



# Canadian Climate Normals 1971-2000

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"Climate averages", "climate means" or "climate normals" are all interchangeable terms. They refer to arithmetic calculations based on observed climate values for a given location over a specified time period. Climate normals are often used to classify a region's climate and make decisions for a wide variety of purposes involving basic habitability, agriculture and natural vegetation, energy use, transportation, tourism, and research in many environmental fields. Normals are also used as a reference for seasonal monitoring of climate temperature and precipitation for basic public interest, and for monitoring drought or forest fires risk. Real-time values, such as daily temperature, are often compared to a location's "climate normal" to determine how unusual or how great the departure from "average" they are.

The World Meteorological Organization (WMO) recommends that countries prepare climate normals for the official 30-year normals periods ending in 1930, 1960 and 1990, for which the WMO World Climate Normals are published. In addition, WMO recommends the updating of climate normals at the end of every decade as provided here for 1971 to 2000.

## 1.0 Calculation method

There are many ways to calculate "climate normals"; the most useful ones adhere to accepted standards. The WMO considers thirty years long enough to eliminate year-to-year variations. Thus the WMO climatological standard period for normals calculations are computed over a 30 year period of consecutive records, starting January 1<sup>st</sup> and ending December 31<sup>st</sup>. In addition, the WMO established that normals should be arithmetic means calculated for each month of the year from daily data with a limited number of allowable missing values. For normals values representing averages, such as temperature, a month was not used if more than 3 consecutive days or more than a total of 5 days were missing. This rule is referred to as the "3 and 5 rule" established as a guideline for completeness by the WMO. Furthermore, its corresponding year-month mean should not be computed and should be considered missing. For normals values representing totals, such as precipitation, degree-days, or days with, an individual month was required to be 100% complete in order for it to be included in the normals calculation.

First, the average or total, as appropriate for the element, for all individual months was calculated for all locations. Normals values were then calculated as the mean for each month from all the individual months in the period that sufficiently fulfilled the requirement for completeness for 1971 to 2000. With the exception of the annual standard deviation (see calculations below), the annual normal value was calculated as the mean or total of monthly normals values only for stations where means or totals for every month of the year were available.

[APPENDIX A](#) lists the specific type of calculation, applicable period, and completeness requirements for each normals and extremes element.

Note: The "3 and 5 rule" is extracted from: "Calculation of Monthly and Annual 30 Year Standard Normals", Prepared by a meeting of experts, Washington, D.C., USA, March 1989. WMO-TD/No. 341 (WCDP-No. 10), Page 5.

## 2.0 Normals code

Once the qualifying months were determined, the "3/5" rule was also applied to the number of months used to calculate average mean or average total within the thirty-year period. For instance, the "normal" value of a monthly element, such as normal maximum temperature for May, can have no more than 3 consecutive or 5 total missing months of May between 1971 to 2000.

Table 1: Normal Codes table for the 1971 to 2000 Climate Normals for Canada

| <b>Normal Code</b> | <b>Number of years with complete months required in the 1971-2000 period</b>   |
|--------------------|--|
| A*                 | WMO "3 and 5 rule" (i.e. no more than 3 consecutive and no more than 5 total missing for <u>both</u> temperature <u>and</u> precipitation).  |
| A                  | WMO "3 and 5 rule" (i.e. no more than 3 consecutive and no more than 5 total missing for <u>either</u> temperature <u>or</u> precipitation). |
| B                  | At least 25 years  |
| C                  | At least 20 years  |
| D                  | At least 15 years  |
| E                  | At least 10 years  |
| F                  | At least 5 years   |
| G                  | < 5 years  |

Note that stations with a normal code of "A" in both temperature and precipitation are designated as meeting the WMO standard for normals calculation.

While normals for all available elements for all stations were calculated, only elements with a normals code of at least Class D are currently available through the Historical Climate Data website.

## 3.0 Uncertainty due to shorter period

Most observing locations in Canada do not have complete records for the 30-year period. To estimate this uncertainty we conducted some trial calculations for locations with a complete record for the 1971-2000 period. For mean temperature and total precipitation, means were calculated for each sub-period representing consecutive years of length from 1 through 30 years for each month and annually. Then the standard deviation of the differences between the mean of each sub-period and the full 30-year mean was calculated. For example, for sub-periods having lengths of 10 years, 21 monthly and annual mean values were calculated for the overlapping sub-periods 1971-1980, 1972-1981,.....,1991-2000. The standard deviation of the differences

between these means and the mean for the 1971-2000 period represents a measure of uncertainty due to an incomplete record. Results are provided in Figures 1 and 2.

Apart from any uncertainty due to site, instrument, or observing program changes, or general representativeness of the observing site with the surrounding region, the normals for most locations will have some uncertainty due to the fact that the observations are not complete for the 30-year period.

