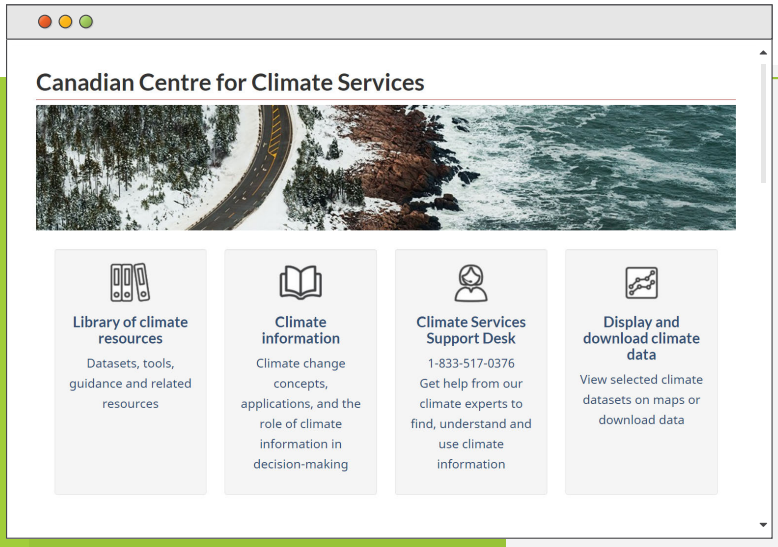
The CCCS provides a variety of climate services relevant to the entire country. The Climate Atlas of Canada and ClimateData.ca are national tools which provide access to Canada-wide climate information and adaptation resources. ClimateWest is focused on providing regional climate services for the Prairie region. PCIC of the Pacific and Yukon region and Ouranos of Québec provide regional climate services, although some of the resources they provide may be relevant to different sectors in the Prairies. PARC is a research centre and a founding partner of ClimateWest, both based in the Prairies. The climate change resources available on each website, and their relevance to the Prairies, are described in the following sections.

2.3 CANADIAN CENTRE FOR CLIMATE SERVICES

The Canadian Centre for Climate Services (CCCS) is a national hub for climate information, services, and training. The CCCS seeks to build and support community resilience and an understanding of climate change by linking Canadians to climate services. It provides climate services through a library of climate resources, articles on climate change concepts, a support desk, and climate data through maps and for download.

2.3.1 Available Resources

- CCCS hosts a library of climate resources, including adaptation planning guidance, tools, and resources.
- Several informative articles are provided relating to climate services and introductory climate change concepts.
- CCCS provides access to climate experts through a climate services support desk via phone or an email form on their webpage.
- National downscaled climate projections are available for viewing or download.
- Coarse (1 x 1 degree grid cell) GCM data is available for temperature, precipitation, snow depth, sea ice thickness, sea ice concentration, and wind speed.



2.3.2 Prairie Content

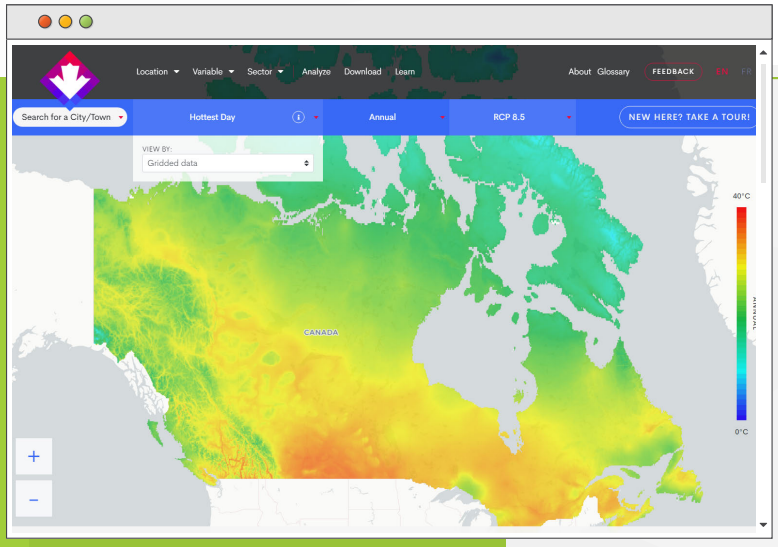
- ✓ *The resources provided are national in scope.*
- ✓ *Downscaled GCM projections are available for the Prairies.*
- ✓ *Additional climate information resources are relevant to the Prairie region.*

2.4 CLIMATEDATA.CA

ClimateData.ca is a national portal that provides climate data to support decision-making. It includes access to high-resolution climate model data through mapping and location-based summaries for a variety of climate variables and indices. Observed climate normals, observed station data, intensity-duration-frequency (IDF) curves, and climate model data for several climate variables and indices are also available for download.

2.4.1 Available Resources

- Sector modules make connections between climate model data and applications in various sectors, including health and agriculture.
- Training materials in the Learning Zone provide background information on climate science and the use of climate information.
- National downscaled climate projections are available for viewing or download.
- Graphs display climate projections for three emission scenarios, allowing for comparisons of projections under the different scenarios.
- Historical climate station data and IDF curves are provided.
- Analysis tool provides the option to define custom thresholds for various climate indices.



2.4.2 Prairie Resources

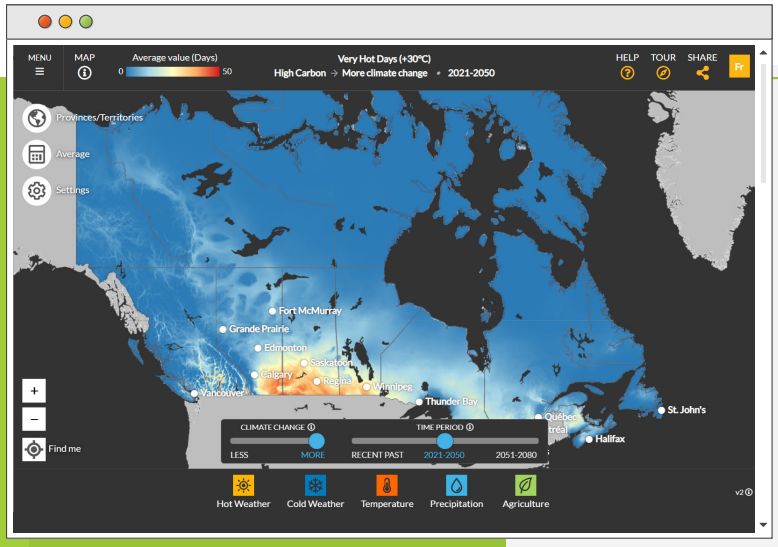
- ✓ *The resources provided are national in scope.*
- ✓ *Downscaled GCM projections are available for the Prairies.*
- ✓ *Additional climate information resources are relevant to the Prairie region.*

2.5 THE CLIMATE ATLAS OF CANADA

The Climate Atlas of Canada is a national data portal and interactive tool which combines climate science, mapping, and storytelling. It features nationwide mapping of climate model data and allows users to explore projected climate changes for many variables and indices. Climate model data can be explored through downloadable graphs and maps or as location-specific climate reports.

