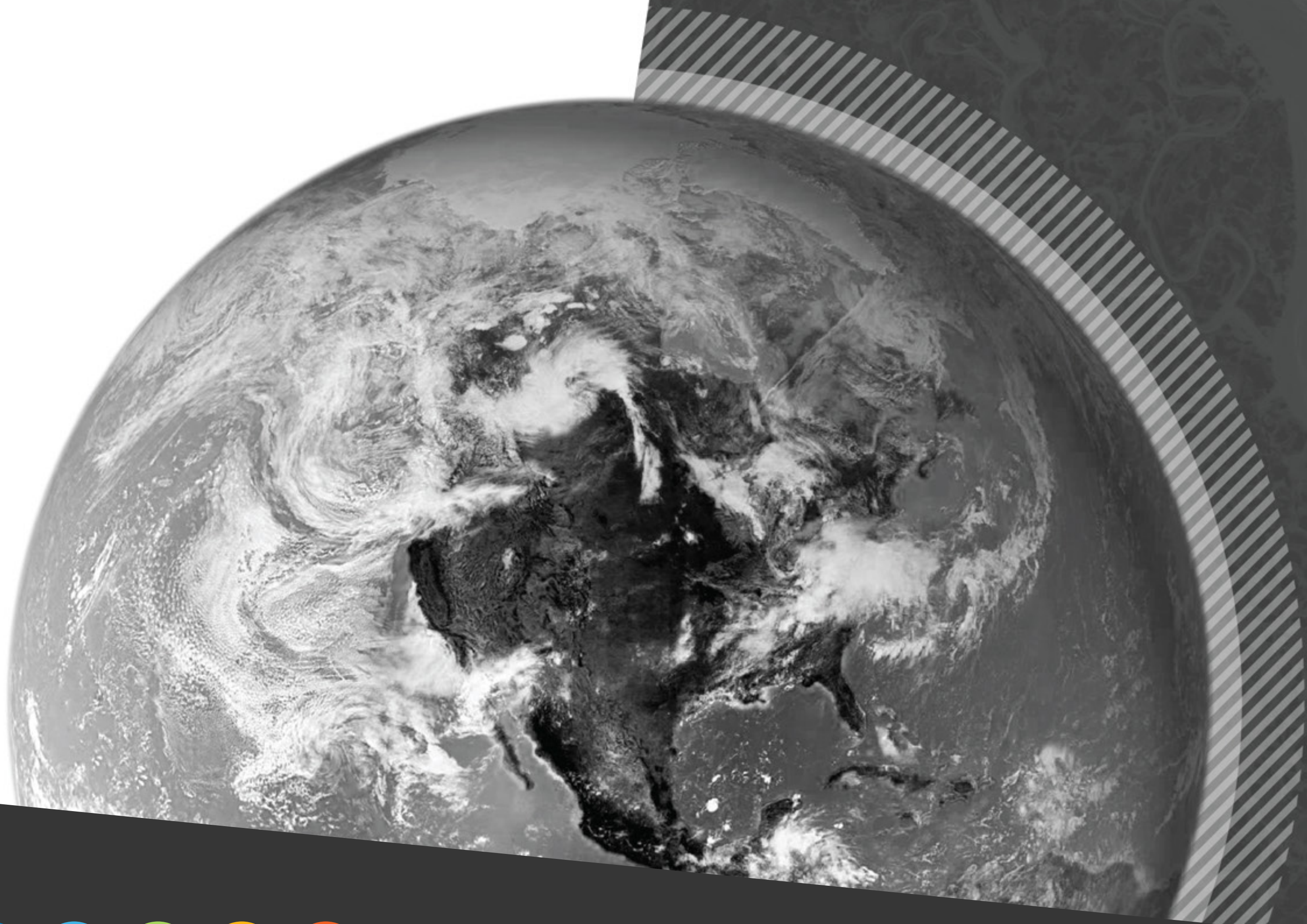
Prairie
Climate Centre

CLIMATE ATLAS

Guidebook



climateatlas.ca

Version 1 *(November 2018)*

WELCOME TO THE PRAIRIE CLIMATE CENTRE'S CLIMATE ATLAS GUIDEBOOK

Climate change is the defining issue of our time, full stop.

*The Intergovernmental Panel on Climate Change (IPCC) – the world's primary resource on the state of climate science and its social, economic, and environmental implications – recently released their most startling report yet, entitled **Global Warming of 1.5°C**. This report indicates that it's possible to limit climate warming to 1.5°C, which is now viewed as a critical threshold for sustainable life on the planet, provided we act within the next decade to be globally carbon neutral by 2050. The time for bold climate action is now upon us.*

As a global society, we must radically reduce our use of fossil fuels, but also prepare for the changes to our social and ecological systems that will be caused by the greenhouse gas emissions already released into the atmosphere. Indeed, we have warmed by 1°C since pre-industrial times, and many impacts are being observed, especially in Canada.

*To understand and visualize the future effects of climate change, our team at the Prairie Climate Centre developed the **Climate Atlas of Canada**. Canadians now have access to meaningful climate data that has been tailored and visualized for about 2,000 regions, cities, and towns across the country.*

While the atlas is in part designed for public education, it's also an advanced decision support tool for planners, landscape architects, and other allied professionals who are on the frontlines of building climate resilience within communities. In partnership with the Canadian Institute of Planners (CIP) and the Canadian Society of Landscape Architects (CSLA), we're launching this "guidebook" to unpack the functionality of the atlas and support its more advanced usage within the professional community.

Given the far-ranging impacts of climate change, new collaborations like this one with CIP and CSLA will help us move, as the Prairie Climate Centre motto goes, "from risk to resilience". We hope that this partnership further strengthens climate action in Canada.

Sincerely

Dr. Ian Mauro
Co-Director
Prairie Climate Centre

Dr. Danny Blair
Co-Director
Prairie Climate Centre

A MESSAGE FROM THE CANADIAN INSTITUTE OF PLANNERS

The global climate is changing, leading to increased hazards, extreme weather conditions, and changes to the physical environment in Canadian communities.

For one hundred years, the Canadian Institute of Planners (CIP) has served as the voice of Canada's planning profession. With over 7,000 members across Canada, CIP recognizes that planners have a key role to play in reducing GHG emissions and in adapting communities to environmental changes.

