Climate Change Scenarios for the Prairies

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■ Introduction

Climate change, and its impacts on natural and human systems, is the subject of intensive world-wide investigation. As a result, a large body of knowledge has accumulated, such that there is a reasonable understanding of the direction of climate change and potential impacts for most regions of the world. There are, however, few cases of the use of this information for modifying practices and policies to minimize the adverse effects of climate change. In part, this simply reflects the lag between scientific findings and their application, but also the need for synthesis and scientific assessment of the research, and to some extent, attempts to exaggerate the level of scientific uncertainty by individuals and organizations that advocate no action in response to climate change.

On October 12, 2007, The Intergovernmental Panel on Climate Change (IPCC) received the Nobel Peace Prize in recognition of their scientific assessment of climate change research. The Fourth Assessment Report (AR4) of the IPCC was released in 2007. These documents represent the understanding of climate change among more than 800 scientists based on their review and interpretation of thousands of recent studies. Because the AR4 is global in scope, details are lacking for the regional scale at which actions are taken to prevent climate impacts and take advantage of opportunities presented by a warmer climate. Therefore, whereas the AR4 supports policy development by and among nations, local action on climate change requires national and regional scientific assessments.

In late 2007 and early 2008, the Government of Canada released the 2nd National Assessment of Climate Change (NACC) (Lemmen et al*.,* 2007). There has been considerable research and observation of climate change since Canada's first national assessment was published in 1997. To produce the Prairies chapter of the NACC (Sauchyn and Kulthretha, 2007), 12 scientists reviewed almost 1000 studies. At the provincial scale, the government of Alberta has undertaken an evaluation of vulnerability to climate change beginning with the construction of a new set of climate change scenarios (Barrow and Yu, 2005) and the assessment of the potential impacts of these projected changes on ecosystems and water resources (Sauchyn et al., 2007).

In the proceedings of the 2006 Banff Pork Seminar, Sauchyn (2007a) described the general pattern of global warming in the Prairie Provinces and the impacts of this warming on water resources:

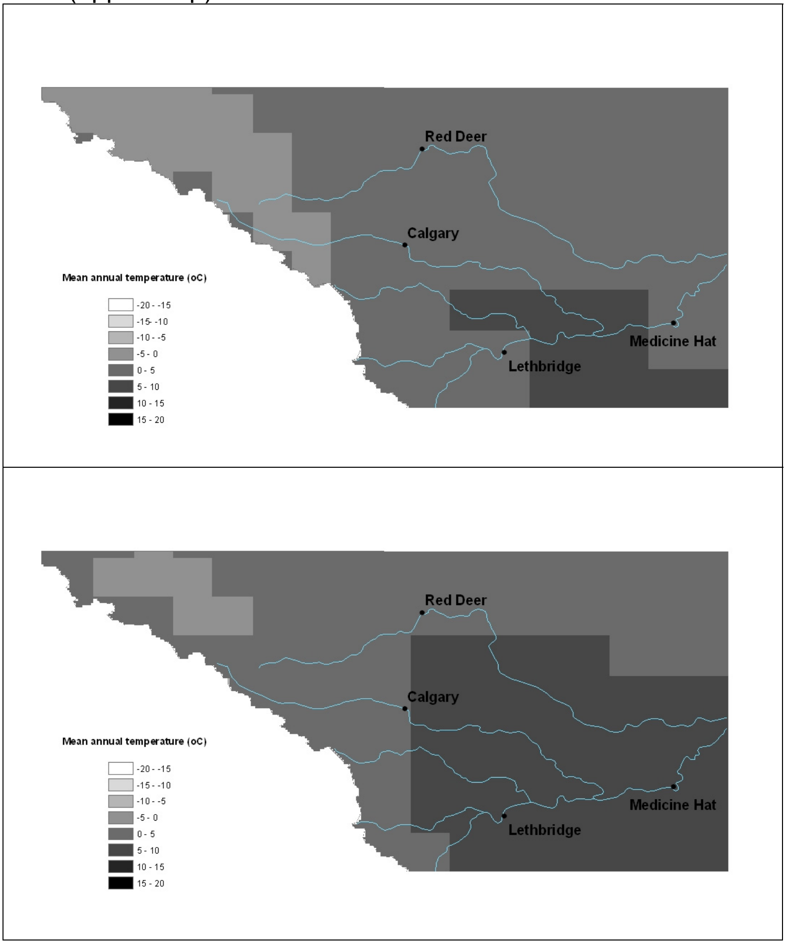
- a shorter winter and longer drier summer
- decreasing trends in spring snowmelt and annual stream flow, with reductions in snowfall and higher temperatures in winter
- increasing soil and surface water deficits as more water is lost by evaporation and transpired from plants in summer, than is gained by the extra precipitation in winter
- model projections of increased climate variability, and therefore droughts of longer duration and greater frequency, as well as unusual wet periods and flooding

Given the intensity and rate of current climate research, and the time required to complete and publish a scientific assessment, recent studies and climate models are more current than reports from the IPCC and governments of Canada and Alberta. This paper includes results from these new studies and output from the latest global climate models (GCMs).

