

Valued Component - Climate (FINAL DRAFT)

STATE OF KNOWLEDGE – WHAT IS HAPPENING?

A very brief overview of the state of knowledge with respect to climate in the NWT is presented below. This overview is preliminary and not intended to be exhaustive.

→ What are the baseline conditions with respect to climate?

* The Mackenzie Valley encompasses a rich variety of eco-climatic regions from the sub-humid high boreal of Great Slave Lake to the high subarctic of Inuvik. The weather and climate are influenced by a number of factors including: latitude, radiation balance, topography and weather systems. At Yellowknife, sunlight varies from about 5 hours in December, to 20 hours in June, while at Inuvik the sun does not rise in December nor does it set in midsummer. The major topographic features include the Mackenzie Mountains and Great Bear and Great Slave Lakes. Numerous small lakes and wetland areas dot the landscape.

* Winters are cold, with monthly average temperatures ranging from -25 to -30°C, while summers are warm with average temperatures reaching 15 to 20°C. Extreme temperatures can be as low as -50°C in winter or above 30°C in summer.

* The mean annual precipitation over the Mackenzie Valley varies with altitude and latitude, from over 600 mm/yr in the Mackenzie Mountains to under 200 mm/yr along the Arctic coast. An area-weighted average for the NWT is estimated at 300 mm/yr. The annual precipitation is split between summer

KEY MONITORING INDICATORS

Air temperature
Evaporation

Precipitation

rain and winter snow (approximately 50 % each), but this split also varies with latitude. Southern areas receive more rain than snow while northern areas receive more snow than rain. Summer precipitation occurs in association with convective storm systems. During the autumn and early winter, cyclonic systems move from the west or southwest producing much of the snowpack over the Mackenzie Valley. Winter systems that enter the region from the northwest contain little moisture so the few disturbances result in only light snow events. The first appearance of snowcover is usually in late September along the northern coast to late October along the southern border. It usually disappears from the southern border in late April but can persist until mid June along the coast and northeastern border with Nunavut. Snow accumulation is greatest over the Mackenzie Mountains.

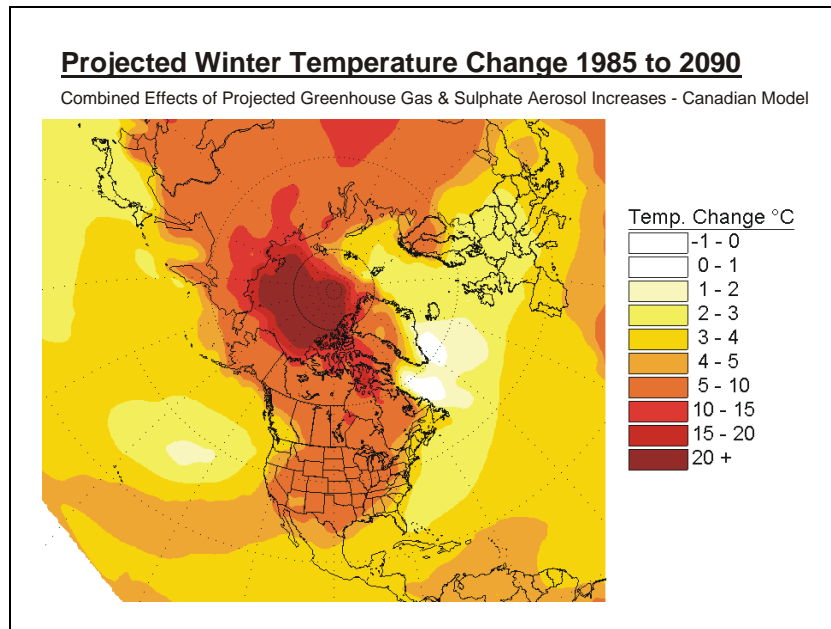
* Forest cover extends over a major portion of the NWT, and interacts with the atmosphere in ways that may influence climate. The northern extent of forest cover is closely associated with the mean summertime position of the arctic front (see Ball, 1986). Forest fires also play an integral role in the northern forest ecosystem and affect local microclimate. Forest fires pose a significant danger, and regularly burn a portion of the forests. Lightning storms are common during the summer and start approximately 80 percent of the fires over the area. Although they are beneficial to the control of diseases and insects as well as maintaining biological diversity, fires also threaten human life, property and commercial resources. Over the past 30 years, an annual

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average of about 310 fires has consumed approximately 650,000 hectares in the NWT. The number of fires and the area burned are highly variable from year to year.

