High-resolution Climate Projections for the Edmonton Metropolitan Region

This case study reveals how the modelling team at PARC provided detailed climate projections to help the city of Edmonton prepare for climate change.

Providing scientific support

The City of Edmonton marked a heightened commitment to climate action through participation in the Intergovernmental Panel on Climate Change (IPCC) Cities and Climate Change Conference in March, 2018. The Edmonton Declaration – a worldwide call to action on cities to take targeted, accelerated and ambitious climate action – arose from the conference. PARC was identified to help provide Edmonton with the climate projections needed to assess its approach to climate adaptation.

Climate projections have been developed over central Alberta from Global Climate Models (GCMs) over large geographic areas before; however, they are not relevant to city planners, engineers, and other practitioners due to limitations in their detail at the municipal level. We address this by providing climate change projections at relevant scales of space and time to the City of Edmonton through Regional Climate Models (RCMs). Various scientific papers and reports (*e.g.*, AOS Foundation, 2018; Jiang *et al*., 2017; Kienzle *et al*., 2012) describe change in the climate and hydrology of central Alberta. In every case, the climate change projections used were based on GCMs with a large degree of uncertainty. Figure 1 illustrates the level of detail gained / lost when comparing GCM and RCM outputs.

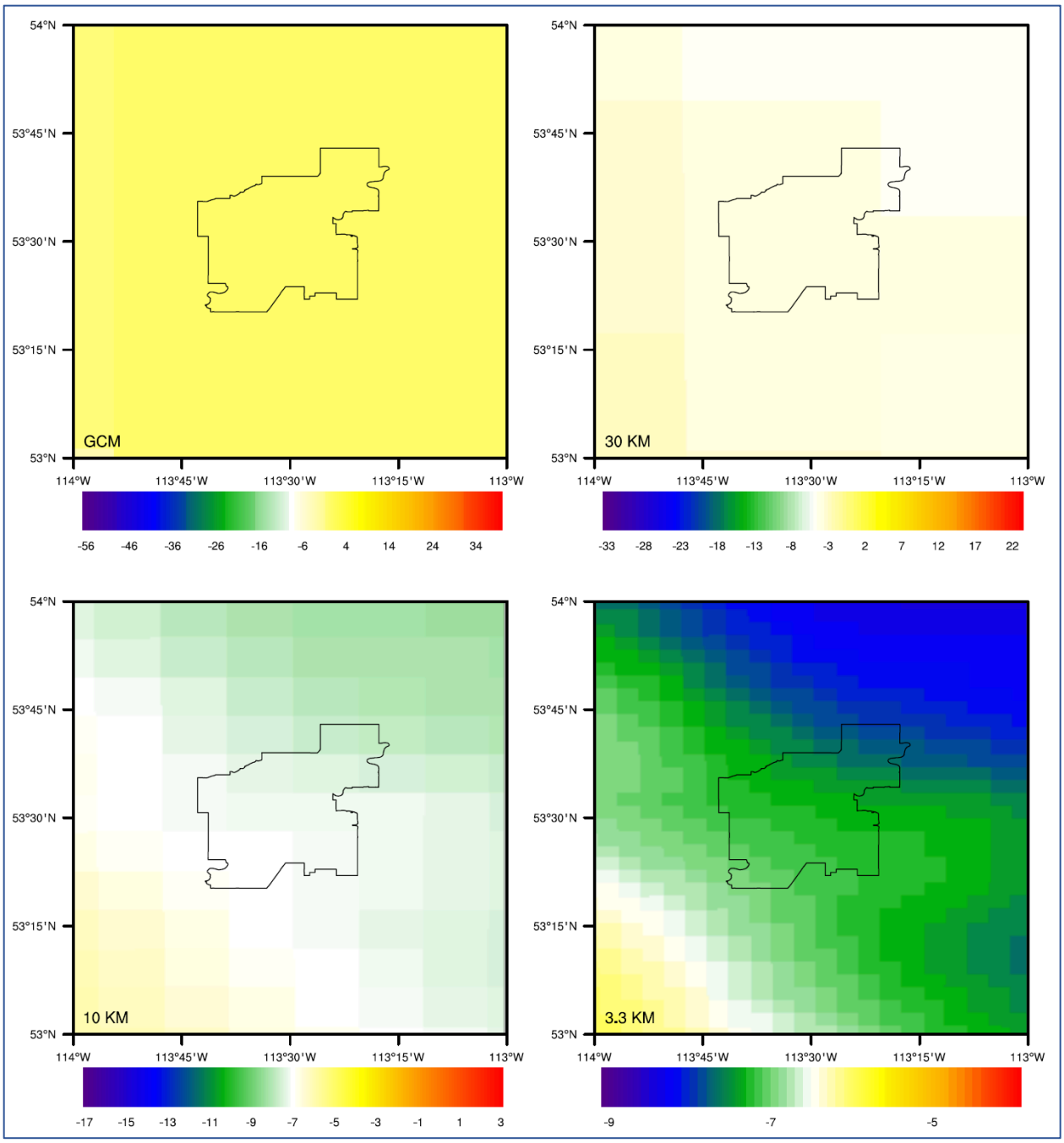

Figure 1. Model projections of the near future (2021 - 2050) average annual temperature in the EMR at four different spatial resolutions: > 110, 30, 10 and 3.3 km. Adapted from Sauchyn *et al*. (2021).

