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Building Prairie Resilience

Uncertainty Primer Abstract

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Plain Language Version
Prepared by the Prairie Adaptation Research Collaborative for ClimateWest

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Understanding and Accommodating Uncertainty in
Climate Change Data: A ClimateWest Primer

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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 effectivel 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.

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Recognizing, understanding and accounting for uncertainty informs robust adaptation decision-making. Conversely, risks can be underestimated when uncertainties are overlooked...

SECTION 1

Uncertainty

Numerical modelling of the earth's climate is the only reliable way to determine the amount of global warming we can expect. The models are considered reliable because they replicate the observed rise in global temperature and other past climate changes. These model simulations are called experiments because the outcome is uncertain. The global climate system is complex and chaotic, with a multitude of interactions and feedback loops between the various components (atmosphere, land, water, ice, vegetation) over a range of scales of time and space. Also, these modelling experiments are based on assumptions and data about circumstances that are unprecedented in the earth's history; a species (i.e., homo sapiens) has never modified the climate.

Uncertainty in climate model data depends on the variable, season, size of the region and timeframe of interest. The most certain climate projections are changes in average global temperature, which are directly related to the earth's energy balance and to the trapping of heat by greenhouse gases (GHGs). The least certain projections are of precipitation and related variables at regional scales, especially in the middle latitudes and continental interiors, where natural variability tends to obscure trends in climate variables. Thus, the Prairie provinces present unique challenges for detecting and communicating climate change, as well as managing the uncertainty.

Using models to project future climate requires estimates of future concentrations of GHGs based on the analysis of the social, political and economic factors that determine emissions and land-use changes. A consistent set of assumptions allows for comparable runs of climate models. Figure 1 shows that each climate model experiment has a different result, whether the GHG forcing is the same or different. Both charts in Figure 1 show changes in mean annual temperature and total annual precipitation between a historical 30-year baseline and a near-future period (2021–2050). The data in Figure 1a is from 23 Global Climate Models with two levels of GHG concentrations. The large spread and overlap among climate projections represents uncertainty resulting from the use of different models and emission scenarios.

Using a single emission scenario and one model is not the solution to eliminating uncertainty. In Figure 1b, the only variation among the 15 experiments is a slight difference in the initial conditions, yet each run of the model produces a different amount of climate change in response to the same external GHG forcing. The only source of uncertainty is the internal natural variability that emerges in response to interactions and feedback among components of the regional climate system. This internal climatic variability is distinct from the natural variability that originates outside the climate system, mostly from the effects of volcanic activity and fluctuations in solar energy.

Models, emission scenarios and internal climate variability cause varying amounts of uncertainty depending on the region's size and location, the climate variable, and the time horizon. At a global scale, models and scenarios account for most of the uncertainty. Internal climate variability is most apparent at the regional scale and in the near term (seasons to decades). At longer timescales (decades to centuries), internal variability becomes less relevant as the climate evolves away from the initial conditions, and as model and scenario uncertainty become more important factors.