The CIP Climate Change Policy (2018) affirms that all planners have an ethical obligation to consider climate change in their practices, and in support of this, CIP strives to ensure that our members have access to the resources, data, and training they need. CIP values the Climate Atlas of Canada -- a comprehensive tool that provides valuable spatial data in a straightforward, easily accessible way -- as it provides practitioners with evidence to assess the causes and consequences of climate change. The ability to model various scenarios, under low and high carbon trends, further provides planners with information to consider worst-case scenarios and incorporate risk-reduction measures into their plans.

*On this **World Town Planning Day**, CIP is pleased to support the launch of the **Climate Atlas Guidebook** with the Prairie Climate Centre, and in collaboration with the Canadian Society of Landscape Architects, and recognize that it is through individual, collective, and collaborative planning practices and problem-solving, that we can tackle the most pressing and complex challenges at the heart of our communities.*

Eleanor Mohammed MCIP, RPP
President
Canadian Institute of Planners

Beth McMahon
Chief Executive Officer
Canadian Institute of Planners

CSLA | AAPC
Canadian Society of Landscape Architects
Association des architectes paysagistes du Canada

A MESSAGE FROM THE CANADIAN SOCIETY OF LANDSCAPE ARCHITECTS

Landscape architects work to accommodate both the needs of human society and the natural environment, respecting the cultural landscapes of the past, and planning sustainably for the future. As the challenges associated with a changing environment mount, Canadians will struggle to find economic and political balance between short-term solutions and long term planning for sustainability.

Landscape architects will play integral roles in the processes of planning, design and management that mitigate continued contributions of greenhouse gases to the atmosphere, that promote ingenuity and build resilience in individuals and organizations, and that ensure the sustainability of our natural environment.

*In 2014, the Canadian Society of Landscape Architects **(www.csla-aapc.ca)** established the Climate Change Task Force, which became the Committee on Climate Adaptation (CoCA) in 2017. The goals of the CoCA are to:*

- *bring national and local perspectives on our changing environment,*
- *promote improved understanding of new science, and*
- *facilitate the dissemination of emerging tools and lessons learned from shared experience.*

The CoCA advocates for the issue of climate adaptation as an integral part of the work of landscape architects, and works to answer an important question: What is a landscape architect's responsibility towards climate change?

Landscape architects recognize that our future climate will be much different than the one we have known throughout our lives. This will require new designs and innovations in how and what we do, recognizing the risks imposed by climate change, the need to adapt our built environment in response and the need to contribute to mitigation efforts to limit the scale of change.

The Prairie Climate Centre's Climate Atlas of Canada provides guidance on the variables that we need to consider for the projects we are planning and building today and that we expect to last for generations. It will be a first line resource to enable landscape architects in our tasks of planning, designing and management of natural and built environments.

*The CSLA and the CoCA congratulate the **Climate Atlas of Canada** team for the development of a useful and important tool.*

Nastaran Moradinejad, BCSLA, CSLA
President, CSLA

Colleen Mercer Clarke, Ph.D., FCSLA
Chair, CSLA Committee on Climate Adaptation

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1.0 Introduction

No matter where we live, climate shapes our lives. It helps determine what we wear, how we get around, how we heat and cool our homes and businesses, the leisure activities we can pursue, the health and diversity of wild plants and animals, the food we grow, the livestock we raise, the likelihood of weather disasters, and much more.

This is why climate change is so important and so challenging to figure out: it affects almost all aspects of our lives.

Climate change is a product of our collective choices, which means we can take effective action to make things better. By reducing our use of fossil fuels, we reduce the severity of climate change. And by looking ahead at future projections, we can make decisions about how to adapt to our new climate reality.

2.0 The Climate Atlas of Canada

The ***Climate Atlas of Canada*** *(climateatlas.ca)* is an interactive tool for citizens, researchers, businesses, and community and political leaders to learn about climate change in Canada. The articles, maps, and videos in the atlas tell a compelling story: climate change is here, it's a serious challenge, and we can take action.

The atlas can help you make sense of climate change, and this guidebook will help you make sense of the atlas. First we'll explain how to find different kinds of information in the atlas. And then we'll give you some help figuring out what it all means.

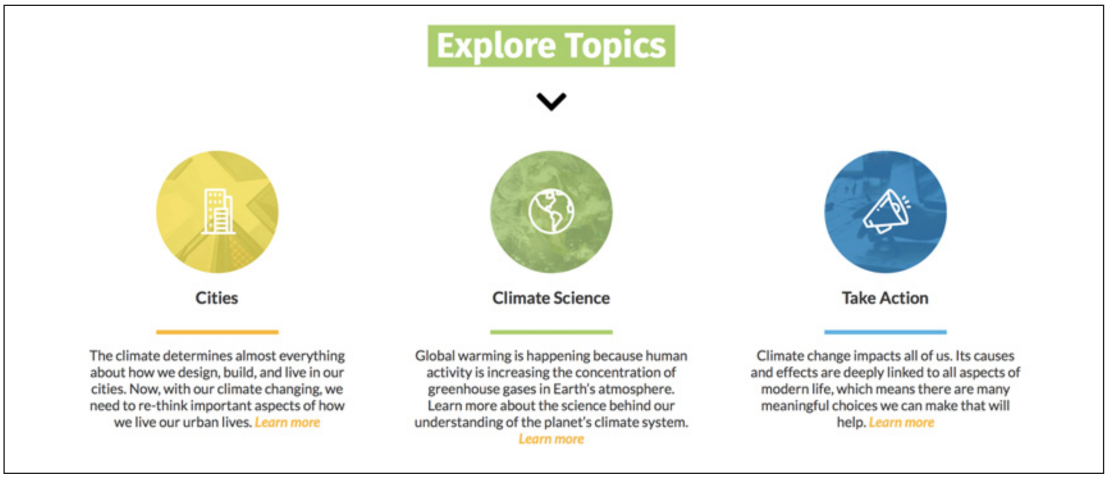
2.1 Finding your way around

The home page of the atlas provides a high-level overview of climate change and some of its impacts. Each panel provides links to more detailed information (such as articles and videos) or special content (such as downloadable PDF reports). Just reading through the home page provides a snapshot of climate change as a serious global issue that affects each of us and our unique communities in specific ways.

2.2 Topics

Because climate change is so complex and far-reaching, it is helpful to break it down into manageable parts. The atlas does this by collecting different kinds of information into related topics, such as ***Cities, Agriculture, Forestry, Take Action,*** and ***Climate Science.***

The topic landing pages work a lot like the atlas' home page: each begins with a general introduction linked to a longer article that provides an overview about a particular aspect of climate change. Featured articles, videos, and other content are highlighted in the graphical panels, and then all available content in the topic is collected together further down on the page.