Thus, this project fills a knowledge gap in terms of the scale and type of information required to implement adaptation plans for Canadian cities, with Edmonton as the case study. Summarized within this case study, you will find the type of scientific support that is required for our partners at the City of Edmonton to implement their ambitious climate change adaptation and resilience strategy.

The Edmonton Metropolitan Region

Home to approximately 1.3 million and covering over 9,000 km^2 (Statistics Canada, 2016), including the North Saskatchewan River valley, the Edmonton Metropolitan Region (EMR) exhibits a wide range of natural and socio-economic diversity. As such, the effects of climate change and extreme events are likely to be different and *experienced* differently among neighbourhoods. Historically, we have seen that community members who are less **resilient** (*i.e.*, have less capacity to prepare for disruptions, recover from stress and adapt to changes) due to their socio-economic status will be disproportionately affected by large-scale extreme events and the progressive impacts of climate change (Rayner and Malone, 2001).

The EMR has seen a progressive increase in average annual temperature (Figure 2) from historical weather station data, with an increase of approximately 2 °C from 1884 to present. The take home message from Figure 2, however, is that Edmonton is not getting *warmer* per se; rather, it is getting less cold with winter temperatures (December, January, February) warming by over 6° C over a similar period (Figure 3). This phenomenon is common in much of Canada and other seasonally-cold regions where snow cover continues to decrease (IPCC, 2021), resulting in less sunlight being reflected back into the atmosphere.

