Overview of Past and Future Climate Trends in Labrador

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ABSTRACT

Conventional scientific opinion holds that since the onset of the Industrial Revolution, and particularly since World War II, increased concentrations of so-called greenhouse gases, such as carbon dioxide and methane, have resulted in global changes to the composition of the earth's atmosphere and, consequently, to the earth's climate systems. In response to an increased international concern in climate change, the World Meteorological Organization and the United Nations Environmental Programme established, in 1988, the Intergovernmental Panel on Climate Change (IPCC), which today is comprised of several hundred international scientists dedicated to studying changes in global climatology. The Third Assessment Report - Climate Change 2001 by the IPCC concluded that "There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities".
Extensive work has been completed on a global scale on changes in a variety of meteorological parameters. Changes in temperature extremes and distribution, precipitation patterns, drought intensities and storm frequencies are just some of the atmospheric signatures by which climate change is measured. However, average variations on a global scale are not necessarily reflected at the local level. Climatological change in Labrador, as with any local climate regime, has its own, unique, characteristics.

INTRODUCTION

The earth's atmosphere retains an inherent capacity to trap the sun's heat. It is known as the greenhouse effect and it supports a temperature regime conducive to the maintenance of life on the earth's surface. Those gases that are primarily responsible for the greenhouse effect, notably water vapour carbon dioxide and methane, are known as greenhouse gases.

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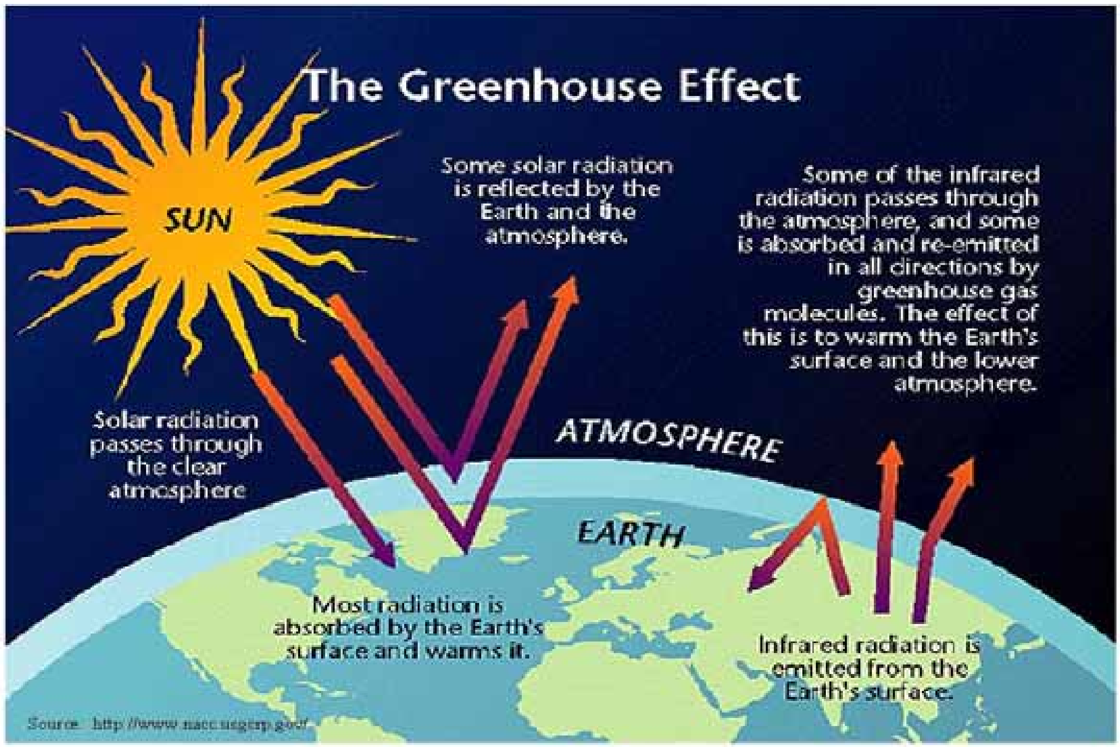
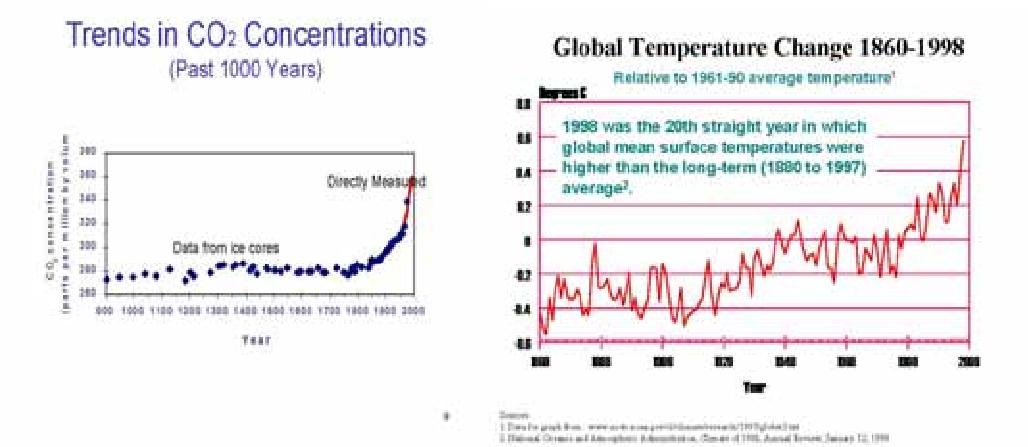