2.3 Articles

Every topic in the atlas is supported by plain-language articles that review our current scientific understanding of the risks and impacts of climate change. These articles are supported by the voices and perspectives of researchers, industry professionals, and community leaders who are dealing with climate change on a daily basis. Where possible, these articles present real-world solutions to the consequences of climate change.

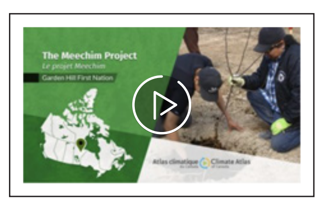
If you like to learn by reading, head directly to our ***Articles*** landing page to find them all in one place.

2.4 Videos

The Climate Atlas features a growing collection of short documentary videos that help make local sense of the global issue of climate change.

These videos have been developed through a unique combination of social science and participatory video techniques and are, in their own way, an important form of "data" about climate change in Canada. These voices of lived experience provide personal perspectives that complement the climate projection data and help explain the reality and the importance of climate change in Canada.

You'll find videos throughout the site: they appear on the map, they are an important part of each topic presentation, and all of them can be found on the ***Videos*** landing page.



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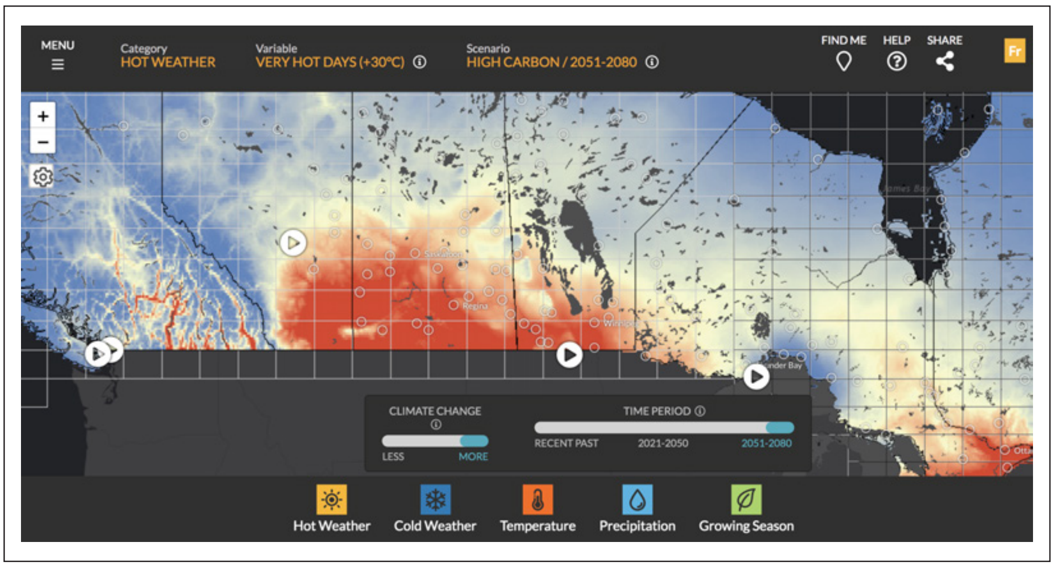
2.5 Maps

These colourful maps allow you to explore what climate models say about future climate across the country and specifically where you live.

The Climate Atlas map works like most online maps: you can move around and zoom in and out. When you click somewhere on the map, a sidebar appears to display a summary of projected climate change for that location in the coming decades.

The map and sidebar are the best ways to quickly browse climate data and find information that's important to you and your community. Learn more about using the map in the next section of this guidebook, *3. Using the map.*



2.6 Find Local Data

You can also explore local climate data without using the map. In the main menu (found at the top left corner of the site), the ***Find Local Data*** item leads to a search page where you can choose to display data for:

- Your current location
- Any of almost 500 cities and towns across Canada; or
- Any region in Canada, using a convenient address or landmark search tool.

Each of these options takes you to the ***Local Data Page***, where you can explore tables and graphs and even download data for any place in Canada.

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3.0 Using the Map

The primary goal of the Climate Atlas is to allow Canadians from all walks of life to explore what climate change means for them, where they live.

Controlling the map should be familiar from other online tools such as Google Maps. You can grab and drag the map to move around, and you can zoom in and out using the +/- buttons (and various other mouse and touchscreen controls, depending on your device).

3.1 Climate Variables

Many kinds of climate data can be displayed on the map. The menu at the very bottom of the page presents categories of climate information:

Hot Weather *Cold Weather* *Temperature* *Precipitation* *Growing Season*

> *You can find a wide range of options inside these categories, including seasonal and annual measures of average and extreme temperatures or amounts of precipitation that will be meaningful to almost everyone.*
>
> *There are also more technical variables, such as heating and cooling degree days, that will be of interest to farmers, planners, and other professionals whose work is directly dependent on our changing climate.*

The following table presents each of the climate variables within the atlas, a plain language description of the variable, as well as a short note explaining why each one is important. Regardless if you're a homeowner, building manager, community planner, or landscape architect you're sure to find variables in the atlas that are important to your life and livelihood. (You can find a much more detailed description of all these variables on the atlas itself at ***climateatlas.ca/variables***.

Variable	*Description*	*Importance*
Coldest Minimum Temperature	The very coldest temperature of the year.	Affects safety, recreation, buildings, transportation, energy use, etc.
Cooling Degree Days	Annual sum of the number of degrees Celsius that each day's mean temperature is above 18 °C.	Often used to estimate how much air-conditioning is required in a year. An increase implies hotter or longer summers.

