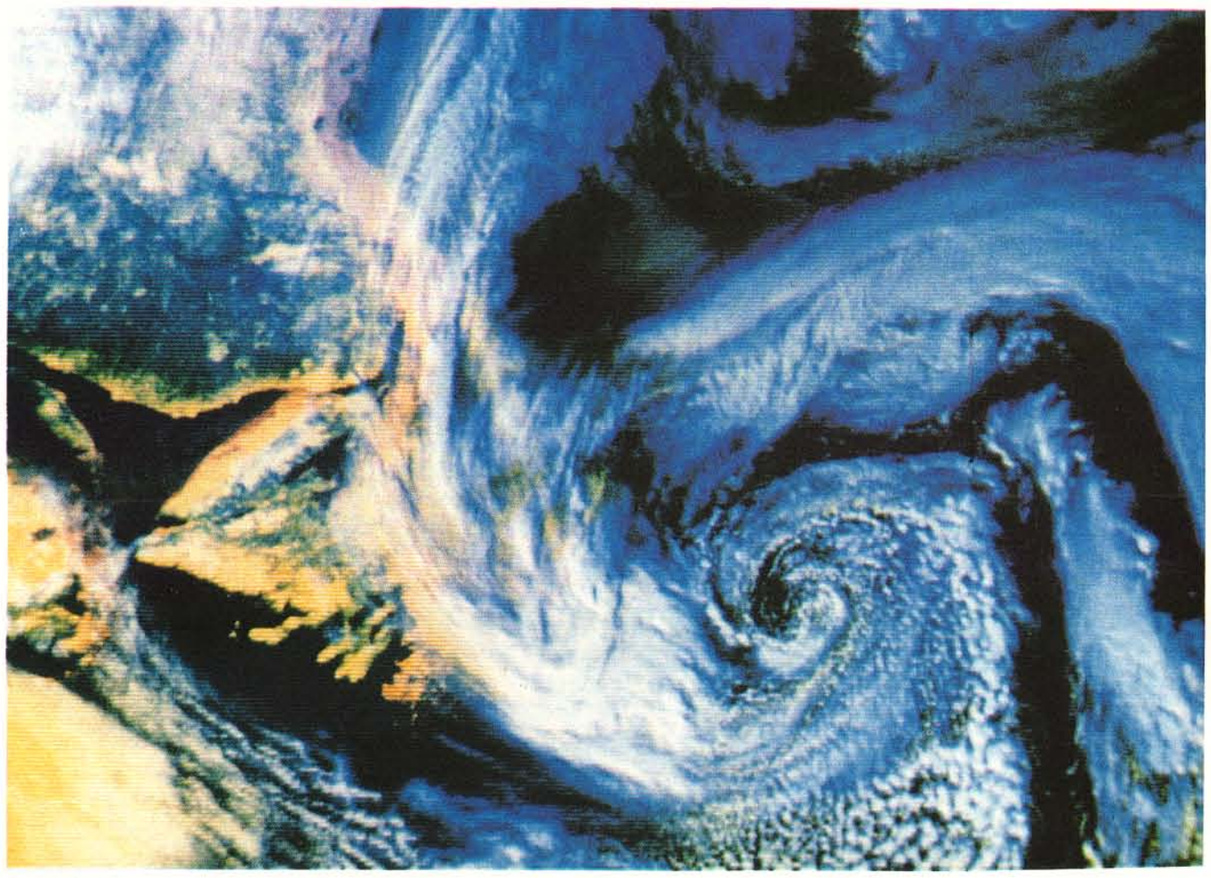
CLIMATE

Introduction

Climate can be defined as the sum total of the meteorological elements that characterize the average and extreme atmospheric conditions over a long period of time at any one place or region of the earth's surface; it can be loosely defined as the "average weather". It is the primary determinant of the amount, distribution, and movement of water over time and space. The regional climates of the province are determined by the atmospheric circulation patterns in the Northern Hemisphere and the proximity of a cold ocean environment. The northern region of Labrador has an Arctic climate, while its interior has a continental climate with cold dry winters and warm summers. The Island, close to the confluence of the warm Gulf Stream waters and cold ex-Arctic waters of the Labrador Current, has mild winters and cool summers. At a local level the climate can be substantially modified by topographic features.

Several parameters such as temperature, precipitation (rain or snow), evaporation, wind speed and direction, etc., are used to characterize the climate of a region. Some or all of these parameters are measured at climatic stations across the province. The next six maps illustrate the location of the climatic stations and the regional and seasonal variations in temperature, rainfall, snowfall, and evapotranspiration in Newfoundland and Labrador.



Satellite Image of Clouds Associated with a Low Pressure System off the East Coast of Newfoundland.
(Image courtesy of Atmospheric Environment Service, Environment Canada)

5 – Weather and Climate Networks

WEATHER NETWORKS:

Synoptic Stations:

Detailed weather observation programs are carried out at the synoptic stations in the province. Parameters measured include: cloud cover, visibility, pressure, temperature, dew point, relative humidity, precipitation, sunshine, and wind velocity. Solar radiation, evaporation and soil temperature are measured at select locations. In addition, the occurrences of thunder, hail, and freezing rain are recorded, as well as a description of sky conditions. Observations are usually made hourly. At a few sites, observations are made every six hours. Synoptic stations are operated by the Atmospheric Environment Service of Environment Canada, other federal government departments (e.g. Ministry of Transport, Department of National Defence), or by private firms under contract.

There are 27 stations in the synoptic network, nine of which are automatic. Most of the stations in the network are located in coastal areas. The range of elements recorded at the automatic stations is not as complete as that of the manned stations. The advantage of automatic stations, however, is that they can be set up in remote areas of the province. The synoptic network provides data for the preparation of weather forecasts on a real time basis. Historical weather records at St. John's date back to 1871. The weather station at St. John's Airport is shown in Figure 5.1.

Upper Air Stations:

Twice daily, at 0000 and 1200 Universal Time, observations of upper air conditions are made at three locations in Newfoundland: Stephenville, St. John's and Goose Bay. A radiosonde (an airborne device that radios meteorological data to the ground) is sent up into the atmosphere via a weather balloon. Parameters measured are: altitude, temperature, humidity, and wind velocity for a number of pressure levels ranging from surface level to an altitude of about 30 kilometres. These stations are operated by the Atmospheric Environment Service and the Department of National Defence. The data obtained from this network are used for forecasting and research. Records for these stations date back to 1942 at Stephenville, 1947 at Goose Bay, and 1971 at St. John's. Data are also available for Argentia from 1945 to 1970.

CLIMATE NETWORKS:

Atmospheric Environment Service (AES) Network:

The network consists of approximately 86 stations and is operated by cooperative government agencies or by private individuals under contract. Observations are normally taken twice daily. Parameters measured include: maximum and minimum temperatures, rainfall, and depth of snow on the ground. In addition, the occurrences of thunder, hail, and freezing rain are recorded, as well as a brief description of sky conditions. A small number of stations are also equipped to record wind velocity, evaporation, radiation, soil temperatures, rainfall intensity, and sunshine. Records date back to the early 1870's.

Newfoundland Department of Environment and Lands Network:

The federal government's requirement for climate stations in the province was basically met in 1986. Due to a need for stations to support provincial programs, the federal and provincial governments signed an agreement in September 1986 regarding climate stations and programs in the province. A number of stations were established during and after 1986 under the cost sharing agreement. Compared to the stations in the AES network, many of the 35 stations in the provincial network have only short periods of record. The parameters measured and the frequency of observations are, however, the same for federal and provincial climate stations.

DATA PROCESSING AND AVAILABILITY:

All climate and weather data are processed at the Atmospheric Environment Service office in Bedford, Nova Scotia. Subsequently, the data are sent to the Canadian Climate Centre in Downsview, Ontario, where they are checked once again before being placed in the National Climatological Archive. Data from this archive are available in paper, microfilm, and computer based formats. In addition, a number of data periodicals and statistical publications is prepared by the Atmospheric Environment Service. Data are also available for approximately 95 discontinued stations which are not shown on the map. Further information on climate services can be obtained from:

Atmospheric Environment Service
Scientific Services Division
P.O. Box 9490, Station B
St. John's, NF
A1A 2Y4
Telephone (709) 772 4695

Atmospheric Environment Service
Scientific Services Division
Climate Services
5th Floor, Bedford Tower
1496 Bedford Highway
Bedford, NS
B4A 1E5
Telephone (902) 426 9226

Figure 5.1 Weather Station at St. John's Airport
(a) Anemometer (Wind speed and direction)
(b) Snow Depth Sensor
(c) Stevenson Screen (Thermometers)
(d) Tipping Bucket Rainguage

WEATHER AND CLIMATE NETWORKS

Newfoundland and Labrador

Nain A.
Hopedale
Makkovik A.
Cartwright
Wabush Lake A.
Churchill Falls A.
Goose Bay A.
Mary's Harbour
0 100 Km
St. Anthony A.
St. Anthony
Ferolle Point
Englee
Daniel's Harbour
La Scie
Twillingate
Comfort Cove
Deer Lake A.
Badger
Gander Int'l A.
Bonavista
Stephenville A.
Port Aux Basques
Burgeo
Sagona Island
Argentia
St. John's A.
St. Lawrence
Cape Race
0 50 100 Km

Weather Networks

- Synoptic Station
- Upper Air Station

Climate Networks

- Atmospheric Environment Service Network
- Newfoundland Department of Environment and Lands

Sources: Environment Canada Atmospheric Environment Service.
Newfoundland Department of Environment and Lands.