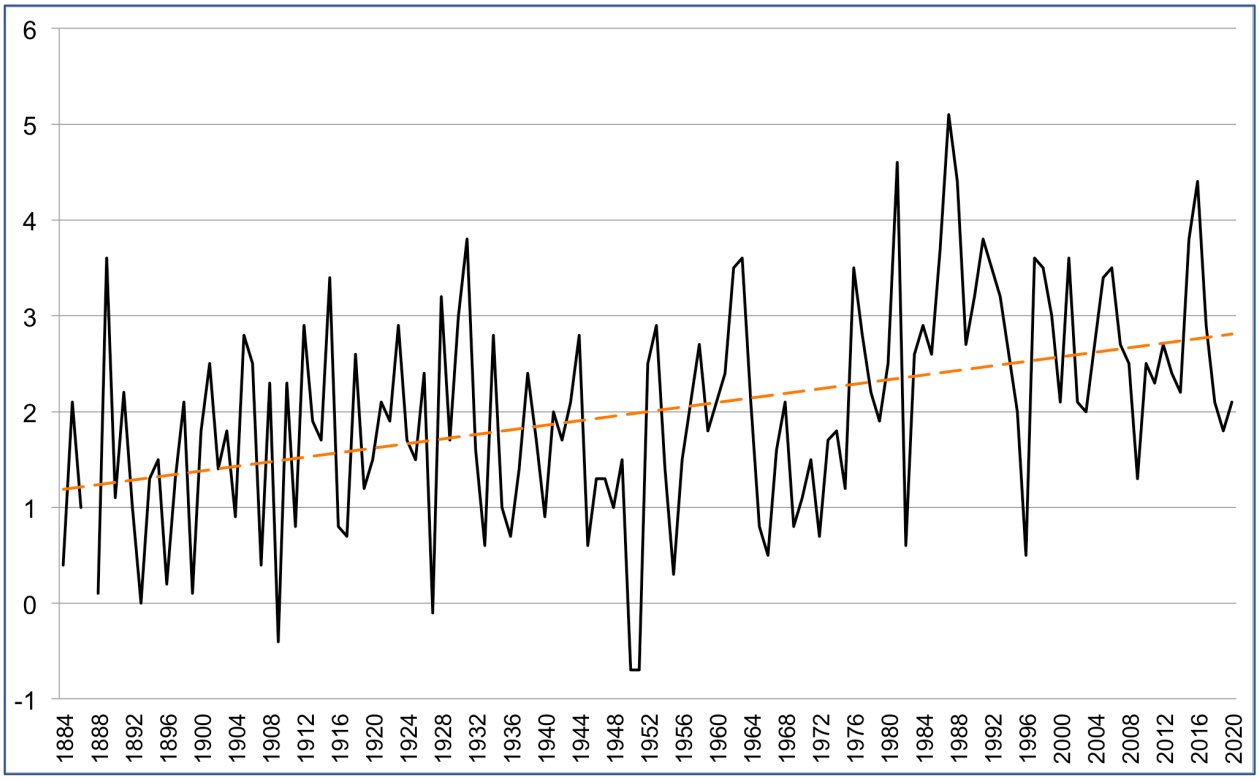

Figure 2. Average annual temperature at Edmonton (° C) from 1884 - 2020 with a linear trendline. Adapted from Sauchyn *et al*. (2021).

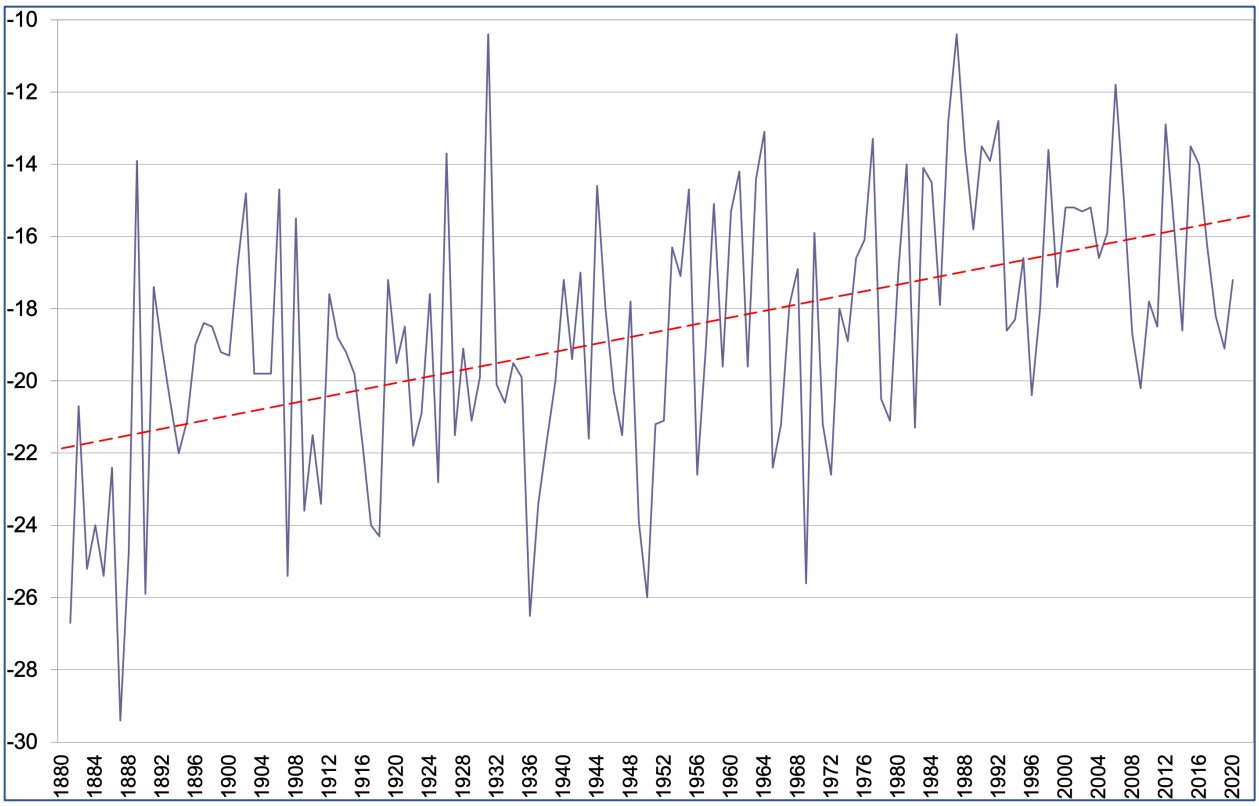

Figure 3. Average daily winter (December, January, February) temperature at Edmonton (° C) from 1880 - 2020 with a linear trendline. Adapted from Sauchyn *et al*. (2021).