Fig. 1. The Greenhouse Effect. (United States Global Change Research Program)

With the advent of the Industrial Revolution, the relative composition of greenhouse gases has changed. In particular, concentrations of carbon dioxide and methane have increased beyond levels seen in recent geological time. Concern about the impact of higher levels of these greenhouse gases on the greenhouse effect and consequent changes to global temperatures, has expanded more recently to concern about changes in the entire climate system.



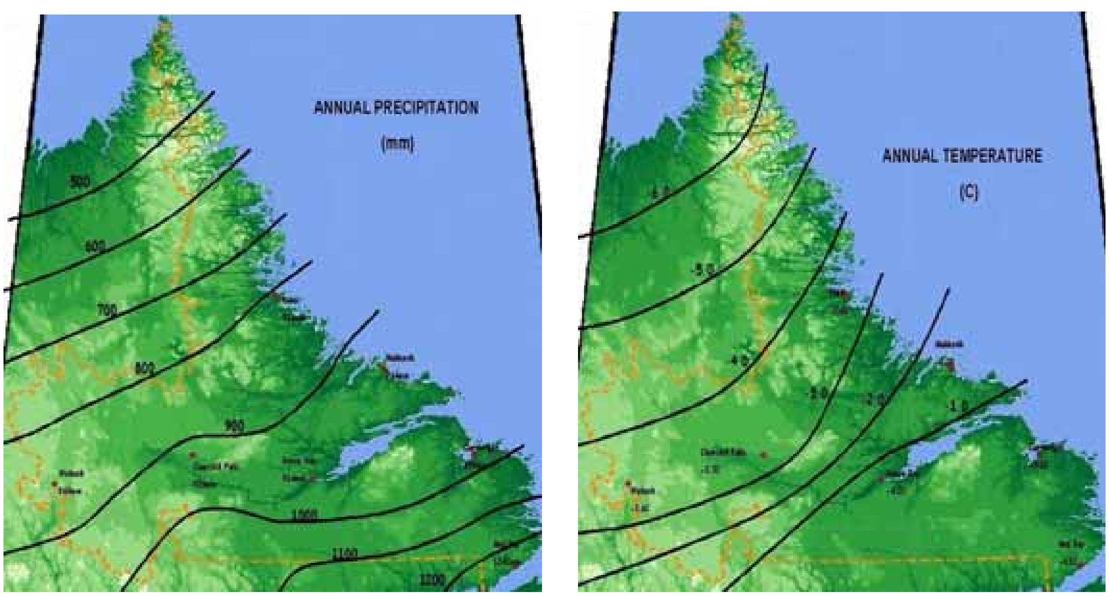
Figs 2 & 3. Historical Changes in CO2 Concentrations and Global Temperatures.

In 1988, the World Meteorological Organization and the United Nations Environmental Programme established the Intergovernmental Panel on Climate Change. This body of scientists was tasked with assessing the scientific, technical and socio-economic information relevant to understanding the risk of human-induced climate change. To date, three extensive Assessment Reports have been published. The Second Assessment Report (1995) concluded that: “The balance of evidence suggests a discernible human influence on global climate”. More recently, the Third Asessment Report (2001) states, perhaps more emphatically, that “There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities”.