2.5.1 Available Resources

- Topic pages explore the impacts of climate change, adaptation strategies, and perspectives across Canada for a variety of subjects, including agriculture, cities, forests, and health.
- Articles, reports, and documentary videos use storytelling to convey the impacts of climate change and the ways that people across Canada are adapting.
- National climate projections are available for viewing through an interactive map or for download.



2.5.2 Prairie Resources

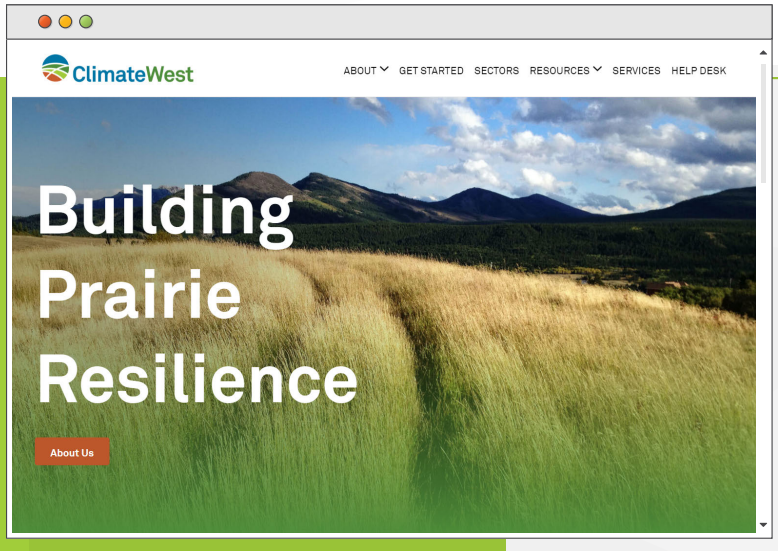
- ✓ *The resources provided are national in scope.*
- ✓ *Downscaled GCM projections are available for the Prairies.*
- ✓ *Additional climate information resources are relevant to the Prairie region.*

2.6 CLIMATEWEST

ClimateWest is the central hub for climate services in the Prairie provinces (Alberta, Saskatchewan, and Manitoba). ClimateWest provides access to regionally relevant information about climate change and supports users to effectively apply that information to planning and decision-making contexts. The ClimateWest website provides Prairie-focused reports and links to finding relevant climate information.

2.6.1 Available Resources

- The website provides a comprehensive Prairie climate report summarizing climate impacts for sectors and communities in the Prairies.
- A curated library of past Prairie project reports and other relevant resources is available, covering several sectors of focus: agriculture, municipalities, Indigenous communities, water management, infrastructure, and health.
- ClimateWest provides a help desk for support in finding and applying climate information.



2.6.2 Prairie Resources

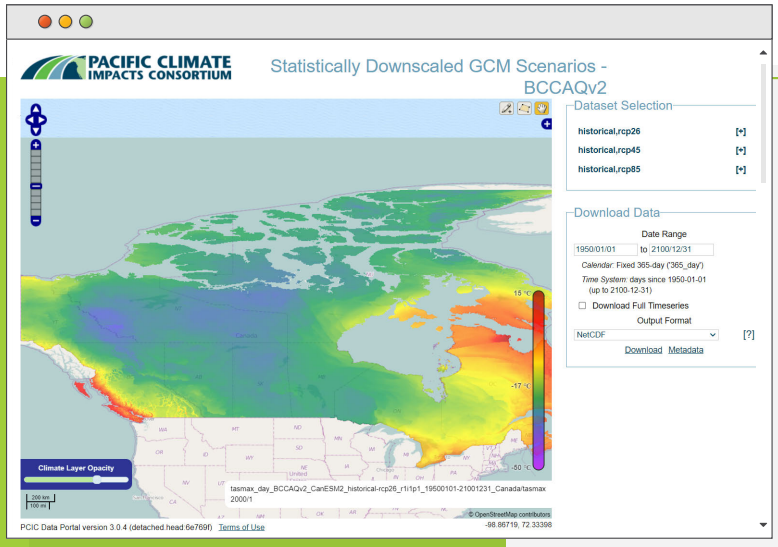
- ✓ *The resources provided are mainly regional (Prairies) in scope, with national relevance.*
- ✓ *Additional climate information resources are relevant to the Prairie region.*
- ✘ *Downscaled GCM projections are not available, though the help desk can help locate climate data from other sources.*

2.7 PACIFIC CLIMATE IMPACTS CONSORTIUM

The Pacific Climate Impacts Consortium (PCIC) is a regional, data-driven climate services provider, focused on the Pacific and Yukon region of Canada. PCIC conducts research related to hydrologic impacts, regional climate impacts, and climate analysis and monitoring.

2.7.1 Available Resources

- The website provides a library of publications, reports, and software developed by PCIC.
- National climate projections for individual GCMs are available for download at the daily scale (statistically downscaled climate scenarios) or for viewing and download through the interactive Climate Explorer tool.
- Statistically downscaled climate scenarios features data from both CMIP5 and CMIP6.
- The site provides gridded model outputs from a VIC-GL hydrologic model driven by six GCMs under two Representative Concentration Pathways (RCPs), RCP 4.5 and RCP 8.5. Model outputs include evapotranspiration, surface runoff, glacier area, and others and extend into northern Alberta.



2.7.2 Prairie Resources

✘ *The resources provided are mainly regional (Pacific and Yukon) in scope.*

✓ *National downscaled GCM projections for individual models are available for the Prairies.*

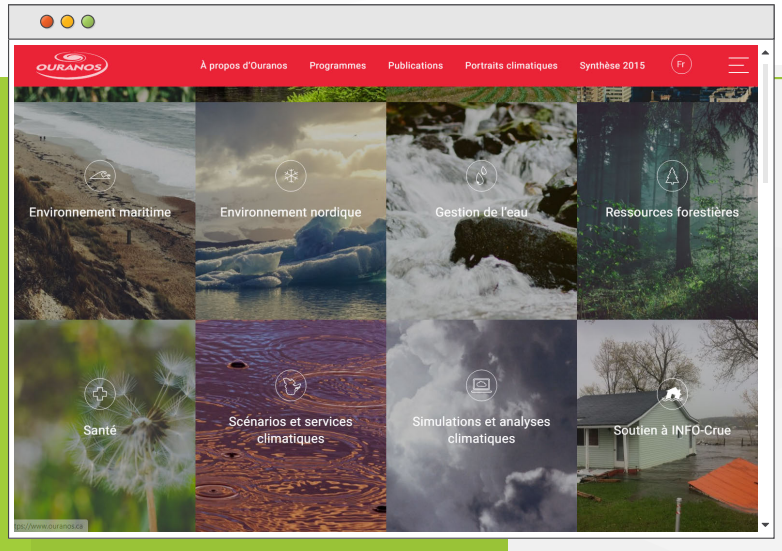
✓ *Technical publications and software have relevance to the Prairie region.*

2.8 OURANOS

Ouranos is a consortium focused on regional climatology and climate change adaptation in Québec. Ouranos has an extensive library of their past work, including technical reports on climate change, with a regional focus on climate change knowledge and adaptation in Québec. Ouranos conducts programs and research in several areas, including agriculture, energy, northern environment, water management, and tourism.

