



Canadian Climate Normals 1991-2020

The production of the 1991-2020 Climate Normals is currently underway and will be published in phases. Phase 1 contains a subset of the Normals and Extremes elements. Future editions of this document will be updated in subsequent publications as additional elements become available.

- 1.0 [General](#)
 - 1.1 [Network and Station Changes](#)
 - 1.2 [Composite Stations](#)
- 2.0 [Calculation Method](#)
 - 2.1 [WMO Standards](#)
 - 2.2 [Calculation of Monthly and Annual Normal Values](#)
- 3.0 [Normals Code](#)
- 4.0 [Uncertainty due to Shorter Period](#)
- 5.0 [Standard Deviation Calculations](#)
- 6.0 [Climate Extremes](#)
- 7.0 [Analytics](#)
- 8.0 [Data Adjustments](#)
- 9.0 [Definition of a Climatological Day](#)
- 10.0 [Data and Observing Stations](#)
 - 10.1 [Temperature](#)
 - 10.2 [Rainfall, Snowfall and Precipitation](#)
 - 10.3 [Number of Days with Specified Parameters](#)
 - 10.4 [Degree Days](#)
 - 10.5 [Quintiles](#)
 - 10.6 [Wind Gust](#)
 - 10.7 [Frost and Freezing-Free Period](#)
 - 10.8 [Hourly Data](#)
 - 10.8.1 [Wind](#)
 - 10.8.2 [Humidity](#)
 - 10.8.3 [Pressure](#)
 - 10.8.4 [Visibility](#)

[APPENDIX A](#)

1.0 General

Climate Normals and Averages are used to summarize or describe the average climatic conditions of a particular location. "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 at the end of every decade for the most recent 30-year period finishing in a year ending with zero. For every decade since the 1940s, the Meteorological Service of Canada (MSC) within Environment and Climate Change Canada (ECCC) has produced Climate normals, with the latest set being 1991-2020.

1.1 Network and Station Changes

Since the 1990s, most stations in the surface climatological network for Canada have undergone some manner of change; from staffed to automatic, daily climate to hourly automatic, and MSC-owned and operated to partner-owned and operated. The 1991-2020 Normals represents the first reporting period where data from automated observing stations are used. Following the rise of automation, the gradual reduction of staffed sites has led to reported elements that are no longer measured or qualify for the Normals (i.e. solar radiation, sunshine, evaporation, soil temperature, etc.).

1.2 Composite Stations

The Climate Normals, Averages and Extremes are based on Canadian climate composite stations with at least 15 years of data between 1991 and 2020. Composite stations are comprised of one or more stations operated by the MSC or its partners, where data from individual stations are joined in order to create a 30-year data series for a given location. Data series used in composite stations may consist of a mix of staffed and automated stations.

Ideally, co-located stations are chosen for the composite data series. Where no co-located stations exist, stations chosen are generally located within a ten (10) kilometre distance and less than fifty (50) meter elevation difference to the current reporting site, with some exceptions such as in data sparse areas.

Station composites are threaded from the beginning of the Normals period starting in 1991 to the end of 2020, where the predecessor site's data is used up until the end of its period of record and is then joined to the current operating site to extend the time series. For long term extremes, the same Normals period threads are extended back in time to the earliest date of data available from the first station used in the data series. Threads are generated by climate element for hourly and daily data, and may vary due to differences in station history, instrumentation, meteorological data availability, data quality or proximity.

Information on each location's composite station metadata and threads used to calculate the Normals/Extremes elements are available on the Historical Climate Data website.

2.0 Calculation Method

There are many ways to calculate "Climate normals". The most suitable methods adhere to accepted standards used internationally. For most countries, this means following the standards set by the WMO.

2.1 WMO Standards

The WMO considers thirty years long enough to eliminate year-to-year variations. Thus, the WMO climatological standard period for normal calculations are computed over a 30-year period of consecutive records, starting January 1st and ending December 31st. In addition, the WMO has 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"¹, 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.