Modelling climate: past and future

Climate projections for Edmonton were generated from the National Center for Atmospheric Research (NCAR) Weather Research and Forecasting (WRF) Model 4.0 (Shamrock *et al*., 2019) at a **spatial resolution** (*i.e.*, the pixel size of the model) of 3.3 km, as well as 10 and 30 km. A number of climate variables (temperature, precipitation, humidity, etc.) were generated every six hours. These were simulated for 30-years periods of 1976 - 2005, 2021 - 2050 and 2051 - 2080, assuming an **RCP 8.5 scenario** – which, in other words – assumes very high greenhouse gas (GHG) emissions in the future. See the end of the case study for more information on RCP scenarios.

In addition to applying RCMs, a reconstruction of the past climate (**paleoclimatology**) from tree-ring data (see PARC's Tree-Ring Lab) of the North Saskatchewan River Basin (NSRB) from Sauchyn *et al*. (2020) was used to understand the natural variability of the region through a larger dataset of climate (1888 - 2100). This record captures a large range of natural variability in Alberta's hydroclimate and is thus noted as a significant source of model uncertainty where departures from the climate change trend are observed.

A snapshot into Edmonton's future climate

Average annual precipitation and temperature are expected to increase from the period 2021 - 2080, following the high-resolution (3.3 x 3.3 km) model projections for Edmonton. Figures 4 and 5 depict this upward trend, with Figure 5 demonstrating a large range of variability in annual precipitation from year to year.

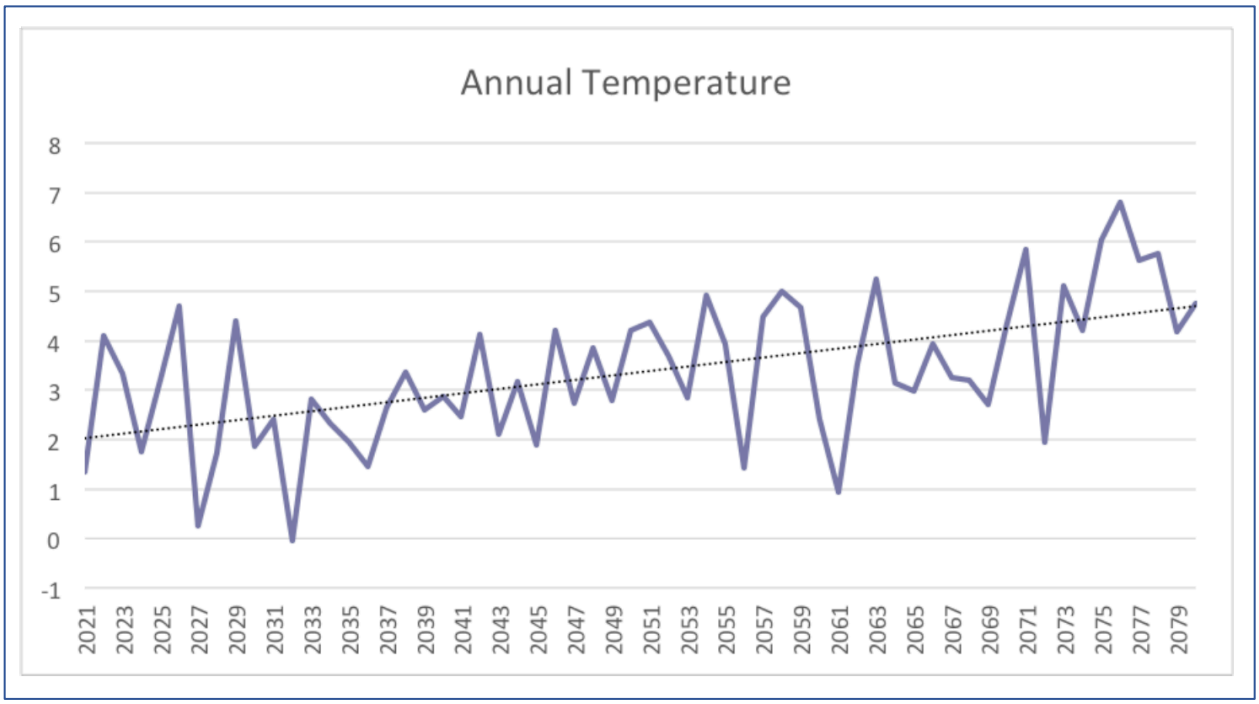

Figure 4. Time series of average annual temperature (° C) with a linear trendline at Edmonton, AB, for 2021 - 2080. Adapted from Sauchyn *et al*. (2021).