2.8.1 Available Resources

- The site provides a library of publications and reports on sectoral climate impacts and adaptation strategies.
- *A Guidebook on Climate Scenarios* provides guidance on using climate model data.



2.8.2 Prairie Resources

✘ *The resources provided are regional in scope with a focus on Québec for data and reports.*

✘ *Downscaled GCM projections are not available for the Prairie region.*

✓ *Written reports may be of interest to different sectors in the Prairies, although they are generally not focused on the Prairies.*

2.9 PRAIRIE ADAPTATION RESEARCH COLLABORATIVE

The Prairie Adaptation Research Collaborative (PARC) is a research centre based in the Prairies that has undertaken many climate change impact and adaptation projects in the region. PARC's library of past projects spans 20-plus years of climate change research and includes numerous project reports, scientific papers, summary documents, and presentations. The website also provides further information on PARC's Tree-Ring Lab, in which researchers collect and examine tree rings to provide insight into the hydroclimate of the past. While climate data is not available for download through PARC's website, the PARC Data Applications Gateway page provides an overview of two unique datasets for the Prairies:

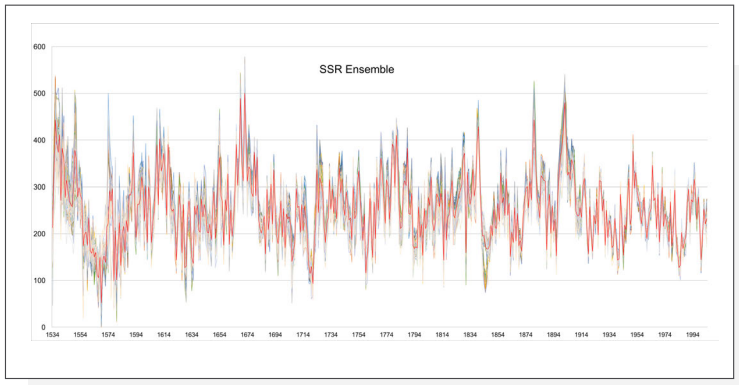


Fig. 1: Sample paleoclimate data.
Source: PARC

- **Paleoclimate data:** PARC's Tree-Ring Lab has a large database of tree-ring data across the Prairie region that has been used to reconstruct the hydroclimate for past centuries. The long-term nature of this dataset provides insight into natural climatic variability in the absence of anthropogenic climate change.

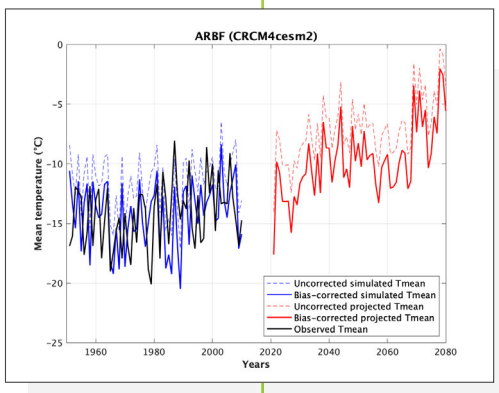
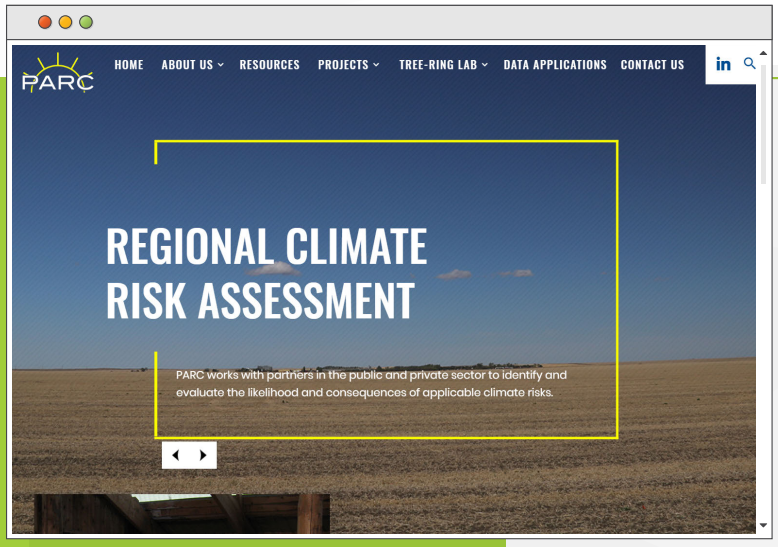


Fig. 2: Sample RCM data.
Source: PARC.

- **RCM data:** PARC has also produced RCM projections across the Prairie region. RCMs are higher-resolution climate models driven by the boundary conditions from a GCM. The regional focus of these models produces climate projections at a smaller spatial scale (10 to 50 km) compared with that of the GCMs (hundreds of kilometres).

2.9.1 Available Resources

- The website provides a library of past research project outputs, drawn from PARC's collection of 100-plus research projects and 400-plus presentations delivered.
- Sample project reports include:
  - Assessment of climate change on the agricultural resources of the Prairies
  - Rural communities' adaptation to drought
  - Variability and trends in Alberta climate and streamflow with a focus on the North Saskatchewan River Basin
- The PARC Data Applications Gateway page provides an overview of PARC's work in the Prairie region with their paleoclimate and RCM datasets.



2.9.2 Prairie Resources

- ✓ *The resources provided are regional in scope, with a focus on the Prairie region.*
- ✓ *The PARC website provides an overview of Prairie-focused RCM and paleoclimate data.*
- ✓ *The resource library feature offers outputs from 20-plus years of research projects in the Prairies.*

SECTION 3

Finding Climate Model Data

All the websites outlined in Section 2 (except for ClimateWest, Ouranos, and PARC) present the same robust downscaled GCM temperature and precipitation data for the Prairies produced by PCIC. Therefore, selecting the right resource to suit your data needs depends largely on how the data is presented, including the grid scale, time step, emission scenarios and climate indices that are available. Your selection of one or more climate information websites can also depend on how you are planning to use that data. A summary of the various file types available for download on each website, as well as the data resolution and format of other available resources, are presented below. Some resources may require additional processing, and therefore will require a basic understanding of specialized software to process the data. The resources that provide downscaled climate model data that includes the Prairie region include:

- The Canadian Centre for Climate Services
- ClimateData.ca
- The Climate Atlas of Canada
- Pacific Climate Impacts Consortium

Several of the differences between the websites are summarized in this section, including those related to:

- ➜ *Global climate models*
- ➜ *Downscaling*
- ➜ *Emission scenarios*
- ➜ *Historical climate data*
- ➜ *Spatial and temporal aspects of data*
- ➜ *File format*
- ➜ *Other types of data and tools available*
- ➜ *Guidance and training materials*

3.1 GLOBAL CLIMATE MODELS

3.1.1 What is a GCM?

Global climate models (GCMs; also referred to as general circulation models) are computer models which simulate key physical processes in order to approximate the global climate system (Taylor et al., 2012). The current suite of GCMs hosted on the Canadian climate information websites were developed as part of the fifth phase of the Coupled Model Intercomparison Project (CMIP5).