3.1 Climate Variables *(Continued)*

Variable	*Description*	*Importance*
Corn Heat Units	Temperature index used by farmers for when it's ideal to grow corn.	Used by farmers and agricultural researchers to make planting decisions and maximize production.
Date of First Fall Frost	The earliest date in the autumn when temperatures drop below freezing.	Marks the approximate end of the growing season and indicates the return of cold weather.
Date of Last Spring Frost	The latest date in the spring when temperatures drop below freezing.	Marks the approximate beginning of growing season and indicates the return of warm weather.
Freeze-Thaw Cycles	Total number of days per year when temperatures fluctuate between freezing and non-freezing.	Can have major structural impact on infrastructure such as roadways, sidewalks, etc.
Freezing Degree Days	Annual sum of the number of degrees Celsius that each day's mean temperature is below 0 °C.	High values are associated with relatively cold conditions, and indicate many days with temperatures significantly below freezing.
Frost Days	Total number of days per year when the coldest temperature of the day is less than 0°C.	These conditions indicate frost might form at ground level or on cold services.
Frost-Free Season	Interval between the first frost of the fall and the final frost of the spring.	Indicates when no freezing temperatures occur that might kill or damage plants or animals.
Growing Degree Days (5, 10, 15 °C)	Index of heat available for organisms (such as plants and insects) for growth.	Helpful for crop selection, insect control, and other management.
Heating Degree Days	Annual sum of the number of degrees Celsius a given day's mean temperature is below 18 °C.	Often used as a measure of how much heating is required in a year.
Heavy Precipitation Days (10mm / 20mm)	Total number of days per year when at least 10 mm or 20 mm of rain or frozen precipitation falls.	Heavy rainfall can impact storm drains, flooding, erosion, roads, etc.

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3.1 Climate Variables *(Continued)*

Variable	Description	Importance
Icing Days	Total number of days per year when the warmest temperature of the day does not go above freezing (0 °C).	Indicator of the length and/or severity of the winter season, which affects human health and safety, recreation, heating costs, and more.
Maximum Temperature	The highest temperature of the day.	The temperature range we expect within a season or year is a very important aspect of climate. Changes in average and extreme temperatures can dramatically affect our everyday lives as well as a wide range of planning and policy decisions.
Mean Temperature	The average temperature of the day.	
Minimum Temperatures	The lowest temperature of the day.	
P-Days	Temperature index used by farmers for when it's ideal to grow potatoes.	Often used by farmers and agricultural researchers to maximize production.
Precipitation	Total annual amount of rain, drizzle, snow, sleet, etc.	Affects water availability, crop viability, hydroelectric power generation, fire risk, snow accumulation, flooding, and drought.
Summer Days	Total number of days per year when the temperature rises to at least 25°C.	Increased health risks to vulnerable people, limits outdoor recreation, increased energy use, increased drought and fire risk, changes to ecosystems and biodiversity, etc.
Tropical Nights	Total number of days per year when the lowest temperature of the day does not go below 20°C.	
Very Cold Days (-30 °C)	Total number of days per year when the temperature drops to -30°C or below.	Indicator of winter severity that affects health, safety, recreation, ecosystems, etc.
Very Hot Days (+30 °C)	Total number of days per year when the temperature rises to at least 30°C.	Increased health risks to vulnerable people, limits outdoor recreation, increased energy use, increased drought and fire risk, changes to ecosystems and biodiversity, etc.
Warmest Maximum Temperature	The highest temperature of the year.	

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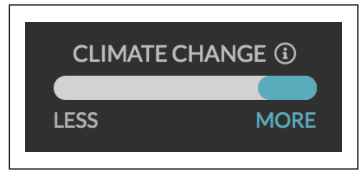
3.2 Climate Scenarios

You can choose between future scenarios that lead to ***more*** or ***less*** climate change, and display information for either the recent past or one of two future time periods.

The climate of the future depends very much on the choices we make as a society: the atlas lets you easily explore the impacts of more or less global warming, resulting from different greenhouse gas emissions scenarios.



High Carbon Scenario

(RCP8.5) **---> MORE**

Choosing ***more*** warming displays the "business as usual" scenario that assumes world greenhouse gas emissions continue to increase at current rates through the end of the century. Not surprisingly, these high emissions results in severe global warming. The Climate Atlas also refers to this as the ***High Carbon*** future, and it is based what scientists call the RCP8.5 emissions scenario.

At present, based on the best available science, global emissions are on track to follow the High Carbon scenario.

Low Carbon Scenario

(RCP4.5) **---> LESS**

Choosing ***less*** warming shows maps and data based on a scenario in which greenhouse gas emissions increase until about 2050 and then rapidly decline. This decline in emissions leads to less severe global warming than the High Carbon scenario. The atlas also refers to this as the ***Low Carbon*** future, and it is based on the RCP4.5 emissions scenario.

The Low Carbon scenario describes a world in which collective global action is taken to reduce greenhouse gas emissions.

Under both scenarios, the impacts of climate change are projected to become more extreme over time. The map displays information for three time periods, and moving back and forth between them allows you to compare the ***Recent Past*** (1976-2005), the ***Immediate Future*** (2021-2050) and the ***Near Future*** (2051-2080).

As you change the various map options (type of data, severity of climate change, and time period), the title bar at the top keeps track of what you've chosen, so you always know what you're looking at. You can also always get more information about what the map is showing. Click on the information (ⓘ) icons to get detailed explanations about the map you're exploring.

3.3 Watch Videos

No matter what climate information you select, you'll see (⦿) ***icons*** scattered around the map. They mark places with documentary videos you can watch to discover how people across Canada are learning about and taking action on climate change.

3.4 Local Data

Once the map is has loaded up the chosen climate information, scenario, and time period, you can display data about places all across Canada.

Climate data is available for specific cities and towns, all the provinces and territories, and for square regions (called "grid squares") all over the country. The grid squares are available from coast to coast to coast, so there is data available for all of Canada, even if your town isn't on the map, or if you want to learn about a remote or rural area.

Click on a place, such as one of the grid squares or a city or town, to get more detailed climate change information about that specific place.

3.5 Map Sidebar

When you click on a map location, a sidebar appears, displaying climate information for that place.

The summary at the top of the sidebar tells you what place, variable, and scenario is being displayed, and provides an overview of the projected change. The summary numbers are averaged over large spans of time (30-year periods) and across 12 different climate models, allowing you to quickly and easily get a sense of the overall change projected by the climate models.

Clicking on the (⊕) "More Detail" button below this summary reveals the range of the 12 model projections, averaged over the 30-year time periods. Examining the low and high values provides some information about the overall variability in the model projections.

Similarly, the graph displayed a little lower down in the sidebar illustrates how the range and mean (average) of the model projections varies within these time periods.

Below the graph are sets of links that provide access to still more data, and to pages of information about how the climate data was created and how it should be used and interpreted.

The ***Explore detailed climate data*** link leads to the ***Local Data Page,*** where all the climate variables can be graphed in various formats. You can even export the values for your own use.

The ***Download climate report*** link will provide you with a PDF report that presents some representative climate change data for the chosen place, for both the High Carbon and Low Carbon scenarios, in a handy one-page format.

(See section 5, "Interpreting Climate Data" in this guidebook for more detailed information about interpreting these values.)