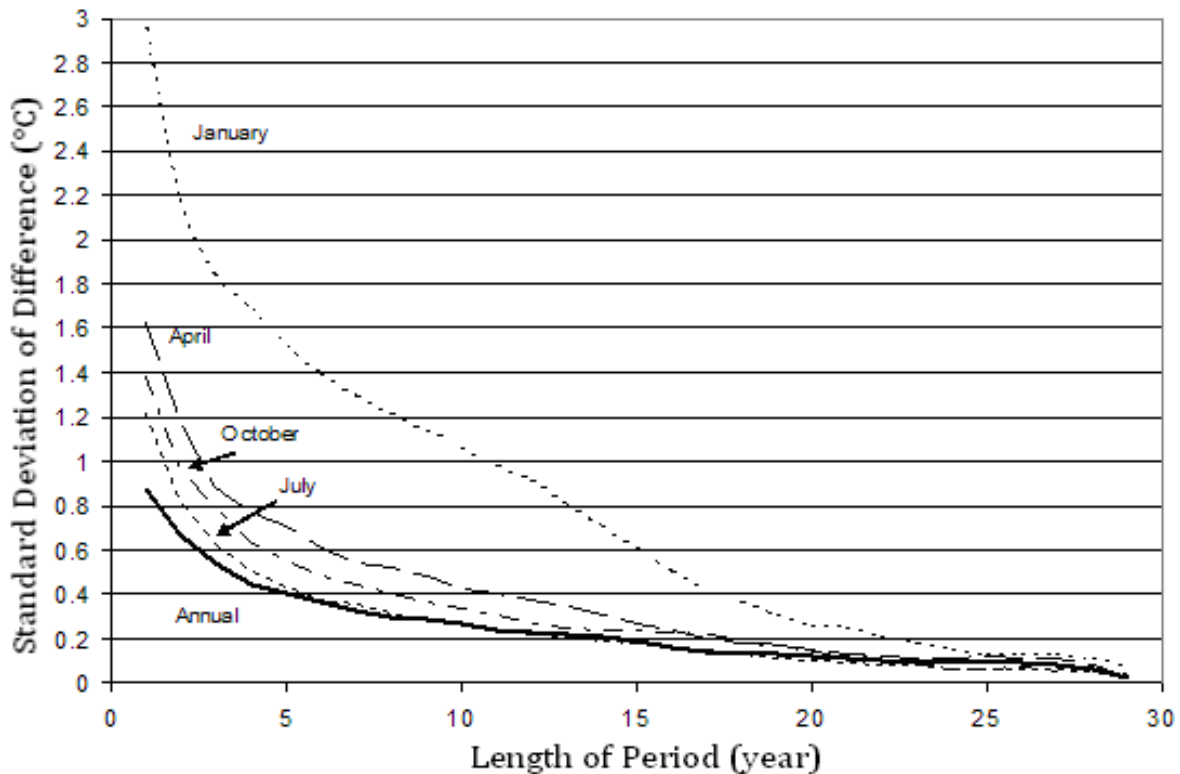
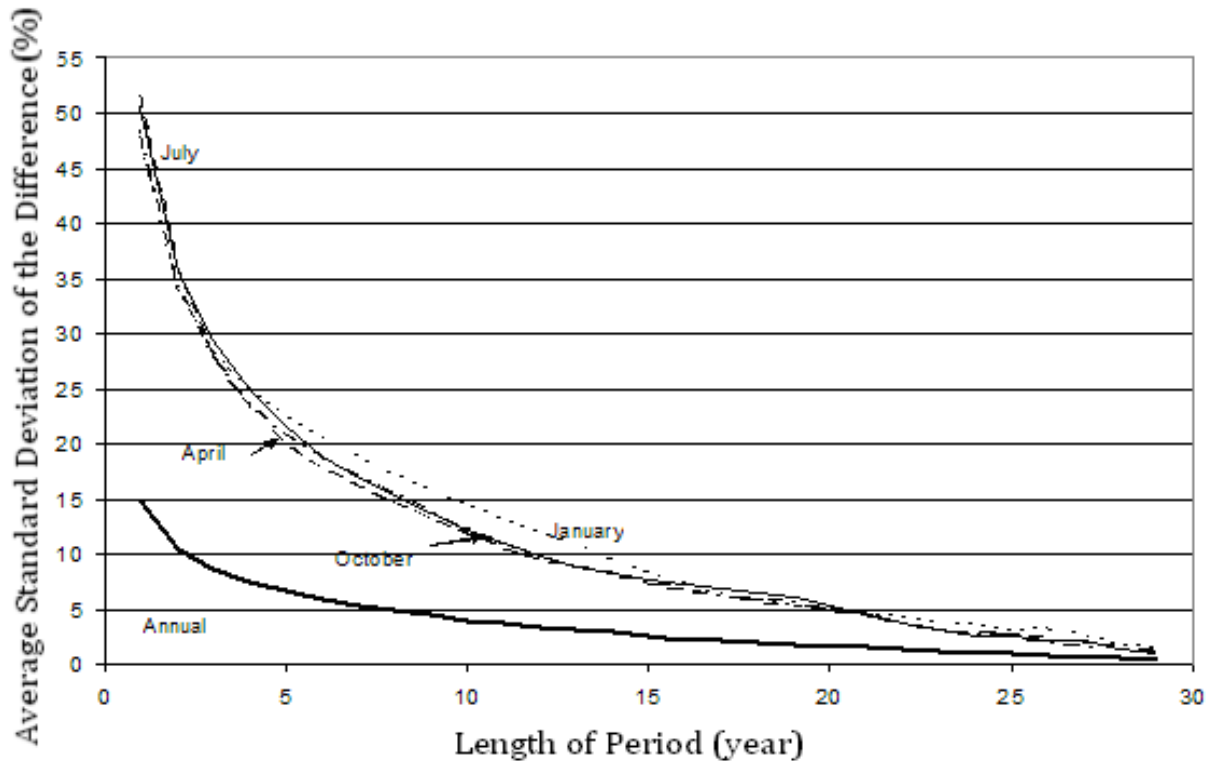


