ANNEX 1: Climate Change Projections for the Arctic & the North

SOURCES OF INFORMATION

Four major studies have provided insights into the changes in climate, forced by greenhouse gas increases in the global atmosphere, for the two Canadian Territories and the Arctic Archipelago. They are:

1. From Impacts to Adaptation: Canada in a Changing Climate 2007 (NRCan, Ottawa),
2. Arctic Climate Impact Assessment, 2005 – Arctic Climate Science Committee,
3. Intergovernmental Panel on Climate Change, 2007, especially WGII, Impacts, Adaptation and Vulnerability, Chapter 15 – Polar regions, and Chapter 14 – North America, and
4. Mackenzie Basin Impact Study, Final Report, 1997, Environment Canada.

In addition, a number of scientific papers have appeared which add more information about the changes that have taken place and are expected in coming decades.

To assist in the use of this Guide a brief summary of the key findings, in these thousands of pages, are provided in this Annex.

RECENT TRENDS

Determination of trends in climatological conditions has been somewhat difficult because of limited observational data in these regions, especially at stations with long consistent records. Local traditional knowledge can be important as well in assessing changes. Nevertheless, since the mid-60s, when atmospheric greenhouse gases began to dominate long-term climate change, the whole circumpolar region north of 60°N warmed at an average rate of 0.4°C per decade (1966–2003).

The rate of warming was greater in Canada than on the Russian side of the Arctic. However, a cooling trend in previous decades (1946–1965) was particularly evident on Baffin Island, but this changed to a warming trend about 1990. The net result was a slightly negative temperature trend values from 1950 to 2000 as shown in Table A1 in eastern Arctic. Throughout these regions, warming has been greatest in winter and spring but is evident in all seasons. Aboriginal hunters have also detected and reported the warming trend.

Precipitation measurements are very difficult in the Arctic where much of the precipitation is snow and often occurs with high winds. As measured, precipitation in all seasons has increased since 1966 in the eastern Arctic and Yukon where precipitation is already greatest in the Arctic. A decline in precipitation in all seasons was observed in most of northern NWT. Overall in the circumpolar region north of 60°N, a precipitation increase of about 2% per decade was recorded from 1966 to 2003. The amount of precipitation occurring as snow has declined somewhat.

In marine areas, a most important feature is the presence of sea ice for much of the year. A contraction of the area covered at the end of the melt season (Aug–Sept.) has been recorded with estimates of the rate of change ranging from 3 to 5.6% per decade. IPCC 2001 suggests a 40% decline in ice thickness.

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Sea level rise reflects the global experience of an average 1.8mm/yr rise since 1961, but an acceleration to 3.1mm/yr has occurred since 1993. However, the relative sea level change is also affected by whether the shoreline land is rising due to postglacial isostatic rebound, as in much of the Arctic, or subsiding. Subsiding areas are on the Beaufort seacoast, including the western edge of the Archipelago, and narrow bands on eastern Devon and eastern Baffin Islands. Sea level rise is becoming a significant concern in these areas of subsiding shorelines, with melting permafrost and less protective shore ice. With upper estimates of sea level rise now about 1 metre this century, many other low lying coastal areas will experience increasing erosion and flooding.

On the land areas in the Arctic islands, glaciers have retreated and ice cover reduced. Many small lakes and ponds have dried up with increased summer evaporation under higher temperatures. In some areas thawing permafrost has made surface waters into groundwater.

These trends, since the mid-60s, reflect not just the effects of increased greenhouse forcing but also the climate pattern called the Arctic Oscillation that is closely linked to the North Atlantic Oscillation (AO/NAO), as well as the Pacific Decadal Oscillation (PDO). The AO was in a warm phase from 1989 to 1994 and accelerated the warming over that period. Since 1994, there have been several short-term phase reversals, but continued warming from greenhouse forcing.

PROJECTIONS FOR THE FUTURE

In most cases changes experienced in the north in the past few decades are expected to accelerate as greenhouse gases accumulate in the global atmosphere.