Climate Change Scenarios

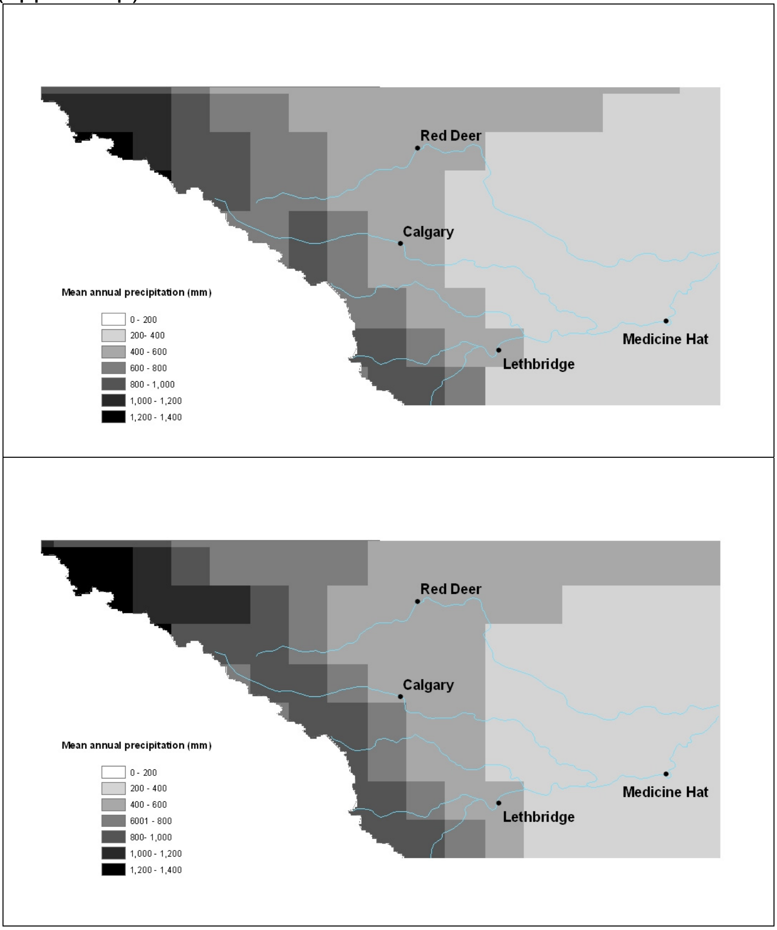
To demonstrate the pattern of global warming expected for the southern Prairies, we derived climate change scenarios from the latest version of the coupled ocean-atmosphere model (CGCM3.1/T47) from the Canadian Centre for Climate Modelling and Analysis. We chose southern Alberta to illustrate the projected changes in temperature and precipitation, because this region includes the Rocky Mountains, the main source of water supplies, and the plains, where communities and agriculture create the demand for water.

Figure 1. Mean annual temperature in southern Alberta from the Canadian Global Climate Model version 3, greenhouse gas emission scenario B1(2) (CGCM3.1/T47 B1(2)). This median model projects an increase in temperature of about 2.5 C by 2040-69 (lower map) relative to 1961-90 (upper map).



A climate change scenario is a plausible change in climate variables between a 30-year baseline period, usually 1961-90, and a future 30-year time slice (e.g., 2040-69; the "2050s"). Climate change is expressed as the difference between 30-year means because the climate of specific years cannot be known; only climate tendencies. In fact, every run of a global climate model (GCM) produces a different future climate. Results are available for many GCM experiments because climate modeling centres exist around the world (e.g. USA, Canada, UK, Japan, Australia, and Germany) and also because climate projections require estimates of future levels of greenhouse gases (GHG) based on various assumptions about global social, political and economic circumstances and trends. The outputs from a large number of runs of various global climate models fall within a range of future conditions. When we plot the change in precipitation and temperature projected by eight GCMs using three greenhouse gas scenarios, output from the CGCM3.1/T47 emission scenario B1 experiment (run 2) plots near the center of the scatter of points, that is, it is a median scenario; GHG scenario B1 assumes a world that is more integrated, and more ecologically friendly than other emission scenarios.