In order to model the effects of greenhouse gases on regional climate variables, GCM simulations have been conducted under different GHG emission scenarios (Moss et al., 2010; Taylor et al., 2012). The CMIP5 GCMs divide the Earth's surface into grid cells measuring hundreds of kilometres (Taylor et al., 2012), which are made relevant at regional scales via statistical downscaling.

Table 2: Number of GCMs included in ensemble on each website.

	Canadian Centre for Climate Services	ClimateData.ca	Climate Atlas of Canada	PCIC Climate Explorer
Number of GCMs	24	24	24	24-27*

*The number of GCMs available through PCIC varies by RCP.

3.1.2 How is the ensemble of GCMs represented?

The climate information websites outlined in this guide present data from an ensemble of 24 to 27 GCMs in different ways. It is standard practice to utilize data from several GCMs, rather than relying on a single GCM, in order to represent differences between the projections of different climate models. Considering the GCM ensemble means being prepared for a range of plausible outcomes, leading to more robust planning. How to treat uncertainty within the ensemble of GCMs is explored in further detail in Section 1.8 of A Guidebook on Climate Scenarios (Charron, 2016).

Depending on your motivation for accessing GCM output data, different methods of representing the GCM ensemble may best suit your needs. Different resources use different summary statistics to represent the ensemble, such as the median and the 10th and 90th percentiles to give an indication of the range of climate model projections. For many purposes, this is adequate; however, for more detailed assessments, you may wish to access climate projections from specific, individual GCMs.

Table 3: Representation of GCM ensemble on each website.

	Canadian Centre for Climate Services	ClimateData.ca	Climate Atlas of Canada	PCIC Climate Explorer
Individual GCM outputs available for download		✓	✓	✓
GCM ensemble statistics	5th, 25th, 50th, 75th, and 95th percentiles	5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles	Ensemble mean, 10th and 90th percentiles	Selected ensemble medians

3.2 DOWNSCALING

3.2.1 What is downscaling?

The type of climate projection data outlined in this guide refers to statistically downscaled GCM data. GCMs provide climate projections for grid cells with dimensions measuring hundreds of kilometres. A process of downscaling the data helps to translate this large-scale information to the local scale to make it relevant for communities. Several techniques are used for downscaling GCM data and they are constantly evolving. Generally, downscaling methods can be categorized as either statistical or dynamical: BCCAQv2 is an example of statistical downscaling while RCMs are dynamical. RCMs have a higher spatial resolution, allowing for an improved representation of climate processes and complex topography.

3.2.2 What does BCCAQv2 mean?

Bias Correction with Constructed Analogues with Quantile Mapping Reordering or BCCAQv2 is a robust statistical downscaling technique that has been shown to perform well relative to other downscaling methods (Murdock et al., 2014; Werner & Cannon, 2016). It was developed by PCIC and is a combination of Bias Correction/Constructed Analogues (BCCA) and quantile delta mapping (Werner & Cannon, 2016). Further details on this downscaling technique are described by Hiebert et al. (2018).

Climate model data hosted on all of the following Canadian climate information websites has been downscaled by PCIC using the BCCAQv2 method. That is, although each website displays the climate model data somewhat differently, the data source is the same robust, statistically downscaled climate model data produced by PCIC.

Table 4: Downscaling method used in data on each website.

	Canadian Centre for Climate Services	ClimateData.ca	Climate Atlas of Canada	PCIC Climate Explorer
BCCAQv2	✓	✓	✓	✓

3.3 EMISSION SCENARIOS

3.3.1 Which RCP do I choose?

Because future emission levels are unknown, climate models are run under different levels of GHG emissions. CMIP5 GCMs use Representative Concentration Pathways (RCPs), which represent different levels of future GHG emissions based on possible long-term socioeconomic trends, such as land use patterns and energy consumption (Moss et al., 2010). The RCPs which are used on the various climate information websites each describe different levels of emissions throughout the 21st century (Moss et al., 2010).

- RCP 2.6: The "low" emission scenario wherein net emissions reach zero in the early to mid-21st century. This scenario results in the least severe global warming.
- RCP 4.5: The "moderate" emission scenario wherein emissions increase until mid-century and then rapidly decline.
- RCP 8.5: The "high" emission scenario. Emissions increase at current or higher rates throughout most of the 21st century, resulting in severe global warming.

Depending on your motivation for accessing climate projections, you may wish to evaluate future projections under a low, moderate, or high emission scenario. Unless you have a strong rationale for limiting the selection of emission scenarios, it is generally best practice to consider the range of plausible futures as defined by the RCPs. It may also be helpful to compare climate projections under multiple emission scenarios to assess the effects of different mitigation strategies.

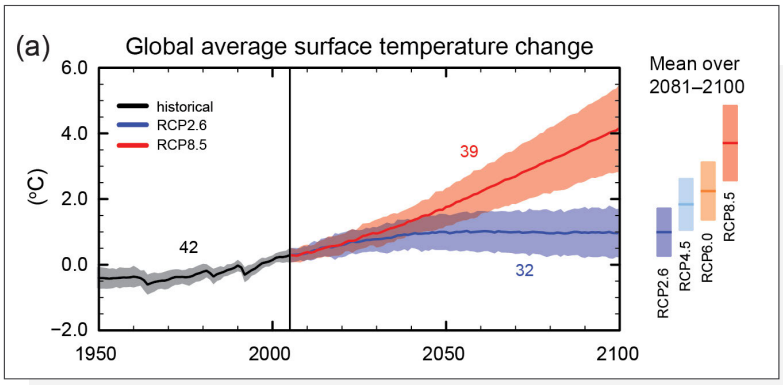


Fig. 3: Average change in global surface temperature as simulated by an ensemble of CMIP5 GCMs under each RCP scenario, relative to 1986-2005. Source: IPCC, 2013.

Table 5: RCPs available on each website.