3.6 Map Settings

You can customize the map display. To access the settings menu, activate the gear icon (⚙) just below the zoom buttons in the top left corner of the map. You can select metric or imperial units of measurement, whether or not to display various helpful visual elements, and whether you would like to see regional information for provinces/territories or the smaller grid boxes.

3.7 Language Selection

The entire content of the atlas is available in English and French. To switch the language, click on the ***En*** or ***Fr*** icons in the upper-right corner of any page.

3.8 Sharing the Map

You can share the map display on social media or by email. The map will get shared exactly as it looks. If you are zoomed in on a specific location, or if you have a sidebar open showing details about a town or region, that display is what others will see when you share.

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4.0 Local Data Page

Many users want more detailed information than the summary provided by the map sidebar. Graphs, tables, and additional statistical and scientific data for users with more detailed needs or interests can be found for all locations using the Local Data Page.

This page is also useful for people who use screen readers or keyboard navigation and find the map difficult to use. The Local Data Page provides access to all the data found on the map, but in more accessible forms and tables.

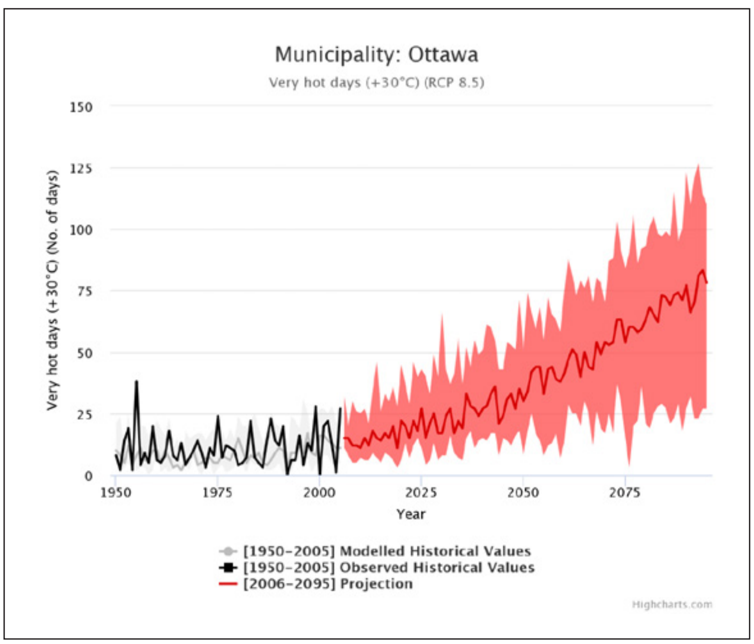
Following the ***Find local data*** link in the main menu (and choosing a location) or following the ***Explore detailed climate data*** link in the map sidebar will take you to the Local Data Page. This page displays climate data in the form of graphs and tables.

There are four types of graphs: time series plots, frequency plots, scatterplots and climographs. The type of data/graph is controlled by the dropdown menu, as are various options such as emissions scenario and season, if relevant.

The time series and frequency data can be displayed for all the climate variables available through the map, in both High and Low Carbon scenarios. Mean, maximum, and minimum temperature and mean precipitation can additionally be displayed annually or seasonally.

4.1 Time Series

The time series graph displays observed historical values for the chosen variable for 1950-2005 and the climate model ensemble mean and range for 1950-2095. This lets you display modelled and historical values at the same time. You can also see the range and mean of the ensemble of 12 models year by year, all the way through to the end of the century.

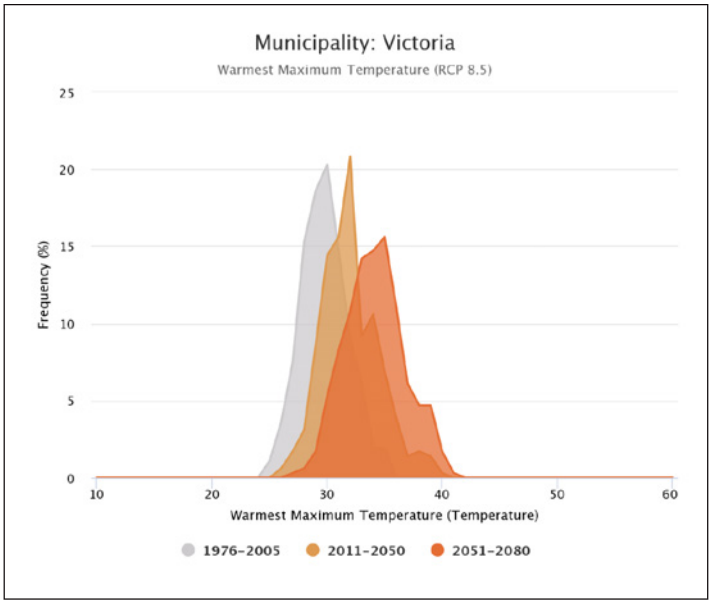


Left: Projected change in the number of +30 °C days under the high carbon scenario (RCP8.5) for Ottawa.

The black line represents historical observations, while the shaded areas illustrate the range of climate model projections (1950-2100).

4.2 Frequency

The frequency graph displays the frequency distribution of modelled values for three different time periods (1976-2005, 2021-2050, and 2051-2080) for the emissions scenario being displayed. This allows you to see how overall variability as well as average values change under different conditions and in different time periods.

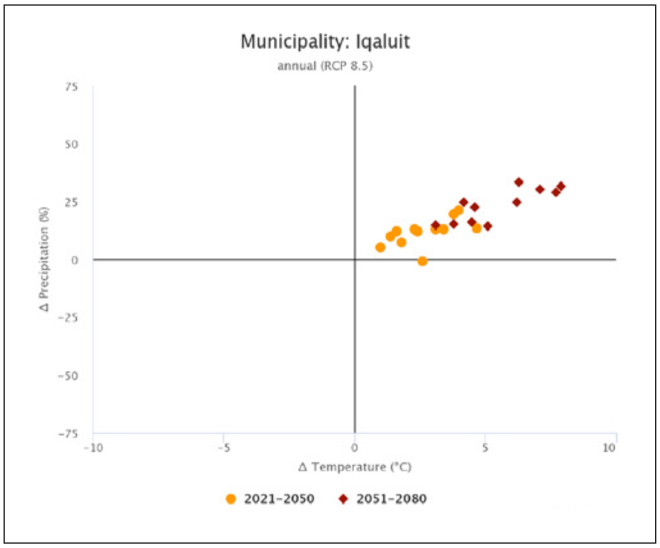


Left: Projected change in the average warmest maximum temperature under the high carbon scenario (RCP8.5) for Victoria.