Figure 2. Mean annual precipitation in southern Alberta from the Canadian Global Climate Model version 3, greenhouse gas emission scenario B1(2) (CGCM3.1/T47 B1(2)). This median model projects an increase annual precipitation of 13% by 2040-69 (lower map) relative to 1961-90 (upper map).



CGCM3.1/T47 B1(2) projects median increases of about 2.5 C in temperature and 15% in precipitation for southern Alberta by 2040-69 relative to 1961-90. The upper maps in **Figures 1 and 2** show the distribution of annual temperature and precipitation, respectively, for 1961-90. The lower maps show the future climate of the 2050s; the darker tones are more prominent than in the upper maps indicating increased temperature and precipitation. As important as the projected annual changes is the shift in seasonal distribution since it will determine, to a large extent, the effects of higher temperatures and precipitations on agricultural production, ecosystems and water supplies. **Figure 3** is a plot of the mean seasonal temperature (left) and precipitation (right) for Lethbridge. The shaded vertical bars give the 1961-90 normals. Solid vertical lines give the range of conditions projected by GCMs for the 2050s. Future temperatures are higher in every season. Precipitation, on the other hand, is higher in winter, but unchanged in spring and fall. An increasing proportion of the extra winter precipitation will fall as rain versus snow (Lapp et al., 2005). Furthermore, most models project decreased summer precipitation relative to 1961-90. This shift in the seasonal distribution of precipitation is one of the most important and consistent scenarios for the western Canada.

Figure 3. Mean seasonal temperature (left) and precipitation (right) for Lethbridge. The shaded vertical bars represent the 1961-90 normals. The solid vertical lines represent the range of future (2050s) conditions projected by GCMs. Whereas future temperatures are higher in ever season, all models project higher future precipitation in winter but most models project decreased summer precipitation relative to 1961-90.

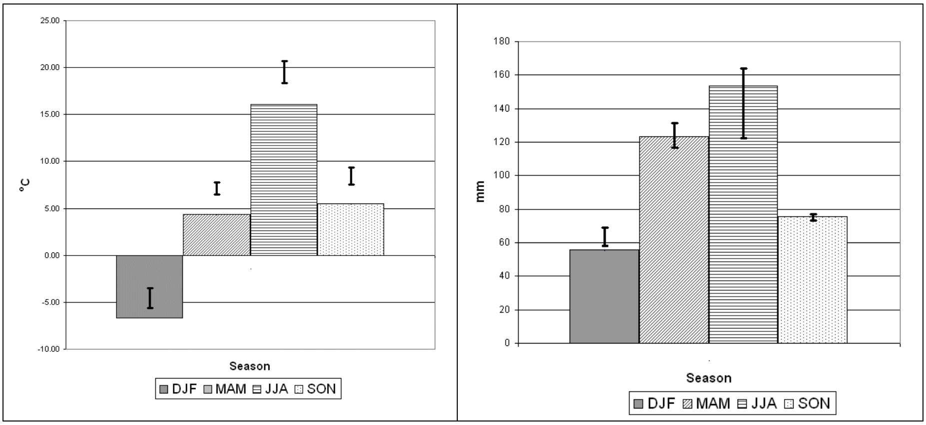
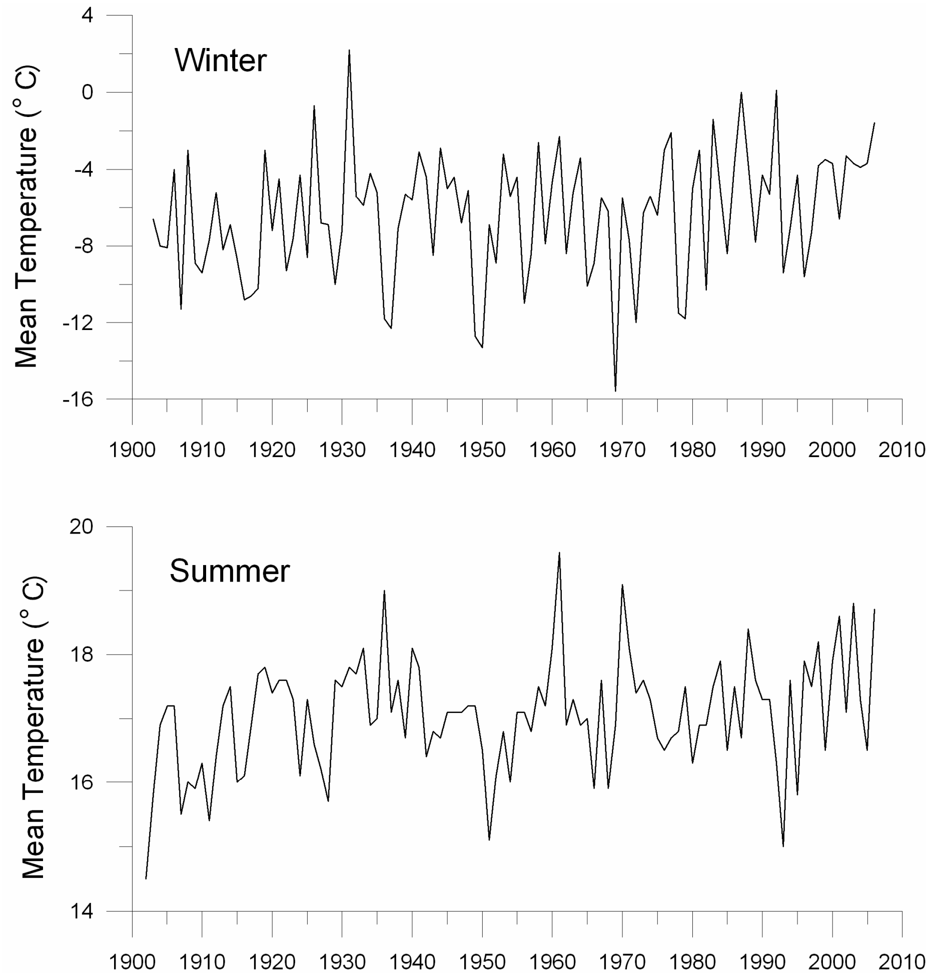