6 – Temperature

Air temperature may be considered to be the most important of all climatological parameters. It determines the types of vegetation possible and, therefore, the forms of wildlife which can exist. Its effects on humans range from determining physical comfort and psychological mood to influencing socio-economic activities such as fishing, construction, transportation, and recreation. It determines the various forms of precipitation, and the rates of snowmelt and evapotranspiration.

Air temperature is measured by self-registering maximum and minimum temperature thermometers. The thermometers are set in a white, wooden, louvered box, which is about 1.5 metres above ground level. The box is designed not to be directly affected by sunlight. Typically, morning and evening observations are made. The maximum daily temperature is the highest temperature recorded by the maximum temperature thermometer during a 24-hour period following the morning observation. The minimum daily temperature is the lowest temperature recorded by the minimum temperature thermometer during a 24-hour period following the evening observation. The mean daily temperature is defined as the average of the maximum and minimum daily temperatures. Figure 6.1 shows a maximum temperature thermometer (top) and a minimum temperature thermometer (bottom). The front door of the louvered box is normally closed.

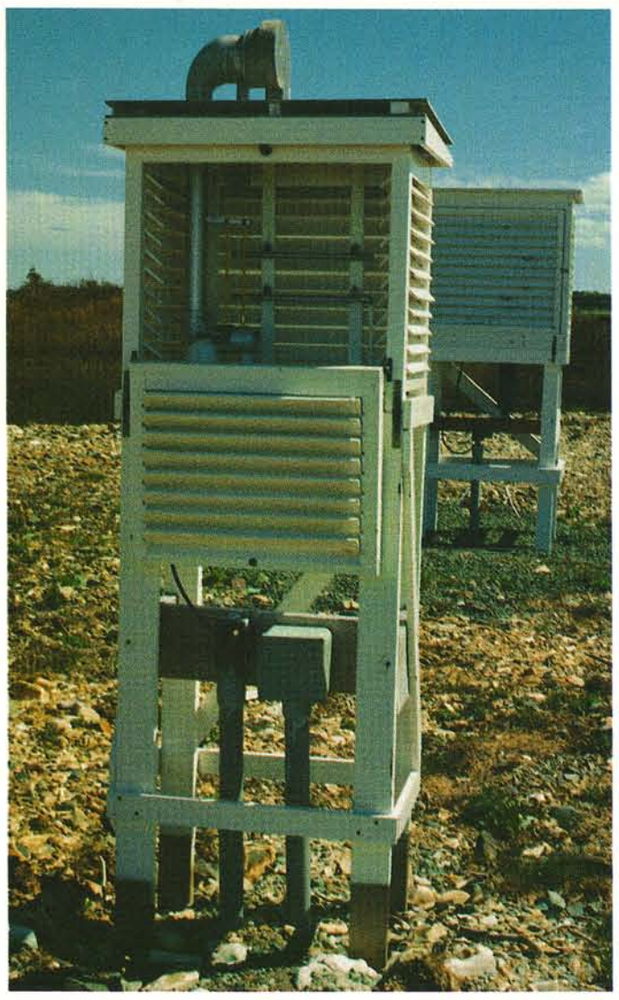


Figure 6.1 Maximum and Minimum Temperature Thermometers

The map on the opposite page shows the variations in mean monthly, seasonal, and annual air temperatures in the province. It is based on temperatures recorded at 62 climatological stations.

Air temperature in the province is primarily influenced by latitude, distance from the ocean, and prevailing winds. Many climatological stations are located in coastal areas and may not give accurate representations of temperature regimes further inland.

On the Island the mean annual air temperature varies from 5°C on the Avalon and Burin Peninsulas to 1°C on the Northern Peninsula. In Labrador the mean temperature varies from 1°C in the southeast to -2°C in the north and -3°C in the west. The warmest month is usually July or August and the coldest is usually January or February.

During summer the south coast of the Island is slightly cooler than central Newfoundland due to the predominant on-shore winds. The Northern Peninsula is significantly cooler than the interior of Newfoundland because of its higher latitude. In Labrador summer mean temperatures are highest in the central region and lowest in the northern coastal zone.

In the fall the south and southwest coasts of Newfoundland are warmer than most of central and northern Newfoundland due to the thermal inertia of the ocean and on-shore winds. In Labrador the fall mean temperatures vary from a few degrees below zero in the west to a few degrees above zero in the east.

Winter temperatures in central and western Labrador are largely influenced by the cold arctic air mass. Near the coast temperatures are higher due to the moderating effect of the Labrador Sea. The arctic air mass also depresses temperatures over the western region of the Island. On the Avalon and Burin Peninsulas temperatures are relatively higher due to frequent warm air masses which originate along the United States eastern seaboard.

In the spring isotherms in Labrador begin to shift from a north-south orientation to an east-west orientation. The coldest areas are in the north and west while the highest mean temperatures are in the southeast. On the Island relatively higher temperatures are recorded in southern areas because of the absence of offshore sea ice.

The highest and lowest temperatures recorded on the Island to date are: +36.7°C near Bishop's Falls, and -45.0°C near Badger. In Labrador the maximum and minimum temperatures were recorded at North West River, +41.7°C and at Esker, -51.2°C. The highest and lowest temperatures recorded in Canada to date are: +45.0°C at Yellow Grass, Saskatchewan and -63.0°C at Snag, Yukon Territory.

Figure 6.2 shows the mean annual temperatures for 14 cities across Canada. The maximum and minimum monthly mean temperatures are also shown. The major influences on air temperature in Canada are latitude and distance from large water bodies.