(For more information on which locations and normal elements meet WMO standards, please refer to section [3.0](#))

2.2 Calculation of Monthly and Annual Normal Values

First, the average or total, depending on the element, for all individual months was calculated for all locations. Normals values were then calculated as the mean for each

¹ 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.

month from all the individual months in the 1991 to 2020 period that met the completeness requirements. With the exception of the annual standard deviation, the annual normal value was calculated as the mean or total of monthly normals values only for locations 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.

3.0 Normals Code

Once the qualifying months were determined, the "3 and 5" rule was also applied to the number of months used to calculate average mean or average total within the 30-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 1991 and 2020.

A normal code was assigned for each month according to the completeness criteria presented in Table 1 below. With the exception of the annual standard deviation calculated for mean temperature, the monthly code that represented the least degree of completeness was assigned to the annual normal code for that element and location.

Table 1: Normal Codes table for the 1991 to 2020 Canadian Climate Normals

Normal Code	Number of years with complete months required in the 1991-2020 period
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

While normals for all available elements for all stations were calculated, only elements with a normals code of at least Class D, or 15 years, are currently available through the Historical Climate Data website.

WMO Standards

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

4.0 Uncertainty Due to Shorter Period

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.

5.0 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 location 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.

6.0 Climate Extremes

Besides the monthly averages and totals, extremes for selected elements by month are also compiled. These include the daily mean, maximum, and minimum temperatures, wind and gust, and the daily rainfall, snowfall, and total precipitation, along with the dates of occurrence.

Long-term extremes are compiled from the entire period of record of each location and are not restricted to just the 1991-2020 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.

7.0 Analytics

During the calculation of normals and extremes, additional accompanying analytics are tabulated. These include: total number of available years, number of missing years, total count of observations and percent possible observations used. The first and last year used in the calculation, based on available qualifying data, are also available. Years used within the normals period are calculated for normals elements, whereas, long-term extremes were determined based on all years available.

8.0 Data Adjustments

Data used to generate the normals values are not homogenized. No corrections, estimations, or adjustments were made to account for any variations or changes 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 Climate Archive 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.

9.0 Definition of Climatological Day

Observations taken based on a calendar day cannot capture the minimums and maximums that are truly reflective of the peaks and lows over a 24-hour period. Normally, the coldest period in any given day is just before sunrise and the warmest period in a day is shortly after the sun reaches its zenith in the afternoon. A climatological day was therefore developed to ensure that the maximum and minimum temperatures could be captured.

The climatological day tends to start and end at the same hour of two consecutive days. For example, the climatological day begins at the 0601 UTC observations on Day 1 and ends at the 0600 UTC observation on Day 2. This is generally the case for most stations since 1961, particularly automated or hourly reporting stations; however, may vary depending on the type of station and/or location. Depending on the time period considered, this has changed throughout the history of the network.

For sites that report two observations over a 24-hour period, MSC uses the following procedure to determine:

- Maximum temperature: For "today" is calculated from the maximum temperature reported for "today's" afternoon (PM) observation compared to the maximum temperature reported for "tomorrow's" morning (AM) observation;
- Minimum temperature: For "today" is calculated from the minimum temperature reported for "today's" morning (AM) observation and for "today's" afternoon (PM) observation;
- Rainfall, snowfall and precipitation totals: For "today" are calculated from "today's" afternoon (PM) observation with "tomorrow's" morning (AM) observation; and
- Snow on the ground: For "today" is based on "today's" morning (AM) observation.

For sites reporting only once per day, the calendar day rather than climatological day applies.

At volunteer sites, the observer determines the times best suited to maintain regular daily observations.

10.0 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 and elements based on hourly data such as wind, humidity, and pressure 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 (also known as [principal stations](#)) is defined by the 24-hour period ending at 0600 UTC ([Universal Time Coordinate](#)). The climate at volunteer observing sites (also known as [ordinary stations](#)) ends at around 8:00 am local time and can vary somewhat from location to location.