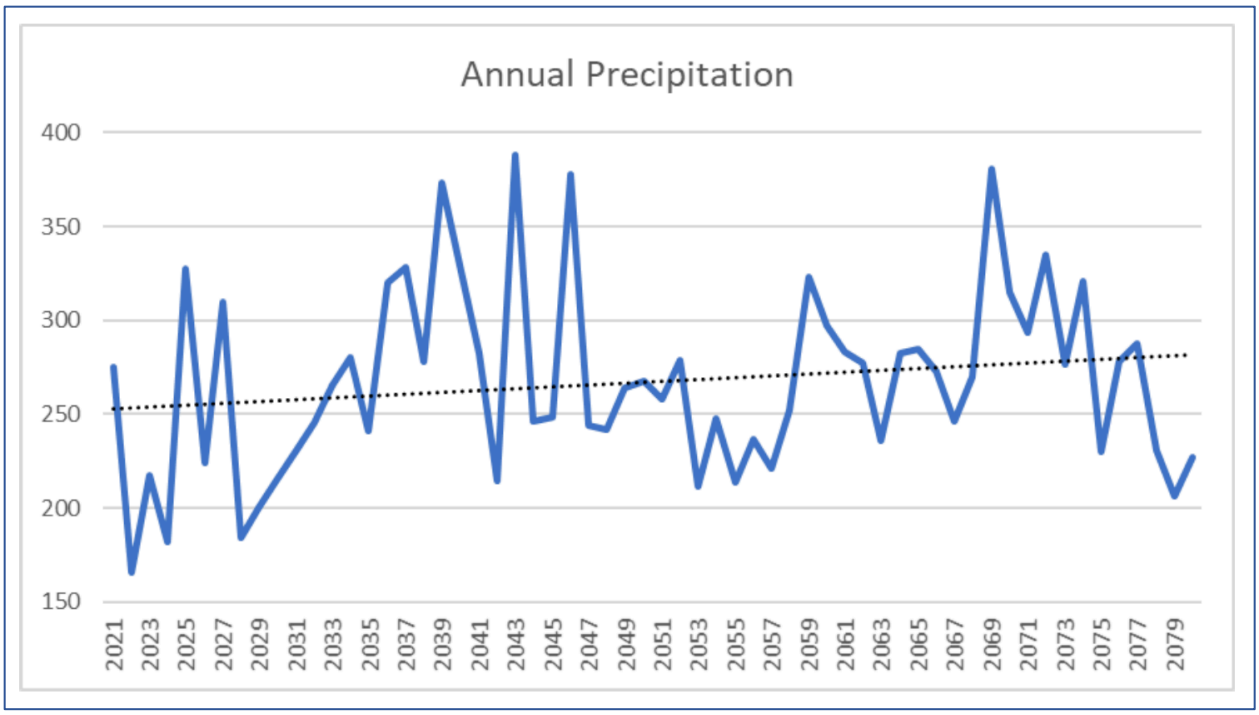

Figure 5. Time series of average annual precipitation (mm) with a linear trendline at Edmonton, AB, for 2021 - 2080. Adapted from Sauchyn *et al*. (2021).

Following the record-setting heat waves felt across western Canada, significant attention has been given to daily maximum temperatures. Although Edmonton did not set a record daily high temperature in the summer of 2021, the City did set a record for the most consecutive days with a daily maximum temperature exceeding 30° C at seven days (June 26 - July 2). Figure 6 shows the projected increase in average annual average daily summer maximum temperature for the City, which is expected to increase 3.6° C from 2021 - 2080 (Sauchyn *et al*., 2021).