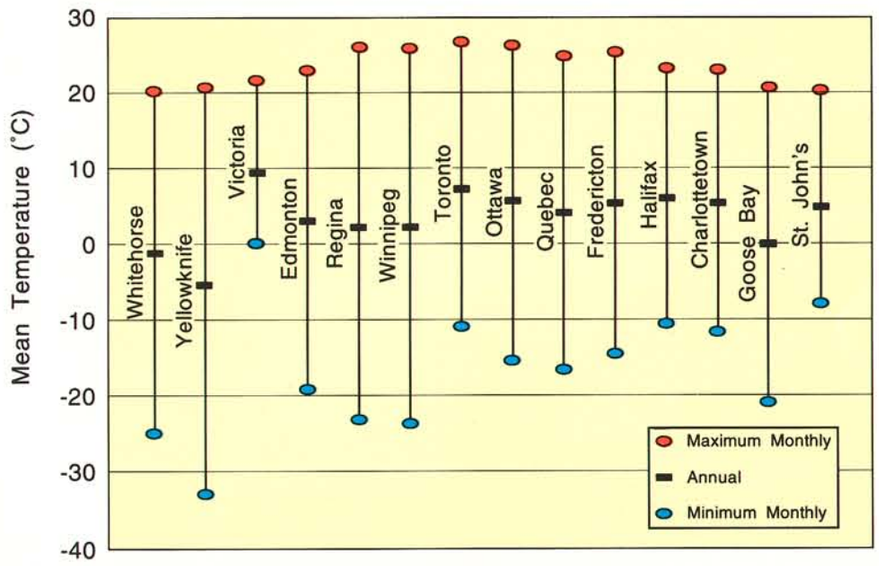


Figure 6.2 Mean Temperatures for Canadian Cities

TEMPERATURE

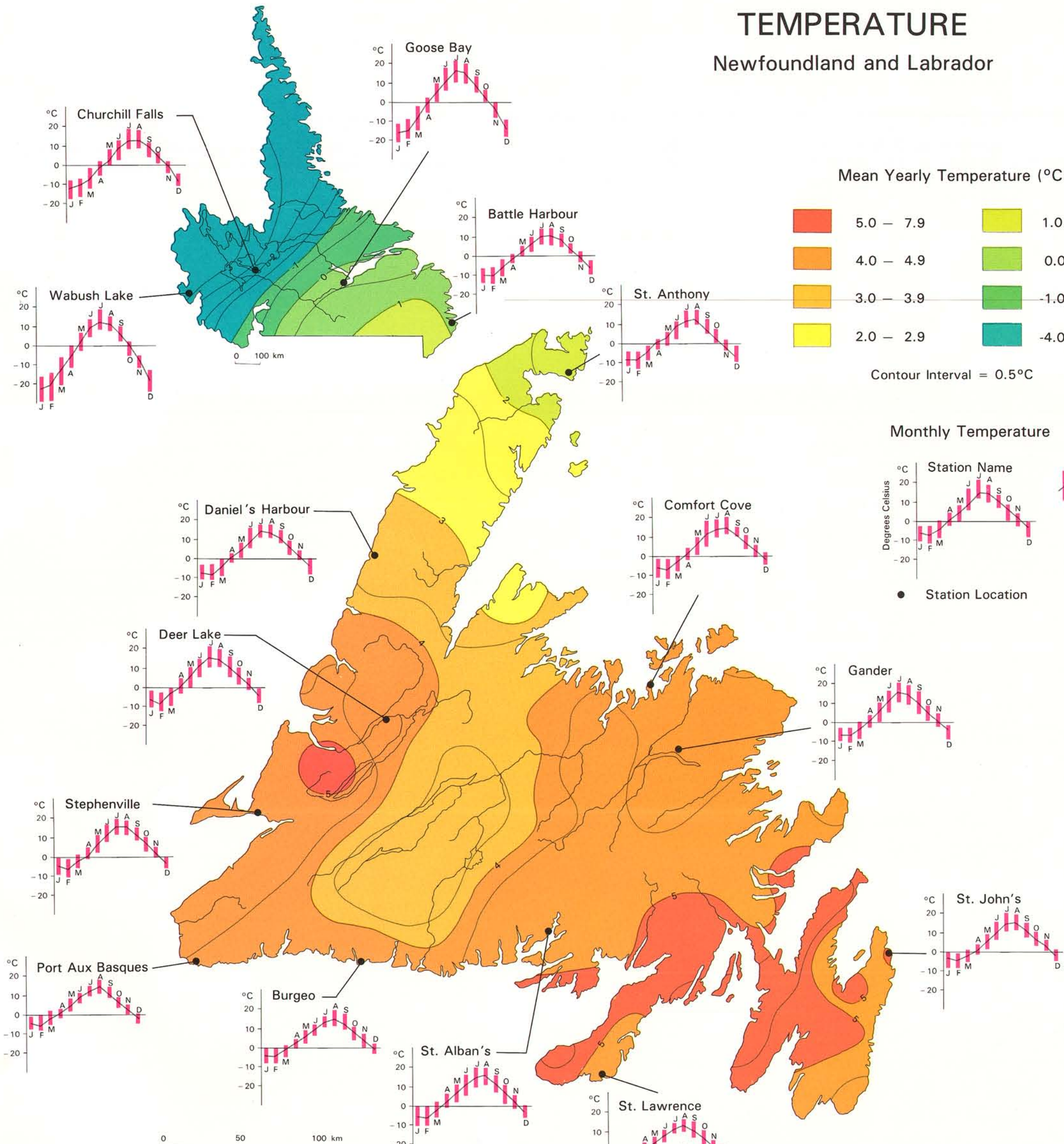
Newfoundland and Labrador

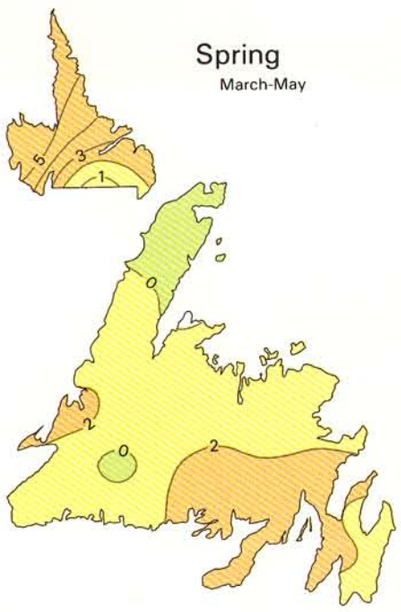
Mean Yearly Temperature (°C)

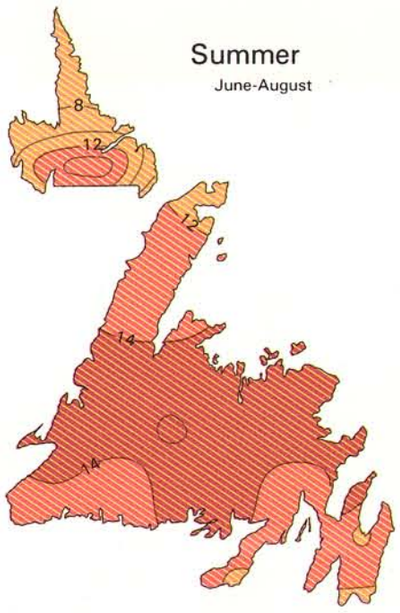
5.0 — 7.9	1.0 — 1.9
4.0 — 4.9	0.0 — 0.9
3.0 — 3.9	-1.0 — -0.1
2.0 — 2.9	-4.0 — -1.1

Contour Interval = 0.5°C

Monthly Temperature

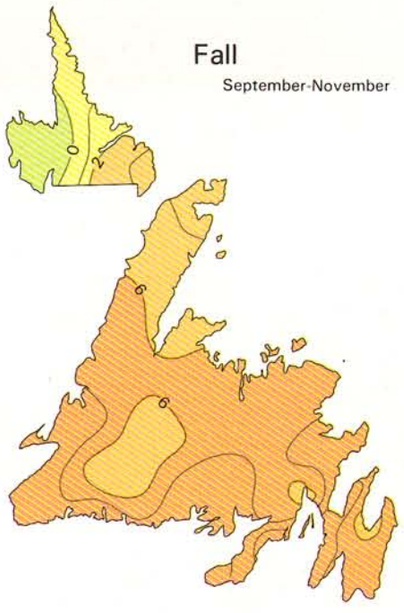


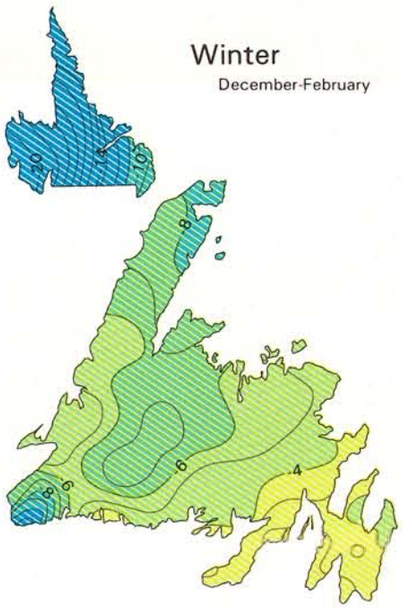




Mean Seasonal Temperature (°C)

14.0 — 19.9	2.0 — 5.9
12.0 — 13.9	0.0 — 1.9
6.0 — 11.9	-4.0 — -0.1
-6.0 — -4.1	-8.0 — -6.1
-12.0 — -8.1	-20.0 — -12.1





Source: Atmospheric Environment Service (AES)
Data up to and including 1986

7 – Mean Annual Precipitation

Precipitation is one of the primary components of the hydrologic cycle. Its usual forms are rain and snow, and variations of these such as drizzle and sleet. Hail, although relatively infrequent and light in Newfoundland, is another form of precipitation. Precipitation is derived from atmospheric water and thus its form and quantity are influenced by other climatic variables such as wind, temperature, and atmospheric pressure.

Evaporation from ocean surfaces is the principal source of atmospheric moisture. Dynamic or adiabatic cooling of the rising moist air causes condensation of water vapour into cloud droplets. Precipitation starts when the cloud droplets have grown to a sufficient size. Vertical transport of moist air masses is a requirement for precipitation.

Precipitation may be classified according to the conditions that generate vertical air motion. The three major categories in this respect are convective, orographic and cyclonic. Convective precipitation is brought about by the heating of air at ground level. This warm and light air absorbs water vapour and begins to rise. At high altitudes cooling takes place causing condensation and precipitation. Convective precipitation may be in the form of light showers or thunderstorms. Orographic precipitation results from mechanical lifting of moist horizontal air currents over natural barriers such as mountain ranges. Cyclonic precipitation is associated with the movement of air masses from high pressure regions to low pressure regions.

Most of the province's precipitation is of the cyclonic type. Low pressure systems typically approach the Island from the St. Lawrence River valley and the eastern seaboard of the United States. An orographic effect is present along the west and south coasts of the Island.

The amount of rain, drizzle, freezing rain, freezing drizzle or hail is measured in standard rain gauges. The rim of the gauge is placed 400 millimetres (mm) above the surface of the ground and has a circular orifice 113 mm in diameter. The rain is funnelled into a clear plastic graduated cylinder, which serves as the measuring device. The depth of the water in the cylinder is read to the nearest 0.2 mm. Figure 7.1 shows a standard rain gauge.