Warming in most of the North has been greater and is projected to be greater in future than in most of the rest of the world. This is mainly because of an important feedback. Once greenhouse gas induced warming begins to melt snow and ice, which reflect most of the sun's energy, the exposed water and land absorb much more of that heat energy, augmenting greatly the direct greenhouse effect.

Some of the Atmosphere/Ocean General Circulation Models (AOCGM) used to project climate changes into the future have been shown to be able to reasonably produce current climate in the Arctic. Three models (U.K, German, Japanese) and two Regional models did a good job of simulating observed temperatures. None replicated precipitation patterns satisfactorily.

In general, the models project for 2050 a 3°C to as much as a 5°C temperature increase in Western areas and 3°C to 4°C in eastern regions for median GHG emission and concentration projections. For high estimates of GHG concentrations, appearing increasingly likely, annual temperature increases in the western archipelago and extreme northern Territories could be in the range of 10 to 12°C, but about 4°C in eastern Arctic. Winter and autumn changes are projected to be greatest.

In general, precipitation increases are projected to be 15% in western areas and 10% in eastern areas with a median projected increase in greenhouse gases although these estimates are less reliable than those for temperature. With high GHG increases, the precipitation increases could be 30 to 40% in much of the Territories and western Arctic, but about 10% in the east. Increases in freshwater flow from rivers are expected to increase, by 12 to 20% for the Mackenzie River, for example.

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Over the next 50 years, the active layer in cold thick permafrost could increase from 0 to 50% depending on local circumstances. In Yukon and much of southern NWT where permafrost is warmer than −2°C on average, much of this permafrost will thaw or continuous permafrost will become discontinuous by 2050. This has important implications for landslides, buildings, pipelines and for surface and groundwater resources.

STORMINESS, EXTREMES AND FIRES

The Canadian GCM (CGCM2) projects an increased frequency of severe winter storms north of 60°N, suggesting more frequent blizzard conditions. An analysis of severe cold season precipitation events at Iqaluit over the 1955–1996 period, indicates that high atmospheric moisture content and low pressure systems from the south were most important for severe events. However, not all heavy precipitation is snow. On June 7–8, 2008, at Pangnirtung, high temperatures (13°C) and heavy rain produced devastating flash floods.

The area burned by forest fires in the two Territories has been rising along with average temperatures. Lightning sparks some 80% of forest fires. The length of the fire season in the Territories is expected to increase by up to 50 days this century.

Inuit knowledge has been combined with instrumented observations to determine an increase in dangerous wind speeds at Kanngiqtugaapik (Clyde River).

SOME IMPACTS TO CONSIDER

1. Coastal erosion has been severe on Territorial northwestern shores, especially near Inuvik. This is due to sea level rise, increased storminess with less protective shore ice, land subsidence and permafrost thaw all likely to continue.
2. The geographical ranges and species composition of both terrestrial and aquatic ecosystems are changing.
3. Climate change effects on thawing of permafrost are often augmented by clearing of vegetation and heat of new structures to compound problems of design and maintenance of buildings, roads, pipelines, etc.
4. Reduction of sea ice has made easier Arctic shipping and access to potential mineral and fossil fuel resources. These provide both economic opportunities on the one hand and potential social and environmental problems for local populations on the other.
5. In areas served by winter roads, especially in the Territories, the length of the safe travel season is shortening.
6. Increasing threats of forest fires, especially in the Yukon and in the Mackenzie basin require action by forest agencies to reduce risks, and preparedness by emergency managers in communities that may be in the potential path of major fires.
7. In the face of rapid snowmelt, combined with intense rains in spring and summer, communities susceptible to flash flooding should review and improve their drainage facilities and remove vulnerable buildings and facilities from locations likely to be affected.
8. Reduction of sea ice and increased frequency of blizzards need to be taken into account by hunters and travelers.

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9. Decreases in mean and maximum depths of winter snow cover have been observed in the past 4 decades and are likely to continue affecting vegetation and important foraging mammals (barren ground caribou, muskox) and migration patterns

10. Changes in marine species distribution and northern movement of ice-edge species like ringed seals and polar bears, as well as changes in fish species, will require adaptive management strategies by coastal communities.

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