THE CLIMATE OF LABRADOR

Labrador’s climate is governed by a variety of meteorological and oceanographic forces. Three major storm tracks pass just south of Labrador, bringing rain and snow especially to southern sections. Thunderstorm activity is not infrequent in summer over western Labrador, sometimes tracking eastward to coastal locations. Cold arctic air frequently invades from the northwest, especially after freeze-up of Arctic waters, and high winter wind chill values are not uncommon. Pack ice moves southward with the Labrador Current in winter and spring while fog and drizzle frequent coastal areas in spring and summer. Freezing rain and freezing drizzle occur especially over southern coastal areas in springtime. Blizzard-like conditions in heavy snow and strong winds during the passage of intense winter storms can be especially crippling along central coastal regions.

Inland sections of Labrador experience continental conditions, with temperatures ranging from above 30 C in summer and –30 C in spring. Average daily maximum temperatures at Happy Valley – Goose Bay in July, for example, are about 21C, which compares closely with much of Atlantic Canada (Mean daily maximum for Halifax, NS is 22C). Meanwhile, in mid winter, Labrador is the coldest region of Atlantic Canada. Winter daily minima temperatures at Happy Valley – Goose Bay, are, on average, about –22C, much lower than sites around the rest of the region.



Figs 4 & 5. Precipitation and Temperature Distribution / Annual (Environment Canada)

Temperatures in coastal regions of Labrador tend to be more temperate, with oceanic influences acting to keep temperatures somewhat cooler in summer and somewhat warmer in winter. This effect is typical throughout Atlantic Canada.

Precipitation amounts are highest over southern Labrador as a consequence of the frequent passage of low pressure centres over the Maritimes and Newfoundland. Snowfall and rainfall totals are highest over southeastern sections with rainfall not uncommon even in the middle of winter.

The Labrador Current runs southward along the coast of Labrador, bringing cold Arctic water in close proximity to the shoreline. Pack ice invades the coast in winter and remains a factor throughout the spring.

Strong southwesterly winds in summer frequently bring warm moist unstable air to Labrador. Some of the highest temperatures for the province of Newfoundland and Labrador have been recorded in Labrador. Thunderstorms, some of which may develop into severe storms, sometimes develop over western areas in these conditions and occasionally track eastwards towards coastal areas. Hail, heavy rain, intense lightning, and even tornadoes are possible with some of these storms.

The climatology of Labrador, then, is forced from a variety of factors, and consequently, is not easily categorized. The identification of changes, and isolation of the causes of those changes, is even more problematic.

RESULTS

This study of the climatology of Labrador has focussed on meteorological and climatological data from four major stations: Goose Bay, Hopedale, Wabush and Cartwright. Although numerous other stations have provided weather information throughout the past century, it was felt that a quality subset would provide best results for this study. Longevity, reliability, continuity and quality representation throughout the region were all taken into consideration in choosing the above stations to provide an overall view of Labrador's climatological makeup and to measure potential climatic changes during the past several decades.

As with any climatological study, temperature and precipitation trends were primarily investigated. This included not only a measurement of average annual values, but incorporated as well more detailed analyses, such as a study of extreme values (e.g. number of days with heavy rain) and precipitation-type seasonal variations (e,g, rainfall totals in springtime). Other parameters, such as snow-on-ground, frost, wind direction frequency, days with rain/snow/thunderstorms, were also studied. Many of these parameters were investigated on both annual and seasonal bases for all four sites. The number of resultant charts (about 200) is clearly more than can be accommodated in this paper. Instead, a presentation and discussion of key points has been attempted.

Temperature

A study of temperature changes in Labrador has indicated little variation over the period of record. Figure 6 highlights data from 1961 to 1983, the overlap period for all four sites. Individual charts over longer time periods show similar results. Slight cooling may be suggested along the coast, with weak warming further inland.

National studies of temperature changes are consistent with these numbers. Temperature trends on an international scale during the latter half of the past century (Figure 7) indicate little overall change in Labrador.

These results are not surprising. Most of the observed temperature changes on a global scale have occurred in inland areas and in extreme northern latitudes. Computer models of climate change in the 21st century suggest that this trend will continue.

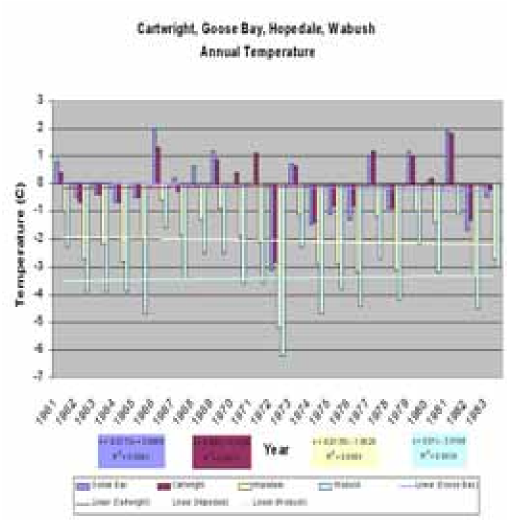


Fig. 6. Annual Temperature Trends (Environment Canada).