	Canadian Centre for Climate Services	ClimateData.ca	Climate Atlas of Canada	PCIC Climate Explorer
RCP 2.6	✓	✓		✓
RCP 4.5	✓	✓	✓	✓
RCP 8.5	✓	✓	✓	✓

3.4 HISTORICAL CLIMATE DATA

3.4.1 Why is there a range of historical climate values?

The range of historical climate data values represents the range of the historical climate as simulated by the ensemble of individual GCMs. The GCMs are run under observed atmospheric composition to simulate the past climate from 1850 to 2005; from 2006 onward they are run under levels of GHG emissions corresponding to the different RCPs (Taylor et al., 2012). Therefore, there is a range of historical climate values within the GCM ensemble, which represents the range of values for a given year modeled by the different individual GCMs. This figure shows a grey band of GCM historical simulations and coloured bands of GCM simulations for the future under different RCPs.

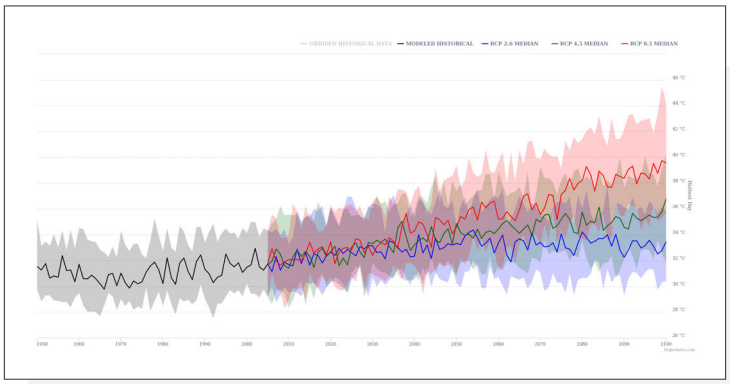


Fig. 4: ClimateData.ca figure for the hottest day for Red Deer, Alberta. Source: ClimateData.ca

Table 6: Availability of simulated historical climate data on each website.

	Canadian Centre for Climate Services	ClimateData.ca	Climate Atlas of Canada	PCIC Climate Explorer
Simulated historical data	✓	✓	✓	✓

3.4.2 Where can I find historical observations?

Environment and Climate Change Canada also hosts a variety of historical climate record products derived from long-term climate station observational data. Historical climate data products include:

- Historical data
- Historical radar
- Canadian climate normals
- Monthly climate summaries
- Almanac averages and extremes
- Engineering climate datasets

Historical station records are also available as station data from ClimateData.ca. Historical climate data may be useful in evaluating historical climate conditions or trends for your region.

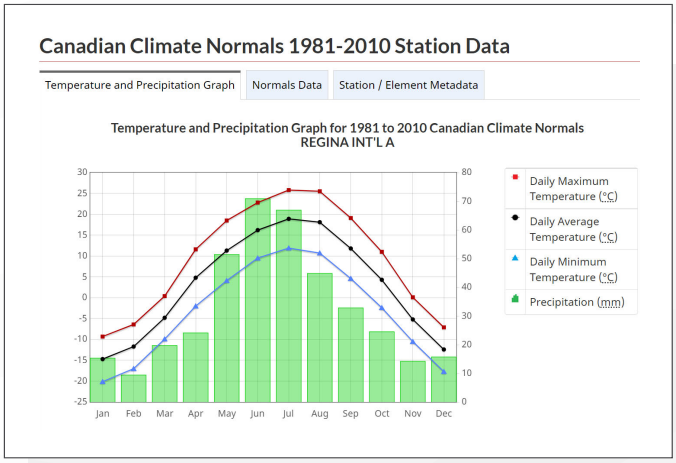


Fig. 5: Climate normals for the Regina International Airport climate station, 1981-2010. Source: Government of Canada, 2021

3.5 SPATIAL AND TEMPORAL SCALES

3.5.1 What is the spatial resolution of the climate data?

By using the BCCAQv2 statistical downscaling method, PCIC has downscaled GCM data to a 1/12° (6 km x 10 km) grid covering all of Canada. The various climate information websites have chosen to display this information at different resolutions or over relevant boundaries using spatial averaging.

Table 7: Spatial resolution of the climate data on each website.

	Canadian Centre for Climate Services	ClimateData.ca	Climate Atlas of Canada	PCIC Climate Explorer
1/12° (6 x 10 km)	✓	✓	✓*	✓
30 x 30 km			✓	
100 x 100 km			✓	
Other	Data can be downloaded for a specified region	Health regions, census subdivisions, and watersheds. Data can also be downloaded for multiple grid cells in the Analyze tool	Provinces and territories	User-defined custom regions

*6 x 10 km data on the Climate Atlas of Canada is only available for select cities.

3.5.2 *What is the temporal resolution of the climate data?*

Downscaled climate projections are available at a variety of time steps.

Table 8: Temporal resolution of the climate data on each website.

	Canadian Centre for Climate Services	ClimateData.ca	Climate Atlas of Canada	PCIC Climate Explorer
Daily		✓		✓*
Monthly	✓	✓	✓	✓
Seasonal	✓	✓	✓	✓
Annual	✓	✓	✓	✓

*PCIC has daily data available through the Statistically Downscaled Climate Scenarios data portal.

3.6 DATA FILE FORMATS

Climate data is available in a variety of file formats. In general, it is likely most appropriate to access climate data in a file format that you are already familiar with, unless otherwise required.

Table 9: File formats available for download from each website.

	Canadian Centre for Climate Services	ClimateData.ca	Climate Atlas of Canada	PCIC Climate Explorer
CSV	✓	✓	✓	✓
GeoTIFF	✓			
GeoJSON	✓	✓		
ASCII				✓
Arc/Info ASCII Grid				✓
NetCDF	✓	✓		✓

*Note: Not all information is available in all formats (e.g. not all information on ClimateData.ca is available in CSV format).

3.7 OTHER TYPES OF DATA AND ANALYSIS TOOLS

Besides GCM projections, several other types of data and analysis tools are available for the Prairies across the climate information websites.

Table 10: Overview of other historical and future data and analysis tools available on each website.

	Canadian Centre for Climate Services	ClimateData.ca	Climate Atlas of Canada	PCIC Climate Explorer
Historical climate products	Adjusted and Homogenized Climate Data (AHCCD); Canadian Gridded Temperature and Precipitation Anomalies (CANGRD); Regional Deterministic Precipitation Analysis (RDPA); Canadian Seasonal to Inter-annual Prediction System (CanSIPS); daily climate records; LongTerm Climate Extremes (LTCE)	IDF curves; 1981-2010 climate normals; observed climate station data		Gridded meteorological datasets: PBCmet2010 (nationwide) and PNWNAmet2015 (includes Alberta and Saskatchewan)
Future climate products	Anomaly values; coarse GCM outputs		Anomaly values; multiple climate data graphs	Numerous climate data graphs
Analytical tools		Custom analysis tool		R packages for climate data

3.8 GUIDANCE AND TRAINING MATERIALS

Each of the climate information websites provide further guidance to help you navigate their website and find the information you are looking for. Some climate information websites also provide additional learning resources that range from introductory materials on climate change to robust guidance on IDF curves.