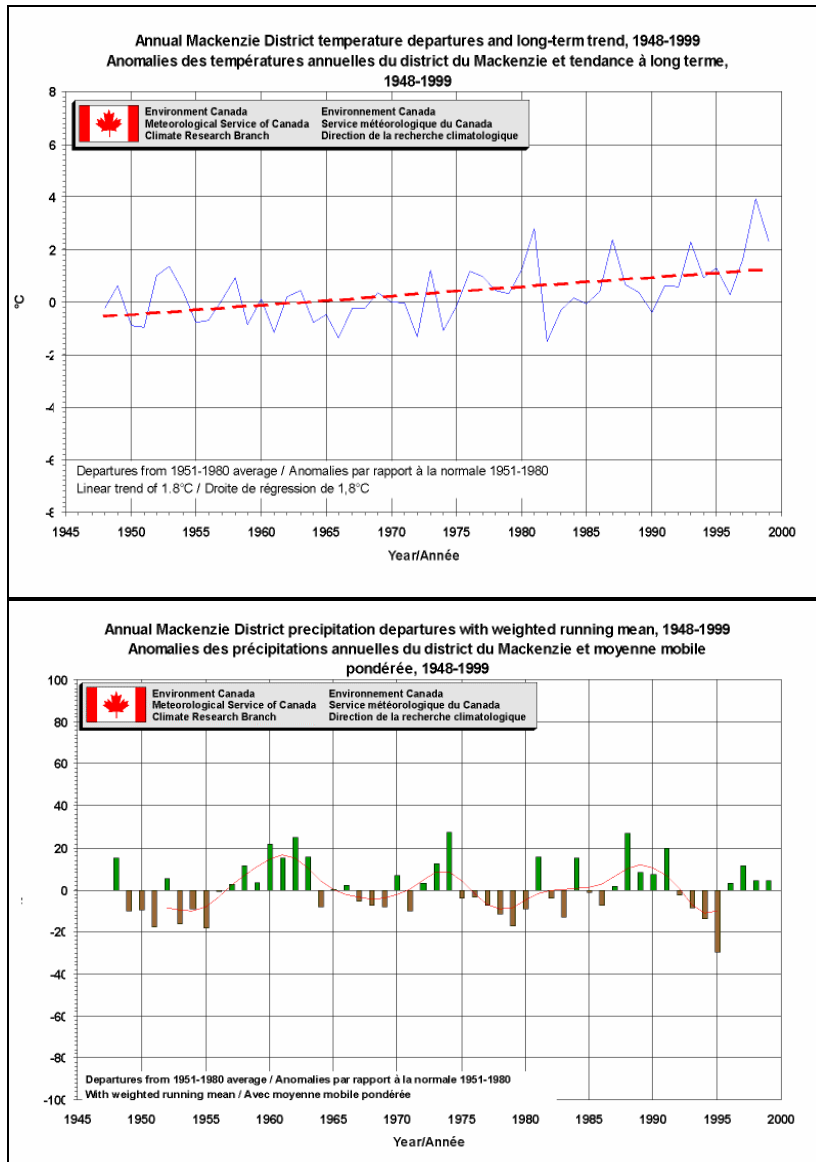
→ How is climate changing?

* Global warming is expected to manifest as more pronounced warming during winter in the polar region. The following graph highlights the enhanced projected winter temperature change over the northern hemisphere (see Zwiers 2000).



* The following graph suggests that climate in the NWT exhibits this overall warming trend over the past 50 years, superimposed on shorter-term fluctuations. Most of the warming has occurred in winter months, with the coldest -40 to -50°C mid-winter temperatures of the December to February period lasting for shorter periods and being much less common, particularly during the past 15 years. The next graph following suggests that no trend in total annual precipitation has resulted from this overall warming trend. There is some evidence to suggest that a decrease in winter precipitation has been offset by an increase in summer precipitation in the Mackenzie District. However, reliable long-term winter-precipitation data from more stations may be required to substantiate this.

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* Projections of future conditions by global climate-change models (GCMs) suggest continuing warming for as much as the next 30 to 50 years, irrespective of any future efforts to reduce greenhouse gas emissions. These changes are expected because of the momentum inherent in the long-term cumulative response of earth's atmosphere, oceans, glaciers, vegetation and watersheds to increases in greenhouse-gas concentrations. Modeling capabilities of GCMs are limited by the algorithms employed, which cannot simulate an abrupt change for which the triggering threshold condition is unknown. A reduction in Arctic sea-ice cover is observed in recent years, which raises concern over reaching a threshold that could trigger abrupt and significant change in the climate regime.

* The predicted impacts projected by changes in temperature and precipitation resulting from climate change will manifest themselves in various ways over the sensitive northern ecosystems. Climate model studies suggest that increases in thunderstorm activity are a possible outcome of global warming. One potential impact of this increased thunderstorm activity could be increased frequency and severity of lightning-initiated forest fires over the boreal regions of the NWT.

→ Can NWT developments influence climate change?