Figure 1: TEMPERATURE. Variation with Length of Period of the Average Standard Deviation of the Difference Between the Average of Sub-Periods and the 30-year Mean Temperature for Selected Months and the Annual Period. Average over 44 Locations.



**Figure 2: PRECIPITATION. Variation with Length of Period of the Average Standard Deviation of the Difference Between the Average of Sub-Periods and the 30-year Mean Precipitation for Selected Months and the Annual Period. Average over 44 Locations.**

The sub-periods used for these calculations overlap so that the mean values calculated for each sub-period are not independent. Nonetheless, the standard deviations of the differences and their means can be viewed as an estimate of a standard error related to uncertainty due to incomplete records.

In Figure 1, the standard deviation is significantly higher for January for all periods than for the other selected months or the annual period. For the 15 year period (the shortest period for which normals are provided on our web site), the January standard deviation is about 0.7°C whereas the other selected months range from 0.2 to 0.3°C, and the standard deviation for the annual period is 0.2°C. Note that winter months are more variable and uncertainty for January temperature normals is higher than for other months.

Standard deviation for precipitation, calculated as the average percentage difference, in Figure 2 shows a somewhat different pattern. The standard deviations for selected months are larger than the annual period, for all lengths of sub-period, but the differences amongst months are small. There is less seasonal variation in the uncertainty of precipitation than is the case with temperature. The standard deviation for precipitation for a 15-year sub-period is about 8% for monthly values and about 3% for the annual value, with decreasing uncertainty with increasing length of period. These results can be a guide to selecting normals based on the normals code (A, B, C, or D).

Note that the average temperature standard deviation for the one-year sub-period is exactly the same as the temperature standard deviation published with the 30 year normals.

## 4.0 Standard deviation calculations

Standard deviations of mean daily temperatures (°C) are calculated from the same data used to calculate the mean for each month. Calculation of annual standard deviation differs from other annual element calculations in that it represents the mean standard deviation calculated from annual means for a given station rather than the mean standard deviation of monthly means. The same "3 and 5" rule for data completeness was applied to the annual standard deviation as was applied to the individual monthly standard deviations. The normal code for the annual standard deviation was assigned according to the qualifications outlined in Table 1 rather than representing the least degree of completeness for all months.

## 5.0 Climate extremes

Besides the monthly averages and totals, extremes for selected elements by month including the daily maximum and minimum temperature, and the daily rainfall, snowfall, and total precipitation, and the dates of occurrence, were compiled and provided along with the normals elements. Extremes are compiled from the entire period of record of each location and not restricted to just the 1971-2000 normals period. In each case, the first or oldest date of occurrence is recorded below the extreme value. Values which occur more than once are identified with a (+). Bolded values and dates indicate the extreme for the year. Because no completeness requirements apply, no normals codes are assigned to extreme elements.

## 6.0 Support information

During the calculation of normals and extremes, additional support information was tabulated. These include for both means and extremes: total number of available years, number of missing years, total count of observations and percent possible observations used. The first year and last year used within the normals period for elements for which means were calculated are available. The first year and last year used for element for which extremes were determined are available.

## 7.0 Data adjustments

No explicit corrections or adjustments were made to normals values to account for any variations in siting, instruments, or observing procedures. To the degree that these confounding influences can affect trends in temperature and precipitation, these normals values should not be used to draw precise conclusions about changes in climate.

All normal values are derived from data in the National Archive System of Environment and Climate Change Canada (ECCC). While considerable effort is made to ensure the accuracy of these data, no guarantee can be given that they are error free.

## **8.0 Data and observing stations**

The normals elements of greatest interest are the daily values of maximum, minimum and mean temperature (°C), rainfall (mm), snowfall (cm) and total precipitation (mm). For principal stations, additional daily elements such as peak wind gusts, days with a variety of weather phenomena such as thunderstorms or freezing precipitation, and elements based on hourly elements such as wind, sunshine, and solar radiation are also available. Generally the network of volunteer stations is limited to basic daily temperature and precipitation observations.

The climate day at first order or primary observing sites is defined by the 24-hour period ending at 0600 UTC (Universal Time Coordinate). The climate at volunteer observing sites ends at around 8:00 am local time and can vary somewhat from location to location.

As in many other countries, observing practices have evolved through the current normals period, and continue to evolve. Observations at one time almost exclusively taken and recorded by human observers are increasingly being automated. Some principal stations in the Meteorological Service of Canada (MSC) network were automated during the 1990's. As this occurred, the only precipitation observations available were daily total precipitation (mm) from an automatic weighing precipitation gauge. The observations from these stations in these years (mostly the late 1990's) were not used for the normals calculations since daily rainfall and snowfall observations were not available.

