Canadian Climate Normals

1981-2010

# Overview

Climate Normals and Averages are used to summarize or describe the average climatic conditions of a particular location.

At the completion of each decade, Environment and Climate Change Canada updates its Climate Normals for as many locations and as many climatic characteristics as possible. The Climate Normals, Averages and Extremes offered here are based on Canadian climate stations with at least 15 years of data between 1981 to 2010.

Table 1: Main Characteristics

|  |  |
| --- | --- |
| Variables | Temperature  Rainfall, snowfall, and precipitation  Snow depth  Number of days with specified parameters  List of days with parameters and thresholds  Degree-days  Soil temperature  Evaporation  Frost and freezing-free period  Hourly data include: Wind, Bright Sunshine, Humidex, Pressure, Solar Radiation, Visibility, Cloud amount |
| Spatial resolution and geographical coverage | Point locations across Canada |
| Time period | 1981-2010 |
| Temporal resolution | Hourly, Daily, Monthly |

# Variables and formats

The normals elements of greatest interest are the daily values of maximum, minimum and mean temperature (deg C), rainfall (mm), snowfall (cm) and total precipitation (mm). For principal stations, additional daily elements such as peak wind gusts 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. 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 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 since the late 1990's) were not used for the normals calculations since daily rainfall and snowfall observations were not available.

## 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 (Universal Time Coordinate) 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.

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## 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.

## 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.

## 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.

##### List of Days with parameters and thresholds

**Days with Maximum Temperature**

* <= 0 deg C
* > 0 deg C
* > 10 deg C
* > 20 deg C
* > 30 deg C
* > 35 deg C

**Days with Minimum Temperature**

* > 0 deg C
* <= 2 deg C
* <= 0 deg C
* < -2 deg C
* < -10 deg C
* < -20 deg C
* < -30 deg C

**Days with Rainfall**

* >= 0.2 mm
* >= 5 mm
* >= 10 mm
* >= 25 mm

**Days with Snowfall**

* >= 0.2 cm
* >= 5 cm
* >= 10 cm
* >= 25 cm

**Days with Precipitation**

* >= 0.2 mm
* >= 5 mm
* >= 10 mm
* >= 25 mm

**Days with Snow Depth**

* >= 1 cm
* >= 5 cm
* >= 10 cm
* >= 20 cm

## Degree-Days

Degree-days for a given day represent the number of Celsius degrees 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 of 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.

## Soil Temperature

Soil temperature measurements provide the 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 World Meteorological Organization (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.

## 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 1981 to 2010 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 1981 to 2010 lake evaporation normal values comparable to previous calculations, multiply the 1981 to 2010 value by the number of days for a given month to obtain an equivalent estimate.

## Frost and Freezing-Free Period

Freezing occurs whenever temperatures fall to 0 deg C or lower. Frost 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 purposes of these calculations, "spring" is defined as days ***on or before*** July 15, "fall" is defined as days ***after*** July 15 and freezing or frost occurs on any day where the daily minimum temperature (Tmin) is observed to be less than or equal to 0 deg C.

"Freezing-free" elements are to be calculated only for stations where the daily minimum temperature observations is 100% complete from July 15 to the last occurrence of Tmin less than or equal to 0 deg C in "spring" and from July 15 to the first occurrence of Tmin less than or equal to 0 deg C in "fall" and at least one complete period occurs within 1981 to 2010.

Frost normals for the 1981-2010 period were calculated as means of the Julian days representing the last “spring” frost, first “fall” frost and frost-free length. These means are calculated for the 1981-2010 period.

Probability statistics are only generated for stations with at least 10 years of data. Calculations for spring freezing at x%, fall freezing at x% and freezing free period at x% were completed using the same methodology. These statistics are calculated for the entire period of record for a station.