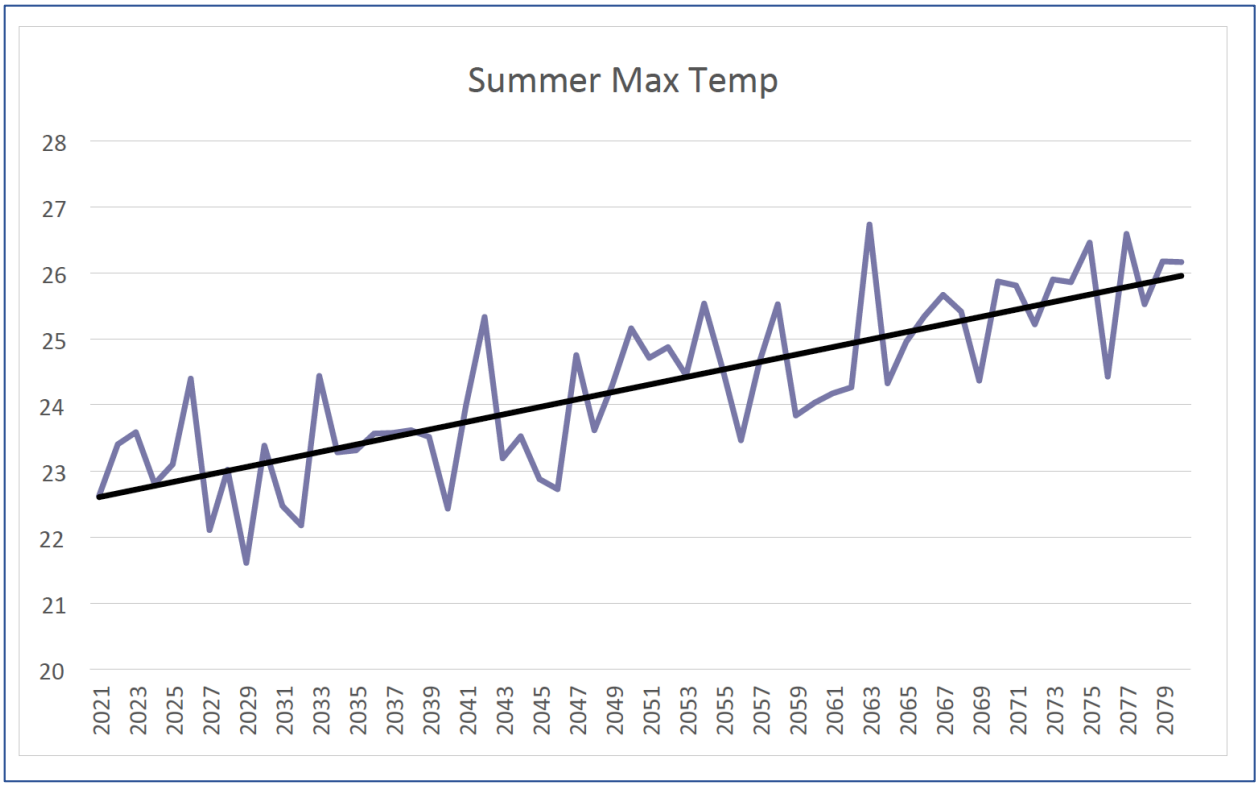

Figure 6. Time series of average daily summer (June, July, August) maximum temperature (° C) with a linear trendline at Edmonton, AB, for 2021 - 2080. Adapted from Sauchyn *et al*. (2021).

Managing uncertainty

This project provides the City of Edmonton with a unique database of climate projections at a scale relevant for planning and decision-making. We controlled for uncertainty due to human-caused climate change by using a single GHG emission scenario (RCP 8.5) throughout our modeling and analysis. RCP 8.5 is a high emission scenario and is commonly used because global GHG emissions continue to escalate and have yet to level off.

Natural climatic variability is the dominant source of uncertainty in the prediction of the future climate of western Canada. It accounts for about 90% of the total variance among climate model projections of future precipitation over the next few decades (Barrow and Sauchyn, 2019). We address this variability through the use of a paleoclimate record (Sauchyn *et al*., 2020), which has the advantage of greater record length that pre-dates substantive human interference with the global climate system.

By explicitly exploring the full range of uncertainty, and understanding the sources, we can make recommendations for accommodating uncertainty in decision making, including the extent to which existing risk and asset management strategies designed for historical weather events will require adaptation to a shift in hydroclimate variability and frequency / magnitude of extreme events.

The research team was able to generate large amounts of data about the regional consequences of anthropogenic climate change and underlying natural variability; however, the analysis of these data is context and partner driven. The data are transformed into information and knowledge by applying the requirements of the City of Edmonton, and focusing on key hydroclimatic variables and critical thresholds identified in consultation with City staff. The City's Adaptation Strategy and Action Plan (City of Edmonton, 2018) includes "Five Paths to Climate Resilience", each with goals and specific actions.

For further reading

PARC Regional Climate Models
RCP Scenarios:

Vuuren *et al*. (2001) The representation concentration pathways: an overview. *Climate Change*, **109**: 5-31. doi: 10.1007/s10584-011-0148-z.

Case Study of the North Saskatchewan River Basin

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Citing this case study

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