### **8.1 Temperature**

Temperature measurements are made from self-registering maximum and minimum thermometers set in a louvered, wooden shelter. The shelter is mounted on a stand so that the thermometers are approximately 1.5 m above ground, which is usually a level, grassy surface.

At most climatological stations, maximum temperature is the highest temperature recorded in a 24-hour period ending in the morning of the next day. The minimum values are for a period of the same length, beginning in the evening of the previous day. Mean temperature is the average of the two.

At most principal stations, the climatological day begins at 0600 UTC and ends at the onset of 0600 UTC on the following day. These times are equivalent or close to midnight local standard time for most of Canada.

## **8.2 Rainfall, snowfall, and precipitation**

Rain, drizzle, freezing rain, freezing drizzle and hail are usually measured using the standard Canadian rain gauge, a cylindrical container 40 cm high and 11.3 cm in diameter. The precipitation is funneled into a plastic graduate which serves as the measuring device.

Snowfall is the measured depth of newly fallen snow, measured using a snow ruler. Measurements are made at several points which appear representative of the immediate area, and then averaged. "Precipitation" in the tables is the water equivalent of all types of precipitation.

At most ordinary stations the water equivalent of snowfall is computed by dividing the measured amount by ten. At principal stations it is usually determined by melting the snow that falls into Nipher gauges. These are precipitation gauges designed to minimize turbulence around the orifice, and to be high enough above the ground to prevent most blowing snow from entering. The amount of snow determined by this method normally provides a more accurate estimate of precipitation than using the "ten-to-one" rule. Even at ordinary climate stations the normals precipitation values will not always be equal to rainfall plus one tenth of the snowfall. Missing observations is one cause of such discrepancies.

Precipitation measurements are usually made four times daily at principal stations. At ordinary sites they are usually made once or twice per day. Rainfall, snowfall and precipitation amounts given in the tables represent the average accumulation for a given month or year.

## **8.3 Snow depth**

Snow cover is the depth of accumulated snow on the ground, measured at several points which appear representative of the immediate area, and then averaged. End-of-month values are given in the tables.

## **8.4 Number of days with specified parameters**

These elements give the average number of days per month or year on which a specific meteorological event or parameter threshold occurs. In the case of rainfall and precipitation, 0.2 mm or more must occur before a "day with" is counted. The corresponding figure for snowfall is 0.2 cm. A day with freezing precipitation is counted if there is an occurrence of 0.2 mm or more of rain or drizzle which turns to ice on contact with the underlying surface. Fog for this purpose is defined as a suspension of very small water droplets reducing the horizontal visibility to less than 1 km. A day with thunderstorms occurs if thunder is heard.



## 8.5 List of days with parameters and thresholds

### Days with maximum temperature

- $\leq 0^{\circ}\text{C}$
- $> 0^{\circ}\text{C}$
- $> 10^{\circ}\text{C}$
- $> 20^{\circ}\text{C}$
- $> 30^{\circ}\text{C}$
- $> 35^{\circ}\text{C}$

### Days with minimum temperature

- $> 0^{\circ}\text{C}$
- $\leq 2^{\circ}\text{C}$
- $\leq 0^{\circ}\text{C}$
- $< -2^{\circ}\text{C}$
- $< -10^{\circ}\text{C}$
- $< -20^{\circ}\text{C}$
- $< -30^{\circ}\text{C}$

### Days with rainfall

- $\geq 0.2 \text{ mm}$
- $\geq 5 \text{ mm}$
- $\geq 10 \text{ mm}$
- $\geq 25 \text{ mm}$

### Days with snowfall

- $\geq 0.2 \text{ cm}$
- $\geq 5 \text{ cm}$
- $\geq 10 \text{ cm}$
- $\geq 25 \text{ cm}$

### Days with precipitation

- $\geq 0.2 \text{ mm}$
- $\geq 5 \text{ mm}$
- $\geq 10 \text{ mm}$
- $\geq 25 \text{ mm}$

### Days with snow depth

- $\geq 1 \text{ cm}$
- $\geq 5 \text{ cm}$

- $\geq 10$  cm
- $\geq 20$  cm

### **Days with**

- Freezing rain or freezing drizzle
- Thunderstorms
- Hail
- Fog, ice fog, or freezing fog
- Smoke or haze
- Blowing dust
- Blowing snow

Note that the "Days With" various weather parameters such as freezing rain or freezing drizzle, thunderstorms, hail, etc. are currently unavailable on the web due to an internal quality control review.

## **8.6 Degree-days**

Degree-days for a given day represent the number of degrees Celsius that the mean temperature is above or below a given base. For example, heating degree-days are the number of degrees below 18°C. If the temperature is equal to or greater than 18, then the number of heating degrees will be zero. Normals represent the average accumulation for a given month or year.

Values above or below the base of 18°C are used primarily to estimate the heating and cooling requirements of buildings and fuel consumption. A temperature base of 24°C is sometimes used as an index of extreme cooling degree-days or as an index of potential heat stress. Values above 5°C are frequently called growing degree-days, and are used in agriculture as an index of crop growth.