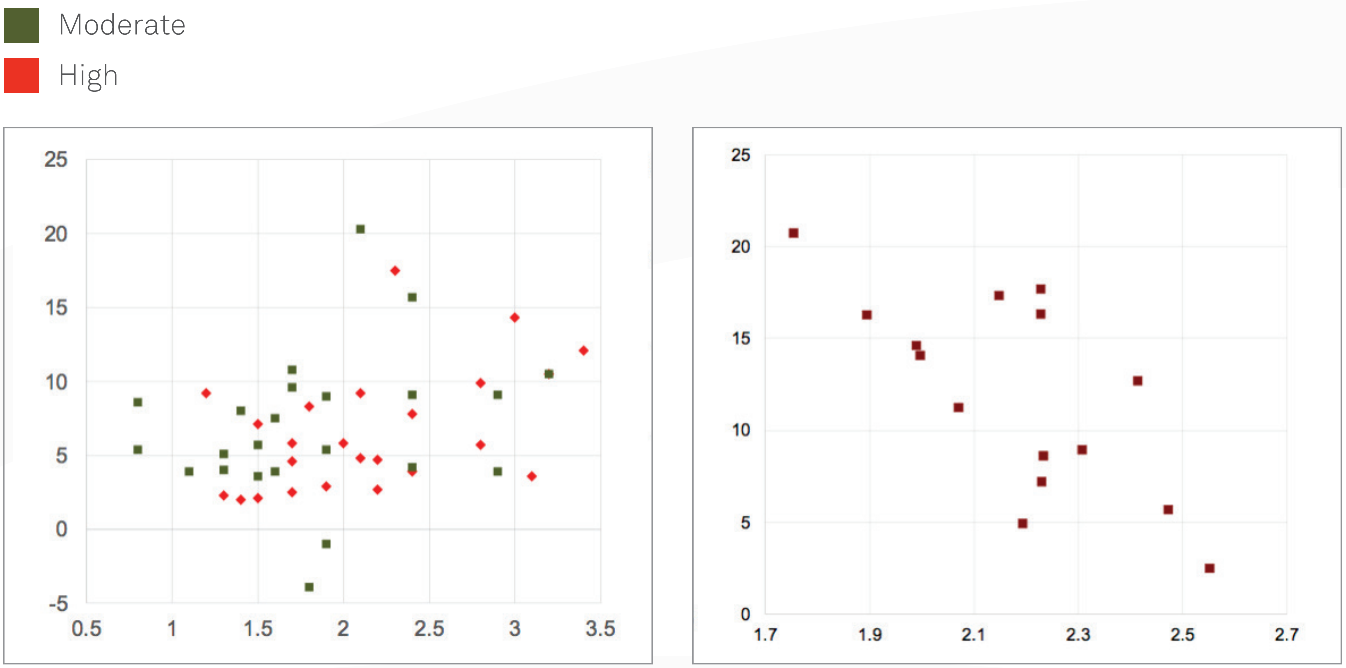

Figure 1: A scatter plot of projected changes in mean annual temperature (°C) and total annual precipitation (%) for a) Alberta from 23 Global Climate Models for two levels of GHG forcing: moderate (green squares) and high (red diamonds); and b) central Alberta, from a single model (CanRCM4) and one GHG emission scenario. The climate changes are between a historical 30-year baseline and the near-future period 2021–2050.
Sources: a) Climate Atlas of Canada and b) Prairie Adaptation Research Collaborative.

At regional scales, internal climate variability makes a much larger contribution to uncertainty. A good example is in western Canada, as illustrated in Figure 2, where the total variance in the model projection of decadal mean summer temperature (left) and precipitation (right) is attributed to the three sources of uncertainty. Model uncertainty is relatively small and fairly consistent. Beyond mid-century, scenario uncertainty is increasingly important for the modelling of summer temperature, but it has virtually no influence on the modelling of summer precipitation, which is completely dominated by uncertainty related to the internal variability of the regional climate. Precipitation is driven by the fluid dynamics of the atmosphere and oceans and is less directly linked to the global energy balance than are temperature and related variables. herefore, the role of emission scenario uncertainty is relatively small for the modelling of precipitation in all regions — and particularly in western Canada, because few places on earth have as much natural interannual variability in hydroclimate.