The grey area shows the distribution of temperatures for the baseline period (1976-2005), while the yellow and orange areas represent the distribution of temperatures for the 2021-2050 and 2051-2080 future periods.

4.3 Scatterplot

The scatterplot graph displays the change (relative to 1976-2005) in average annual temperature (in °C) and average annual precipitation (in %) for each of the twelve climate models in the ensemble, for the chosen emissions scenario. This provides a way to visualize the amount of agreement within the ensemble of models for this location. Note that the scatterplots are only produced for annual temperature and precipitation values.



Left: Projected changes in mean annual temperature and total annual precipitation made by twelve climate models under the high carbon scenario (RCP8.5) for Iqaluit.

Yellow dots represent the time period 2021-2050 and red dots represent the time period 2051-2080.

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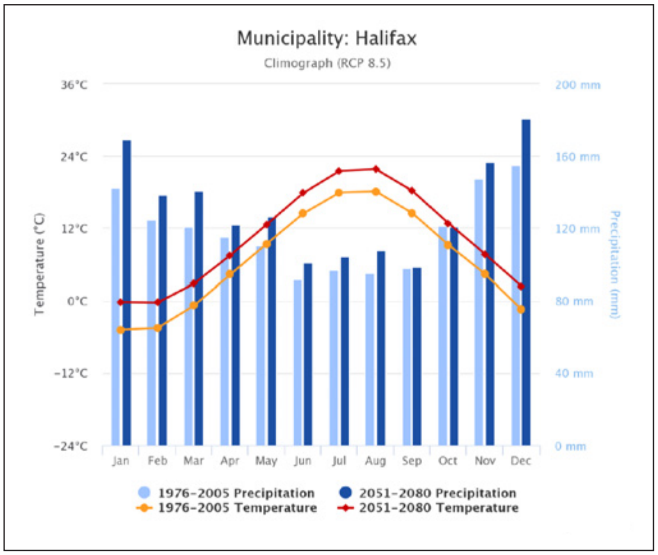
4.4 Climograph

The climograph displays modelled monthly average temperature and total precipitation for two time periods: the 1976-2005 baseline and either the 2021-2050 or 2051-2080 future period.



Left: Projected monthly mean temperature and total precipitation projections under the high carbon scenario (RCP8.5) for the 1976-2005 (baseline) and 2051-2080 time periods, for the city of Halifax.

Vertical Bars represent precipitation and lines represent temperature.

4.5 Exporting Data and Graphs

The data used to create the graphs is displayed in a simple table beneath the graph, and the data can also be downloaded in comma-separated values (CSV) format, which is easily opened by any spreadsheet or statistics program.

In addition, the graphs themselves can be exported in a variety of image formats using the menu icon (≡) in the top right corner of the graph.

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5.0 Interpreting Climate Data

Climate model data is complex. In the past, trying to answer questions such as "how might summer temperatures in my town change in coming decades?" required a lot of technical skill and effort: climate data had to be found, selected, and downloaded; time periods and emissions scenarios had to be chosen; the data had to be computed, analyzed, mapped, graphed, and interpreted. The Climate Atlas has done all that work for you, freeing you up for the important business of exploring, learning, and responding.

But that doesn't mean it's easy to interpret the data, especially if you need to develop adaptation policies or do detailed planning. This section of the guide explains how to understand the data presented in the atlas so you can confidently work with it to answer your questions and best understand the future climate and its potential consequences.

5.1 Historical and Modelled Data

Most of the values presented in the Climate Atlas are from climate models. In particular, the 1976-2005 (Recent Past) values used throughout the Atlas as the baseline are from climate model simulations for this period. In the maps and on the Local Data Page, the atlas puts simulated means and ranges side-by-side with observed historical data for easy comparison. For the most part, you will see that the historical values fall within the range of the simulated data, especially for temperature.

For the period 2006-2095 the atlas uses climate model data to show how the climate is projected to change, using two emissions scenarios. For more about climate models and modelling, see the ***"Climate Change Projections"*** article on the Atlas.

5.2 Mean Values

Many of the numbers presented in the Climate Atlas are averages. The map sidebar and various reports, for instance, prominently display the mean value for 12 climate models over one of three 30-year time periods (1976-2005, 2021-2050, 2051-2080). Looking at mean values provides a simple sense of the direction and general magnitude of change.

The use of 30-year periods is a scientific convention based on the statistical guideline that a minimum of 30 points of data are required to reliably determine a mean. Thus, averaging data over 30 years is used to represent the average state of a climate. Taking the average for a 30-year period helps ensure that what is being described is an aspect of the climate system and not the more variable experience of weather.

Yearly averages can change a lot from year to year, whereas a 30-year average removes a lot of that variation, and reveals common conditions across the time period more so than differences between years. This means that when 30-year averages differ, that difference is probably noteworthy because it represents a multi-year trajectory of change that's unlikely to be caused by short-term (seasonal, yearly, or even decadal) variability.

Averaging across an ensemble of 12 climate models is an important strategy that means we are not relying on results from just one or two climate models. Models take a variety of approaches and make different assumptions about how best to represent the amazing complexity of the global climate system; as such, they of course provide different projections of future climate conditions and different simulations of past climates. Taking the mean of an ensemble of 12 models—like taking the mean over a period of 30 years—emphasizes their common agreement about the direction and magnitude of change.

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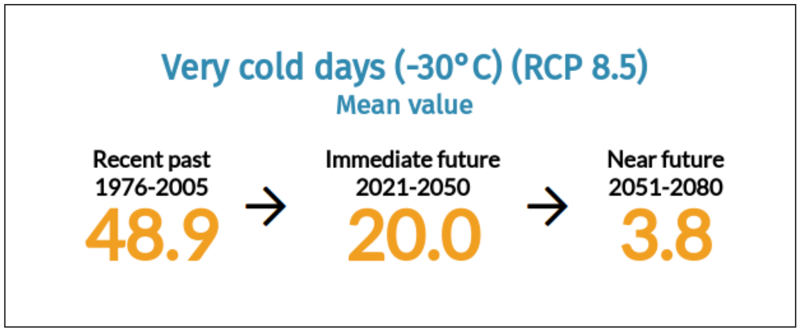
5.2 Mean Values *(Continued)*

Below is an example of projected change in the number of very cold days (under RCP8.5, the High Carbon emissions scenario leading to more severe climate change) for the region surrounding Iqaluit in Nunavut. These numbers tell a story of dramatic change, with the region losing 90% of its mean number of very cold winter days.