## **8.7 Soil temperature**

Soil temperature measurements provide a climatology of soil thermal characteristics such as the depth of frost penetration into the soil and the duration that the soil remains frozen. It is of interest to hydrologists because it affects surface runoff, infiltration and snowmelt and to agriculturalists because it affects seed germination.

Measurements of soil temperature are made in accordance with the WMO recommendations at the standard depths of 5, 10, 20, 50, 100, 150 and 300 cm. They are measured daily as close as possible to 08:00 LST and again at the shallowest depth at 16:00 LST.

## 8.8 Evaporation

Evaporation refers to the calculated lake evaporation occurring from a small natural open water-body having negligible heat storage and very little heat transfer at its bottom and sides. It represents the water loss from ponds and small reservoirs but not from lakes that have large heat storage capacities. Lake evaporation is calculated using the observed daily values of pan evaporative water loss, the mean temperatures of the water in the pan and of the nearby air, and the total wind run over the pan.

Lake evaporation normals for the 1971 to 2000 period were calculated as means of daily means for a given station. This in effect is a measure of the rate of evaporation per day rather than a measure of total evaporation as was calculated in the 1961 to 1990 normals. To make the 1971 to 2000 lake evaporation normal values comparable to previous calculations, multiply the 1971 to 2000 value by the number of days for a given month to obtain an equivalent estimate.

## 8.9 Freezing-free period

Freezing occurs whenever temperatures fall to 0°C or lower. Freezing data normals are based on the occurrence of freezing temperatures as recorded from minimum thermometers. The "Freezing-free Period" is defined as the number of days between the last occurrence of frost in spring and first occurrence of frost in the fall for a given year. For the purpose of these calculations, "spring" is defined as days on or before July 15, "fall" is defined as days after July 15. Freezing or frost occurs on any day where the daily minimum temperature ( $T_{\min}$ ) is observed to be less than or equal to 0°C.

"Freezing-free" elements are calculated only for stations where daily minimum temperature observations are 100% complete from the period of July 15 to the last occurrence of  $T_{\min}$  less than or equal to 0°C in "spring", and from July 15 to the first occurrence of  $T_{\min}$  less than or equal to 0°C in "fall". At least one complete period must occur within 1971 to 2000.

## 8.10 Hourly data

Some climate elements are observed on an hourly rather than a daily basis. For these elements, the "3 and 5" rule for completeness is inapplicable given the comprehensive volume of data. Instead, to qualify for inclusion, hourly elements must have at least 90% of all available hours for a month complete where means or "days with" statistics are calculated. As with daily elements, where average totals are calculated, the record required 100% complete data. The monthly mean was then assigned an annual code following the completeness requirements outlined in Table 1.

Hourly elements include: hourly wind speed and direction, bright sunshine, humidex, wind chill, humidity, pressure, radiation, visibility and cloud amount.

## 8.10.1 Wind

Most principal climatological stations are equipped with a standard type U2A anemometer, taking one or (since 1985) two-minute mean speeds values at each observation. At other wind-measuring sites, values are usually obtained from autographic records of U2A or 45B anemometers. Averaging periods at these sites may vary from one minute to an hour.

In observing, wind speed is measured in m/s or nautical miles per hour and converted to kilometers per hour. The extreme gust speed is the instantaneous peak wind observed from the anemometer dials, or abstracted from a continuous chart recording. A value of zero (0) denotes a calm or no wind.

**Conversion factors: 1 nautical mile = 1852 meters or 1.852 km  
therefore 1 knot = 1.852 km/h and 1 km/h = 0.54 knot**

Wind direction measured by U2A's is recorded to the nearest ten degrees, while those from the 45B are provided to 8 points of the compass. All wind directions are defined as the direction from which the wind blows with respect to true or geographic north. For example, an easterly wind is blowing from the east, not toward the east. A wind direction observation represents the average direction over the two minutes period ending at the time of observation.

The most frequent wind direction is based on the total number of occurrences of each of the 36 possible directions for each month. A monthly total is calculated for each direction for all months having sufficient record (90% complete for hourly elements). The direction with the highest total count is mapped directly to one of the 8 compass points and that is assigned as the most frequent wind direction for the month. The most frequent wind direction for the year is simply deduced as the direction with the highest total occurrence count for all months. The 8 compass directions are determined from the chart given below.

Table 2: 8 compass directions

| <b>8 points</b> | <b>Direction/Range</b> | <b>10's of Degrees</b> |
|-----------------|------------------------|------------------------|
| NE              | 034-078                | 05                     |
| E               | 079-123                | 09                     |
| SE              | 124-168                | 14                     |
| S               | 169-213                | 18                     |
| SW              | 214-258                | 23                     |
| W               | 259-303                | 27                     |
| NW              | 304-348                | 32                     |
| N               | 349-033                | 36                     |
| CALM            | 000                    | 00                     |

NOTE: The Direction/Range for wind direction has been updated since the calculation of the 1971-2000 Normals. For the updated Direction/Range please refer to the Technical Documentation for the Digital Archive of Canadian Climatological Data (Surface).