Like Canada, many other countries' observing practices have evolved from observations taken almost exclusively by human observers to stations that are fully automated. By the end of the 1991-2020 Normals period, the majority of principal stations in the Canadian network were automated.

Principal Station

A 'Principal Station' is a WMO term that refers to a climate observing site that should give a satisfactory representation of the climate characteristics of all types of terrain in the territory of the country concerned (e.g. plains, mountainous regions, coasts, islands, etc.). Observations include at least temperature and precipitation; other climatological elements being observed include wind direction and speed, cloud amount, humidity, atmospheric pressure, visibility, and snow cover. Not every station will report all observed elements.

(For more information, please refer to the WMO's [Guide to Global Observation System](#))

Ordinary Station

In Canada, an 'Ordinary Station' is also referring to a T&P (temperature and precipitation) climate observing station, and they are volunteer or CCN ([Co-operative Climate Network](#)) sites. The operation of this type of station may be restricted to a much shorter period, but not less than three years.

(For more information, please refer to the WMO's [Guide to Global Observation System](#))

10.1 Temperature

At stations with human observers, temperature measurements are made from self-registering maximum and minimum thermometers set in a louvered, wooden shelter

(called a Stevenson Screen) to protect sensors from environmental exposure. 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 automatic climate stations, temperature measurements are recorded by thermistors – usually three, set in a Stevenson Screen which are predominantly aspirated to provide consistent air circulation. The shelter is mounted on a stand so that the thermistors are approximately 1-2 m above leveled ground.

Maximum temperature is the highest temperature recorded in a 24-hour period ending in the morning of the next day for that day. The minimum value is for a period of the same length, beginning in the evening of the previous day and ending the evening of the current day. Mean temperature is the average of the two.

At most principal stations, the climatological day begins at 0601 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.

(For more information regarding temperature observations, please refer to [MANCLIM](#))

10.2 Rainfall, Snowfall, and Precipitation

This is the first set of Normals where rainfall, snowfall and total precipitation are treated as separate elements and are threaded independently of one another, meaning the sum of rainfall and water equivalent of snowfall may not necessarily equal to total precipitation. Data series used in composite stations may consist of a mix of staffed and automated stations with varying data availability, which could lead to inconsistencies between precipitation elements.

Staffed Stations

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 that appear representative of the immediate area, and then averaged.

“Precipitation” is the water equivalent of all types of precipitation. The water equivalent of snowfall is either measured using a Nipher gauge, by melting the snow that falls into the gauge, or using the "ten-to-one" rule, where the snowfall amount (cm) is divided by ten to obtain the amount in mm. The Nipher gauge is a precipitation gauge 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.

At staffed stations, total precipitation is the sum of rainfall and the water equivalent of snowfall. Precipitation measurements are usually made four times per day at principal stations, whereas, at ordinary sites, usually made only once or twice per day. Rainfall, snowfall and precipitation amounts given in the tables represent the average accumulation for a given month or year.

Automated Stations

Automated stations only report hourly precipitation and do not report rainfall and snowfall.

Total precipitation is measured using an automated weighing-type gauge, which are typically shielded, to minimize the impact of wind and improve catch efficiency. The standard MSC automatic weather station (AWS) currently uses an all-weather precipitation gauge (AWPG) with either a single or double-alar shield for the year-round measurement of precipitation accumulation. The AWPG orifice is installed approximately 2 m above ground level at most sites to be high enough to limit blowing snow from entering the gauge and low enough to minimize wind turbulence.

To measure the water equivalence of snow in colder winter temperatures, anti-freeze is added to the gauge bucket to melt the snow. At airport sites, heated-type gauges such as a heated tipping bucket rain gauge (TBRG) or heated-rim weighing gauge are used.