Table 11: Website documentation and educational resources available on each website.

	Canadian Centre for Climate Services	ClimateData.ca	Climate Atlas of Canada	PCIC Climate Explorer
Website Documentation	Written technical documentation	Explanatory videos in the Learning Zone	Guidebook on using the website	Video tutorial and FAQs
Educational Resources	Explanatory articles	Learning Zone videos and articles	Introductory articles	Science briefs

SECTION 4

Applications Of Climate Data

Climate projections can be used to understand and plan for future changes in the climate and to assess risks in different sectors. How you are planning to use climate projections will help determine which climate information website best suits your needs. For example, one website may be better suited for you than another based on the specifications of the climate model data you require (e.g. grid size, emission scenarios, or whether you require individual GCM data), the usability of the website, or the additional climate information resources available.

In general, considering 30-year time frames and using multiple climate models is standard practice for using climate model data. Further information and direction on using climate projections is provided by Ouranos in A Guidebook on Climate Scenarios (Charron, 2016). The Ouranos guidebook also provides guidance on determining the level of detail of climate projections you may be looking for, which can further help in selecting a suitable climate information website.

The climate information websites described in this document allow you to explore how a variety of climate indices are projected to change in the future for your community under different levels of GHG emissions. Several climate information websites provide reports, publications, articles, and documentary videos that describe current climate change adaptation strategies within various communities and sectors. These stories and technical reports provide a picture of how people in the Prairies and across Canada are responding to climate change and building resilience and can be an informative resource to better understand climate change at the local level.

The following section presents several case studies to illustrate how climate model data has been used for different types of applications throughout the Prairies. In some cases, high level overviews formed the basis for subsequent risk assessment, whereas in others, granular climate data was utilized to characterize potential impacts of climate change on a specific sector. These case studies are intended to provide further context for the level of climate data and general approach that best suits your needs.

4.1 CASE STUDIES IN THE APPLICATION OF CLIMATE MODEL DATA

4.1.1 Selecting relevant climate indices to better understand agricultural impacts of climate change

Keystone Agricultural Producers (KAP) is a member-based agricultural policy organization in Manitoba. KAP partnered with the PCC in order to understand how climate change could affect the sector and to provide insights into the selection of agriculturally relevant indices for the Climate Atlas of Canada. In KAP's report on agriculture and climate change, the Climate Atlas of Canada was used to understand future (2021-2050 and 2051-2080) climate conditions for Manitoba under RCP 8.5, focusing on the Winnipeg and Brandon regions. Climate projections for several variables important to agriculture were obtained, including frost-free days, very hot days (above 30°C), and seasonal precipitation, focusing on changes between the recent past and the two future time periods. Climate model data and consultation with producers informed the remainder of KAP's report, which focused on how the government could further climate resilience in the agricultural sector (Goertzen, 2018).

4.1.2 Municipal adaptation planning

In the summer of 2018, the PCC and the City of Selkirk, Manitoba partnered to collaborate on the development of the city's climate change adaptation strategy (CCAS). Working with a multi-disciplinary team comprised of the city's Capital Asset Management Program team and city service experts, the PCC facilitated a two-day climate adaptation planning workshop.

The workshop was informed by climate model data for the City of Selkirk sourced from the Climate Atlas of Canada. The data was organized seasonally to better reflect the operational cycle and service delivery schedule on which the city runs. This climate information was used to determine where potential risks may exist for the city and its service delivery. From the workshop and in close collaboration with the PCC, the city staff developed a final adaptation strategy. The CCAS was designed to integrate seamlessly into the city's long-term business planning process, ensuring the adaptation actions generated from the strategy were implemented and not left sitting on a shelf.

4.1.2 MUNICIPAL ADAPTATION PLANNING

The final CCAS is an excellent example of designing municipal adaptation plans for successful implementation. In May 2019, the City of Selkirk was awarded the 2019 Canadian Network of Asset Managers' Tereo Asset Management Award for their climate change adaptation strategy (City of Selkirk, 2019).

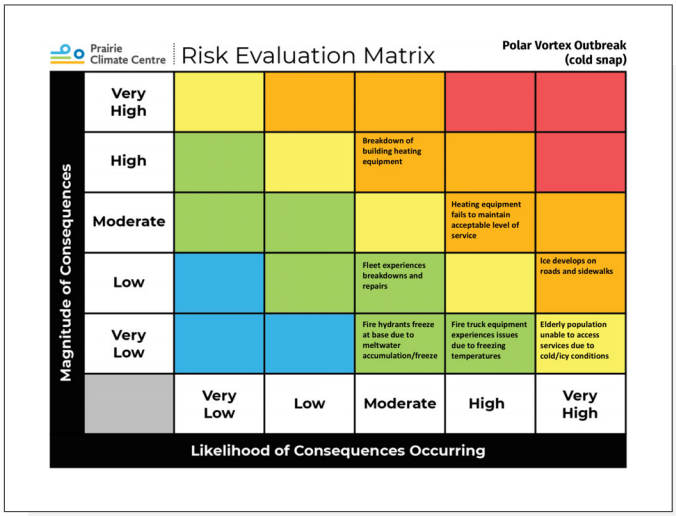


Fig. 6: Risk matrix used to evaluate the potential consequences of changes in the local climate; used in the City of Selkirk's adaptation planning process. Source: City of Selkirk, 2019.

4.1.3 Transportation Risk Assessment

An assessment was conducted for the Alberta Ministry of Transportation to identify how climate change could affect their mandate. The assessment used trends in the historical observational climate record, combined with future climate projections, to identify potential changes in the future climate. These changes then formed the basis for a workshop with key departmental stakeholders around the impacts that future climate change could have for traffic disruptions and transportation infrastructure. This assessment included a process of ranking impacts, analyzing various adaptation strategies, and developing recommendations for the department to prepare for climate change (ICF Marbek, 2012).

4.1.4 Understanding Future Project Risks

As part of the federal Environmental Assessment process, Manitoba Hydro conducted a study to determine potential climate change effects on the Manitoba-Minnesota Transmission Project. A trend analysis on observed temperature, precipitation, and wind speed data was first conducted to identify significant historical climate trends in the region.

Next, Manitoba Hydro used data from an **ensemble** of 15 **GCMs,** downscaled using quantile mapping, across all **RCP** scenarios to describe future temperature, precipitation, and wind speeds for 2010-2039, 2040-2069, and 2070-2099. The report also described the prevalence of extreme events in the future as determined by assessing the literature, including freezing precipitation, forest fire conditions, and tornadoes. This assessment helped Manitoba Hydro to understand future climate change risks for a new project (Klaas et al., 2015).