## 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.

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

## Wind

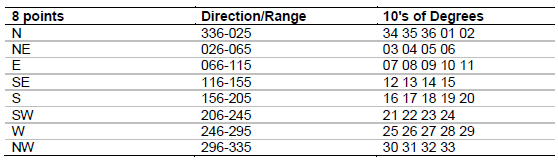
Most principal climatological stations are equipped with a standard type U2A anemometer, taking one-minute or (since 1985) two-minute mean speeds values at each observation. At other wind-measuring sites, values are usually obtained from autographic records of U2A or 45B anemometers. Averaging periods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

In observing, wind speed is measured in 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 metres or 1.852 km  
therefore 1 knot = 1.852 km/h and 1 km/h = 0.54 knot.**

Wind direction measured by U2A's are 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 calculation of most frequent wind direction has been updated in the 1981-2010 normals. Most frequent wind direction is based on the total number of occurrences of each of 36 possible directions (in 10s of degrees) for each month converted into one of 8 compass directions. For each of the 8 compass directions the total counts for these 10s of degrees are added together. The direction with the highest summed amount is the most frequent wind direction. The most frequent wind direction for the year is simply deduced as the summed direction with the highest total occurrence count for all months. The 8 compass directions are determined from the chart given below.

Table 2: 8 points, range and 10’s of deg

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 metres above the ground surface.

## 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 are counted, as indicated by the burn on the card, and the total is recorded.

## 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 Environment Canada 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 \* ( (1/273.15) - (1/dewpoint) ) ]

Dewpoint is expressed in kelvins (temperature in K = temperature in °C + 273.15) and 5417.7530 is a rounded constant based on the molecular weight of water, latent heat of evaporation, and the universal gas constant.

## 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°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°C.

In the previous normals, wind chill was calculated when the temperature of the air was ≤ 10°C and the reported wind speed was ≥ 5km/h. The first equation listed below was used for these calculations. In the 1981-2010 normals there are two Wind Chill formulas used by Environment Canada. The first equation is used when the temperature of the air is ≤ 0°C and the reported wind speed is ≥ 5km/h. The second equation is used when the temperature of the air is ≤ 0°C and the reported wind speed is > 0km/h but < 5km/h.

The standard Wind Chill formula for Environment Canada is:

1. W = 13.12 + 0.6215 × Tair - 11.37 × V10m0.16 + 0.3965 x Tair × V10m0.16

2. W = Tair + [(-1.59+0.1345 × Tair)/5] × V10m

Where   
W is the wind chill index, based on the Celsius temperature scale   
Tair is the air temperature in degrees Celsius (°C), and   
V10m is the wind speed at 10 metres (standard anemometer height), in kilometres per hour (km/h).

## 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/dew point difference is small, some of the internal water vapour condenses to form liquid water droplets either as fog or clouds.

## 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 (kPa) 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.

## 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 metre (MJ/m2).

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. (RF1 + RF2 + RF3)

## Visibility (km)

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.

## 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.

# 3. Application of Climate Normals

"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 1981 to 2010.

# 4. Limitation

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.

# 5. Methods

Environment and Climate Change Canada Canadian Climate Normals 1981-2010 Calculation Information:

<ftp://client_climate@ftp.tor.ec.gc.ca/Pub/Documentation_Canadian_Climate_Normals/1981_2010/Canadian_Climate_Normals_1981_2010_Calculation_Information.pdf>

# 6. User Limitation

Limited use software and data product license agreement (<http://climate.weather.gc.ca/prods_servs/attachment1_e.html> )

# 7. Contact Information

Climate Services Support Desk

[Info.cccs-ccsc@canada.ca](mailto:Info.cccs-ccsc@canada.ca)

833-517-0376

# 8. References

Environment and Climate Change Canada Canadian Climate Normals 1981-2010 Calculation Information: <ftp://client_climate@ftp.tor.ec.gc.ca/Pub/Documentation_Canadian_Climate_Normals/1981_2010/Canadian_Climate_Normals_1981_2010_Calculation_Information.pdf>