Figure 7.1 A Standard Rain Gauge

Snowfall amount is quantified by measuring depths of freshly fallen snow at a number of representative points with a standard snow ruler and recording the average to the nearest 0.2 centimetre (cm). The water equivalent of the snowfall is obtained by dividing the average snowfall depth by 10; thus, 1 cm of snow is assumed to be equivalent to 1 mm of water.

At most stations precipitation measurements are made twice daily, in the morning and late in the afternoon. At some stations only one observation is taken daily, while at synoptic stations observations are taken four times daily.

The map on the opposite page illustrates the distribution of mean annual precipitation in the province. The accompanying graphs show the distributions of the mean monthly precipitation as well as the amounts occurring as rain and snow at several climate stations.

The data for the map were obtained from records at 76 climate stations located in the province. For each station daily precipitation amounts for each year from 1951 to 1980 were added and these annual precipitation amounts were averaged over the 30-year period to give the mean annual precipitation. The mean monthly precipitation values were similarly calculated for each month of a year. In the cases where stations did not have a complete record of 30 years of data, the precipitation records were extended using statistical techniques.

A computer program was used to generate the isohyets (lines of equal precipitation depth) from the point data at the climate stations. The inadequacy of the climate network, both in terms of density and geographical distribution, on the Island and in Labrador may have introduced some errors in the estimates of precipitation amounts shown on the map.

The mean annual precipitation on the Island ranges from 779 mm in Fogo to 1644 mm in St. Albans. Relatively higher precipitation occurs over the Avalon Peninsula, along the south coast, and over the highlands of the Long Range Mountains. Precipitation is generally greatest during the autumn and early winter months and lowest in the spring or early summer months. Average annual snowfall varies from 92 cm in St. Shotts to 523 cm in Woody Point, with the higher snowfall amounts occurring over the western mountains and along the east coast.

The mean annual precipitation in Labrador varies from 740 mm in the north at Nain to 963 mm in Churchill Falls. Precipitation is fairly evenly distributed throughout the year with slightly higher values occurring during the summer and early autumn. Snowfall is relatively heavy with annual amounts ranging from 396 cm to 481 cm.

Figure 7.2 shows the spatial variation of mean annual precipitation amounts in selected regions of Canada as published in the Hydrological Atlas of Canada.

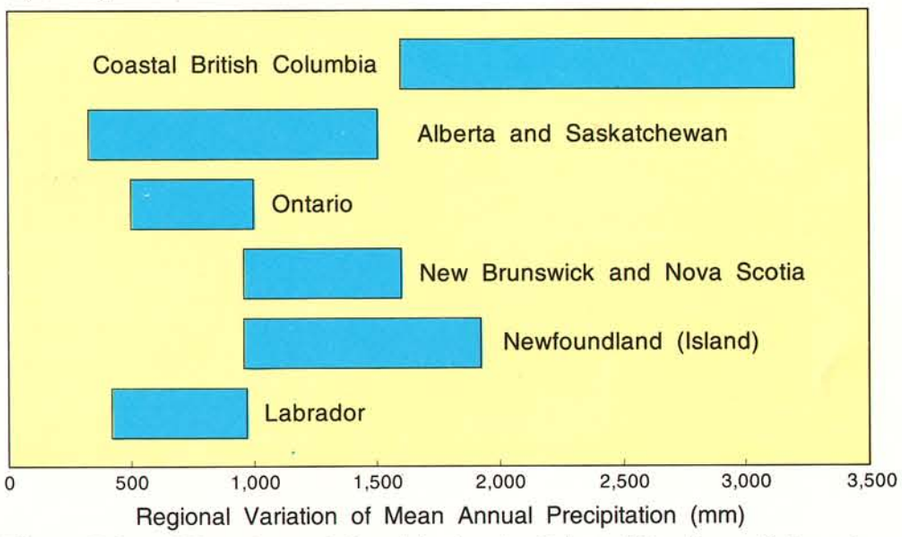
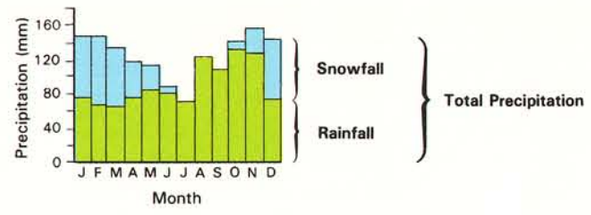


Figure 7.2 Mean Annual Precipitation in Selected Regions of Canada

MEAN ANNUAL PRECIPITATION

Newfoundland and Labrador

Monthly Preciptation by Station

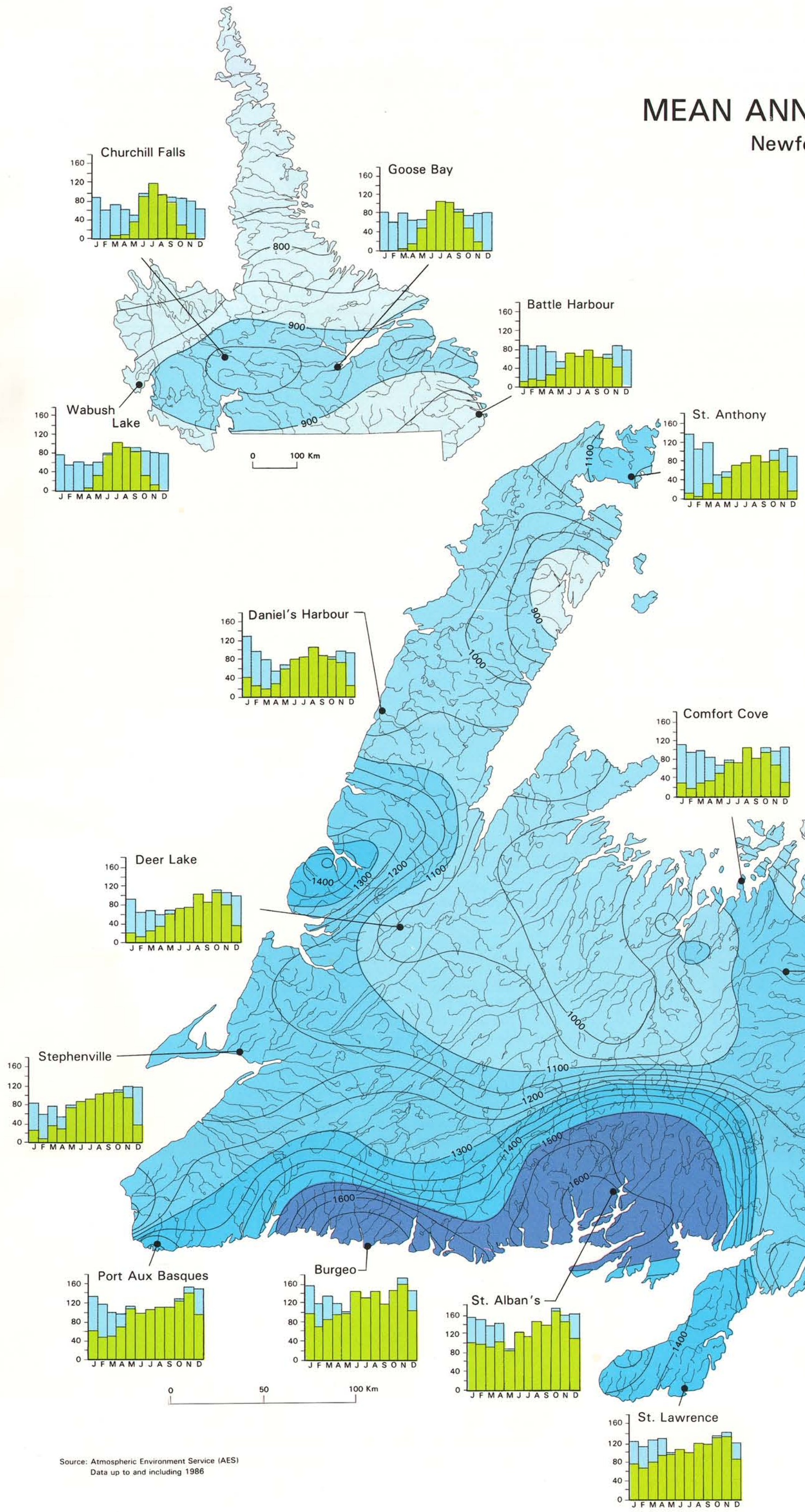


Mean Annual Preciptation

millimetres

- 700 — 900
- 900 — 1100
- 1100 — 1300
- 1300 — 1500
- 1500 — 1700

Contour interval = 50mm



Source: Atmospheric Environment Service (AES)
Data up to and including 1986

8 – Rainfall Intensity for Selected Frequencies and Durations

Mean annual precipitation is a measure of the total amount of precipitation expected during a typical year. For the engineering design of hydraulic structures such as bridges, dams, spillways, canals, etc., however, it is necessary to analyze individual rainfall events. The required carrying capacities of the hydraulic structures are estimated from the extreme amounts of rainfall recorded over minutes or hours.