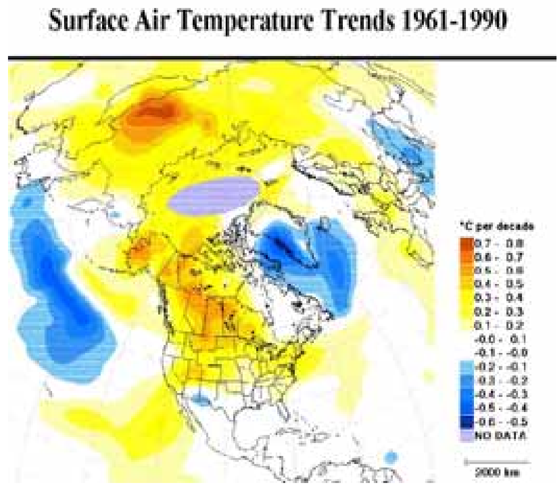
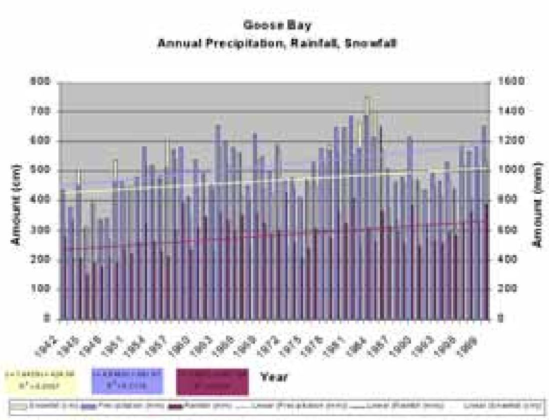
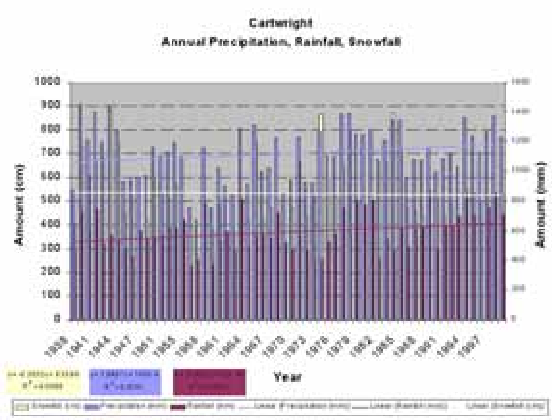


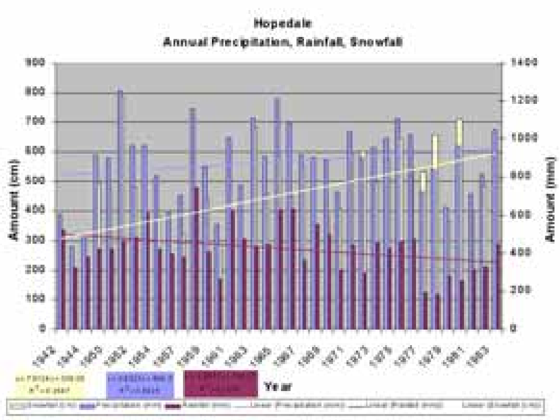
Fig. 7. Global Temperature Trends (Environment Canada).

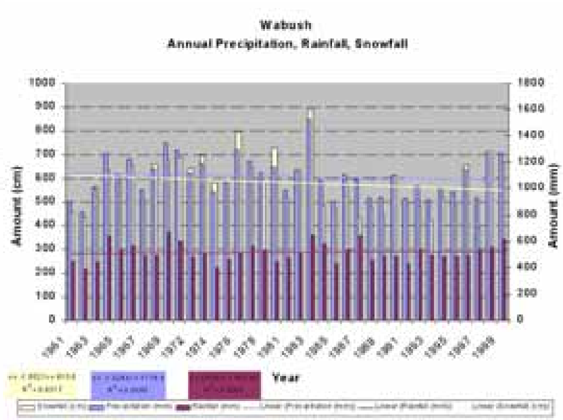
Precipitation

On average, precipitation amounts have increased throughout coastal Labrador during the past half-century. At Goose Bay, average annual rainfall, snowfall, (and, consequently, total precipitation) have all increased over the period of record from 1942 to present day. At Cartwright and Hopedale, total precipitation numbers have also increased. At Hopedale, the precipitation increase was entirely a consequence of higher snowfall numbers, while Cartwright saw an average increase in rainfall. Precipitation amounts inland at Wabush remained relatively steady, with increased rainfall counterbalanced by a reduced snowfall.