4.1.5 Researching Hydrologic Impacts of Climate Change

Climate model data has been used in research studies to understand the impacts of climate change on regional hydrology. Kienzle et al. (2012) selected five representative **GCMs** from the PCIC database, based on precipitation and temperature changes for the Cline River Basin in the Upper North Saskatchewan River Basin in Alberta. Data was obtained for the baseline climate (1961-1990) as well as three future time periods (2010-2039, 2040-2069, and 2070-2099). Climate model data for all time periods was applied to the ACRU agro-hydrological modelling system to study projected changes in several hydrologic variables. This climate change hydrologic impact study broadened the understanding of potential future changes in several streamflow characteristics, including peak and low streamflow.

SECTION 5

Frequently Asked Questions

5.1 WHERE CAN I GO FOR FURTHER HELP IN FINDING THE INFORMATION I NEED?

We are glad you asked! ClimateWest has a help desk that is well equipped to answer your questions about climate science, finding climate information, and best practices for using climate information. Contact information for the help desk is available on the ClimateWest website. The ClimateWest help desk is a service targeted at Prairie audiences, although CCCS provides a national climate support desk for climate data users across Canada more broadly.

5.2 HOW MUCH CONFIDENCE CAN I HAVE IN FUTURE PROJECTIONS?

Future climate projections are, by their very nature, uncertain. However, the GCMs are the best tools that we have to estimate how the Earth's climate will respond to higher levels of GHGs in the atmosphere. Uncertainty can be broken down into three main categories as defined by Hawkins & Sutton (2009) and analyzed for the Prairie region by Barrow & Sauchyn (2019):

- ***Natural climatic variability:***
  We do not experience the same climate from year to year because of natural variation, which is especially high in the Prairie region. Natural variation occurs alongside increased radiative forcing due to GHGs.
- ***GCM uncertainty:***
  Climate modelling groups have developed models to represent the main processes of our climate. The variations in how different modelling groups represent key processes lead to differences in their projections.

➜ *Emissions uncertainty:*
The level of GHGs that will be emitted in the future is also uncertain, as it relates to many complex socioeconomic factors. Thus, climate modelers take a scenarios approach (the RCPs in CMIP5) to run climate model simulations under different possible future levels of GHG emissions.

For these reasons, it is generally considered good practice to use a GCM ensemble rather than relying on individual models, and to consider 30-year averages when assessing projected changes in the climate. Despite this uncertainty, statistically downscaled GCMs represent some of the best information available for understanding changes in the future climate. For a more complete discussion of uncertainty in climate change projections, see A Guidebook on Climate Scenarios (Charron, 2016).

5.3 WHICH CLIMATE INDICES ARE AVAILABLE?

All currently available climate variables and indices for each climate information website are listed and described below. If you are looking for a specific index which is not listed but can be derived from daily temperature (minimum, maximum, mean) or precipitation data, you may wish to download the relevant datasets from ClimateData.ca or PCIC as daily data in order to calculate your index of interest. The Analyze tool on ClimateData.ca also provides the option to define custom climate indices of interest based on specified thresholds, including some of the following indices available pre-calculated on other websites. Similar indices listed in the table below that can be calculated using the ClimateData.ca Analyze tool are indicated in the following table by the  symbol.

Table 12: Climate indices derived from downscaled GCM outputs available on each website.

Climate indices	Description	Canadian Centre for Climate Services	ClimateData.ca	Climate Atlas of Canada	PCIC Climate Explorer
Mean temperature	Average temperature for a given time period (average of T_{min} and T_{max} each day).	✓	✓	✓	
Minimum temperature	The daily minimum temperature.	✓	✓	✓	✓
Maximum temperature	The daily maximum temperature.	✓	✓	✓	✓
Total precipitation	Total precipitation for a given time period.	✓	✓	✓	✓
HOT WEATHER					
Hottest day	Highest T_{max} value.		✓	✓	✓
Tropical nights (days with T_{min} > 18°C)	Number of days with T_{min} > 18°C.		✓		
Tropical nights (days with T_{min} > 20°C)	Number of days with T_{min} > 20°C.		✓	✓	✓
Tropical nights (days with T_{min} > 22°C)	Number of days with T_{min} > 22°C.		✓		
Cooling degree days	Indicator of air conditioning requirements. Degree days when T_{mean} exceeds 18°C.		✓	✓	✓
Number of heat waves	The average number of heat waves per year.		🖩	✓	
Average length of heat waves	The average length of a heat wave where a heat wave occurs when at least three days in a row reach or exceed 30°C.		🖩	✓	
Longest spell of +30°C	The maximum number of days in a row with temperatures 30°C or higher.			✓	
Hot (+30°C) season	The length of the season when maximum temperatures above 30°C can be expected.			✓	

Climate indices	Description	Canadian Centre for Climate Services	ClimateData.ca	Climate Atlas of Canada	PCIC Climate Explorer
Days with T_{max} > 25°C	Number of days with T_{max} > 25°C.		✓	✓	✓
Days with T_{max} > 27°C	Number of days with T_{max} > 27°C.		✓		
Days with T_{max} > 29°C	Number of days with T_{max} > 29°C.		✓		
Days with T_{max} > 30°C	Number of days with T_{max} > 30°C.		✓	✓	
Days with T_{max} > 32°C	Number of days with T_{max} > 32°C.		✓	✓	
Extremely hot days (+34°C)	Number of days with T_{max} > 34°C.			✓	
Warm spell duration index	Number of days with at least 6 consecutive days with T_{max} > 90th percentile.		🖩		✓
Percentage of days with T_{max} < 10th percentile	Percentage of days with T_{max} < 10th percentile.				✓
Percentage of days with T_{max} > 90th percentile	Percentage of days with T_{min} > 90th percentile.				✓
Lowest T_{max}	Minimum T_{max} over a given time period.				✓
Mean diurnal temperature range	Average difference between daily T_{min} and T_{max}.				✓
5-, 20-, and 50-year annual maximum temperature	Annual maximum daily maximum temperature with a return period of 5, 20 or 50 years.				✓
COLD WEATHER					
Very cold days (-30°C)	Total number of days per year when T_{min} drops to -30°C or below.		🖩	✓	
Freeze-thaw cycles	Total number of days per year when temperatures fluctuate between freezing and non-freezing (T_{max} > 0°C and T_{min} ≤ -1°C).		🖩	✓	
Frost days	Number of days with T_{min} < 0°C.		✓	✓	✓