10.3 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 precipitation, 0.2 mm or more must occur before a "day with" is counted.

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 Total Precipitation

- ≥ 0.2 mm
- ≥ 5 mm
- ≥ 10 mm
- ≥ 25 mm

Days with Weather

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

‘Days with weather’ is the observation of atmospheric phenomena, indicated by the presence or absence of any type of weather or obstruction to vision. This is typically measured at staffed hourly stations or airport sites.

10.4 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. Each difference in degree equates to 1 degree day. 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. Cooling degree-days are the number of degrees above 18°C .

Values above or below the base of 18°C are used primarily to estimate the heating and cooling requirements of buildings and fuel consumption. The higher the number of degree days, the more energy for heating or cooling that is required. 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.

Normals represent the average accumulation for a given month or year. The sum of degree days above or below the specified threshold is determined for each month across the 30-year period, then averaged.

10.5 Quintiles

Quintiles are calculated for monthly precipitation to statistically assess its distribution of values, in ascending order, for a given month across the averaging period. The dataset is divided into five equal groups, otherwise known as a quintile. Each quintile represents 1/5 or 20% of the dataset; the first quintile includes the lowest fifth of values (0-20%), whereas, the fifth quintile includes the highest fifth of values (80-100%). This is used as an indicator to report when the monthly precipitation for future occurrences is higher than or lower than, any values recorded in the averaging period.

Although there are many ways to define quintile boundaries, the recommended procedure proposed in 2007 by the WMO² is used in this set of Normals. The formulas used to calculate each of the quintile boundaries are outlined below in Table 2. This methodology was selected over others, including that defined by the WMO in updated publications³, to allow for missing values in the 30-year period with a minimum completeness of 80% (minimum 24 years out of 30).

Table 2: Quintile boundaries for monthly precipitation

Quintile Boundary	Formula
Quintile 1 (lower bound)	Lowest observation during the averaging period
Quintile 1 (upper bound)	$(1 + (n - 1) / 5)$ -th ranked observation during the averaging period (6.8 for a 30-year dataset)
Quintile 2 (upper bound)	$(1 + 2(n - 1) / 5)$ -th ranked observation during the averaging period (12.6 for a 30-year dataset)
Quintile 3 (upper bound)	$(1 + 3(n - 1) / 5)$ -th ranked observation during the averaging period (18.4 for a 30-year dataset)
Quintile 4 (upper bound)	$(1 + 4(n - 1) / 5)$ -th ranked observation during the averaging period (24.2 for a 30-year dataset)
Quintile 5 (upper bound)	Highest observation during the averaging period

n is the number of observations in the dataset

Lower bound is defined as the first or lowest value in the quintile, and upper bound as the last or highest value. For example, if the lowest value is 5.0 and the highest value is 105.0 for the first six ascending monthly precipitation values for June, the lower bound and upper bound in the first quintile is 5.0 and 105.0, respectively. For locations where there are missing monthly values or periods shorter than 30-years, this will result in a slight underrepresentation in the first and fifth quintiles.

10.6 Wind Gust

Gusts are sudden, rapid and brief changes in wind speed. They are characterized by more or less continual fluctuations between high (peak) and low (lull) speed. Daily wind gust is

² *The Role of Climatological Normals in a Changing Climate* (WMO, 2007)

³ *Guide to Climatological Practices* (WMO, 2011)

the maximum gust observed over the past 24 hours. At hourly reporting stations, this is based on the maximum gust speed reported during the 10-minute period ending at the hour when exceeding 16 knots.

The extreme wind gust speed is the instantaneous peak wind observed in a 24-hour period from the anemometer dials or abstracted from a continuous chart recording.

Direction of extreme wind gust speed is the gust direction that was recorded at the time when the extreme wind gust speed occurred. Prior to 1977, the gust direction was measured based on 16 points directions before switching to the current 36 points (10's of degrees).