Figs. 8-12. Annual Precipitation, Rainfall and Snowfall Trends at Goose Bay, Cartwright, Hopedale and Wabush.

Closer examination of precipitation does not indicate preferential trends in a given season. At Goose Bay, for example, increases in rain and snow occur throughout all seasons (where statistically significant). The same applies in regions where a single precipitation type is responsible for the trend. At Cartwright, for example, increased rainfall occurs in all seasons.

Meanwhile, the number of days with rain/snow, and the number of days with heavy snow/heavy rain all follow the trends reflected by the total precipitation counts. Where increased snowfall is recorded, the number of days with snow, and the number of days with heavy snow, also increases. Even the number of days with thunderstorms also shows an increasing trend throughout the region.

Precipitation in Labrador occurs primarily as a consequence of two processes – synoptic storms and convection (i.e. thunderstorms). Since precipitation and "days with" indicators all show increases, on average, throughout Labrador, we would expect that indicators reflective of the causes of increased precipitation would show a similar increase. In fact, this is not the case. For example, although the number of days with thunder increases throughout Labrador, summertime temperatures have remained relatively constant (Figure 13). Meanwhile, an increase in synoptic storms should be reflected in a redistribution of wind direction frequency.

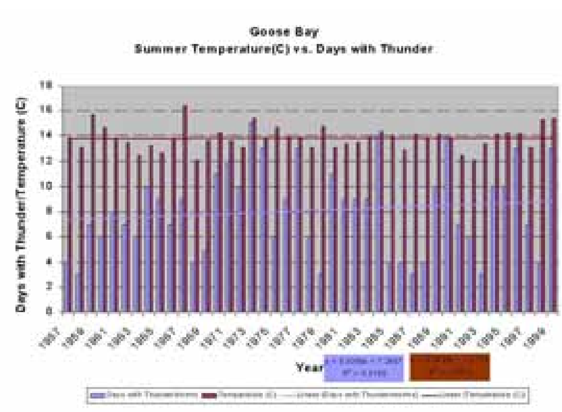


Fig. 13. Thunder / Temperature Distribution at Goose Bay (Environment Canada).

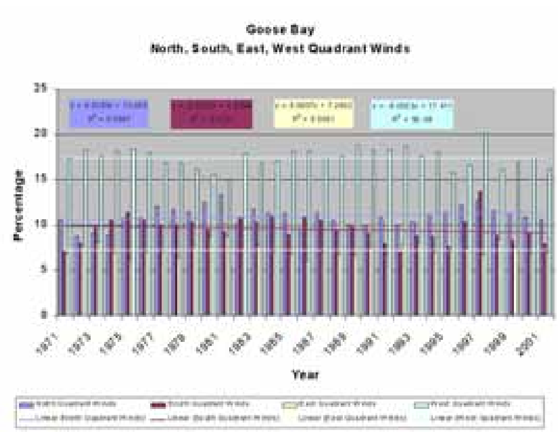


Fig. 14. Wind Direction Frequency Distribution at Goose Bay (Environment Canada).

Storms passing more frequently just south of Goose Bay, for example, (the preferred path for increased precipitation) should be reflected in increased northeasterlies. In fact, Figure 14 illustrates that no change has occurred in directional frequencies over the past half century.

It is difficult within the scope of this work, then, to assign an explanation for the increased precipitation numbers over Labrador. A more detailed analysis of storm tracks, storm and thunderstorm intensity and temperature patterns are required to assign specific answers. It is noteworthy, however, that these trends are consistent with observations generally throughout North America and are consistent with expected trends under modelled climate change scenarios.

Frost and Snow-on-Ground

Inland conditions as depicted by Wabush records indicate reduced frost and less snow-on-ground during springtime. This is likely a direct consequence of warmer springtime temperatures, increased rainfall, and reduced snowfall (see Figure 15).