* There have been in recent year's substantial increases in greenhouse gas emissions from oil and gas industry in the NWT. Land use practices can also affect the microclimate in the immediate vicinity of developments. A major portion of NWT is naturally forested. Deforestation affects the hydrometeorology by altering summer evapo-transpiration rates and winter sublimation rates. Oil and gas developments involve deforestation along access roadways, seismic lines, drilling sites and pipeline rights of way. Access roads

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encourage hunting and camping and can lead to increased frequency of forest fires caused by human error. Large mining operations such as the BHP EKATI mine produce wind-blown dust, which may encourage early ablation of snow cover in spring. Alone, any one of these activities may be insignificant, but with continued development in the region their cumulative effects may potentially influence the rate of climate change.

→ **Do development activities outside the NWT and global climate change influence the valued ecosystems of the NWT?**

* This may be considered beyond the mandate of the MVRMA. However, if a changing climate can adversely affect natural ecosystems and human developments, and the cumulative impacts of development within and outside the NWT can accelerate climate change, then the long-range impacts on climate change of continued development must be monitored closely.

RECENT AND CURRENT MONITORING

Ongoing monitoring programs with respect to climate in the NWT are found below.

- ✓ Daily monitoring of climatic variables (Environment Canada since 1948)
 - Basic surface climatic variables such as air temperature, humidity, and precipitation, are monitored on a daily basis at numerous weather stations throughout the NWT. Most communities have weather stations at the local airports. Climatic data is also

measured at all Ecological Monitoring and Assessment Network (EMAN) sites in the NWT. A limited number of stations have longer-term records. See Appendix A for more information on EMAN.

- ✓ Global climate change models (Environment Canada - Canadian Centre for Climate Modelling and Analysis)
 - Several climate simulation models have been developed for climate prediction, for the study of climate change and variability, and to better understand the various processes that govern our climate system. A brief description of these models and their corresponding references can be found at: <http://www.cccma.bc.ec.gc.ca/models/models.shtml>.
- ✓ Upper air monitoring program (Environment Canada since 1948)
 - Instrumented weather balloons are released twice daily from upper air stations at Fort Smith, Norman Wells and Inuvik to gather quantitative information about the vertical structure of the atmosphere over the NWT. The data include atmospheric pressure, temperature, moisture and winds from ground level to about 15 km.
- ✓ Mackenzie GEWEX Study (MAGS) (World Climate Research Programme since 1992)
 - The Global Energy and Water Cycle Experiment (GEWEX) seeks to understand and model the high latitude water and energy cycles that play roles in the climate system, and improve the ability to assess the changes to Canada's water resources that arise from climate variability and anthropogenic climate change. Canada is carrying out an investigation of the water and energy cycles of a northern river, the Mackenzie, under a program called the Mackenzie GEWEX Study

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(MAGS). A series of large-scale hydrological and related atmospheric and land-atmosphere studies is being conducted over the Mackenzie basin under MAGS to help understand the role which high latitude hydrological and meteorological processes play in the global climate system. MAGS is one of several experiments in different regions of the world under GEWEX. See <http://www.usask.ca/geography/MAGS/> for further details. The climate data-gathering phase of MAGS ended in 1999, however, several of the remote meteorological stations have been integrated into the surface weather monitoring network.

- ✓ Studies of environmental effects of disturbances in the subarctic (SEEDS) (University of Alberta since 1985)
 - The program was established to investigate impacts of various disturbances associated with simulated transport corridors within upland subarctic ecosystems. The research site is 10 km north of Tulita, Northwest Territories. Automated dataloggers have been deployed over the experimental area to monitor microclimatic, soil and permafrost conditions. Data have been collected since 1985, but temporal gaps exist. In 1995 a forest fire burned much of the site. Efforts to monitor post-fire ecosystem recovery continued until 2000. The microclimate installations have been removed, but plans to continue small mammal and vegetation monitoring are being pursued.
- ✓ Ecological and geomorphological studies in the Mackenzie Mountains (University of Alberta since 1974)
 - The program was established to investigate regional post-disturbance recovery associated with Canol corridor development, and to monitor climate change impacts on permafrost landforms such as palsas and

peat plateaus in the Macmillan Pass area of the Mackenzie Mountains. The permafrost landform research area is located within the Northwest Territories to approximately 40 km west of the Yukon border. Automated dataloggers were established in 1990 to monitor surface climatic variables at 6 sites. Ecological studies initiated in 1974 have focused on the post-disturbance recovery of tundra ecosystems affected by the Canol Project. Data collection was most intense during 1974, 1977-79, 1993-98, and new studies are planned for the next 3 years. A continuous record of active layer depth and near-surface permafrost observations exists since 1990.