(For more information on how hourly wind speed is measured, please refer to section [10.8.1](#))

10.7 Frost and Freezing-free Period

Freezing occurs whenever temperatures fall to 0°C or lower. Frost data normals are based on the occurrence of freezing temperatures recorded using minimum thermometers. The "Freezing-free Period" is defined as the number of days between the last occurrence of frost in the 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 15th, "fall" is defined as days after July 15th, and 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 locations where daily minimum temperature observations are 100% complete for the period of the last occurrence of T_{\min} less than or equal to 0°C up to July 15th in "spring", and from July 15th to the first occurrence of T_{\min} less than or equal to 0°C in "fall". At least one complete period must occur within 1991 to 2020.

Frost normals (average date of last Spring frost, average date of first Fall frost and average length of frost-free period) for the 1991-2020 period were calculated as means of the Julian days and represent the last "spring" frost, first "fall" frost and frost-free length.

Probability statistics are only generated for locations with at least 10 years of data. These statistics outline the probability of an event occurring either before or after a specified date. For example, a date of May 15th given for the 10th percentile of the "Probability of last temperature in spring \leq 0°C, on or after indicated dates", implies that there is a 10% likelihood that the last spring frost occurred on either May 15th or later. Similarly, a date of August 15th given for the 10th percentile of the "Probability of first temperature in fall \leq 0°C, on or before indicated dates", implies that there is a 10% likelihood that the first fall frost occurred on either August 15th or earlier. Finally, a location with 100 days given for the 10th percentile of the "Probability of frost-free period equal to or less than indicated period (days)", implies that there is a 10% likelihood that the frost-free period for the location is 100 days or less. Calculations for probability of 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 location.

10.8 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. Unlike daily elements where 100% completeness is required to calculate average totals, only 90% completeness is required for hourly elements. The monthly mean was then assigned an annual code, using the completeness requirements outlined in Table 1.

Hourly elements include: hourly wind speed and direction, humidity, pressure, and visibility.

10.8.1 Wind

Wind represents the horizontal flow of air at an altitude. Information on the characteristics of the current (i.e. direction, speed) are captured using an anemometer. Since wind tends to increase in speed and veer with height, the standard exposure of anemometer dials is typically set at a height of 10 m above the ground surface, at open leveled sites away from any interferences. This is due to wind speed and direction being greatly affected by proximity to the ground and by the presence of obstacles such as hills, buildings, and trees.

Wind speed is measured in meters per second (m/s) or nautical miles per hour (knot or kt), before being converted to kilometers per hour (km/h). A value of zero denotes calm or no wind. Normal values are calculated as the average hourly wind speed for a month averaged across the normals period. Annual values are an average of the yearly normal values.

Conversion factors:

1 nautical mile = 1852 meters or 1.852 kilometers

Therefore:

1 knot = 1.852 km/h

1 km/h = 0.54 knot

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. Prior to 1971, wind direction was measured based on 16 points directions before switching to the current 36 points (10's of degrees).

Since the update to the “Most frequently occurring wind direction” in the 1981-2010 normals, the calculation is now based on the total number of occurrences of each of 36 possible directions (in 10's of degrees) for each month converted into one of 8 compass directions. For each of the 8 compass directions, the total counts for these 10's 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 in Table 3.

Table 3: 8 Points, Direction/Range and 10's of Degrees

8 Points	Direction/Range	10's of Degrees
N	336-025	34 35 36 01 02
NE	026-065	03 04 05 06
E	066-115	07 08 09 10 11
SE	116-155	12 13 14 15
S	156-205	16 17 18 19 20
SW	206-245	21 22 23 24
W	246-295	25 26 27 28 29
NW	296-335	30 31 32 33

Staffed Stations

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.

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. For a U2A, 9 represents an east wind or 90 degrees true, 36 represents a wind blowing from the geographic North Pole or 360 degrees true, and 0 represents a calm or no wind. A wind direction observation represents the average direction over the two minutes period ending at the time of observation.