Most analyses of extreme rainfall events involve the determination of the following parameters: duration of the rainfall event in minutes or hours, volume of rainfall over the duration of the storm expressed as a total volume or an equivalent depth, and the frequency of occurrence of rainfall events with specified duration and volume.

Rainfall is also described in terms of its intensity. Intensity is calculated by dividing the equivalent depth of rainfall by its duration. A given volume or depth of rainfall may occur from many different combinations of intensities and durations. For example, 30 millimetres (mm) of rainfall may result from a 1-hour storm having an intensity of 30 mm per hour or from a 15-hour storm having an intensity of 2 mm per hour. In the design of hydraulic structures the former storm is considered to be a more severe and critical storm. Although the volume or depth of rainfall is the same for both storms, in the first storm this amount of rainfall must be handled by the hydraulic structures in a shorter period of time.

The intensity of rainfall during a storm can be extremely variable in time and space. Rainfall intensity is usually highest at the centre of the storm and decreases away from the storm's centre. The intensity at any given point in the storm also changes with time. Thus, as a storm moves over a climate station, the rainfall intensity recorded will show considerable variation with time.

Rainfall intensity is measured with a recording rain gauge such as a tipping-bucket rain gauge. The tipping-bucket is a small container mounted on the cylindrical gauge; every time it fills up, it tips over and empties. The gauge works by having a clock-driven drum carrying a chart on which a pen records a series of blips made each time the tipping-bucket spills its content. The higher the intensity of rainfall, the shorter is the time between successive tips of the bucket. Figure 8.1 shows a tipping-bucket rain gauge and a recorder. The recorder is usually located in a sheltered place.

Figure 8.1 Tipping-bucket Rain Gauge (left) and Recorder (right)

The strip charts recording the rainfall data are analyzed with a digitizer to obtain the maximum rainfall amounts for selected durations of rainfall events. The durations are generally 5, 10, 15, 30, and 60 minute periods as well as 2, 6, 12, and 24 hour periods. The analysis is repeated for every year of rainfall record. The series of annual data for each duration is then processed using statistical methods to obtain the frequencies of rainfall events.

Very often, the frequency of a rainfall event is expressed as a return period. The return period is the average number of years, over a long time, between rainfall events with the same duration equalling or exceeding a given intensity. The return period is also the reciprocal of the probability of a rainfall intensity being equalled or exceeded in any year. The relationship between rainfall intensity, duration, and frequency (return period) is usually expressed graphically as a set of Intensity-Duration-Frequency (IDF) curves. It is considered necessary to have at least 10 years of data before reliable IDF curves can be generated. One set of such curves for the St. John's Airport area is shown in Figure 8.2.

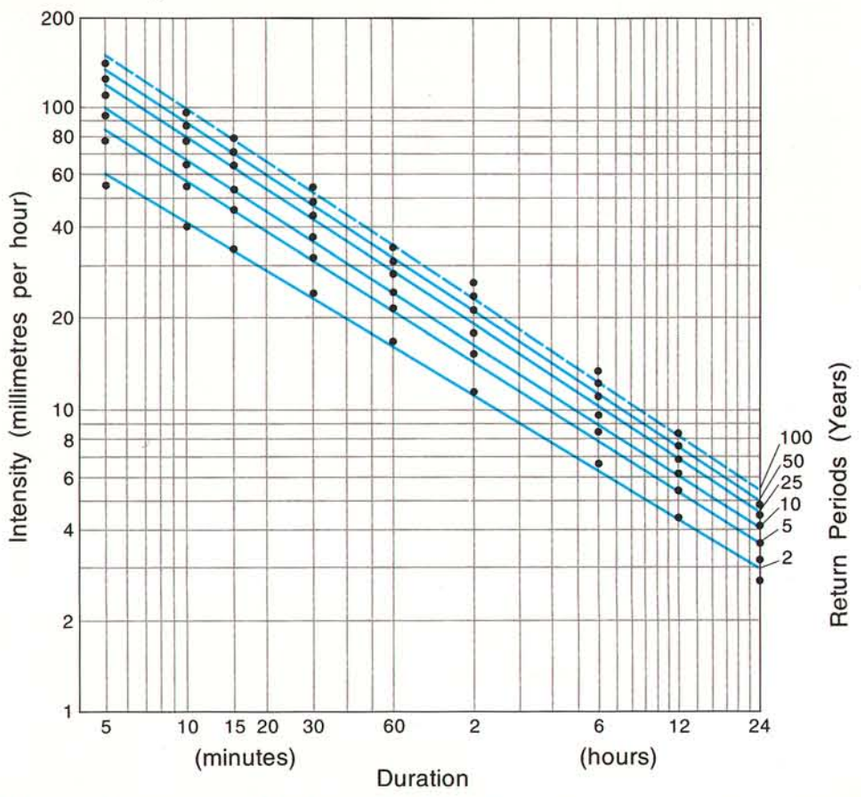


Figure 8.2 Rainfall Intensity-Duration-Frequency Curves (St. John's)

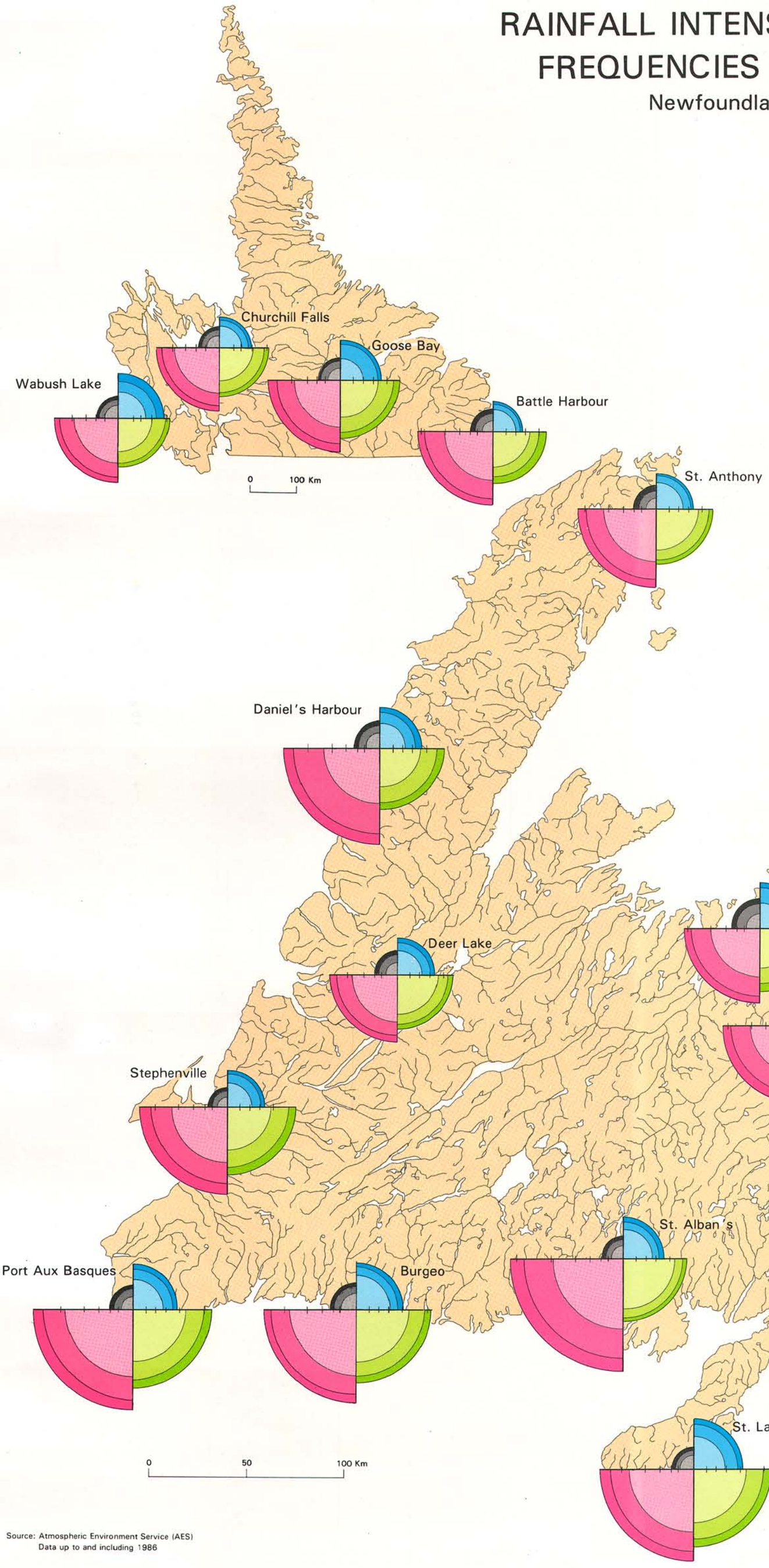
As shown in Figure 8.2, in the St. John's area, 6-hour duration rainfall events have intensities equalling or exceeding 8 mm per hour every 5 years on the average.