Figure 4. Mean winter (top) and summer (bottom) temperatures at Lethbridge, 1902-2006. Temperatures in both seasons display an increasing trend in recent years, but the upward trend in winter temperatures has been more consistent, extending to 1970 and consistently high for the past 10 years.



Global climate models are the only credible tools currently available for simulating the response of the global climate system to increasing greenhouse gas concentrations. They simulate the mechanics and forcing of global climate. The scientific community has confidence in GCMs because they are able to replicate global temperature trends of the past recorded at weather stations. At Lethbridge, weather has been observed since 1902. **Figure 4** illustrates that since about 1970 winter temperatures have risen steadily and remained relatively high for the past 10 years. Summer temperatures (Figure 4, bottom) have increased more recently and with greater interannual variability. Thus the recent temperature trends at Lethbridge coincide with the scenarios from GCMs. There are no obvious trends in precipitation; the increase projected by GCMs is relatively small compared to the large variability between seasons and years. The more revealing water records are of streamflow and lakes levels, since they reflect the water balance and not just inputs of water. Declining levels of many prairie lakes and streams (Sauchyn and Kulshreshtha, 2007) can be linked to longer warmer summers, and the seasonal shift in precipitation described above (Figure 3).

■ The Response: Adaptation

Crop and livestock livestock production has been sustained for more than 100 years in the Prairie Provinces, near the climatic limits of North American agriculture, through a continuous process of adaptation to a dry climate, large climate variability and extreme weather events. This resilience and history of adaptation is good preparation for the regional impacts of global warming, but the sector and producers will be challenged by a shift in the distribution of water over time and space that could bring conditions that are outside the range of those previously experienced by at least the last two generations of prairie farmers and ranchers (Sauchyn 2007b). The most challenging scenario is droughts of a severity and duration that exceeds the worst droughts since the plains were settled by EuroCanadians, but occurred in paleoclimate records (Sauchyn, 2007a, b). This would force producers to consider new technologies and management practices.

There is also an opportunity to take advantage of the shorter winters and longer frost free season provided that water supplies are sufficient to sustain production. Thus, much adaptation will involve the improved conservation and management of agricultural water supplies, such as the use of ball-bite water drinkers on a commercial hog facility (McKerracher, 2007). Supply management could involve both engineered on-farm water storage and restoration of the storage capacity of wetlands and riparian ecosystems.

While most adaptation will be adjustments in structures and practices on farms and in communities, this must be facilitated and coordinated so that the implementation is efficient, effective and equitable. This is the role of government and industry. These formal institutions have an important responsibility in terms of policy, legislating, rewards and disincentives; however, less formal institutions and social networks, like producer associations, have an equally important role to play in raising awareness, sharing information, and encouraging changes on farms and within communities. Inviting climate experts to society seminars is part of this process, but adaptation to climate change will require more direct action and participation in identifying and testing options for the adaptation of farm management practices.

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