Automated Stations

At MSC automatic weather stations, a propeller anemometer and wind vane are used to measure wind speed and direction. Hourly wind speed is the average speed observed during the 10-minute period ending at the hour. At airport sites, ultrasonic wind sensors are used to measure the average speed during the two-minute period ending at the time of observation.

10.8.2 Humidity

Humidity is the amount of water vapour or moisture in the air as a measure of vapour pressure. 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.

To calculate vapour pressure, dewpoint temperature is used. This is the temperature in which the air would have cooled at constant pressure to reach saturation with respect to liquid water, without the addition or removal of water vapour. Saturation occurs when the air is holding the maximum water vapour possible at that temperature and atmospheric pressure. When the dewpoint is high, the moisture content of the air is also high.

Observations are made using either a dewcel remote temperature sensing unit or psychrometers (humidity probes). At automatic weather stations, the humidity probe is installed inside the Stevenson Screen, alongside the temperature thermometers. Using the temperature measurement from the humidity sensor, the dew point temperature is derived. Prior to 1977, psychrometric tables were used to determine dew point.

10.8.3 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. At staffed stations, the standard instrument for the measurement of atmospheric pressure is the mercury barometer, where the air pressure is balanced against the weight of a column of mercury in a glass tube that contains a vacuum. At automated stations, mounted digital or analog barometers are used to measure atmospheric pressure.

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.

The standard sea-level pressure is 29.92 inHg (1013.25 mb; 760.00 mmHg). Pressure conditions greater than 29.92 inHg are considered high pressure, and anything less than 29.92 inHg are considered low pressure.

10.8.4 Visibility

Visibility in kilometers (km) is the distance at which objects of suitable size can be seen and identified. Atmospheric phenomena such as weather (precipitation, fog, haze) or other obstructions (blowing snow or dust) can reduce atmospheric visibility. When no weather or other obstructions to visibility occur, the total cloud amount is additionally observed to reflect the current sky conditions.

Visibility is typically observed at staffed stations. Human observers use the aid of visibility charts and markers to report standardized increments in miles. If the observed value of visibility is between two reportable values, then the lower value is reported. Most stations no longer report visibility, with the exception of a select number of automated airport sites which use sensors that direct scattered light at a volume of air to simulate human perception of visibility.

(For more information regarding visibility observations at staffed stations, please refer to [MANOBS](#))

APPENDIX A

Table 4: Normals and extremes elements calculation for the 1991-2020 Climate Normals for Canada, grouped by climate element, and includes type of calculation, period used, and completeness rules.

Climate Element	Normals Element	Type of Calculation	Period Used	Completeness Rule
Temperature				
Mean Temperature	Mean Daily Temperature (°C)	Mean	*Normal	3 and 5 rule
	StdDev of Mean Monthly Daily Temperature (°C)	StdDev	*Normal	3 and 5 rule
	Extreme Maximum Daily Mean Temperature (°C)	Maximum	Period of Record	all available values
	Extreme Minimum Daily Mean Temperature (°C)	Minimum	Period of Record	all available values
Maximum Temperature	Mean Daily Max Temperature (°C)	Mean	*Normal	3 and 5 rule
	Extreme Maximum Daily Max Temperature (°C)	Maximum	Period of Record	all available values
	Extreme Minimum Daily Max Temperature (°C)	Minimum	Period of Record	all available values
Minimum Temperature	Mean Daily Min Temperature (°C)	Mean	*Normal	3 and 5 rule
	Extreme Maximum Daily Min Temperature (°C)	Maximum	Period of Record	all available values
	Extreme Minimum Daily Min Temperature (°C)	Minimum	Period of Record	all available values
Precipitation				
Total Precipitation	Total Precipitation (mm)	Total	*Normal	100% complete
	Extreme Daily Precipitation (mm)	Maximum	Period of Record	all available values
Days with...				
Maximum Temperature	Days with Max Temperature <= 0°C	Total	*Normal	100% complete
	Days with Max Temperature > 0, 10, 20, 30, 35°C	Total	*Normal	100% complete
Minimum Temperature	Days with Min Temperature > 0°C	Total	*Normal	100% complete
	Days with Min Temperature <= 0, 2°C	Total	*Normal	100% complete
	Days with Min Temperature < -2, -10, -20, -30°C	Total	*Normal	100% complete
Total Precipitation	Days with Precipitation >= 0.2, 5, 10, 25 mm	Total	*Normal	100% complete