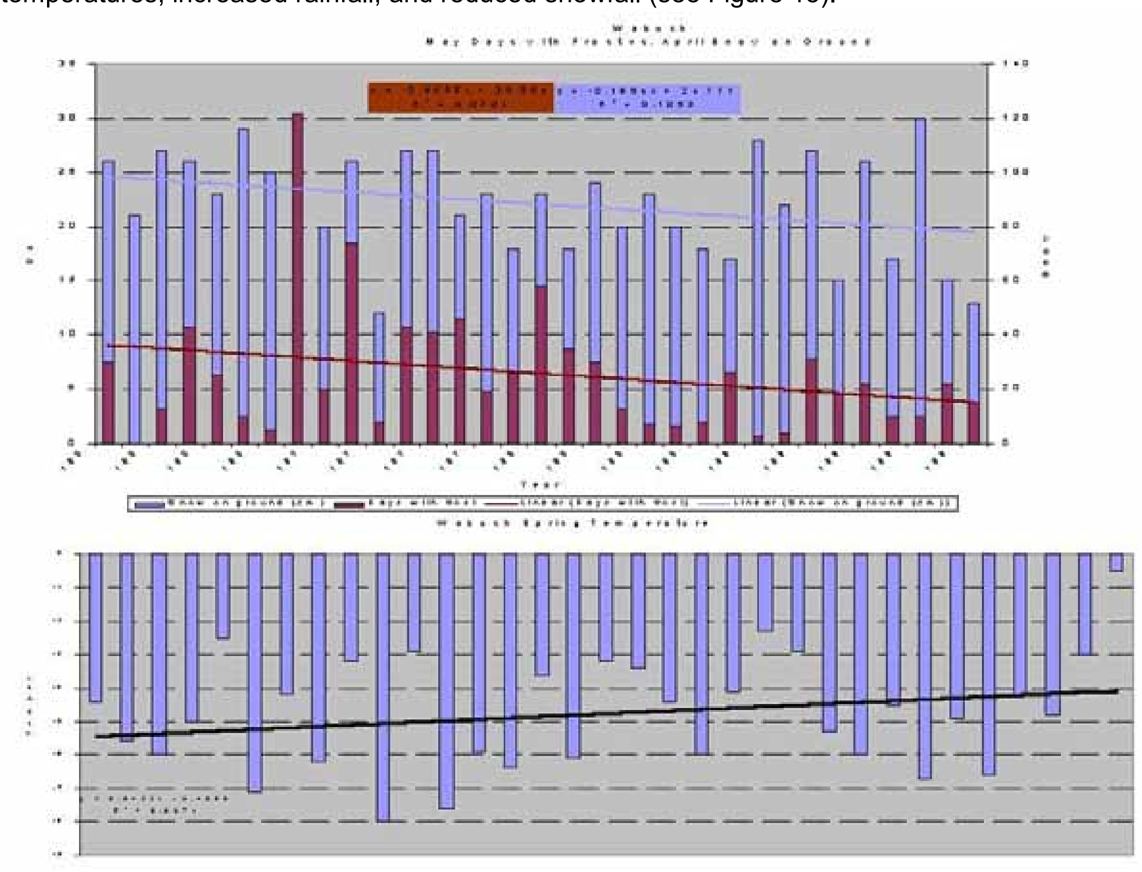


Fig 15. Wabush: Spring Frost/Snow on Ground/Temperatures (Environment Canada)

Trends along coastal Labrador are less clear. At Hopedale, little change in frost or snow-on-ground is evident in springtime despite much colder springtime temperatures. Goose Bay records indicate little change in frost conditions, while snow-on-ground numbers are, on average, falling. Snow-on-ground at Cartwright has been declining, (likely as a consequence of increased spring rain and warmer spring temperatures), though, in contrast, frost has slowly increased.

CONCLUSIONS

Temperature and precipitation trends at Labrador over the past half-century are generally consistent with those observed, on average, throughout North America and those anticipated, on average, under a global warming scenario. Temperatures have increased marginally inland, while minimal cooling has occurred along the coast. Precipitation increases have been observed, on average, throughout the region, with regional and precipitation-typing details.

Trends in secondary fields, such as frost and snow-on-ground, are generally consistent with expected results from trends noted in temperature and precipitation.

Attributing these changes to “global warming” or “anthropogenic forcing” does not address the specific meteorological changes resulting in these trends. A preliminary analysis of wind directional frequencies and “days-with” analyses does not provide even a preliminary indication of cause and further work is required to provide a better understanding of the reasons driving these trends.

ACKNOWLEDGEMENTS

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