Fifteen stations in the province equipped with recording rain gauges and for which IDF curves were available are represented on the rainfall intensity map on the opposite page. The pie-charts give the 2, 25, and 100-year rainfall depths of events with 5-minute and 1, 6, and 24-hour durations (the intensity is calculated as the ratio of depth in millimetres to duration in hours).

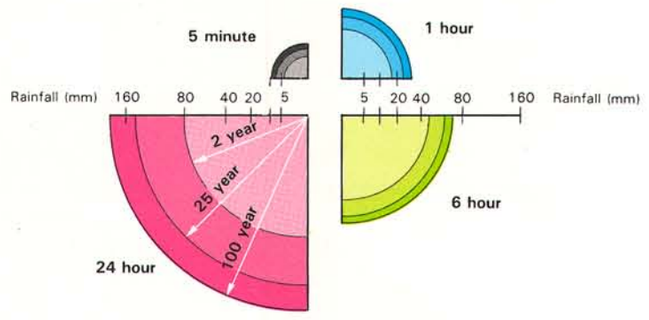
The map indicates that the rainfall events are relatively more severe along the southwest, south, and east coasts of the Island. The climatic conditions of Newfoundland are such that the worst storms generally track into the Island from the southwest. As they progress inland they lose some of their energy and the intensity decreases. Labrador is less likely to be affected by intense storms.

RAINFALL INTENSITY FOR SELECTED FREQUENCIES AND DURATIONS

Newfoundland and Labrador



Duration and Intensity by Station



Source: Atmospheric Environment Service (AES)
Data up to and including 1986

9 – Snowfall

Snowfall accounts for a significant percentage of annual precipitation amounts in virtually all regions of the province, and has a considerable influence on the regional characteristics of river flows. The occurrence of floods in the springtime due to snowmelt is a major concern in certain communities. In our daily lives, especially during the winter, the amount of snowfall determines resources which have to be allocated to the snow-clearing of roads, parking lots, and airport runways. Heavy snowfall can seriously reduce visibility and disrupt travel plans. On the other hand, heavy snowfall can be beneficial to skiers.

Snowfall is generally associated with freezing temperatures. The meteorological conditions producing snowfall are the same as those generating other forms of precipitation such as rainfall. Orographic features such as mountain ranges tend to increase the total amount of snowfall depending on the moisture-bearing characteristics of the air masses.

Snow measurements are usually obtained with rain gauges fitted with heating systems or with snow stakes. A snow stake is a calibrated wooden post which is inserted into the snowpack to determine its depth. Direct measurement of snow depth at a single station is of limited value because drifting and blowing snow can make the measured depth highly unrepresentative of the snowfall in the area. Furthermore, the density of fresh snow is significantly different from packed snow, hence, the amount of snow depends upon the state of the accumulated snow. To circumvent these measurement problems snow surveys of depth and water equivalent are carried out at various points along a snow course. The water equivalent is the depth of water that would weigh the same amount as the sampled snow. As snowfall is a form of precipitation, climatological records commonly report snowfall depth as measured at the time of fall, and the water equivalent of the snow is included in precipitation totals.

The snowfall records for the period 1951-1980 at fifteen stations in the province were used to derive information on the mean annual snowfall, average number of days in a year with snowfall, mean monthly snow depth, and maximum 24-hour recorded snowfall. These characteristics are shown on the map opposite. The lack of data from stations located at high altitudes, where snowfall is generally higher, and the low density of climatic stations limit the accuracy of the information presented.

Snow occurs in measurable quantities on the ground from November to May in most regions of insular Newfoundland; in Labrador the period is from October to early July. In the eastern region of Newfoundland the average number of days with measurable snowfall is approximately thirty and is significantly less than the one hundred and ten days for the interior region of Labrador. The early occurrence and longer period of snow in Labrador are indicative of its relatively colder climate.

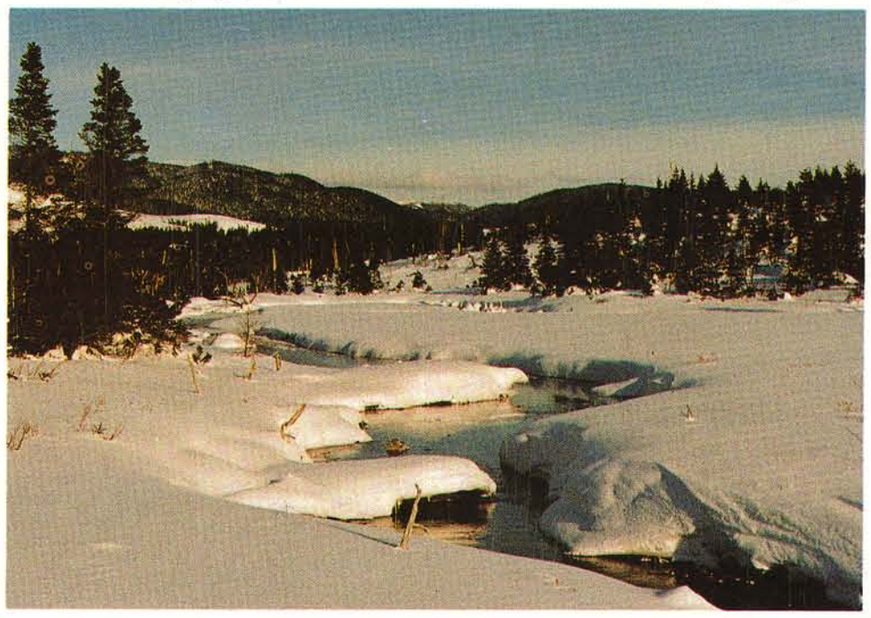
The mean annual snowfall in the province varies from approximately 150 centimetres (cm) in the southeast region of the Island to nearly 475 cm in the interior of Labrador. The orographic effect of the Long Range Mountains on snowfall amounts in the western region of the Island is evident from the map. The high mean annual snowfall around Gander is believed to be due to local factors.

The data for mean monthly snow depth show that, for most regions of the Island, the maximum values occur between February and April. In Labrador the maximum values occur between March and May, thus spring snowmelt occurs about a month later in Labrador than on the Island. The mean monthly snow depth varies from nearly 30 cm on the east coast of the Island to over 100 cm in Labrador. The sequence of snowfall accumulation and subsequent melt generally governs the pattern of mean monthly snow depth. In the maritime climate of Newfoundland it is not uncommon for several freeze-thaw cycles to occur during the winter season. In Labrador, in contrast, the climate is relatively colder and mid-winter snowmelt events are less common; therefore, more snow is likely to accumulate on the ground.

Regions with high annual snowfall generally also have high values for maximum mean monthly snow depth, although interesting exceptions do occur. For example, Gander has a much higher mean annual snowfall than Port aux Basques, but the values for maximum mean monthly snow depth are similar.

The data on the maximum 24-hour snowfall give an indication of the intensity of winter snow storms. Coastal regions seem to experience relatively higher storm intensities than the interior regions.

The estimation of the contribution of snow to river flows and the forecasting of floods resulting from combined large-scale rainstorms and snowmelt are highly dependent upon an adequate knowledge of the extent and characteristics of the snow cover within a watershed. Such information cannot be easily obtained from ground surveys when the watersheds are large and rugged. Recent advances in remote sensing have enabled hydrologists to use data collected by satellites equipped with appropriate sensors to map the areal extent of seasonal snow cover over large areas with good accuracy. The acquisition and analysis of satellite imagery promises to be very valuable in snow hydrology.