Wind speed and direction are greatly affected by proximity to the ground and by the presences of obstacles such as hills, buildings and trees. It tends to increase in speed and veer with height above ground. For meteorological purposes, the standard exposure of anemometer cups is at a height of 10 meters above the ground surface.

### **8.10.2 Bright sunshine**

Bright sunshine observations are made using the Campbell-Stokes sunshine recorder. It consists of a glass sphere that is 10 cm in diameter, mounted concentrically in a portion of a spherical bowl. The sun's rays are focused by the glass sphere on a card held in position by a pair of grooves in the bowl. The focused rays scorch the card or burn a trace right through it. The card size used depends on the length of the day and is available in three classes corresponding to the time of the year equinox, summer or winter solstice.

Cards are changed daily so that the duration of sunshine for each hour of the day can be scaled. It is important to note that the amount of "bright sunshine" is less than the amount of "visible sunshine" because the sun's rays are not intense enough to record especially just after sunrise and towards sunset. The number of tenths of hours of sunshine is counted, as indicated by the burn on the card, and the total is recorded.

### **8.10.3 Humidex**

Humidex is an index to indicate how hot or humid the weather feels to the average person. It is derived by combining temperature and humidity values into one number to reflect the perceived temperature. For example, a humidex of 40 means that the sensation of heat when the temperature is 30 degrees and the air is humid feels more or less the same as when the temperature is 40 degrees and the air is dry.

The standard humidex formula used by ECCC is:

humidex = (air temperature) + h

Where

$h = (0.5555) * (e - 10.0);$

e = vapour pressure in hPa (mbar), given by:

$e = 6.11 * \exp [5417.7530 * ((1/273.16) - (1/\text{dewpoint}))]$

Dew point is expressed in Kelvins (temperature in K = temperature in °C + 273.16) and 5417.7530 is a rounded constant based on the molecular weight of water, latent heat of evaporation, and the universal gas constant.

## 8.10.4 Wind chill

Wind chill is an index to indicate how cold the weather feels to the average person. It is derived by combining temperature and wind velocity values into one number to reflect the perceived temperature. For example, if the outside temperature is  $-10^{\circ}\text{C}$  and the wind chill is  $-20$ , it means that your face will feel more or less as cold as it would on a calm day when the temperature is  $-20^{\circ}\text{C}$ .

The wind chill is calculated when the temperature of the air is  $\leq 10^{\circ}\text{C}$  and the reported wind speed is  $\geq 5$  km/h.

The standard Wind Chill formula for 1971-2000 Canadian Climate Normals is:

$$W = 13.12 + 0.6215 \times T_{\text{air}} - 11.37 \times V_{10\text{m}}^{0.16} + 0.3965 \times T_{\text{air}} \times V_{10\text{m}}^{0.16}$$

Where

$W$  is the wind chill index, based on the Celsius temperature scale

$T_{\text{air}}$  is the air temperature in degrees Celsius ( $^{\circ}\text{C}$ ), and

$V_{10\text{m}}$  is the wind speed at 10 meters (standard anemometer height), in kilometers per hour (km/h).

NOTE: The calculation for wind chill has been updated since the calculation of the 1971-2000 Normals. For the updated calculation please refer to the Glossary.

## 8.10.5 Humidity

Vapour pressure is the pressure exerted by the water present in an air parcel. This pressure is one of the partial pressures that make up the total pressure exerted by an air parcel. The vapour pressure increases as the amount of water vapour increases.

If an enclosed container of air and liquid water is maintained at a constant temperature, water molecules escape from the liquid surface into the air until an equilibrium is reached when no more water will evaporate (saturation occurs). The air parcel can hold no more water vapour molecules unless external heating is applied. The pressure exerted by the water vapour, in this case, is known as the saturation vapour pressure. The ratio of the actual vapour pressure to the saturation vapour pressure is another way of defining the relative humidity of an air mass.

Relative humidity is the ratio of the actual amount of water vapour present in a given parcel of air to the maximum amount that the parcel is capable of holding at a given temperature. It is usually expressed as a percentage. It is derived from either dry bulb and wet bulb temperatures or, in the case of a Dewcel remote temperature sensing unit, from dry bulb temperature and dew point values, with the aid of psychrometric tables.

Relative humidity changes with the air temperature even though the actual amount of water vapour present in an air parcel may remain constant. When a parcel of air is

heated, without the addition or removal of water vapour, the relative humidity decreases and conversely, if the parcel is cooled under the same conditions, the relative humidity increases.

The closer the dew point temperature is to the dry bulb temperature, the higher the relative moisture content of the air. At 100% relative humidity the dew point temperature and the dry bulb temperature are the same. When the dry bulb and dew point difference is small, some of the internal water vapour condenses to form liquid water droplets either as fog or clouds.

### **8.10.6 Pressure**

Pressure is the weight of a column of air of unit cross-sectional area extending from the level of the observing station vertically to the outer limit of the atmosphere. The standard instrument for the measurement of atmospheric pressure is the mercury barometer, in which the air pressure is balanced against the weight of a column of mercury in a glass tube that contains a vacuum.