Climate Element	Normals Element	Type of Calculation	Period Used	Completeness Rule
<i>Days with Weather</i>				
Freezing Rain	Days with Freezing Rain/Freezing Drizzle	Total	*Normal	all available values
Thunderstorm	Days with Thunderstorms	Total	*Normal	all available values
Hail	Days with Hail	Total	*Normal	all available values
Fog	Days with Fog/Ice Fog/Freezing Fog	Total	*Normal	all available values
Smoke	Days with Smoke/Haze	Total	*Normal	all available values
<i>Wind</i>				
Wind Speed Direction	Most Frequently Occurring Wind Direction (deg true)	-	*Normal	90% of hours
	Direction of Extreme Hourly Wind Speed (deg true)	-	Period of Record	all available values
Wind Speed	Mean Hourly Wind Speed (km/hr)	Mean	*Normal	90% of hours
	Extreme Hourly Wind Speed (km/hr)	Maximum	Period of Record	all available values
Wind Gust Direction	Direction of Extreme Daily Maximum Gust (deg true)	-	Period of Record	all available values
Wind Gust Speed	Extreme Daily Maximum Gust (km/hr)	Maximum	Period of Record	all available values
<i>Degree Days</i>				
Mean Temperature	Degree Days above 0, 5, 10, 15, 18, 24°C	Total	*Normal	100% complete
	Degree Days below 0, 5, 10, 15, 18°C	Total	*Normal	100% complete
<i>Quintiles</i>				
Total Precipitation	Quintile 1 (Lower Bound)	Quintile	*Normal	80% complete
	Quintile 1, 2, 3, 4, 5 (Upper Bound)	Quintile	*Normal	80% complete
<i>Humidity</i>				
Dewpoint	Mean Vapour Pressure (kPa)	Mean	*Normal	90% of hours
<i>Pressure</i>				
Pressure	Mean Station Pressure (kPa)	Mean	*Normal	90% of hours
Sea-Level Pressure	Mean Sea-Level Pressure (kPa)	Mean	*Normal	90% complete
<i>Visibility</i>				
Visibility	Hours with Visibility <1 km	Total	*Normal	90% complete
	Hours with Visibility 1-9 km	Total	*Normal	90% complete
	Hours with Visibility >9 km	Total	*Normal	90% complete
<i>Frost and Freezing-Free</i>				
Frost	Average Last Spring Frost	Mean	*Normal	100% complete

Climate Element	Normals Element	Type of Calculation	Period Used	Completeness Rule
(Minimum Temperature)	Average First Fall Frost	Mean	*Normal	100% complete
	Average Length of Frost-free period	Mean	*Normal	100% complete
Freezing Free (Minimum Temperature)	Probability of Last Temperature in Spring <= 0°C, on or after date (10, 25, 33, 50, 66, 75, 90%)	Probability	Period of Record	100% complete
	Probability of First Temperature in Fall <= 0°C, on or before date (10, 25, 33, 50, 66, 75, 90%)	Probability	Period of Record	100% complete
	Probability of Frost-free Period equal to or less than indicated period (day) (10, 25, 33, 50, 66, 75, 90%)	Probability	Period of Record	100% complete

*Normal indicates that all available data between 1991 and 2020, which qualified under the appropriate completeness rule for this element, was used.