5.3 Range and Distribution

The mean values presented in the Climate Atlas provide a very important summary of a the climate data, but also a very partial one. Means are simple measures of the "central tendency" or average midpoint of the values, but don't convey how much the values vary from one another. Thus, another key aspect of the climate model data presented in the atlas is the variation among the 12 models, and across each 30-year period.

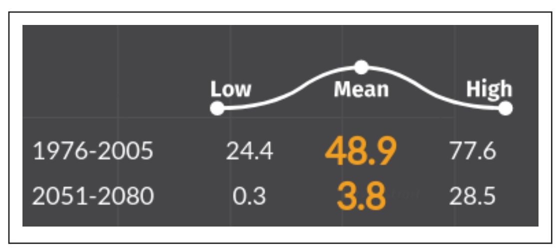
This aspect of climate model data is present in the atlas in the form of model agreement (how much the projections from the 12 models in the ensemble vary) and yearly variability (how much the 30 individual years in a time period vary).

Model agreement

The 12 climate models used to generate the data presented in the atlas vary in their simulations of past climate and projections of future climate. The range of values produced by the models is presented in a couple of places in the Atlas.

High and low model values

The highest and lowest values in the ensemble of 12 models can be revealed in the map sidebar using the "More Detail" option that can be found below the mean value and above the graph.



	Low	Mean	High
1976-2005	24.4	48.9	77.6
2051-2080	0.3	3.8	28.5

The above illustration shows the model range for some of the same data described above (very cold days for the region surrounding Iqaluit in Nunavut, under RCP 8.5, the ***"High Carbon"*** emissions scenario), comparing the Recent Past (1976-2005) with the Near Future (2051-2080).

The ***Low*** and ***High*** ends of the range show the full range of model results for this time period and carbon scenario. In this case, it shows that the very highest projected number of cold days in the future is very close to the lowest end of the simulated historical values, confirming that a drastic overall change is projected across the range of models. The data also confirms that there is quite a bit of spread between the lowest and highest modelled values for each time period.

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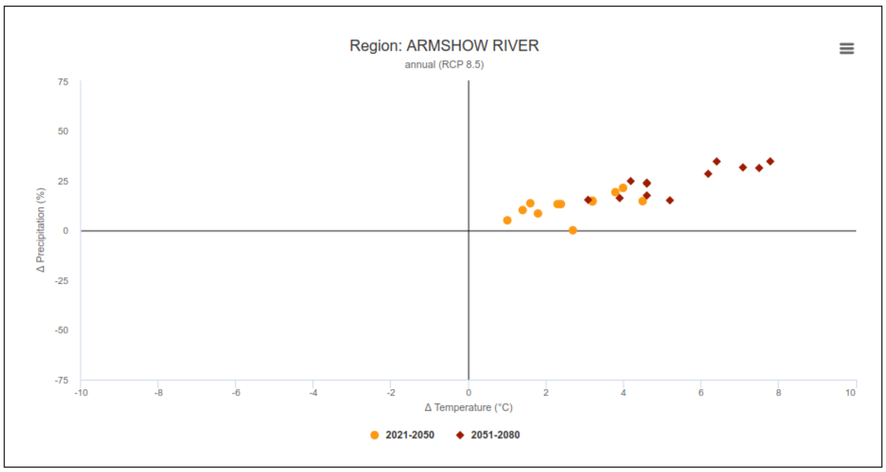
5.3 Range and Distribution *(Continued)*

Scatterplot

Knowing the very top and bottom values of the range is helpful, but doesn't fully capture the degree of agreement between the models. In order to provide a better visual sense of model variability, the atlas provides scatterplots of the basic model output (annual temperature and precipitation).

This visualization can be found on the Local Data Page for any location in the atlas. This graph displays the projected change (or 'delta', Δ) in annual mean temperature and annual mean precipitation for the time periods 2021-2050 and 2051-2080, relative to the simulated values for 1976-2005.

This scatterplot shows a high level of model agreement. All the models indicate that the climate is projected to get warmer and wetter.



Yearly variability

Thirty-year mean ensemble values are very helpful summaries, but of course they collapse thirty different yearly values into a single number. The differences between years are also important, and the distribution of those yearly values around the mean can look very different, given various climate scenarios and time periods.

There are at least two graphs in the atlas that convey the yearly variation that is helpful to consider in addition to the overall 30-year mean.

Line graphs

These graphs display the full spread of the modelled values, year by year, and also display the observed historical record for easy comparison. A small version of this graph is found in the map sidebar, and a larger, downloadable version is available at the ***Local Data Page.***

The following image is a sample of the annual graphs available at the Local Data Page, showing the number of very cold days in the Iqaluit region. For the period 1950-2005 you can see a black line; this is the historical data, based on meteorological observations. Behind that line is a grey line and a shaded grey area. The line is the 12-model average of the data simulated for this location and time period; the shaded area marks the range of the simulations. For the period 2006-2095, the red line is the average of the 12 model projections for the chosen emissions scenario, and the shaded area defines the range among the models.

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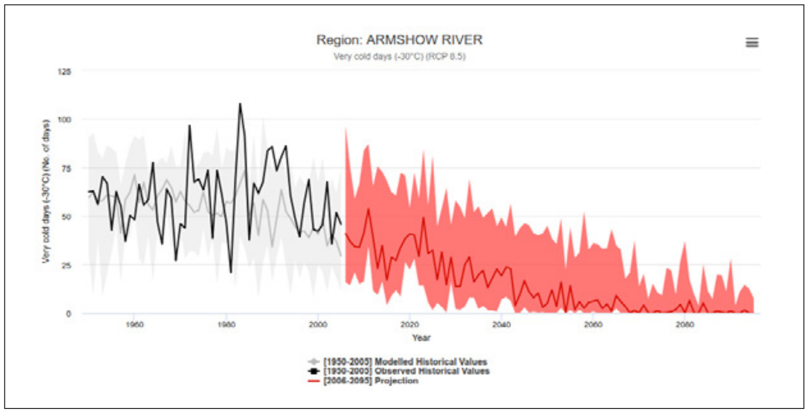
5.3 Range and Distribution *(Continued)*

Thus, in one graph you can see how well the models were able to simulate past conditions, and the trajectory, magnitude, and range of the changes projected for the coming decades. Switching between the Low and High Carbon scenarios also shows you how different the climate is expected to be under the two scenarios.