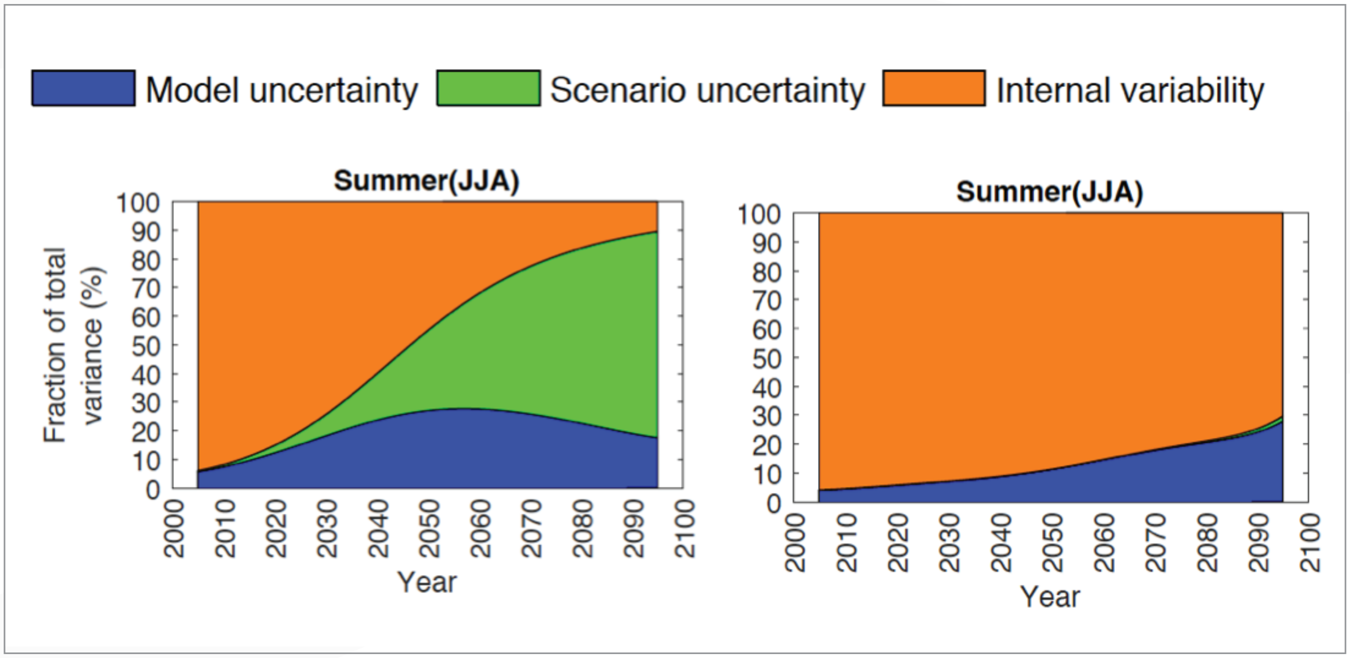

Figure 2: The contributions of the three sources of uncertainty to the model projections of decadal mean summer temperature (left) and precipitation (right) for western Canada. Summer temperatures are measured in June, July and August.

Source: Barrow and Sauchyn (2019).[1]

Recognizing, understanding and accounting for uncertainty informs robust adaptation decision-making. Conversely, risks can be underestimated when uncertainties are overlooked, undermining adaptation efforts and increasing the likelihood of maladaptation. Uncertainty is best managed by:

- Using the most applicable and relevant climate data in terms of scale, variables, statistics, time horizon, and resolution or amount of data.
- Developing adaptation plans for a range of climate changes. A scenario approach supports adaptation planning for multiple outcomes by comparing how well each solution performs under different future conditions.
- Assessing sensitivity and risk: Where is the system vulnerable? What are the critical climate thresholds?
- Considering how other types of uncertainty (e.g., economic) are managed. How much uncertainty and risk can be tolerated?
- Communicating uncertainties and assumptions and avoiding potential misunderstandings in the transfer of information to stakeholders and among domains of expertise and communities of practice.
- Using climate information from multiple sources: weather observations, proxies (paleoclimate), model simulations, expert judgment and traditional knowledge.

Note:
[1]Barrow, E.B., and Sauchyn, D. J. (2019). Uncertainty in climate projections and time of emergence of climate signals in western Canada. *The International Journal of Climatology, 39* (11), 4358–4371. https://doi.org/10.1002/joc.6079

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