Snow-covered Landscape

SNOWFALL

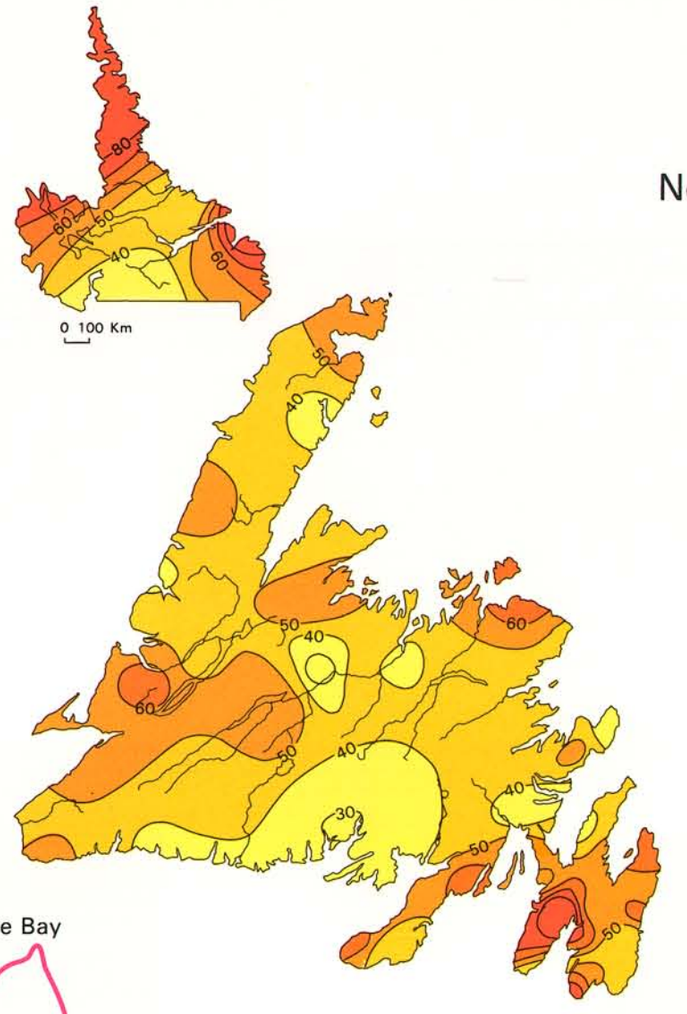
Newfoundland and Labrador

Maximum 24 Hour Snowfall
in centimeters

30 – 40
40 – 50
50 – 60
60 – 70
70 – 90

contour interval = 10 cm

0 100 km

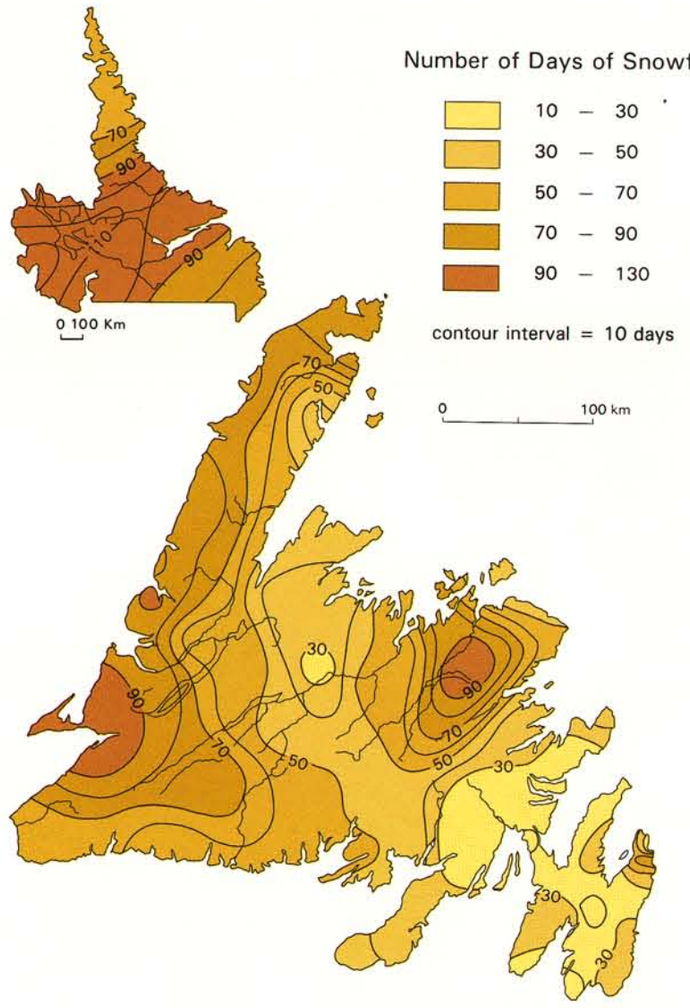


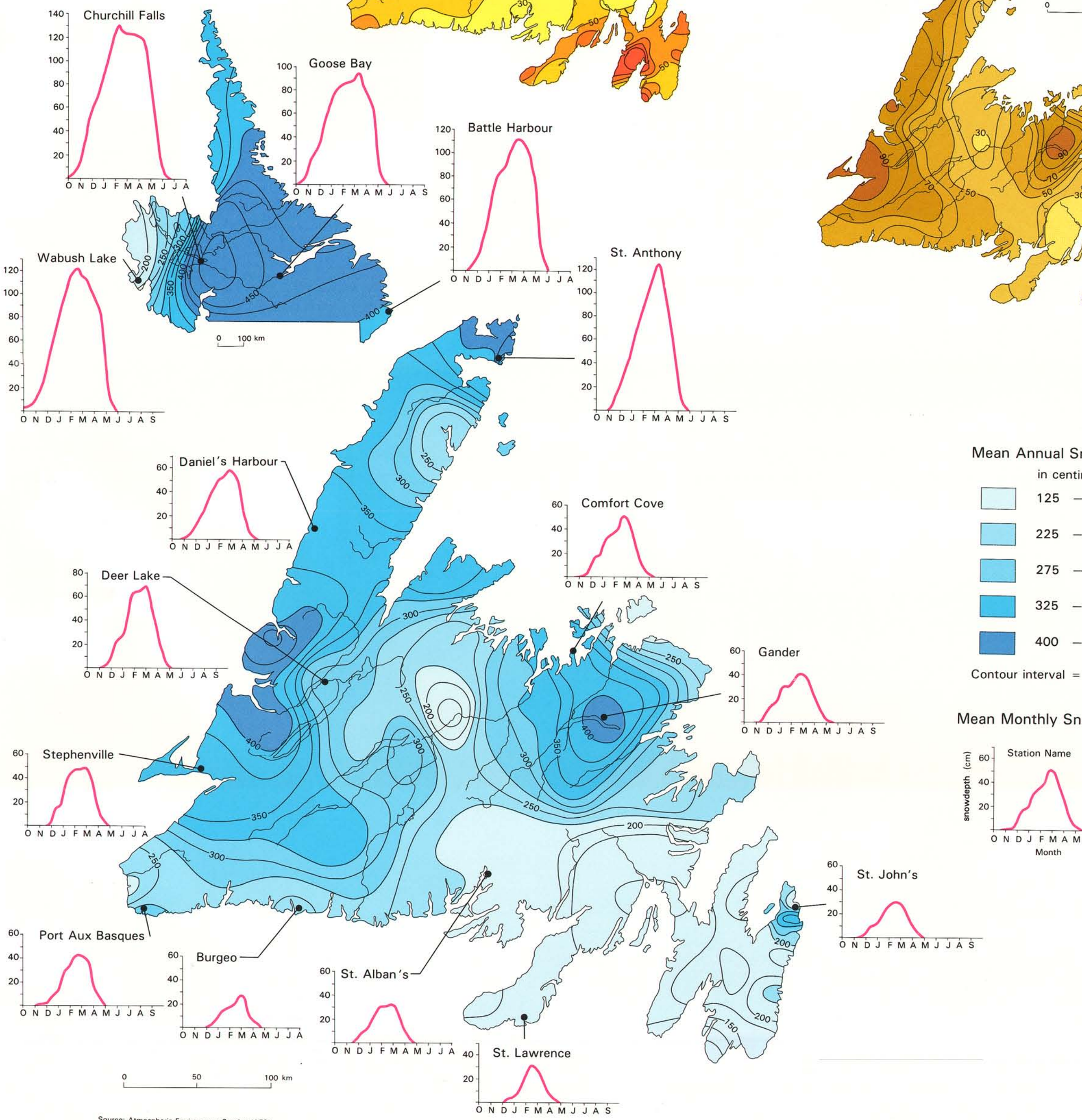
Number of Days of Snowfall

10 – 30
30 – 50
50 – 70
70 – 90
90 – 130

contour interval = 10 days

0 100 km



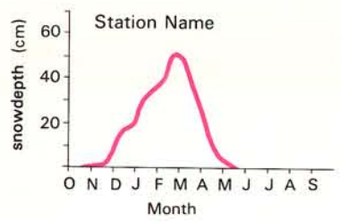


Mean Annual Snowfall
in centimeters

125 – 225
225 – 275
275 – 325
325 – 400
400 – 500

Contour interval = 25 cm

Mean Monthly Snowdepth



Source: Atmospheric Environment Service (AES)
Data up to and including 1986

10 – Potential Evapotranspiration

Evaporation is the process which transforms water from the land and water masses of the earth into atmospheric water vapour by solar radiation. Transpiration is the process by which soil moisture and groundwater absorbed by roots of plants are released to the atmosphere as water vapour through the pores in leaves. In vegetated areas evaporation and transpiration take place simultaneously; the two processes are usually considered together and referred to as evapotranspiration.