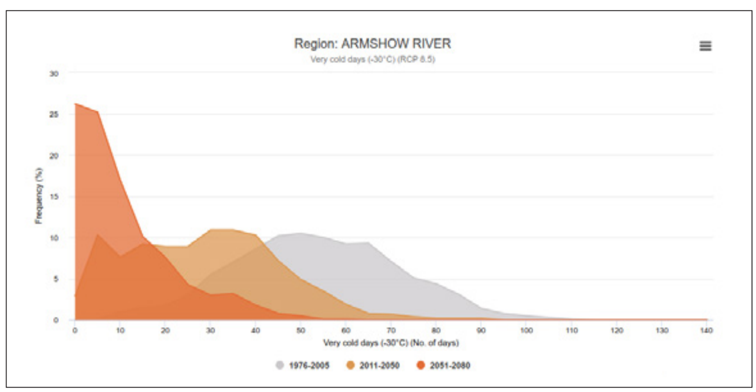


Frequency plots

One very effective way to examine and compare the conditions expected in the various time periods is through the use of frequency distribution curves. This graph is available on the Local Data Page, and presents the distribution of yearly ensemble values in each of the 30-year periods.

These frequency curves show how often various values are projected to occur over each 30-year period. The impact of our changing climate can show up quite dramatically in the increased likelihood of what were previously rare and extreme conditions.

They reveal what kinds of extremes might occur, and how often. Some very warm years, for example, might have many times more the number of hot days than the long-term average.



The range of modelled values across a 30-year period highlights how variable our climate system is. In many cases, these ranges become larger the further you look into the future, an indication of increased climatic variability.

For the Iqaluit region, the graph above shows that years with low numbers of very cold days were relatively rare in the Recent Past, but are projected to become much more common in the coming decades under the High Carbon scenario. The historically typical number of very cold days is set to become an unusually cold season, even in the 2021-2050 period, and vanishingly rare thereafter. Toggling between the Low and High Carbon scenarios shows how different the changes will be under the two scenarios.

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5.4 Uncertainty

As the foregoing discussion of ranges and variability demonstrates, interpreting and understanding climate data inevitably means working with uncertainty. Climate scientists identify three main sources of uncertainty in the modelling of future climates.

Natural Climate Variability

The climate system has many components, some more important than others, and which operate over different time scales. This results in year-to-year and decade-by-decade variations in weather patterns.

Climate Model Uncertainty

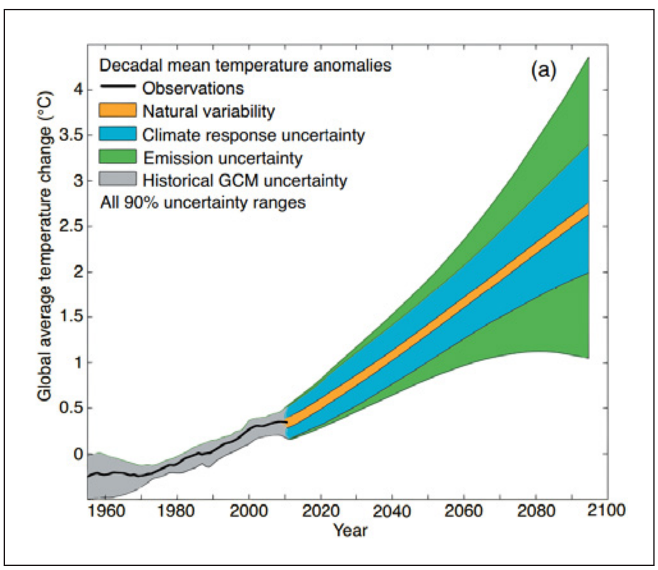
Techniques are constantly improving and computers are getting more powerful, but climate models will always be partial simulations of the real world. Furthermore, each climate model produces somewhat different results, depending on how the modellers have chosen to represent different aspects of the climate system.

Future Emissions Uncertainty

Earth's future climate is highly dependent on worldwide greenhouse gas emissions. Possible changes in the intensity of emissions depend on global demographic shifts and political decisions that are very complex to predict and model.

The diagram below shows that the uncertainty related to emissions is much larger than that from model uncertainty (here called "climate response uncertainty") and natural variability. In fact, the narrow band showing "Historical GCM uncertainty" shows that models do a very good job of simulating the climate of the past, which means we should pay careful attention to what they say about the climate of the future.

There is a much fuller discussion of uncertainty in the Climate Atlas at ***climateatlas.ca/uncertainty*** if you want to know more.



Source:
https://www.ipcc.ch/report/ar5/wg1/docs/WG1AR5_FAQbrochure_FINAL.pdf

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5.4 Uncertainty *(Continued)*

Working with uncertainty

Understanding these various kinds of uncertainty is helpful when it comes to interpreting climate data.

Representative Concentration Pathways (RCPs) have been developed to address the problem of uncertain future emissions by defining a variety of possible scenarios that lead to greater or lesser greenhouse gas concentrations in the atmosphere. This means, however, that one must decide which emissions trajectories to include in one's climate studies.

The Atlas offers two scenarios, RCP8.5 ("High Carbon") and RCP4.5 ("Low Carbon"), that result in more warming or less warming, respectively. Other IPCC climate scenarios exist, specifically RCP6.0 and RCP2.6, but they have been excluded from the atlas to simplify the interface and to be consistent with national and international impact assessments that focus on RCP8.5 and RCP4.5.

The Climate Atlas includes observed historical data to illustrate how well the climate models simulate the natural variability of past climates. For the most part, these historical values fall within the range of the simulated data, especially for temperature (precipitation tends to be more variable). And the atlas uses ensemble mean values to avoid the risk of relying on any one model and to mitigate the challenge of model uncertainty.

In the simplest sense, "uncertainty" means we don't have 100% of the information about a situation or system. As we almost never have absolutely all the information about anything, we constantly have to make decisions in the face of uncertainty. Our changing climate is no different.

Importantly, uncertainty doesn't prevent us from drawing confident conclusions about overall future patterns. Climate models are remarkably consistent in their overall results, and all of them tell essentially the same story: severe climate changes are likely to happen if we do not reduce greenhouse gas emissions soon.

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THE Great-West Life ASSURANCE COMPANY

THE UNIVERSITY OF WINNIPEG

This project was undertaken with the financial support of:

Environment and Climate Change Canada

Environnement et Changement climatique Canada

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