Station Pressure is the atmospheric pressure in kiloPascal (kPa) at the station elevation. Atmospheric pressure is the force per unit area exerted by the atmosphere as a consequence of a mass of air in a vertical column from the elevation of the observing station to the top of the atmosphere.

Sea level pressure is the weight of a column of air of unit cross-sectional area extending from sea level vertically to the outer limit of the atmosphere. It is directly measured at stations situated at sea level, but is calculated at other stations by adding to the station pressure, the equivalent weight of an air column extending from the station elevation down to sea level. Mean sea level pressure is computed so that the barometric pressures at stations of different elevations can be compared at a common level for analysis purposes.

### **8.10.7 Solar radiation**

Solar radiation is the measurement of radiant energy from the sun, on a horizontal surface. There are several standardized components of independent measurements. Each component is assigned a different identifying number referred to as Radiation Fields (RF). The standard metric unit of radiation measurement is the Mega Joule per square meter (MJ/m<sup>2</sup>).

Components measured and used by MSC:

**RF1: Global Solar Radiation** – the total incoming direct and diffuse short-wave solar radiation received from the whole dome of the sky on a horizontal surface.

RF2: **Sky Radiation (Diffuse)** – the portion of the total incoming short-wave solar radiation received on a horizontal surface that is shielded from the direct rays of the sun by means of a shade ring.

RF3: **Reflected Solar Radiation** – the portion of the total incoming short-wave radiation that has been reflected from the Earth's surface and diffused by the atmospheric layer between the ground and the point of observation onto a horizontal surface.

RF4: **Net Radiation** – the resultant of downward and upward total (solar, terrestrial surface, and atmospheric) radiation received on a horizontal surface.

### 8.10.8 Visibility

Visibility in kilometers (km) is the distance at which objects of suitable size can be seen and identified. Precipitation, fog, haze or other obstructions such as blowing snow or dust can reduce atmospheric visibility.

### 8.10.9 Cloud amount

A cloud in the atmosphere is a visible collection of minute particle matter, such as water droplets and/or ice crystals, in the air. Condensation nuclei, such as smoke or dust particles, form a surface around which water vapour can condense and create clouds.

## 9.0 APPENDIX A

Table 3 shows the calculation, period of record and completeness required for each normal and extreme element.

Table 3: Normals Calculation for the 1971 to 2000 Climate Normals for Canada including element by Group, type of Calculation, period used and completeness required fields

| <b>Element by group</b>                    | <b>Type of calculation</b> | <b>Period used</b> | <b>Completeness required</b> |
|--|----------------------------|--------------------|------------------------------|
| <b>Temperature</b>                         |                            |                    |                              |
| Mean daily temperature (°C)                | mean                       | *Normal            | 3 and 5 rule                 |
| Std Dev mean monthly temperature (°C)      | std dev                    | *Normal            | 3 and 5 rule                 |
| Mean daily max temperature (°C)            | mean                       | *Normal            | 3 and 5 rule                 |
| Extreme maximum daily max temperature (°C) | maximum                    | period of record   | all available values         |
| Mean daily min temperature (°C)            | mean                       | *Normal            | 3 and 5 rule                 |
| Extreme minimum daily min temperature (°C) | minimum                    | period of record   | all available values         |
| <b>Precipitation</b>                       |                            |                    |                              |
| Total rainfall (mm)                        | total                      | *Normal            | 100% complete                |



| <b>Element by group</b>  | <b>Type of calculation</b> | <b>Period used</b> | <b>Completeness required</b> |
|--|----------------------------|--------------------|------------------------------|
| Total snowfall (cm)  | total                      | *Normal            | 100% complete                |
| Total precipitation (mm)   | total                      | *Normal            | 100% complete                |
| Extreme daily rainfall (mm)  | maximum                    | period of record   | all available values         |
| Extreme daily snowfall (cm)  | maximum                    | period of record   | all available values         |
| Extreme daily precipitation (mm)   | maximum                    | period of record   | all available values         |
| Mean daily snow depth (cm)   | mean                       | *Normal            | 3 and 5 rule                 |
| Median daily snow depth (cm)   | median                     | *Normal            | 3 and 5 rule                 |
| Extreme daily snow depth (cm)  | maximum                    | period of record   | all available values         |
| Mean month end snow depth (cm)   | mean                       | *Normal            | all available values         |
| <b>Days with ...</b>   |                            |                    |                              |
| For all specified parameters including:<br>Maximum temperature (°C)<br>Minimum temperature (°C)<br>Rainfall (mm)<br>Snowfall (cm)<br>Precipitation (mm)<br>Snow Depth (cm) |                            |                    |                              |
|  | total                      | *Normal            | 100% complete                |
| <b>Wind</b>  |                            |                    |                              |
| Mean of hourly wind speed (km/h)   | mean                       | *Normal            | 90% of hours                 |
| Most frequently occurring wind direction (deg true)  |                            | *Normal            | 90% of hours                 |
| Direction of extreme of hourly wind speed (deg true)   |                            | period of record   | all available values         |
| Extreme of hourly wind speed (km/h)  | maximum                    | period of record   | all available values         |
| Extreme of daily max gust (km/h)   | maximum                    | period of record   | all available values         |
| Direction of extreme of daily max gust (deg true)  |                            | period of record   | all available values         |
| Days With Wind ≥ 28 knots  | total                      | *Normal            | 100% complete                |
| Days With Wind ≥ 34 knots  | total                      | *Normal            | 100% complete                |
| <b>Degree days</b>   |                            |                    |                              |
| Specified temperature thresholds   | total                      | *Normal            | 100% complete                |
| <b>Soil temperature</b>  |                            |                    |                              |
| Mean of soil temperature at specified depths and times   | mean                       | *Normal            | 3 and 5 rule                 |
| <b>Evaporation</b>   |                            |                    |                              |