- ✓ Northern Climate Exchange (Northern Research Institute, Yukon College since 1999)
 - The Northern Climate Exchange (NCE) is not a monitoring program, however it is very relevant to climate monitoring in the NWT. The NCE is a Yukon-based centre proposed as an exchange point for climate change study in the circumpolar north. It aims to conduct research and education on the impacts of, and adaptations to, climate change in the north; and to facilitate exchange of scientific, traditional and local knowledge, technology, and expertise. The NCE is working on a gap analysis of the northern climate change knowledge base. An on-line database of northern climate change information sources has been developed. To date 106 documents related to the Northwest Territories are summarized on-line (see <http://www.taiga.net/nce>).
- ✓ Lightning monitoring programs (Government of the Northwest Territories since 1987; Environment Canada since 1998)

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- The Government of the Northwest Territories established a real-time lightning detection network in 1987 to detect lightning strikes for forest fire management. A network of 14 stations operates continuously between May and September. The network senses the electromagnetic fields radiated from cloud-to-ground lightning flashes. There are varying degrees of uncertainty associated with the location accuracy of the lightning data and the detection efficiency of the network.

The Canadian Lightning Detection Network (CLDN) has continuously monitored lightning occurrence across Canada since February 1998. The network of 82 sensors was designed by Environment Canada to provide a cloud-to-ground flash detection efficiency of 85-90%, with a median spatial accuracy of about 500m. Since February 1999, the network has been able to discern between cloud-to-ground and cloud-to-cloud flashes. There are 3 CLDN sites located in the Mackenzie Valley (Fort Smith, Yellowknife and Fort Simpson).

- ✓ Northwest Territories evaporation network (Indian and Northern Affairs Canada since 1993)
 - The program was established to determine evaporation rates from mine tailings ponds for minesite water management. Surface weather parameters including temperature, precipitation, humidity, wind, and radiation (net solar) are recorded on an hourly and a daily basis. Six sites are currently operating at Salmita, Pocket Lake, Discovery, Silver Bear, Lupin and Colomac mine sites in the Northwest Territories and Nunavut.

- ✓ Dendrochronology sampling and analysis (initiated in 1999)
 - This project correlates standardized tree ring widths with streamflow and precipitation records. Hydrological records have been extended to the late 1600s with these proxy data methods. Sampling has been done in the Yellowknife area, along the Mackenzie Highway, and in the Great Bear Lake watershed and the South Nahanni watershed.
- ✓ Daring Lake research station (GNWT RWED since 1994)
 - The station was established as a base camp from which to conduct wildlife studies. The site is also used as an educational summer camp for high-school students. In 1996 DIAND WRD initiated hydro-meteorological studies in the vicinity of the camp, which includes a weather station and snow. Wilfrid Laurier University also initiated small-basin hydrological studies in 1999 that are continuing. The Climate Research Branch of Environment Canada has implemented a remote snowpack monitoring project that is making use of the Daring Lake research station.
- ✓ Tibbitt Lake Post Fire Microclimate Study (GNWT RWED and DIAND WRD since 1998)
 - The program was established to study the effects of fire on the microclimate and the vegetation succession of burned areas, with two weather stations and snow surveys in different vegetation types. The Tibbitt Lake burn is also used as an educational facility for Yellowknife high-school students in a spring science camp that has run since 1999.

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- ✓ Mackenzie Delta Permafrost Studies (Carlton University, University of British Columbia and DIAND WRD since 1998)
- Ongoing studies across tree line in the delta region, to identify trends in permafrost melting since the 1950s, from slumping activity (remote sensing) and ground temperature data.

GAPS AND RECOMMENDATIONS FOR MONITORING

A list of monitoring gaps and recommendations for future monitoring under the NWT Cumulative Impact Monitoring Program is found below.

Gaps

- Long-term climate data is lacking in the entire NWT region. Current climate-station coverage is also sparse.
- Particular areas of current data gaps are:
- Mackenzie Mountains
 - Mackenzie River east bank
 - north of Great Bear Lake
 - Coppermine River basin
 - North Slave and South Slave

Recommendations

→ Enhance baseline monitoring of Climate VEC indicators in areas of proposed or anticipated developments and in conjunction with monitoring of the related Water Quantity VEC and Snow, Ground Ice and Permafrost VEC indicators (i.e. temperature, precipitation, relative humidity, etc. at Water Survey of Canada stations)

- Conduct trend analyses of existing data sets, particularly trends in temperature, precipitation, evaporation and regional snow-cover season duration
- Use proxy data, derived from dendro-chronological studies, to reconstruct past climate and streamflow history of the NWT

REFERENCES

Relevant monitoring reports, past monitoring programs, research documents, and scientific publications are found below. This list is a sample of what is available.

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Harding, R.J. and J.W. Pomeroy (1996). **The energy balance of the winter boreal landscape**. *Journal of Climate*, 9. 2778-2787.

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