Climate indices	Description	Canadian Centre for Climate Services	ClimateData.ca	Climate Atlas of Canada	PCIC Climate Explorer
Ice days	Number of days when daily T_{max} does not exceed 0°C.		✓	✓	✓
Coldest day	Lowest T_{min} over a given time period.		✓	✓	✓
Heating degree days (18°C)	Annual sum of the number of degrees Celsius a given day's T_{mean} is below 18°C.		🖩	✓	✓
Heating degree days (17°C)	Indicator for space heating requirements. Degree days with T_{mean} below 17°C.		✓		
Freezing degree days	Annual sum of the number of degrees Celsius that each day's T_{mean} is below 0°C.		🖩	✓	✓
Cumulative degree-days above 0°C	Degree days with T_{mean} > 0°C.		✓		
Mild winter days (-5°C)	Number of days when T_{min} is less than or equal to -5°C.		🖩	✓	
Days with T_{min} < -15°C	Number of days with T_{min} < -15°C.		✓	✓	
Days with T_{min} < -25°C	Number of days with T_{min} < -25°C.		✓		
Cold spell duration index	Number of days with at least 6 consecutive days with T_{min} < 10th percentile.				✓
Percentage of days with T_{min} < 10th percentile	Percentage of days with T_{min} < 10th percentile.				✓
Percentage of days with T_{min} > 90th percentile	Percentage of days with T_{min} > 90th percentile.				✓
Highest T_{min}	Maximum T_{min} over a given time period.				✓
5-, 20-, and 50-year annual minimum temperature	Annual minimum daily minimum temperature with a return period of 5, 20 or 50 years.				✓

Climate indices	Description	Canadian Centre for Climate Services	ClimateData.ca	Climate Atlas of Canada	PCIC Climate Explorer
PRECIPITATION					
Precipitation as snow	Total precipitation when mean daily temperature is below freezing.				✓
Wet days > 1mm	Number of days with precipitation > 1 mm.		✓		✓
Wet days > 10mm	Number of days with precipitation > 10 mm.		✓	✓	✓
Wet days > 20mm	Number of days with precipitation > 20 mm.		✓	✓	✓
Wet days	Number of days in a year with 0.2 mm or more of rain or snow.		🖩	✓	
Dry days	Number of days in a year with less than 0.2 mm of rain or snow.			✓	
Maximum length of wet spell	Maximum number of consecutive days with precipitation > 1 mm.		🖩		✓
Maximum length of dry spell	Maximum number of consecutive days with precipitation < 1 mm.		✓		✓
Number of periods with 5 or more consecutive dry days	The number of occurrences of 5 or more consecutive dry days (precipitation < 1 mm).		✓		
Maximum 1-day total precipitation	Largest single day precipitation event.		✓	✓	✓
Max 3-day precipitation	Maximum precipitation in a 3-day consecutive period.			✓	
Max 5-day precipitation	Maximum precipitation in a 5-day consecutive period.		✓	✓	✓
Simple precipitation intensity index	Daily precipitation amount on days with precipitation > 1 mm divided by the number of wet days (precipitation > 1 mm).		🖩		✓
Precipitation > 95th percentile	Total precipitation when daily precipitation > 95th percentile.				✓
Precipitation > 99th percentile	Total precipitation when daily precipitation > 99th percentile.				✓
5-, 20-, and 50-year annual maximum 1-day precipitation	Annual maximum 1-day precipitation with a return period of 5, 20 or 50 years.				✓

Climate indices	Description	Canadian Centre for Climate Services	ClimateData.ca	Climate Atlas of Canada	PCIC Climate Explorer
AGRICULTURE					
Growing season length	Interval between the first 6 days with daily T_{mean} > 5 °C and the first span after July 1 of 6 days with T_{mean} < 5 °C.				✓
Frost-free season	Interval between the last frost of the spring and the first frost of the fall.		✓	✓	
Date of first fall frost	The earliest date in the fall when temperatures drop below freezing.		✓	✓	
Date of last spring frost	The latest date in the spring when temperatures drop below freezing.		✓	✓	
Corn heat units	Temperature index used to indicate whether there are sufficient heat units in a region to permit growing corn.			✓	
Growing degree days (base 4°C)	Degree days with T_{mean} > 4°C.		🖩	✓	
Growing degree days (base 5°C)	Degree days with T_{mean} > 5°C.		✓	✓	✓
Growing degree days (base 10°C)	Degree days with T_{mean} > 10°C.		✓	✓	
Growing degree days (base 15°C)	Degree days with T_{mean} > 15°C.		🖩	✓	
Standardized precipitation evapotranspiration index (3 months)	Drought index indicating the moisture balance (difference between precipitation and potential evapotranspiration) for the current month and previous 2 months.		✓		
Standardized precipitation evapotranspiration index (12 months)	Drought index indicating the moisture balance (difference between precipitation and potential evapotranspiration) for the previous year.		✓		

SECTION 6

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SECTION 7

Glossary

Adaptation: Actions taken to prepare for the effects of climate change, including actions to maximize the potential to take advantage of new opportunities and actions to minimize the consequences of risks.

Coupled model intercomparison project, phase 5 (CMIP5): CMIP5 is a coordinated climate modelling exercise involving over 20 climate modelling groups from around the world. It has produced a standard experimental protocol for studying the output of many different global climate models.

Downscaling: A process of translating large-scale climate model outputs to a higher spatial resolution. Downscaling techniques include both dynamical methods, such as RCMs run at a finer scale, and statistical methods, which combine observed climate information with climate model simulation outputs.

Emission scenario: Because future emission levels are unknown, climate models are run under different potential levels of future emissions, based on plausible long-term socioeconomic trends, including land use patterns and energy consumption.

Ensemble: Many different climate models exist, and they take various approaches. Because no one model can be considered the best, it is standard practice in climate change studies to use the outputs of many models when studying projected future climate changes. This provides a plausible range of outcomes for analysis and decision-making. The group of models that contribute to any such aggregate result is called the ensemble of models.

Global climate model (GCM): GCMs use powerful computers to model the planet's climate using equations and parameters to describe patterns, processes, and interactions in the atmosphere and oceans and to project future climate changes under different carbon emission scenarios.

Greenhouse gases (GHGs): Gases that can absorb and emit thermal infrared (heat) energy, including water vapour, carbon dioxide, methane, nitrous oxide and ozone. Too high of a concentration of GHGs in the atmosphere can result in planetary warming.

Historical data: Data about the past climate, including that collected by weather stations across the country (observed historical data) or generated from climate models (simulated historical data).

Mitigation: Actions taken to reduce GHG emissions or enhance sequestration of GHGs, thereby reducing the long-term severity of climate change.

Percentile: Used to indicate where a value falls in a dataset. For example, the 90th percentile represents the value below which 90% of the data falls.

Projection: In climate science, projections are the simulated outputs of climate models ran under different scenarios representing potential future levels of GHG emissions.

Radiative forcing: The change in the balance of incoming and outgoing energy in Earth's climate system resulting from a change in a driver of climate change, measured in Watts per square meter. Positive radiative forcing increases the energy of the climate system and thereby the temperature of the planet.

Regional climate model (RCM): High-resolution climate models driven by the boundary conditions from a GCM through a process known as dynamical downscaling. The regional focus of these models produces climate projections at a smaller spatial scale (10 to 50 km) compared with that of the GCMs (hundreds of kilometres).

Representative concentration pathways: These are standard scenarios that are used in CMIP5 to simulate how the climate might change in response to different levels of human activity. In effect, they represent possible trajectories of GHG concentrations. Four RCP scenarios were used in CMIP5 to guide climate research, each leading to a different degree of radiative forcing (indicated by the number given to each RCP).

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