| <b>Element by group</b>   | <b>Type of calculation</b> | <b>Period used</b> | <b>Completeness required</b> |
|---|----------------------------|--------------------|------------------------------|
| Mean of daily lake evaporation (mm)                             | mean                       | *Normal            | 3 and 5 rule                 |
| <b>Bright sunshine</b>  |                            |                    |                              |
| Total hours bright sunshine                                     | total                      | *Normal            | 100% complete                |
| Days with measurable bright sunshine                            | total                      | *Normal            | 100% complete                |
| Extreme daily bright sunshine hours                             | maximum                    | *Normal            | all available values         |
| Percent of daylight hours based on civil sunrise/sunset         | percentage                 | *Normal            | 100% complete                |
| <b>Humidex</b>  |                            |                    |                              |
| Extreme maximum humidex value (°C)                              | maximum                    | period of record   | all available values         |
| Days with humidex value ≥ 30                                    | total                      | *Normal            | 90% complete                 |
| Days with humidex value ≥ 35                                    | total                      | *Normal            | 90% complete                 |
| Days with humidex value ≥ 40                                    | total                      | *Normal            | 90% complete                 |
| <b>Wind chill</b>   |                            |                    |                              |
| Extreme minimum wind chill value (°C)                           | minimum                    | period of record   | all available values         |
| Days with wind chill value < -20                                | total                      | *Normal            | 90% complete                 |
| Days with wind chill value < -30                                | total                      | *Normal            | 90% complete                 |
| Days with wind chill value < -40                                | total                      | *Normal            | 90% complete                 |
| <b>Humidity</b>   |                            |                    |                              |
| Mean of hourly vapour pressure (kPa)                            | mean                       | *Normal            | 90% of hours                 |
| Mean of 0600 LST relative humidity (%)                          | mean                       | *Normal            | 90% complete                 |
| Mean of 1500 LST relative humidity (%)                          | mean                       | *Normal            | 90% complete                 |
| <b>Pressure</b>   |                            |                    |                              |
| Mean of hourly station pressure (kPa)                           | mean                       | *Normal            | 90% of hours                 |
| Mean of hourly mean sea level pressure (kPa)                    | mean                       | *Normal            | 90% complete                 |
| <b>Radiation</b>  |                            |                    |                              |
| Total hourly global solar radiation RF1 (MJ/m <sup>2</sup> )    | total                      | *Normal            | 100% complete                |
| Total hourly diffuse solar radiation RF2 (MJ/m <sup>2</sup> )   | total                      | *Normal            | 100% complete                |
| Total hourly reflected solar radiation RF3 (MJ/m <sup>2</sup> ) | total                      | *Normal            | 100% complete                |
| Total hourly net radiation RF4 (MJ/m <sup>2</sup> )             | total                      | *Normal            | 100% complete                |
| Extreme Daily global solar radiation RF1 (MJ/m <sup>2</sup> )   | maximum                    | period of record   | all available values         |
| Extreme daily diffuse solar radiation                           | maximum                    | period of          | all available                |

| <b>Element by group</b>   | <b>Type of calculation</b> | <b>Period used</b> | <b>Completeness required</b> |
|---|----------------------------|--------------------|------------------------------|
| RF2 (MJ/m <sup>2</sup> )  |                            | record             | values                       |
| Extreme daily reflected solar radiation<br>RF3 (MJ/m <sup>2</sup> ) | maximum                    | period of record   | all available values         |
| Extreme daily net radiation RF4<br>(MJ/m <sup>2</sup> )             | maximum                    | period of record   | all available values         |
| <b>Visibility</b>   |                            |                    |                              |
| Hours with visibility < 1 (km)                                      | total                      | *Normal            | 100% of hours                |
| Hours with visibility 1 to 9 (km)                                   | total                      | *Normal            | 100% complete                |
| Hours with visibility > 9 (km)                                      | total                      | *Normal            | 100% complete                |
| <b>Cloud amount</b>   |                            |                    |                              |
| Hours with total cloud opacity 0 to 2 tenths                        | total                      | *Normal            | 100% of hours                |
| Hours with total cloud opacity 3 to 7 tenths                        | total                      | *Normal            | 100% complete                |
| Hours with total cloud opacity 8 to 10 tenths                       | total                      | *Normal            | 100% complete                |

\*Normal indicates that all available data between 1971 and 2000 which qualified under the appropriate completeness rule for this element was used.