The meteorological factors which affect the rate of evapotranspiration are solar radiation, wind speed, relative humidity, and temperature. Other factors include the type and extent of vegetation and the availability of water. The maximum amount of water which can evaporate and be transpired will be limited by the amount of water available. The availability of water, however, is difficult to quantify over time and space. For estimation purposes it is usually assumed that there is an abundant supply of water, and the estimated values are then called potential evapotranspiration as opposed to actual evapotranspiration.

Direct measurements of evaporation are made with the Class A evaporation pan which is 25 centimetres deep, 120 centimetres in diameter, and partly filled with water. Figure 10.1 shows an example of the Class A evaporation pan. Changes in water levels, as well as air and water temperatures, total wind run, and precipitation, are noted on a daily basis. The relative difficulty in measuring small changes in water levels in the pan introduces some errors in the determination of evaporation. The observed data from the evaporation pans can be used, after adjustment, to estimate evaporation from large water bodies such as lakes. In Newfoundland evaporation is measured at three locations, namely, St. John's, Gander and Goose Bay. The measurements are only taken for three or four months of the year because of overnight freezing of water during the winter months. Figure 10.2 shows the spatial variation of estimated mean annual lake evaporation across Canada as published in the Hydrological Atlas of Canada.

Figure 10.1 Class A Evaporation Pan

The highest value for mean annual lake evaporation, about 900 mm, occurs in southern Alberta and Saskatchewan. Such a high evaporation rate has necessitated the use of irrigation to sustain agriculture. The lowest value for mean annual lake evaporation, about 100 mm, occurs in the Arctic region of Canada because of the relatively lesser amounts of solar radiation and longer period of below freezing temperatures. The spatial variation of mean annual lake evaporation is a function of the latitudinal range within each region.

A number of methods can be used to estimate evapotranspiration. These include the water budget method, the energy budget method, and several empirical formulae. The water and energy budget methods require several meteorological data of adequate accuracy as inputs. These data are often not available. Among the empirical methods, the Thornthwaite's formula is one of the simplest. The formula uses the mean monthly temperatures and latitude of the climatic station to give an estimate of mean annual potential evapotranspiration. Based on Thornthwaite's formula and the temperature and location data available at 56 climatic stations in the province, isolines of mean annual potential evapotranspiration were generated for the province. These isolines are shown on the map on the opposite page.

The mean annual potential evapotranspiration in the province ranges from a low of about 350 millimetres (mm) in northern Labrador to a high of about 550 mm in central Newfoundland. This pattern is a result of the increasing latitude and decreasing mean temperature from the central region of insular Newfoundland to the northern region of Labrador.

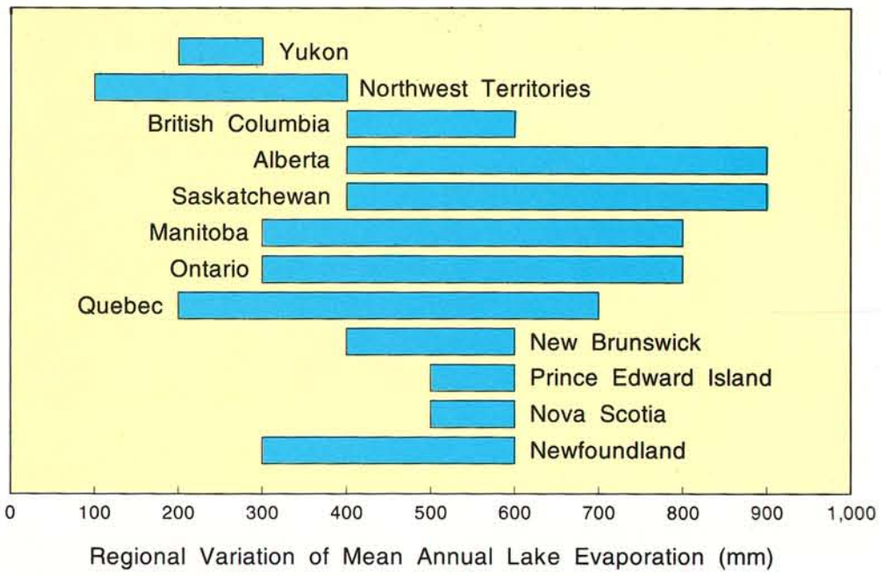
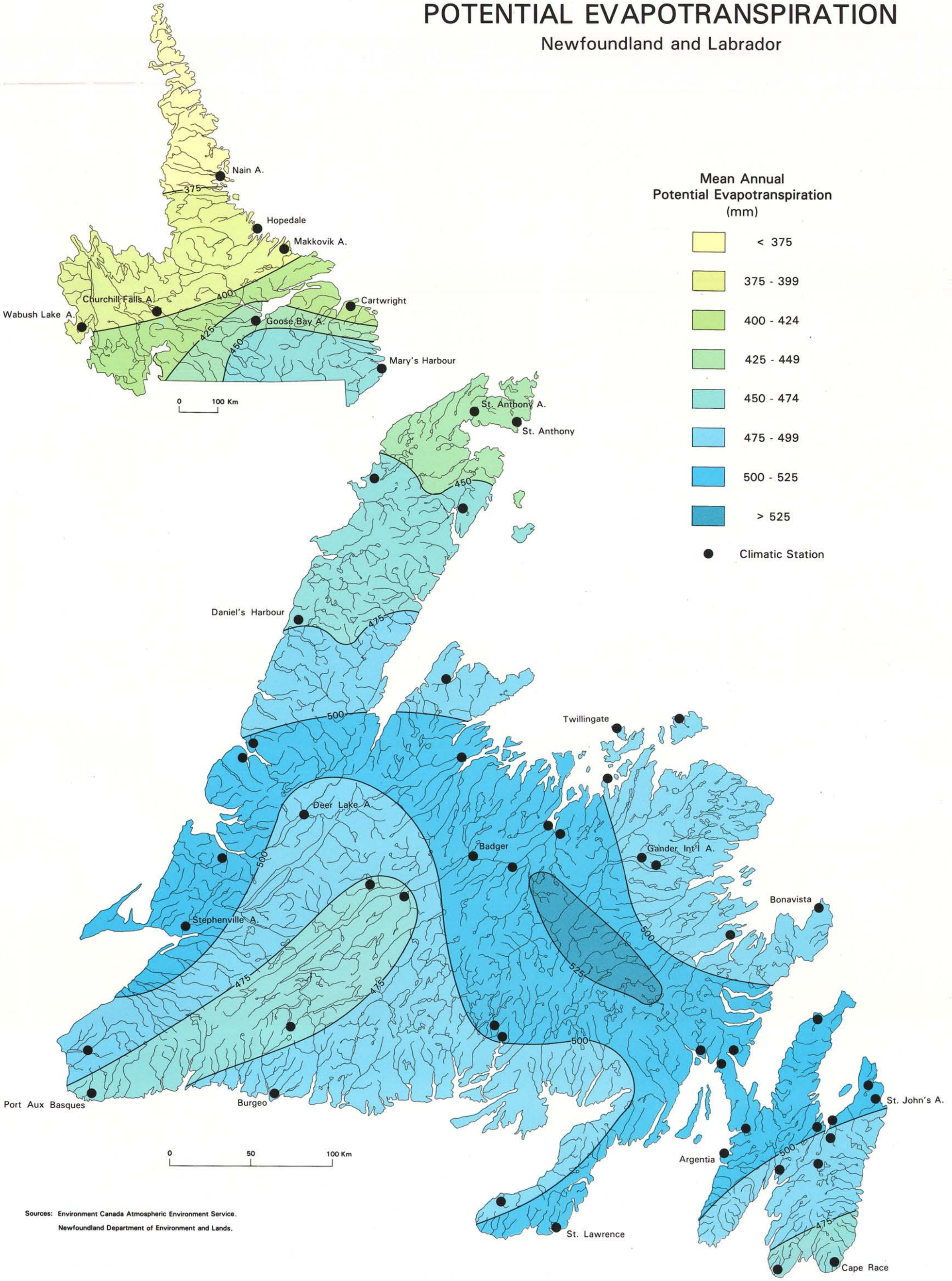


Figure 10.2 Mean Annual Lake Evaporation Across Canada

POTENTIAL EVAPOTRANSPIRATION

Newfoundland and Labrador



Mean Annual Potential Evapotranspiration (mm)

- < 375
- 375 - 399
- 400 - 424
- 425 - 449
- 450 - 474
- 475 - 499
- 500 - 525
- > 525
- Climatic Station

Sources: Environment Canada Atmospheric Environment Service.
Newfoundland Department of Environment and Lands.